GRINDING MACHINE FOR AUTOMOBILE PISTONS.

The latest grinding machine to be developed by Messrs. Arthur Scrivener, Limited, Tyburn-road, Birmingham, solves the difficult production problem of finish-grinding automobile pistons to a form which differs slightly from a true cylinder to allow for the effects of variations in piston-wall thickness and operating temperatures on the expansion of the piston. If a piston is to be truly cylindrical when it is at its normal working temperature it must, when cold, have a slight taper from the bottom of the skirt to the head (to compensate for the temperature gradient in service), and it must be slightly smaller in diameter across the gudgeon-pin bosses than across the intervening thrust faces to allow for the greater expansion where the greater mass of metal is concentrated.

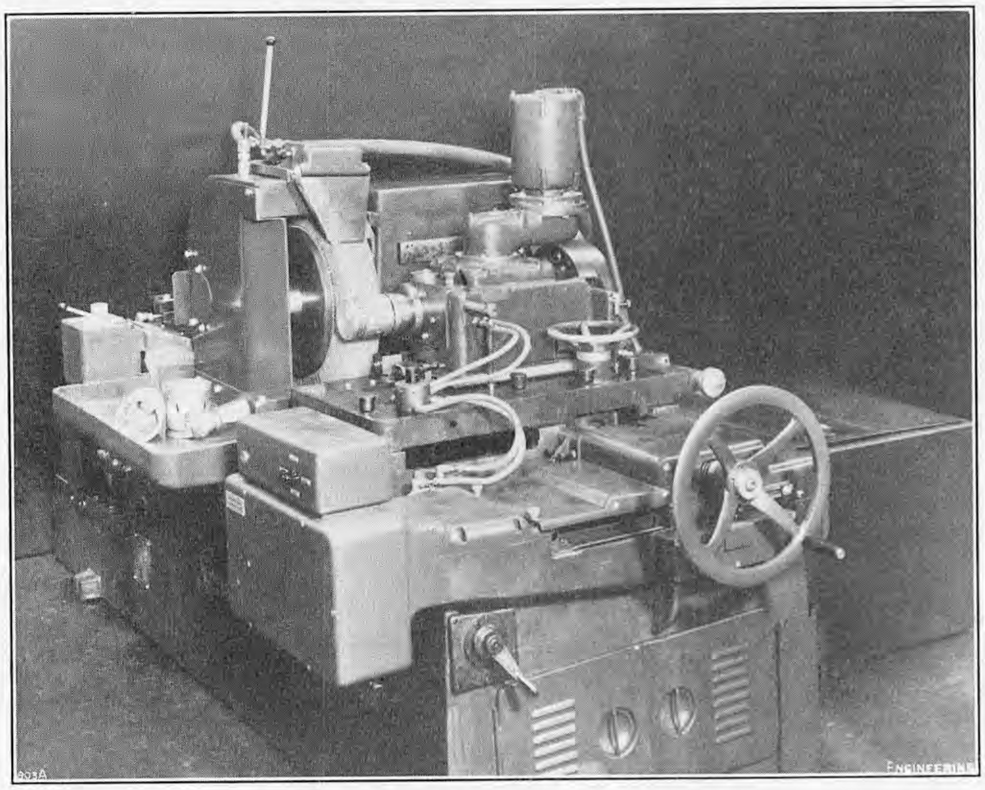
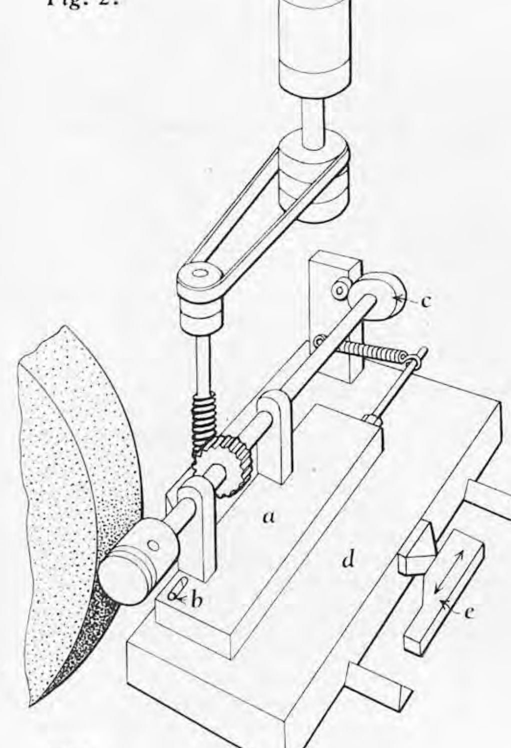


Fig. 1. Machine with Piston in Position.

Fig. 2.



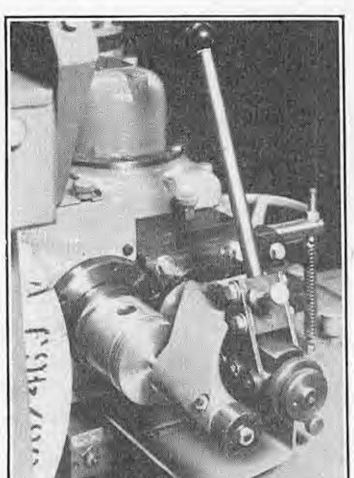


Fig. 3. Piston Held by Centring Device.

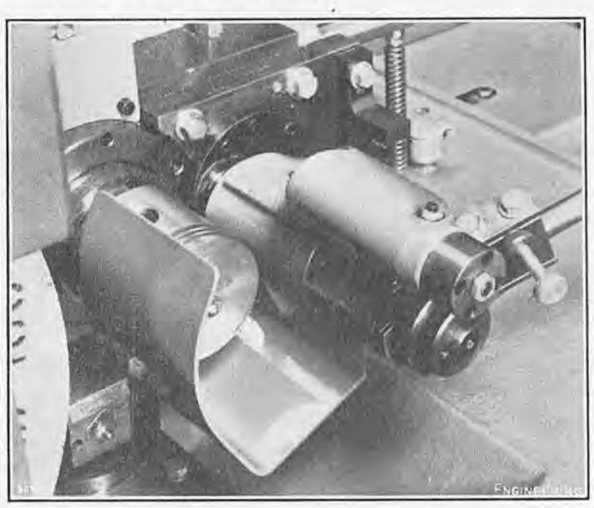


Fig. 4. Centring Device Swung Clear for Loading Piston.

Fig. 5. Group of Automobile Pistons.

The new machine, which is illustrated in Fig. 1, herewith, is not, like many Scrivener machines, a centreless grinder; it employs only one grinding wheel, against the periphery of which the piston is rotated. While the piston is being rotated about a horizontal axis, the inclination of its axis in relation to the grinding wheel is varied by means of a cam mechanism, so as to generate the required form of piston. The principle of this mechanism is shown diagrammatically in Fig. 2. The piston is mounted in a work-holding fixture on a spindle carried in a housing *a*, which can be oscillated about the pivot *b*; the oscillating movement is imparted by a cam *c*, which is maintained in contact with a fixed abutment by a spring. Thus, during each revolution of the spindle the lobes of the cam cause the piston to be swung towards the grinding wheel, thereby generating a taper, the amount of which is determined by the geometry of the mechanism, particularly the dimensions of the cam and the position of the pivoting point relative to the piston. In the plane vertically above the pivoting point the cross-section of the piston will be a true circle, irrespective of the angle of the spindle, but when the spindle is at its extreme angular displacement the depth of grinding will be proportional to the distance from the pivot, thus giving the desired form to the piston.

The cam normally has two lobes, each in line with the gudgeon-pin hole, so that as the piston rotates each lobe swings the piston closer to the grinding wheel; a predetermined greater amount of metal is therefore removed from the areas adjacent to the gudgeon-pin bosses. The two lower parts of the cam, which correspond to the thrust faces of the piston, produce parallel work, or at any rate a considerably less degree of taper, as determined by the position of the pivoting point.

As the skirt of the piston is thin and liable to deformation under pressure, it has been found advantageous, in some cases, to centre the piston by means of an outboard centring device, instead of holding the piston on its seating by a spring-loaded drawbar, as is usually done. This centring device is shown in Figs. 3 and 4, herewith. Pressure on the centre is provided by toggles actuated by a hand lever, suitable means being provided for pre-setting the applied loading. On withdrawing the centre by pulling back the lever, the whole device can be swung clear, as shown in Fig. 4, so as to allow the piston to be withdrawn and another piston to be loaded for grinding. The angular position of the piston on the spindle in relation to the cam is determined by the use of a pin in the gudgeon-pin hole engaging a fork in the nose of the spindle, and the normal spigot is used for locating the piston in the other plane. Fig. 5 shows a group of pistons, of various types, that can be ground in the machine.

Though it has no effect on the mechanics of the elliptical and taper grinding operation, the Scrivener controlled-cycle method has been adopted in the machine, both for controlling the grinding operation and for facilitating loading and unloading. The mechanism described so far is carried on a lower table *d*, which is movable to and from the grinding wheel on accurate ways, the forward position of the table determining the size of the finished work. The controlled-cycle mechanism is represented by the cam plate *e*, the profile of which gives a quick advance of the work to the wheel, followed by a predetermined rate of stock removal. With the cam plate *e* in the position shown in Fig. 2, the piston is being ground; when the grinding is finished the cam plate is withdrawn to the rear of the machine, thus removing the main table and mechanism sufficiently from the grinding wheel to allow the ground piston to be unloaded and another piston to be inserted.

The grinding cycle can be adjusted to give a production of 60 to 70 pistons an hour, but the actual rate depends on the accuracy to which the piston has been held in preceding machining operations and on the tolerances that have been worked to previously. The makers claim that the new machine will enable pistons to be ground more accurately and more closely to the required form than has been possible by previous methods.

LITERATURE.

Eléments d'Optique Electronique.

By PROFESSOR GASTON DUPOUY. Collection Armand Colin No. 267. Librarie Armand Colin, 103, Boulevard Saint-Michel, Paris, Ve. [Price 260 francs.]

THOUGH electron optics dates back only some 25 years, it has expanded rapidly and has given rise to scientific developments and technical applications of the greatest interest and importance. The latest addition to the Physics Section of this well-known series gives a masterly survey of this branch of physics. In his introduction, Professor Dupouy outlines the discovery and properties of the electron, its deflection by uniform electric and magnetic fields, and the evidence, from electron diffraction experiments, of the correctness of de Broglie's conception that it must exhibit undulatory aspects as well as corpuscular properties. The analogy between an electron traversing a region within which the potential changes and a light ray passing through a medium having a refractive index which varies is developed in the next chapter, which then goes on to consider the focusing properties of axially symmetrical electrostatic fields and the paths of electrons traversing the single-aperture immersion objective and symmetrical three-electrode types of electrostatic electron lenses subject to conditions equivalent to the Gaussian approximation in optics. Though the potential distribution within a region bounded by electrodes at different voltages is determined uniquely by Laplace's equation, in conjunction with the appropriate boundary conditions, relatively few cases admit of analytical solution. Recourse must be had, therefore, to experiment, and Chapter III provides a clear account of potential mapping by means of the ordinary and wedge types of electrolytic tank as well as of devices for obtaining values of the first and second derivatives of the potential at points throughout the field. Automatic tracers of electron trajectories are mentioned, though no description is given of the rubber-sheet model technique. On account of its extensive use in practice a separate chapter is devoted to a more detailed study of the characteristics of the symmetrical three-electrode electrostatic electron lens, which can also be made to serve as a convergent or divergent electron mirror.

The next three chapters treat of electron motion in magnetic fields and lenses. It is shown that an axially-symmetrical invariable magnetic field is capable of converging to a point focus in the image space a narrow cone of monokinetic electrons whose vertex is located in the object space and which makes a small angle with the axis. Induction and electromagnetic methods of exploring magnetic fields within lenses of the solenoid and armoured coil patterns—the equivalent of thick and thin lenses in optics—are described. The determination of the cardinal points of such lenses is explained and attention drawn to two properties peculiar to magnetic lenses—the rotation of the final image, which can, if necessary, be eliminated, and the formation of multiple foci. Chapter VIII outlines the various defects exhibited by electron lenses under the headings geometrical, chromatic and space charge aberrations, misalignment of components, initial electron velocities, supply voltage fluctuations, energy loss in traversing specimens and diffraction effects. Indications are also given as to how they may be minimised, while a short chapter summarises admirably the respects in which optical lenses resemble and differ from electron lenses. The concluding chapter, dealing with the electron microscope, the most significant scientific application of the principles of electron optics, is noteworthy, as the author constructed the first high-power electron microscope in France during his tenure of the Chair of Physics at Toulouse. The main advantage of the electron microscope lies in the fact that its limit of resolution, of the order of 20 Å or under, is some thousand times better than its optical counterpart. Moreover, the necessity of keeping the angular aperture of the imaging pencils small gives the instrument a considerable depth of field, as is apparent in some of the electron microphotographs reproduced. After detailing essential precautions concerning the preparation and mounting of specimens and their protection against vibration, voltage regulation and shielding against extraneous magnetic fields mention is made of some of the results so far obtained in the physical and biological sciences and of the possibilities of the proton microscope under construction at the College de France.

The factor $\frac{1}{\sqrt{V_2}}$ is omitted from the second term on the right-hand side of the equation at the foot of page 48; other misprints, such as 10^{-16} for 10^{16}, on page 14, are few and obvious. In this lucid, comprehensive and authoritative introduction to electron optics, Professor Dupouy has contributed an outstanding addition to the Collection Armand Colin.

AN ANALYSIS OF THE FORCES AND PRESSURE DISTRIBUTION IN BRAKE SHOES.

By J. HIRSCHHORN, Dipl. Ing. (Vienna), A.M.I.E. (Aust.)*

THE useful life of a brake lining is determined by its wear. When wear has progressed far enough for the means of attachment of the lining to become insecure, the lining must be renewed. Hence, in the case of a brake with highly localised wear, a large proportion of the initially-provided lining volume will have to be discarded, having performed but little useful work. Therefore, to ensure optimum utilisation of the lining material the wear should be kept as uniform as possible. Since wear at a given point is directly proportional to the locally prevailing pressure, it follows that for reasons of economy the pressure distribution on the lining should be as uniform as possible. The laws formulated below are based on the following assumptions—(1) the brake posts and shoes are rigid, (2) the wear is confined to the lining only, (3) the coefficient of friction is independent of pressure. These assumptions approximate very closely to the actual conditions prevailing in brakes used on cranes, hoists and similar machines, and equipped with cast or fabricated posts and shoes, cast iron or steel brake drums, and bonded asbestos or similar linings.

The following symbols are used.

a, b, c	distances or lengths (in.).
θ, ϕ, ϵ	angles (deg. or rad.).
r	brake drum radius (in.).
s	effective length of lining, measured along the periphery of the drum (in.).
w	effective width of lining (in.).
t	arm of resultant friction force with respect to brake-drum centre (in.).
p	radial pressure between lining and drum (lb. per square inch).
P	resultant normal, i.e. radial, force on shoe (lb.).
F	resultant frictional force on shoe (lb.).
R	resultant of P and F (lb.).
μ	coefficient of friction.
$\overset{v}{\Sigma}$	vector-sum of forces (lb.).
$\overset{a}{\Sigma}$	algebraic sum of forces (lb.).
T	restraining torque exerted by brake (lb. in.).
S	force applied to brake post by brake mechanism (lb.).
k, K, C	constants.

* Senior Lecturer, Mech. Eng. Dept., University of Technology, New South Wales.

The fundamental law of pressure distribution, which forms the basis of the constructions described in this article, may be formulated as follows. The pressure between lining and brake drum at a given point is proportional to the point's virtual radial displacement, i.e., its virtual displacement towards the centre of the brake drum. This result may be proved as follows: Fig. 1, opposite, shows a brake drum and a portion of the lining in the original condition, and Fig. 2 shows the arrangement after a time δt when a certain amount of wear has taken place. It is assumed that, owing to some geometrical constraint, the "wear movement" of point A follows the path A A′. The elemental volume δv worn off during the process is

$$\delta v = w\,\delta s\,\text{A A}'\cos\phi$$
$$= w\,\delta s\,\delta m\cos\phi. \quad . \quad . \quad (1)$$

This volume is proportional to the amount of work δW done in the time δt by the frictional force; this work equals the frictional force multiplied by the distance moved, i.e.

$$\delta \text{W} = (\mu\, p\, w\, \delta s)\,(2\pi r\,\delta\text{N}), \quad . \quad . \quad (2)$$

where δN is the number of revolutions made by the brake drum in the time interval δt. Since $2\pi r\mu\,\delta$N has the same value for all points of the lining in contact with the drum, it follows from the proportionality mentioned above that

$$p \propto \delta m \cos\phi. \quad . \quad . \quad . \quad (3)$$

Instead of the finite movement $\delta\, m$, a virtual motion "dm" may be considered; so that

$$p \propto dm\cos\phi. \quad . \quad . \quad . \quad (4)$$

Since ($dm\cos\phi$) is the component of the virtual movement in the direction of the radius, the fundamental law referred to above follows.

For "fixed" shoes, i.e., shoes rigidly attached to the brake posts, the most convenient method of determining the pressure distribution is that of the "pressure circle," the derivation of which will now be given.

Fig. 3 is a diagrammatic representation of a brake having the shoe rigidly attached to the brake post which pivots about the point C. Owing to the physical constraint, the virtual movement of each point is perpendicular and proportional to its radius l from C, i.e., A A′ and B B′, in Fig. 4, are normal to C A and C B, respectively, and $\frac{\text{A A}'}{l_{\text{A}}} = \frac{\text{B B}'}{l_{\text{B}}} = k$. Therefore, in Fig. 3,

$$p \propto k\,l\cos\phi,$$

or

$$p = \text{K}\,l\cos\phi \quad . \quad . \quad . \quad . \quad (4)$$
$$= \text{K}\,l\sin(90 - \phi),$$

But

$$r\sin(90 - \phi) = d\sin\epsilon,$$

and

$$\sin\epsilon = \frac{y}{l}.$$

Hence

$$p = \text{K}\frac{dy}{r}$$

or

$$p = \text{K}'\,y. \quad . \quad . \quad . \quad (5)$$

Since $y = r\sin\theta$, the above relation may be stated as:

$$p = \text{C}\sin\theta. \quad . \quad . \quad . \quad (6)$$

Thus, the pressure at any point is proportional to the sine of the angle between the positive x-axis and the radial line through the point, or proportional to its y-coordinate. If the y-coordinates are set off radially from O, as in Fig. 5, opposite, the locus of their end points is a circle of radius $\frac{r}{2}$, disposed as shown in Fig. 5. This follows at once from the polar equation of such a circle or may, of course, be proved by Cartesian methods.

To construct the pressure circle a radial line y-y (see Fig. 6), is drawn at right angles to the axis x-x which passes through the brake post pivot and brake drum centre. Any circle with its centre located on y-y and passing through the drum centre could be used as pressure circle for the given arrangement of the brake. Generally, however, the centre of the pressure circle is placed at the mid-point of the y-radius as shown in Fig. 6. The pressure at any point is proportional to the length of the chord of the pressure circle contained in the radial line passing through the point. The construction shows

FORCES AND PRESSURE DISTRIBUTION IN BRAKE SHOES.

Fig. 1.

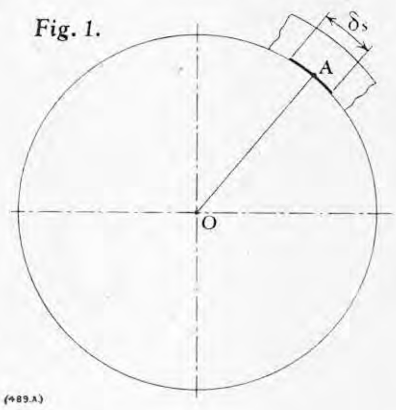


Fig. 2.

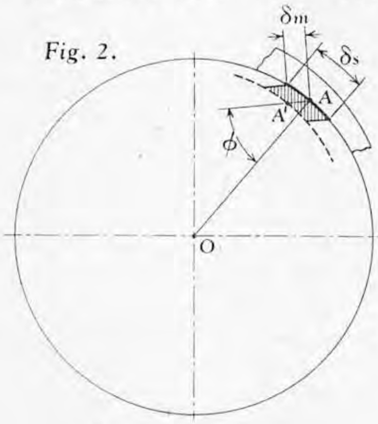


Fig. 3.

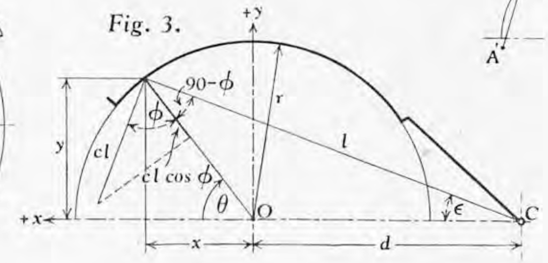


Fig. 4.

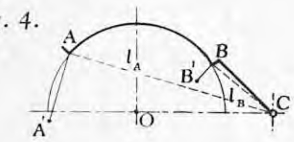


Fig. 5.

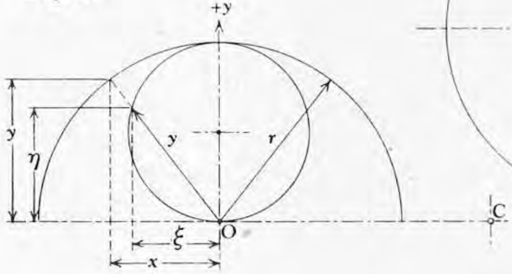


Fig. 6.

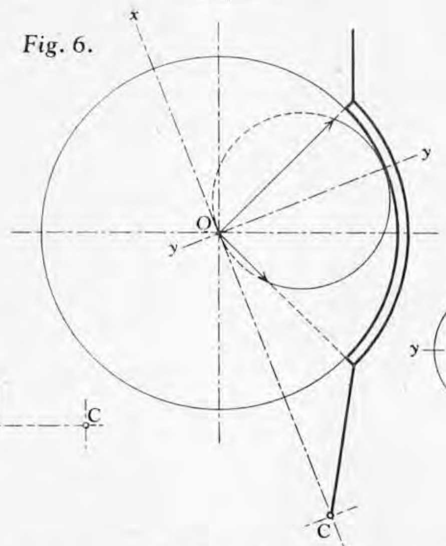


Fig. 7.

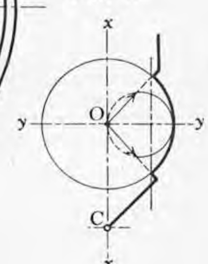
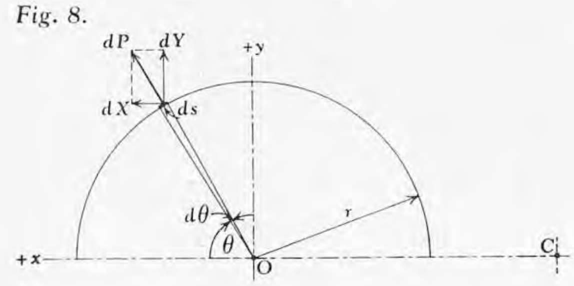


Fig. 8.



that as long as the pivot C is located on a given line x-x its distance from the brake centre O does not influence the pressure distribution. More important, however, is the also obvious fact that, for greatest uniformity of pressure distribution, the line x-x should be parallel to the chord subtended by the lining, as indicated in Fig. 7. Finally, it can be seen that the use of linings subtending angles greater than 80 to 90 deg. at the brake centre is not to be recommended as the difference between maximum and minimum pressure intensities becomes excessive.

The normal pressures acting on the shoe result in a radial force P giving rise to a friction force F, perpendicular to P, which provides the required restraining torque. The lines of action of these forces are best determined by the method of "brake coefficients," the application of which will be illustrated by means of several examples.

Since the pressure at any point is given by the equation (6), where θ is the angle between the positive x-axis (i.e., the line passing through post pivot and drum centre) and the radius vector of the point, the elemental force d P acting on the element of length ds (see Fig. 8) is

$$d\,\mathrm{P} = \mathrm{C}\,w \sin\theta\, ds$$
$$= \mathrm{C}\,w\,r \sin\theta\, d\theta \quad . \quad . \quad . \quad (7)$$

This force can be resolved into components in the x and y directions respectively:

$$\left.\begin{array}{l} d\mathrm{X} = \mathrm{C}\,w\,r \sin\theta\cos\theta\, d\theta \\ \text{and} \quad d\mathrm{Y} = \mathrm{C}\,w\,r\sin^2\theta\, d\theta \end{array}\right\} \quad . \quad . \quad (8)$$

On integrating between the limits $_0$ and θ, the following expressions are obtained:

$$\mathrm{X}_\theta = \mathrm{C}\,w\,r\,\frac{\sin^2\theta}{2}, \quad . \quad . \quad (9)$$

where $\frac{\sin^2\theta}{2}$ may be called the "x-coefficient,"

$$\mathrm{Y}_\theta = \mathrm{C}\,w\,r\,\frac{\theta - \sin\theta\cos\theta}{2}, \quad . \quad (10)$$

where $\frac{\theta - \sin\theta\cos\theta}{2}$ is the y-coefficient,

$$\overset{a}{\Sigma}_\theta\, d\mathrm{P} = \int_0^\theta d\mathrm{P} = \mathrm{C}\,w\,r\,(1 - \cos\theta), \quad . \quad (11)$$

and $1 - \cos\theta$) is the Σ-coefficient.

If the brake shoe extends from θ_1 to θ_2, the component of the force P in the direction x is proportional to the difference of the corresponding x-coefficients, since

$$\mathrm{P}_x = \Delta\mathrm{X} = \mathrm{C}\,w\,r\left(\frac{\sin^2\theta_2}{2} - \frac{\sin^2\theta_1}{2}\right) = \mathrm{C}\,w\,r\,\Delta x.$$

The same argument applies to P_y and to the algebraic sum of the forces. To find the direction of the force P, the values of Δx and Δy are determined and plotted along their respective axes, starting from O. Their vector sum is the required result. The line of action of the friction force F is found by reasoning as follows: The elemental radial force dP gives rise to an elemental friction force $d\mathrm{F} = \mu\, d\mathrm{P}$ acting tangentially to the brake drum. The resultant radial force P is the vector sum of the elemental components dP:

$$\mathrm{P} = \overset{v}{\Sigma}\, d\mathrm{P}. \quad . \quad . \quad . \quad (12)$$

The resultant friction force F is the vector sum of the elemental components d F and is perpendicular to P, since each component d F is proportional and perpendicular to its corresponding dP. Thus,

$$\mathrm{F} = \overset{v}{\Sigma}\, d\mathrm{F} = \mu\overset{v}{\Sigma}\, d\mathrm{P} = \mu\,\mathrm{P}. \quad . \quad (13)$$

Its line of action is found by taking moments about O, noting that the moment of the resultant is equal to the algebraic sum of the moments exerted by the components.

Hence,

$$\mathrm{F}\,t = \overset{a}{\Sigma}\,\mu\,r\,d\mathrm{P}$$

or

$$\mu\,t\overset{v}{\Sigma}\,d\mathrm{P} = \mu\,r\overset{a}{\Sigma}\,d\mathrm{P}$$

and

$$t = \frac{\overset{a}{\Sigma}\,d\mathrm{P}}{\overset{v}{\Sigma}\,d\mathrm{P}}\,r$$

but

$$\frac{\overset{a}{\Sigma}\,d\mathrm{P}}{\overset{v}{\Sigma}\,d\mathrm{P}} = \frac{\text{difference in }\Sigma\text{-coefficients for }\theta_2\text{ and }\theta_1}{\text{length of force vector P}}$$

Hence

$$t = \frac{\Delta\Sigma}{\mathrm{P}}\,r. \quad . \quad . \quad . \quad (14)$$

In the above equation $\Delta\Sigma$ and P must be expressed in the same units. The brake coefficients are tabulated in Table I below for angular increments of 15 deg., and are shown graphically in Fig. 9.

TABLE I.

θ deg.	x.	y.	Σ.
0	0·000	0·000	0·000
15	0·033	0·006	0·034
30	0·125	0·045	0·134
45	0·250	0·143	0·293
60	0·375	0·307	0·500
75	0·467	0·530	0·741
90	0·500	0·785	1·000
105	0·467	1·041	1·259
120	0·375	1·264	1·500
135	0·250	1·428	1·707
150	0·125	1·526	1·866
165	0·033	1·565	1·966
180	0·000	1·571	2·000
195	0·033	1·577	1·966
210	0·125	1·616	1·866
225	0·250	1·714	1·707
240	0·375	1·878	1·500
255	0·467	2·100	1·259
270	0·500	2·356	1·000

In applying the method of brake coefficients to the solution of problems, the calculations are set out conveniently in tabular form. For example, in Fig. 10, herewith, $\theta_1 = 66$ deg. and $\theta_2 = 156$ deg. Hence, using Fig. 9,

θ deg.	x.	y.	Σ.
156	0·08	1·55	1·91
66	0·42	0·39	0·59

Therefore:

$$\Delta x = -0\cdot34 \text{ force units}$$
$$\Delta y = +1\cdot16 \text{ force units}$$
$$\Delta\Sigma = +1\cdot32 \text{ force units.}$$

Δx and Δy are set off from O along their respective axes. Their resultant vector represents the total radial force P in direction and magnitude expressed in terms of the force-unit used in plotting the brake coefficients.

In this case,

$$\mathrm{P} = 1\cdot21 \text{ force units.}$$

Hence,

$$t = \frac{\Delta\Sigma}{\mathrm{P}}\,r = \frac{1\cdot32}{1\cdot21}\,r = 1\cdot09\,r$$

FORCES AND PRESSURE DISTRIBUTION IN BRAKE SHOES.

Fig. 9.

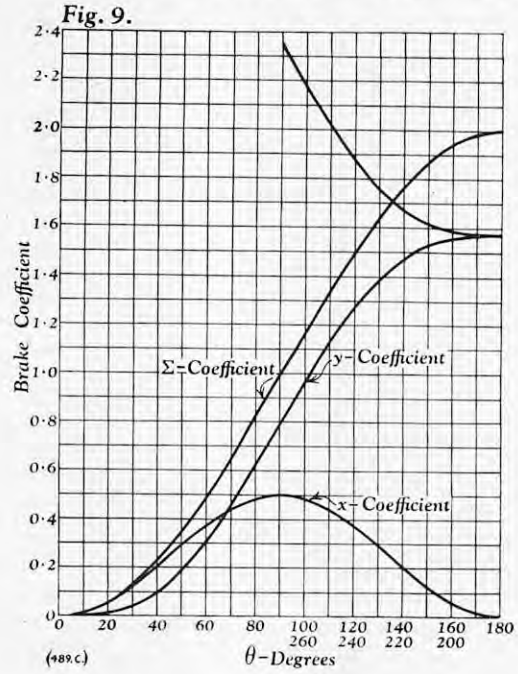


Fig. 10.

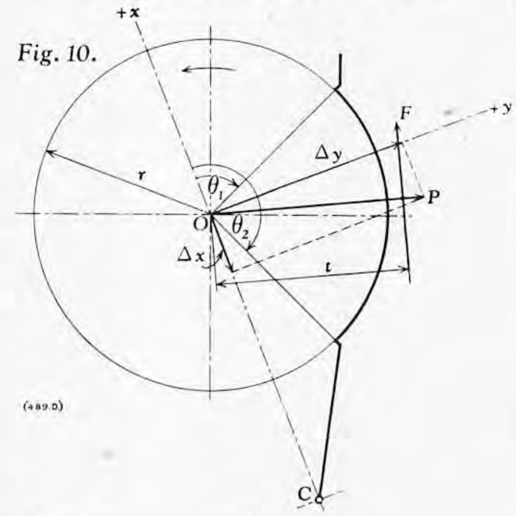


Fig. 11.

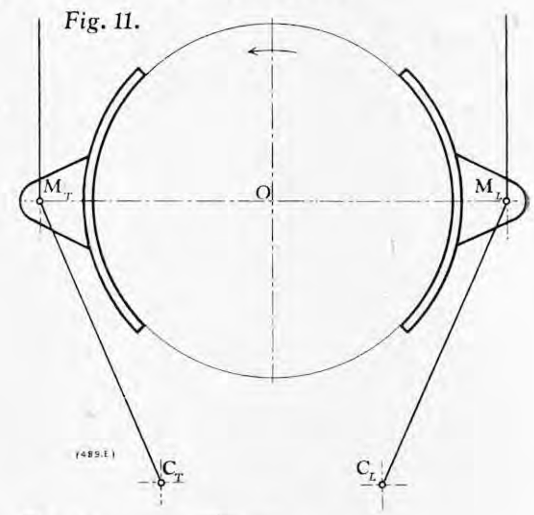


Fig. 12.

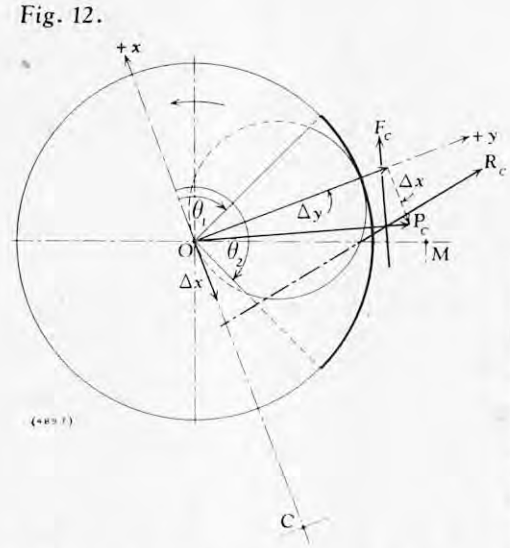


Fig. 13.

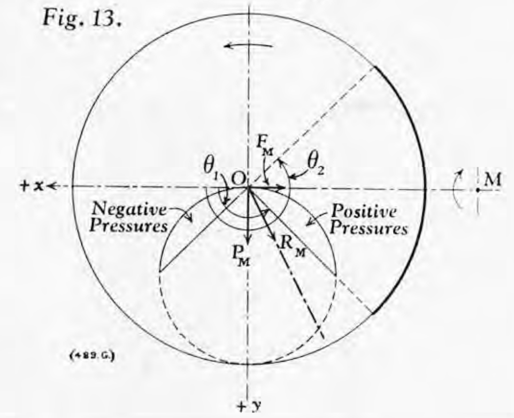
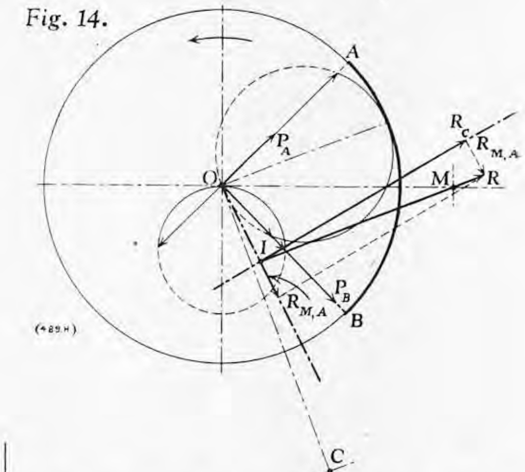


Fig. 14.



As F is perpendicular to P, its line of action can now be drawn. Its direction is given by the sense of rotation of the brake drum and its magnitude is $F = \mu P$.

The length of the force-unit used in plotting the vectors is of no consequence, except when it is desired to calculate the pressure-intensities. In that case it is recommended that the force-unit be made equal to the brake radius.

The problem of finding the pressure distribution in brakes having shoes pivoted to the brake posts i.e. hinged shoes, is much more complex than for brakes with fixed shoes because the virtual movement of the shoe is the result of two virtual movements occurring simultaneously, namely, one about the post pivot, and another about the shoe hinge. The line of attack is based on the equilibrium condition that the resultant R of all normal and friction forces acting on the shoe must pass through the centre point of the hinge. In solving this problem, the forces related to each of the two component movements are determined separately and their relative magnitudes are then adjusted so that, on their superposition, a resultant force passing through the centre of the shoe hinge is obtained. To clarify the procedure, the pressure distribution on the shoes of the brake shown diagrammatically in Fig. 11, herewith, will be determined.

The forces related to the virtual movement about the brake-post pivot are determined with the aid of the brake-coefficients. Here $\theta_1 = 66$ deg. and $\theta_2 = 156$ deg.; thus we have, from Fig. 9, on this page.

θ deg.	x.	y.	Σ.
156	0·08	1·55	1·91
66	0·42	0·39	0·59

Therefore, $\Delta x = -0 \cdot 34$ units, $\Delta y = 1 \cdot 16$ units, and $\Delta \Sigma = 1 \cdot 32$ units. The components Δx and Δy result in the force P_C (see Fig. 12, herewith) of magnitude 1·21 units. Assuming a coefficient of friction $\mu = 0 \cdot 5$, the magnitude of the friction force F_C is 0·605 units, and its moment arm t equals 1·09 r, since $t = \frac{1 \cdot 32}{1 \cdot 21} r$. P_C and F_C are combined to a resultant R_C of 1·35 units.

As regards the forces related to the virtual movement about the shoe hinge, consideration of the action of the force R_C, determined in the previous step, shows that the virtual movement about the hinge will be clockwise, increasing the pressures on the lower half of the shoe and decreasing them on the upper half. As before, the forces are determined by means of the brake-coefficients. Here $\theta_1 = 135$ deg. and $\theta_2 = 225$ deg., whence, by Fig. 9,

θ deg.	x.	y.	Σ.
225	0·25	1·71	1·71
135	0·25	1·43	1·71

Since $\Delta x = 0$, the resultant radial force P_M is equal to the component Δy, i.e., it is directed downwards along the positive y-axis and its magnitude is 0·28 units. The algebraic sum of the forces is zero, since the negative pressures on the upper half of the shoe balance the positive pressures acting on the lower half. As $\mu = 0 \cdot 5$, the resultant frictional force F_M is of magnitude 0·14 units. It is directed to the right and passes through the centre O. ($t = \frac{0 \cdot 00}{0 \cdot 28} r = 0$.) P_M and F_M, combined, have a resultant R_M of magnitude 0·32 units passing through O, as shown in Fig. 13, herewith.

The result of superposing the forces obtained from the preceding calculations is shown in Fig. 14 herewith. The forces R_C and R_M intersect at the point I. Equilibrium conditions require that the resultant R of the forces R_C and R_M pass through the shoe pivot M. Hence, the line I-M is the line of action of this resultant force. If R_C is set off from I, a force of magnitude $R_{M,A}$ along the line of action of R_M must be added to it to furnish a resultant along the line I-M. $R_{M,A}$ is obviously the adjusted value of R_M and accordingly the radius of the pressure circle related to the virtual movement about the shoe hinge must be adjusted in the ratio $\frac{R_{M,A}}{R_M}$. In the present case, $R_{M,A}$ measures 0·23 units and the scale-adjustment factor is $\frac{0 \cdot 23}{0 \cdot 32} = 0 \cdot 72$. The adjusted pressure circle is shown in Fig. 14.

The resultant pressure at any point is the sum of the pressures from both pressure circles, as indicated for points A and B. Instead of adjusting R_M to the scale of R_C the opposite procedure could have been adopted. However, the former method is more convenient for the determination of the pressure scale as outlined previously.

The resultant pressure distribution on both shoes is shown in Fig. 15. For the sake of clarity the pressures were plotted radially outwards from the brake-drum circumference.

The suffixes L and T denote respectively the leading and trailing shoe. It can be seen that, in this case, the hinging has a very pronounced effect on the pressure distribution of the leading shoe, while that of the trailing shoe is hardly affected. The degree of modification depends on the moment arm of the force R_C, i.e., the force related to the virtual movement about the brake post pivot, with respect to the shoe hinge. In the above example this arm is large for the leading shoe and very small indeed for the trailing one. By moving the hinge points M closer to the centre of the drum, the former arm would be reduced and the latter increased, resulting in a much more uniform pressure distribution on both shoes.

Thus far, the results of the investigation have been purely qualitative. To obtain quantitative results, the restraining torque to be exerted by the brake must be considered. From Fig. 16, opposite, this is

$$T = (F_L + F_T) t = t \mu (P_L + P_T) \quad . \quad (15)$$

FORCES AND PRESSURES IN BRAKE SHOES.

Fig. 15.

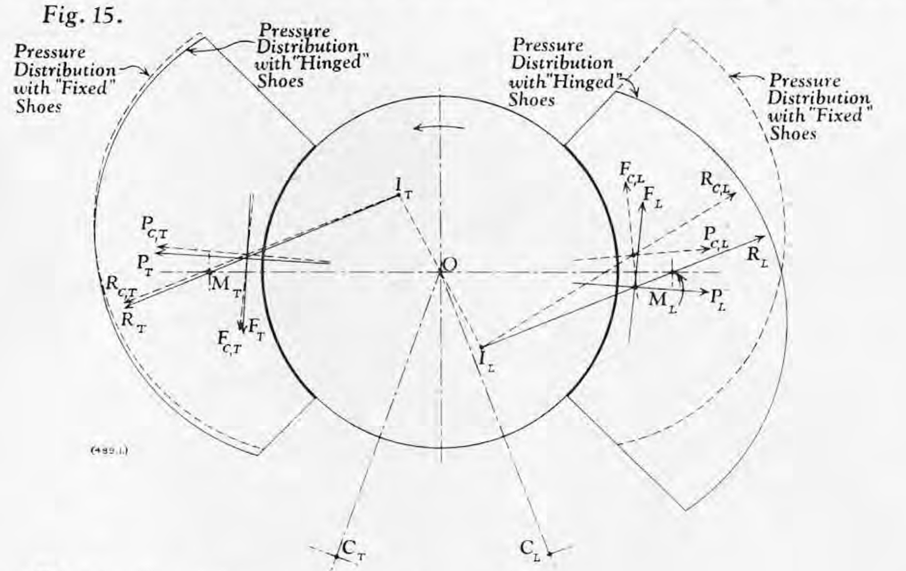


Fig. 16.

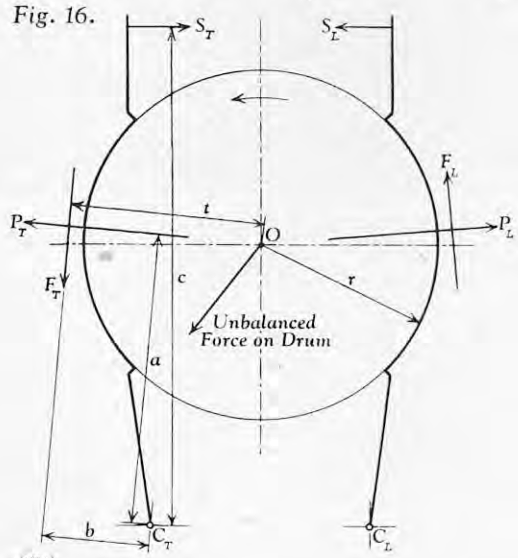
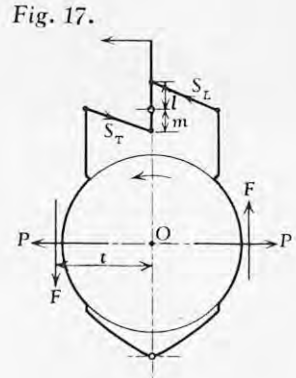


Fig. 17.



P_L and P_T are next expressed in terms of the forces S_L and S_T, applied at the brake posts by the brake mechanism. If the brake is equipped with a closing spring, then $S_L = S_T = S$. This condition will be assumed in the subsequent calculations. By taking moments about the post pivots, the following relations are derived :

$$\left.\begin{aligned} P_L &= \frac{S\,c}{a - \mu\,b} \\ \text{and} \quad P_T &= \frac{S\,c}{a + \mu\,b} \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (16)$$

Hence,

$$T = t\,\mu\,S\,c\left\{\frac{S\,c}{a - \mu\,b} + \frac{S\,c}{a + \mu\,b}\right\}. \quad (17)$$

From the last equation, the required force S is obtained, and, by its substitution into equation (16), the radial forces P_L and P_T are calculated.

Having found the magnitudes of the forces, the scales on which they are represented by the vectors on the drawing can be determined.

$$\text{Force scale} = \frac{\text{Magnitude of force (lb.)}}{\text{Length of vector (force units)}}$$

Generally the force scales for the two shoes will be different.

The pressure scale is calculated as follows. The algebraic sum of the forces between $\theta = 0$ deg. and $\theta = 90$ deg. is given by equation (11) as

$$C\,w\,r \int_0^{90} \sin\theta\,d\theta = C\,w\,r$$

and is represented by one force-unit since the Σ-coefficient for 90 deg. equals unity. Its actual magnitude, therefore, is numerically equal to the force scale. Hence,

$$C = \frac{\text{Force scale}}{w\,r} \quad . \quad . \quad . \quad (18)$$

The pressure p, at any point, is given by equation (6) which shows that for $\theta = 90$ deg.,

$$p = C = \frac{\text{Force scale}}{w\,r}$$

This pressure is represented, in Fig. 16, by the radius of the brake drum, and if this radius is chosen as the force unit as recommended earlier, it follows that, for any other angle θ, the intensity of the pressure is obtained by reading the corresponding pressure vector to this scale.

As an example for solution, the following data refer to the brake depicted in Fig. 16.

Restraining torque	T	= 2,500 lb. in.
Coeff. of friction	μ	= 0·5
Brake radius	r	= 5 in.
Width of lining	w	= 3 in.
Moment arm of spring	c	= 14·25 in.
Arm of friction force with respect to O	t	= 5·45 in. (by brake-coefficients)
Arm of friction force with respect to C	b	= 3·03 in. (by scaling)
Arm of radial force with respect to C	a	= 8·25 in. (by scaling)

It is required to determine the following :

(a) The force S to be exerted by the spring.
(b) The maximum pressure intensities.
(c) The pressure intensities at the shoe tips.
(d) The internally-unbalanced force on the brake drum.

From equation (17), S = 257 lb. By substituting this result into equation (16), $P_L = 544$ lb. and $P_T = 376$ lb.

Both these forces are represented as vectors measuring 1·21 force units. The force scales are, therefore :

$$\text{For leading shoe, } \frac{544}{1\cdot21} = 450 \text{ lb. per force unit.}$$

$$\text{For trailing shoe } \frac{376}{1\cdot21} = 310 \text{ lb. per force unit.}$$

For the leading shoe,

$$\text{Pressure scale} = \frac{450}{3 \times 5} = 30 \text{ lb. per sq. in. per force unit.}$$

Max. pressure = 1 unit = 30 lb. per sq. in.
Pressure at top = 0·90 units = 27 lb. per sq. in.
Pressure at bottom = 0·40 units = 12 lb. per sq. in.

For the trailing shoe,

$$\text{Pressure scale} = \frac{310}{3 \times 5} = 20\cdot7 \text{ lb. per sq. in. per force unit.}$$

Max. pressure = 1 unit = 20·7 lb. per sq. in.
Pressure at top = 0·90 units = 18·6 lb. per sq. in.
Pressure at bottom = 0·40 units = 8·3 lb. per sq. in.

The forces acting on the drum are, therefore:

P_L = 544 lb., F_L = 272 lb.
P_T = 376 lb., F_T = 188 lb.

Their directions are opposed to those indicated by the arrow-heads in Fig. 16, and their resultant, i.e., the unbalanced force on the drum, is determined by means of a force-diagram. It is found to have a magnitude of 200 lb. and a direction as shown in Fig. 16.

CONCLUSIONS.

For brakes with fixed shoes, the pressure distribution depends on the inclination of the chord subtended by the shoe to the line connecting the brake centre and post pivot, and is most favourable if these two lines are parallel. The pressure distribution is independent of the distance between the brake centre and the post pivot. It is also independent of the coefficient of friction. If the brake is symmetrical in design, the shape of the pressure distribution curve is identical for both shoes. Generally, the forces exerted by the shoes on the drum do not balance but cause bending of the drum shaft. Complete balance, however, may be achieved with the design shown diagrammatically in Fig. 17, herewith. With a properly-selected lever ratio $\frac{l}{m}$, the virtual movements of both shoes are made equal, thus causing the forces to balance.

The use of hinged shoes is of advantage if it is not practicable to place the brake post pivots directly below the drum centre, for in such cases the pressure distribution on fixed shoes may become excessively non-uniform. By hinging the shoes on pins judiciously located, the form of the pressure distribution can be greatly improved. The pressure distribution is influenced by the distance between shoe hinge and drum centre, and depends also on the coefficient of friction, since μ determines the directions of R_C and R_M. The form of the pressure distribution curve is different for both shoes.

Generally, the brake forces are internally unbalanced but, by the adoption of special designs, such as the suspended shoe construction, used occasionally on winding engines, the forces can be balanced. Theoretically, complete balance could also be obtained with a design similar to the one shown in Fig. 17, with the shoe hinges placed at the intersection of the forces P and F. In practice, however, this would present some difficulty, as the distance is rather small, thus precluding the use of orthodox hinge-pins. For example, for a 10 in. diameter drum, $t = 5\cdot5$ in. In conclusion, it may be mentioned that hinged shoes are advantageous in the case of slightly out-of-round or eccentrically-running brake drums, as, because of their self-aligning properties, they are able to follow the motion of the drum without imposing additional bending forces, such as would undoubtedly be caused by fixed shoes.

SUSPENSION OF DUTY-FREE LICENCES FOR IMPORTED MACHINERY.—The Board of Trade draw attention to the Chancellor of the Exchequer's Budget statement that, for the time being, the issue of duty-free licences under Section 10 of the Finance Act, 1932, for imports of machinery would be suspended and that no appplication posted after March 11 would be considered. In this connection, importers are reminded that on December 13, 1949, it was announced that : "Applicants for a duty-free licence should provide evidence of their intention to import by sending to the Board of Trade copies of their order and the supplier's acceptance of the order, or invoice. Importers will be required to certify that the machines are for their own use ; or, if they are acting as agents, to produce evidence that they have received firm orders from manufacturers who will use them." The Board of Trade therefore announce that an application for a duty-free licence under Section 10 of the Finance Act, 1932, dispatched on or before March 11, 1952, by an agent, will not be considered unless the agent, by that date, had received a firm order from the United Kingdom user for the machine or machines covered by the application.

ELEVATED-TEMPERATURE FATIGUE-TESTING MACHINE FOR CERAMIC MATERIALS.

By J. DICK, M.A., M.I.Mech.E., and Ll. S. WILLIAMS, D.Phil.

THE machine described below has been developed in the course of an investigation of the mechanical fatigue endurance and delayed fracture properties of simple ceramics and alumina-base "cermets" (composite metal-ceramic bodies) at ordinary temperatures and elevated temperatures. The engineer's interest in such materials is increasing, because the comparatively poor mechanical properties of most materials at high temperatures constitute a decided limiting factor in many engineering designs, and there is now considerable support for the opinion that ceramic materials can be developed having adequate properties at these temperatures. For one proposed application, gas-turbine blading, it is particularly desirable that fatigue-endurance data should be available, and as a first step towards this end, the present investigation was undertaken at the Engineering Laboratory, Oxford University.

Three main factors influenced the choice of the principle of operation employed: (i) the machine should be simple and robust; (ii) in view of the extreme hardness of most ceramics, test specimens should not require complicated machining, and it would be desirable, particularly in the early stages of the investigation, to save trouble and expense by using specimens in the "as-fired" condition, without machining; (iii) the type of machine should permit comparison of test results with a considerable volume of data for other engineering materials. Employment of the principle of Wöhler's own modification of his rotating-cantilever machine, i.e., clamping the specimen at one end and rotating the load about the other, appeared to be the solution to the design problem which would most readily satisfy the above requirements. In a machine employing this principle, the inevitable deflections of the loading point would result in adding an alternating inertia load due to the oscillation of the mass of the loading head. This effect can be cancelled or reduced to negligible magnitude by using the well-known artifice of tuning by fitting springs of appropriate stiffness, thus permitting calculation of stress directly from the applied load. Further advantages are inherent in the use of a "stationary" specimen, notably for temperature recording, strain measurement and photographic observation during testing.

By machining specimens in a comparatively soft intermediate state of firing to dimensions which allowed for further shrinkage during the complete firing schedule, diameters were obtained regularly within a tolerance of 0·002 in. and not infrequently within 0·001 in.; and by careful control of the sintering schedule, the bending distortion almost invariably encountered during the firing of ceramics was kept within limits which did not render the product unfit for use as a non-rotating specimen. Thus it was possible to conduct useful tests while the problem of machining fully-fired specimens was being investigated, and at a later date results on "as-fired" and machined specimens could be compared. Fire-skin effects would be expected to influence a property so sensitive to surface condition as fatigue endurance.

Fig. 1 shows the test assembly without the furnace and its support, and Fig. 2 illustrates diagrammatically the essentials of the design. The centrifugal force of a rotating out-of-balance mass provides the load for the cantilever specimen. The three tuning springs reduce the effect of the alternating inertia force due to the oscillation of the loading assembly, and may also be adjusted to eliminate the effect of its weight. Provision has been made for mounting two dial gauges, which are visible in Fig. 1, to permit the accurate adjustment of the tuning springs.

The simple theory of the tuning arrangement is as follows: let the load be applied by a mass $\frac{W}{g}$ rotating at a radius r with angular velocity ω, and let $\frac{w}{g}$ be the mass of the loading assembly. Under the conditions of forced vibration the loading assembly oscillates with amplitude y. Assuming the stiffness of the specimen to have the same value, K, in all directions in the plane of rotation of the out-of-balance mass, the movement is a rotation of radius y at angular velocity ω. If the tuned springs have an effective stiffness k, then, neglecting damping, we have

$$\frac{W}{g}\,\omega^2 r + \frac{w}{g}\,\omega^2 y = (k + K)\,y.$$

That is, the amplitude of the load on the specimen is

$$K\,y = \frac{W}{g}\,\omega^2 r + \left(\frac{w}{g}\,\omega^2 - k\right) y.$$

Hence, if $k = \frac{w}{g}\,\omega^2$, the inertia force of the loading head is borne by the tuning springs and is not transmitted to the specimen.

It was found that the design of the machine could be greatly simplified if it were not necessary to have a high degree of accuracy in cancelling the inertia force $\frac{w}{g}\,\omega^2 y$. With no tuning springs, the equation becomes

$$\frac{W}{g}\,\omega^2 r + \frac{w}{g}\,\omega^2 y = K\,y,$$

and the fractional error in the load due to the inertia of the loading head is

$$\frac{w\,y}{W\,r} = \frac{w}{W}\,\frac{\frac{W}{g}\,\omega^2 r}{K - \frac{W}{g}\,\omega^2} = \frac{1}{\frac{K\,g}{w\,\omega^2} - 1}.$$

The net effective stiffness of the tuning springs is $k = \frac{w}{g}\,\omega^2$; hence the fractional error to be cancelled is of the order of $\frac{1}{\left(\frac{K}{k} - 1\right)}$.

Static measurements of the deflection of an alumina specimen showed that, for the running speed used, a little above 3,000 r.p.m., the value of $\frac{K}{k}$ was approximately 40, and hence the error to be cancelled was less than 3 per cent. of the applied load. Thus for an error of as much as 20 per cent. of the spring load (10 per cent. of the speed) in the accuracy of tuning, the net error in the load on the specimen would be approximately ½ per cent. This allowed a degree of latitude which simplified the design problem. The springs were not placed in the radial plane which contained the centre of gravity of the loading assembly, but for convenience

FATIGUE-TESTING MACHINE FOR CERAMICS.

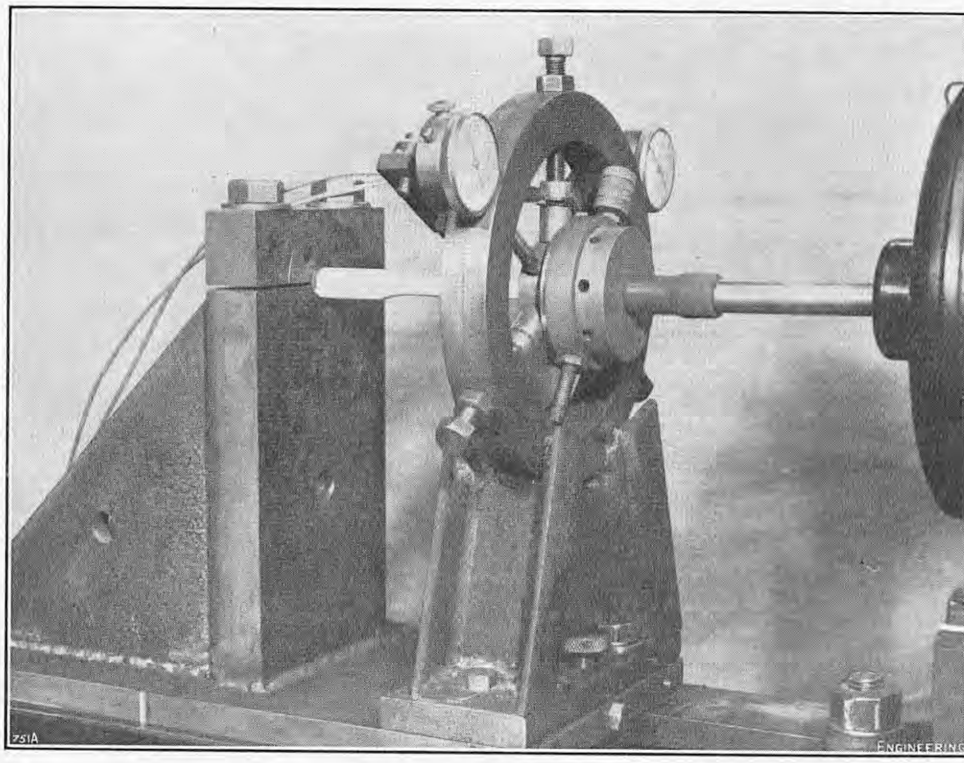
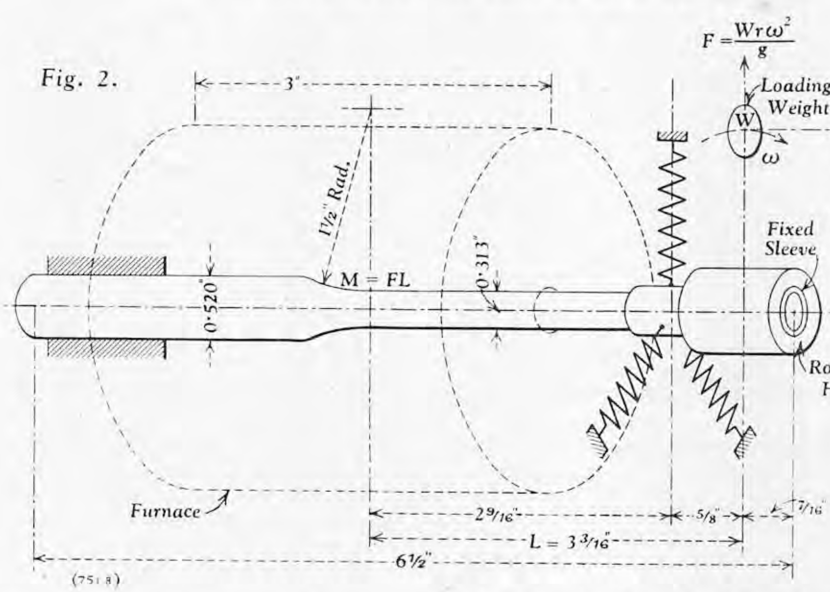


FIG. 1. MACHINE PREPARED FOR TESTS AT ROOM TEMPERATURE.

Fig. 2.



FATIGUE-TESTING MACHINE FOR CERAMICS.

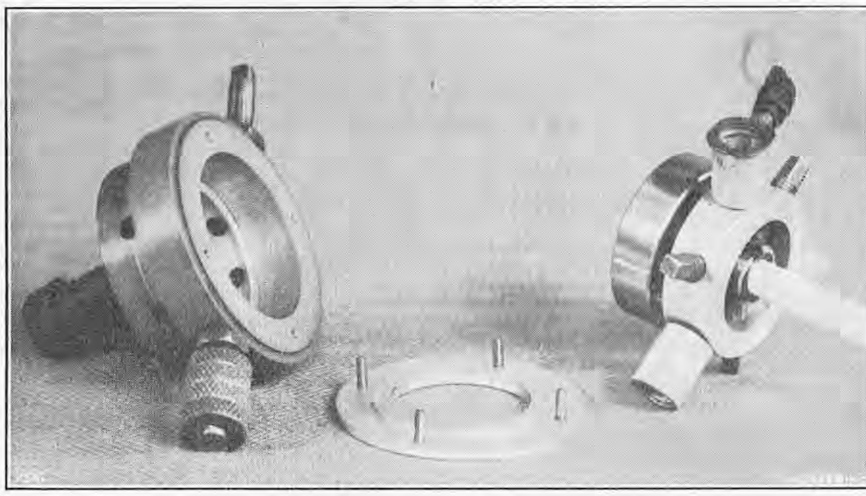


FIG. 3. COMPONENTS OF LOADING ASSEMBLY.

were located as indicated in Fig. 2. This meant that the "effective" stiffness had to allow for the fact that the deflection in the plane of the springs was not the same as the deflection at the centre of gravity of the loading assembly. The effect of the ⅝ in. offset on the bending moment at the test section can also be counteracted to a large extent by tuning the springs for a speed slightly higher than the actual running speed.

In Fig. 1 the assembly is shown in course of preparation for a test at room temperature. Before starting, the leads to the contacts in the stopping circuit are supported clear of the assembly and the dial gauges are removed. The main dimensions are indicated in Fig. 2. The dimensions of the specimens were decided by a number of factors, such as the limitations of the method of forming (for example, slip-casting for the alumina specimens), the acceptable degree of firing distortion (slender rods suffer more in this respect), the desirable specimen proportions for loading, the minimum size for avoidance of the range within which size appreciably affects test results, and the shortest length required by the assembled components of the test rig. The minimum overall length of 5¾ in. was determined by the allowance necessary for gripping, for fitting a furnace and the loading assembly, and to permit cooling of the bearing of the loading head during tests at elevated temperatures. In the case of simple ceramics, such as alumina and alumina-base "cermets" having less than a critical metal content, the low thermal conductivity of the specimen helps in limiting the heat flow to the bearing. Later improvements in fabrication techniques have permitted the overall specimen length to be increased to 6½ in.

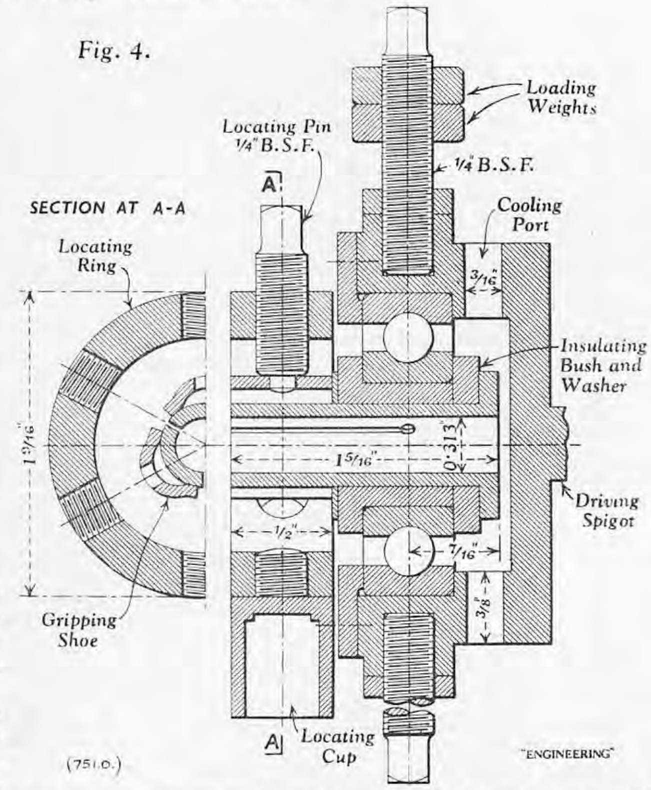
The details of the loading head and the method of mounting it on the specimen are shown in Figs. 3 and 4. The Duralumin casing of the loading head houses a deep-groove ball bearing. It carries two threaded pins, to one of which the loading weights are attached, and also a spigot for coupling to the spindle of the driving motor by a short length of rubber tubing. The inner ring of the ball bearing is mounted on a heat-insulating bush, which, in turn, is mounted on an aluminium-bronze sleeve. This sleeve has longitudinal slits to permit clamping on to the specimen; the difficulty of forming a thread on ceramic materials necessitated recourse to a clamping method for attaching the loading head. This is effected through Nimonic 80A gripping shoes by three screws fitted through a ring, which also carries the locating cups that act as the inner seatings of the tuning (compression) springs. The outer seatings for these springs are carried by screws passing through a larger ring attached to a fabricated frame, the latter being mounted on the baseplate of the test assembly. A pair of electrical contacts, essential to the automatic stopping system, are attached to the inner and outer spring seatings in the vertical position (Figs. 1 and 3). The stock of the specimen is clamped in its mounting by three hardened-steel grips, stress-concentration being reduced by a 0·002-in. layer of nickel foil between the grips and the specimen.

The centrifugal loading head is driven by a direct-current shunt motor, supplied from a motor-generator set. Since the applied load varies as the square of the running speed, it was necessary to have an automatic speed control in view of appreciable fluctuations in mains voltage and frequency. The control is essentially a voltage stabiliser for the motor. The automatic stopping device is designed to make use of the most obvious signal indicating fracture of the specimen, that of increase in the amplitude of vibration of the loading head. The contacts provided between one pair of inner and outer spring seatings remove at their first touch a standing bias on the grid of a gas-thyratron, which at once passes current to a sensitive relay. This operates three mercury switches, thus de-energising the holding coil of the motor starter, the speed-control system, and the test furnace. The tuning springs provide a measure of restraint sufficient to prevent damage to the equipment when the specimen breaks.

For tests at elevated temperatures the furnace is held in a cradle supported by a bracket bolted to the specimen mounting. The furnace consists essentially of a well-insulated nichrome heating coil with a second winding of a few turns at each end to compensate for end losses. A short silica tube located between the two windings houses a thermocouple tip at the centre of the furnace length, permitting temperature measurement during testing. In calibrating this couple the temperature at the section of maximum bending stress was given by a second thermocouple inserted into a hollow specimen. Preliminary tests showed that special cooling of the bearing housing was necessary for successful operation appreciably above 600 deg. C. on the basis of 10×10^6 cycles for a complete endurance test. Although the small centrifugal pumping action of the radial holes in the Duralumin casing of the loading head provided sufficient cooling to enable the above-mentioned number of cycles to be completed at 600 deg. C., at higher temperatures neither lithium-base nor silicone greases could withstand for this specimen life the combined effect of the temperature attained by the bearing and the tightening of the bearing due to differential expansion.

By employing an air jet to aid cooling of the loading head, satisfactory operation at 900 deg. C. with alumina specimens has been achieved. With a Nimonic 80A specimen having a thermal conductivity many times greater than that of alumina at the test temperature, the condition of the bearing lubricant was satisfactory after 20×10^6 cycles at 750 deg. C. Testing at higher temperatures with ceramic and metal specimens respectively has not been attempted, but with the longer specimens (6½ in.) in preparation, the additional ¾ in. between

Fig. 4.



loading head and furnace should ensure appreciable improvements in the permissible temperature and duration of tests.

As explained above, full-length tests at 900 deg. C. can now be conducted on materials having thermal conductivities of the same low order as that of alumina. Results of tests on alumina using a conventional Wöhler cantilever machine, suitable for room-temperature tests only, agree within usual scatter with results at room temperature on the centrifugal machine. The greater deflections experienced in testing materials such as steels and the Nimonic alloys, particularly at elevated temperatures, due to reductions in Young's moduli, can be accommodated after slight modification of the tuning-spring seatings. Owing to the conditions under which this work has been financed in the later stages, it is not yet possible to give actual test results. A serious limiting factor has been the difficulty of preparing, with only basic facilities, sufficient specimens free from detectable flaws. Commercial material has proved unsatisfactory.

In conclusion, it may be pointed out that, since only slight modification is required to enable tests to be conducted on established high-temperature alloys, direct comparison between these materials and ceramics is possible. The performance of the machine in its present experimental form is encouraging, and current development should permit the testing of ceramic materials at 1,000 deg. C.

OVERHAUL LIFE OF GIPSY QUEEN 70 ENGINE.—The Air Registration Board have approved an extension of the overhaul life of the Gipsy Queen 70-4 engine from 600 to 800 hours. Gipsy Queen 70 engines, constructed by the de Havilland Engine Co., Ltd., Edgware, Middlesex, are fitted in the de Havilland Dove and Handley Page Marathon I air liners and the Short Sealand amphibious aircraft.

WEEK-END COURSE ON WORK STUDY.—The Institute of Industrial Supervisors are to hold a week-end residential course for foremen and supervisors on "Work Study for Supervisory Management," from May 2 to 4, at Dillington House, Ilminster, Somersetshire. The course will be conducted by Mr. Geoffrey P. Wade, B.Sc., A.M.I.E.E., and Mr. Victor N. Picken, A.M.I.E.E. The subjects covered include motion study, time study and job evaluation; practical work will be introduced and examples of industrial applications will be illustrated by films. Application forms, which should be returned by April 22, may be obtained from the general secretary, Institute of Industrial Supervisors, Bank Chambers, 47, Temple-row, Birmingham, 2. The fee for the course is 5l. 10s. (4l. 10s. to members of the Institute).

THE INSTITUTE OF METALS.

(*Continued from page* 404.)

Last week we gave a report of the first two sessions of the 44th annual general meeting of the Institute of Metals, namely, that held at the Royal Institution, London, on Monday, March 24, for the reading of the 42nd annual May Lecture, and the business meeting, held in the Park Lane Hotel, Piccadilly, W.1, on the morning of Tuesday, March 25, at which the reports of the Council and of the honorary treasurer were presented, and the new President, Dr. C. J. Smithells, M.C., was inducted and delivered his presidential address. We now give summaries of the four papers considered at the afternoon session of March 25, held in the Park Lane Hotel.

Copper, Copper-Nickel and Copper-Zinc Powder Compacts.

The first three papers on the agenda each dealt with a phase of powder metallurgy and were presented jointly. The first was by Dr. E. C. Ellwood and Mr. W. A. Weddle and was entitled "The Production and Properties of Oxide-Reduced Copper Powder." The second paper was by Dr. J. M. Butler and Dr. T. P. Hoar and referred to "Unrelated Simultaneous Interdiffusion and Sintering in Copper-Nickel Compacts," and the third, by Dr. D. D. Howat, Mr. R. L. Craik and Dr. J. P. Cranston, was on "The Sintering of Copper-Zinc Powder Compacts."

The first paper described work carried out in the Metallurgy Department of King's College, University of Durham. The authors stated that conditions had been established under which scrap copper wire of electrical purity could be oxidised, and roasting for two hours at 900 deg. C. in a gas-fired reheating furnace had been found to give the best results. Two hundredweights of oxide for the later experiments had been made under these conditions. The product was mainly cuprous oxide and after comminution the material was reduced to a copper powder which was suitable for use in powder metallurgy. The properties of powders of different size distribution, prepared by the reduction of the oxide by hydrogen and, to a limited extent, by carbon monoxide, had been compared with those of commercially-available powders produced by electrolysis and steam atomisation. A comparison had also been made of the properties of the pressed compacts made from such powders before and after sintering. With the oxide-reduced powders, the best strength properties (12-13 tons per square inch) were obtained with high-compacting pressures of the order of 60 tons per square inch and relatively low sintering temperatures, such as 600 deg. C. On the other hand, with electrolytic and atomised powders, the best strength properties (10-11 tons per square inch) were obtained with compacting pressures of 40 tons per square inch, and sintering temperatures of 1,000 deg. C. Oxide-reduced powders gave superior results, except at 1,000 deg. C., and compacting pressures of 40 and 60 tons per square inch, where large expansions occurred, particularly when hydrogen was the reducing gas. The high tensile-strength figures for oxide-reduced powders were reached without any appreciable decrease in hardness during sintering, indicating that it was possible for pronounced sintering to take place at temperatures below the recrystallisation temperature.

In the second paper, Dr. J. M. Butler and Dr. T. P. Hoar gave an account of work carried out at the University of Cambridge. They stated that they had assessed metallographically metallic interdiffusion occurring during the heat treatment of 50 : 50 (by volume) copper-nickel powder compacts. Length changes in the compacts had been followed dilatometrically. At temperatures below those at which sintering began, namely, from 500 to 700 deg. C., there was a large expansion and the production of fissures (not found in either pure copper or pure nickel compacts) caused by unequal metallic interdiffusion. At higher temperatures, of the order of 700 to 800 deg. C., sintering shrinkage, very similar to that found in pure copper compacts, began; isothermal sintering at 775 deg. C. was also similar to that found with pure copper. These results showed that, although interdiffusion and sintering could take place simultaneously, they were not causally related. It was inferred that neither interdiffusion nor self-diffusion was important as a mechanism for metal transfer in the sintering of metal compacts, which took place rather by plastic deformation, namely, by slip or creep, or both, of mechanically-weak hot metal under the action of surface forces. It was believed that the evidence was now conclusive that the rapid early stages of sintering, which were of great importance in practice, took place by plastic deformation, independent of any atom-by-atom diffusion.

Work carried out in the Metallurgy Department of the Royal Technical College, Glasgow, was described in the third paper, on "The Sintering of Copper-Zinc Powder Compacts," by Dr. D. D. Howat, Mr. R. L. Craik and Dr. J. P. Cranston. These authors stated that they had found that data obtained by differential thermal analysis, together with changes in volume and in electrical resistivity, could be taken as criteria of the sintering and alloying processes occurring when compacts of copper and zinc powders were heated.

The compacts for testing had been pressed cold into the form of thin flat discs. Discs weighing 10 grammes had been employed for all tests except those for the determination of differential thermal analysis, for which 25-gramme discs were required. The mould used was a hollow steel cylinder, 3·25 in. in external diameter and 2·4 in. long, with a 1·15 in. diameter bore. Compacts had been prepared at pressures of from 5 tons to 80 tons per square inch. Geometrical considerations indicated that it would be expected that the increase in voids due to the growth of the copper particles would be greater the larger the particles. This had been confirmed during the tests and it had been shown that, for a constant composition, the total disc expansion became greater as the size of the copper particles increased. The effect of compacting pressure on expansion could also be explained largely in terms of the growth of copper particles and voids. An increase in compacting pressure led to a decrease in the initial voids and to a greater mechanical strength of the disc. It appeared that up to a compacting pressure in the range of 25 to 35 tons per square inch the combination of these two factors prevented expansion of the disc from occurring to the same extent. With packing pressures above this range, the voids had been reduced to such an extent that the growth of the individual copper particles resulted in an increased expansion of the disc.

The first stage in the sintering of the compacts was the transfer of zinc atoms to the surfaces of copper particles and the formation of the body-centred cubic β phase of the copper-zinc system. X-ray diffraction evidence indicated that substantially all the zinc in the compact was transferred to the copper particles, forming β phase. Phase changes on further heating had been found to be due to diffusion of the metals in the solid state and to the volatilisation of the zinc from the β phase.

Creep of Copper Rotor Windings.

The fourth and last paper dealt with in the afternoon of Tuesday, March 25, was a communication from the British Non-Ferrous Metals Research Association, entitled "The Creep and Softening Properties of Copper for Alternator Rotor Windings." It was by Mr. N. D. Benson, Dr. J. McKeown and Mr. D. N. Mends. The authors stated that the rotor windings of some large turbo-alternators were subject to longitudinal compressive stresses on account of the higher coefficient of expansion of the copper relative to the steel rotor. These stresses could give rise to creep deformation, and the resistance to creep of a number of high-conductivity coppers had been investigated in the temperature range 130 deg. to 225 deg. C. In cold-worked coppers the resistance to creep might be reduced by softening occurring at the operating temperature. In consequence, the softening characteristics of high-conductivity coppers had been determined over the same temperature range.

The effective gauge-length of the creep-test specimen was 5 in. The extensometer was fixed rigidly to the enlarged ends of the specimen and the extension measured by two micrometers reading to 1×10^{-4} in., giving a strain sensitivity of $1{\cdot}7 \times 10^{-5}$. The temperature of the specimen was maintained constant to ± 1 deg. C. Creep tests of up to 500 hours duration had been carried out in triplicate at 130 deg. C. on silver-free tough-pitch copper and at 225 deg. C. on silver-bearing tough-pitch copper, and the reproducibility of the results had been found to be good. The programme of tests had been most complete for the tough-pitch coppers, the oxygen-free high-conductivity coppers having been tested only at 130 deg. and 225 deg. C., and at a limited number of stresses. Some of the tests on the tough-pitch coppers had been carried on to 10,000 hours or even longer, but it had become clear that comparisons made on a test duration of 5,000 hours or longer were equally valid at a duration of 1,000 hours.

As a result of the experiments carried out, the creep resistance and the resistance to softening had been found to be very much greater for silver-bearing (0·1 per cent. silver) than for silver-free tough-pitch copper. The effect of the silver addition was such that the creep-resistance of the silver-bearing material at 225 deg. C. was equal to that of the silver-free material at 130 deg. C. The creep resistance and the resistance to softening of oxygen-free high-conductivity copper were greater than those of tough-pitch copper, when both were silver free. Silver-bearing (0·1 per cent.) oxygen-free high-conductivity copper and tough-pitch coppers, on the other hand, had very similar resistances to creep and softening. In silver-bearing tough-pitch copper, the resistance to creep increased with increase in the degree of cold work, up to 10 per cent. Beyond this amount there was no further increase in creep resistance, and it was clear that the maximum resistance to creep, coupled with the maximum resistance to softening, was obtained with cold work of this degree.

Annual Dinner.

When proposing the toast of "The Institute of Metals and the Non-Ferrous Metal Industries" at the annual dinner of the Institute, held in the Park Lane Hotel, on March 25, Mr. A. S. Quartermaine, C.B.E., M.C., President of the Institution of Civil Engineers, said that the advances made in non-ferrous metals in recent decades could only be due to the enthusiastic work of those engaged in the industry, and this had been greatly helped and fostered by the formation of the Institute of Metals in 1908. In the course of his reply, the President, Dr. C. J. Smithells, M.C., stated that, when the Institution of Civil Engineers had been established over 130 years ago, the main constructional metal available to engineers in quantity had been cast iron. About half a century later, Bessemer had furnished them with mild steel, which had given rise to immense developments. Of late years, however, engineers were turning, to an increasing extent, to the light alloys, in which extensive progress had been made. A new material to appear on the horizon was titanium, the ores of which occurred plentifully in nature, but present obstacles to its use were the difficulties encountered in smelting the metal. The only other toast honoured at the dinner, that of "The Guests," was proposed by Major P. Litherland Teed, A.R.S.M., a member of Council of the Institute, and was acknowledged by Sir Lewis Fermor, O.B.E., D.Sc., F.R.S., President of the Institution of Mining and Metallurgy.

(*To be continued.*)

Telephone Service Congestion.—In a written reply to Mr. C. R. Hobson on Wednesday, March 26, the Assistant Postmaster-General (Mr. L. D. Gammans) said that 163 telephone exchanges were completely full, while at a further 1,039 only priority applications could be accepted. Together these represented just over 20 per cent. of the total number of exchanges.

Vacation Courses for University Students.—The Dunlop Rubber Company have 100 vacancies for university students over the age of 18 who wish to spend six or eight weeks of the long vacation in acquiring practical experience of industrial and commercial conditions. Salaries ranging from 3*l*. to 6*l*. per week are offered. The vacancies will be filled through the appointments' officers at the universities.

EXHIBITS AT THE PHYSICAL SOCIETY'S EXHIBITION.

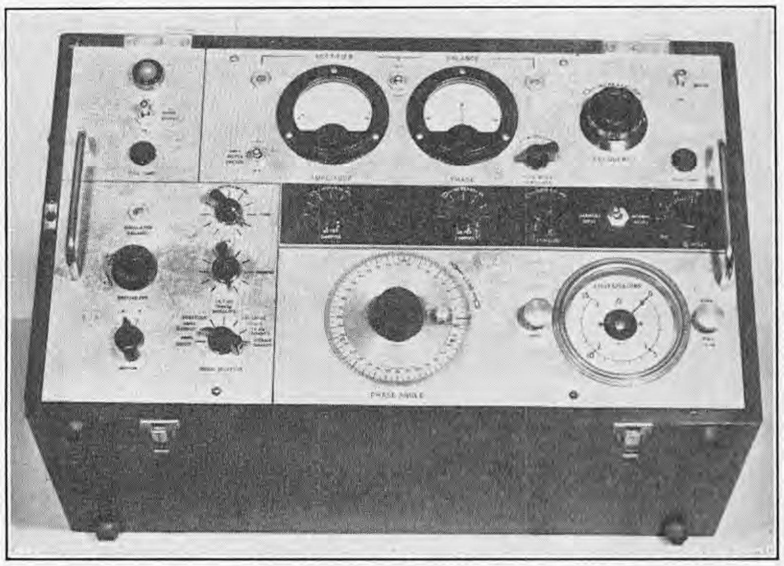


FIG. 3. HARMONIC RESPONSE TEST GEAR; VICKERS-ARMSTRONGS LIMITED.

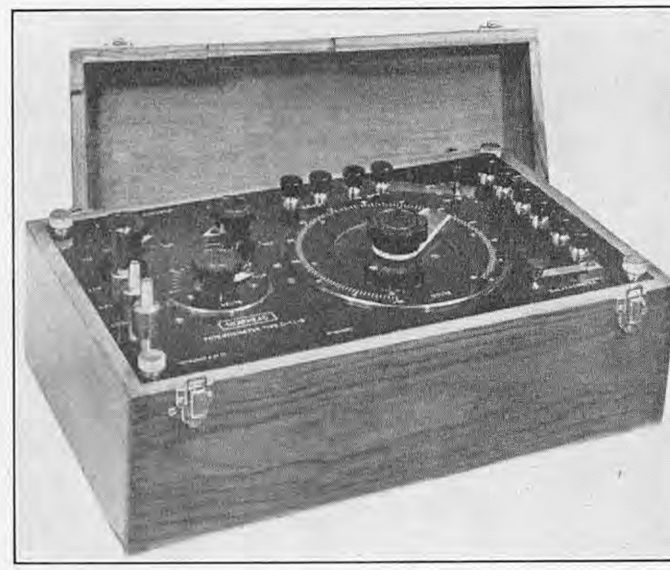


FIG. 4. MUIRHEAD-PAMETRADA WAVE ANALYSER; MUIRHEAD AND COMPANY, LIMITED.

THE PHYSICAL SOCIETY'S EXHIBITION.

(*Continued from page* 406.)

As mentioned on page 404, *ante*, the Physical Society's 36th annual exhibition of scientific apparatus and instruments was opened by Professor L. F. Bates, F.R.S., at the Imperial College, South Kensington, London, S.W.7, yesterday (Thursday, April 3); and will remain open daily, with the exception of Sunday, April 6, until Tuesday, April 8. Both the main building of the College in Imperial Institute-road and the Huxley Building in Exhibition-road are being utilised for the display. The exhibition is open from 10 a.m. to 1 p.m. and from 2 p.m. to 9 p.m. to-day and Monday, April 7, and from 10 a.m. to 1 p.m. and from 2 p.m. to 5 p.m. tomorrow and on Tuesday.

In accordance with custom, discourses on scientific subjects will be delivered during the exhibition. This year the lecturers will be Mr. B. N. Wallis, of Vickers-Armstrongs Limited, who will take "Engineering Supersonic Aerodynamics" as his subject, and Mr. E. R. Davies, of Kodak, Limited, who will speak on "The Physical Basis of Colour Photography." To-morrow (Saturday, April 5) the prizes for craftsmanship and draughtsmanship in the Society's annual competition for apprentices will be presented in the large chemistry lecture theatre. As usual, the entries to the competition will be on show during the exhibition.

Turning to the individual exhibits, Messrs. Vickers-Armstrongs Limited, Elswick Works, Newcastle-upon-Tyne, 4, are showing the harmonic response test gear, an illustration of which appears in Fig. 3. This instrument was invented to provide a quick and simple method of experimentally determining harmonic response curves for a complete servo-mechanism system and for its component units. The principle employed is, however, of general application. The instrument gives direct readings of the response amplitude on a meter and of the phase on a manually-operated phase scale. The pointer on this scale is arranged to agree with the direction of the vector on a conventional Nyquist diagram. The general principle is simple and is based on the method of determining coefficients in a Fourier series. Thus, if the function is given by

$$f(e) = A_0 + A_1 (\sin \theta + \phi_1) + \dots A_n (\sin N\theta + \phi N) + \dots$$

then the coefficient A_1 is determined by multiplying the series by $\sin (\theta + \phi_1)$ and finding the average value over a whole number of cycles. The harmonic response gear carries out this operation electrically on the input and output signals.

The harmonic input signal is derived from a resetter Magslip, which is rotated by a variable-speed electric motor and is wired to a transmitter Magslip. The rotor of the latter is supplied from a 400-cycle source and is coupled to a pointer which can be moved manually over the phase scale. A sine-cosine resolver Magslip is mechanically coupled to the resetter and rotates with it. The phase relationship between the electrical output of the resetter and the sine-cosine resolver thus depends on the position of the phase-scale pointer. Potentiometers provide a means of adjusting the input voltage. A selector switch is wired to the input, to the output and also to the other sources of electrical signals in the servo-mechanism chain. The selected signal is applied through a potentiometer system and, if necessary, through a modulator to an amplifier with a cathode follower output valve. This valve feeds the rotor coils of the resolver. The sine and cosine coils of the stator are each coupled to a "phase-conscious" rectifier stage with a moving-coil meter in the output. These meters have adjustable damping circuits and respond only to the average values of the output currents taken over some time. By this means the effect of frequencies other than the fundamental is eliminated. By rotating the phasing Magslip until the "cosine" meter reads zero the phase angle ϕ and the amplitude A_1 can be read directly. The phasing adjustment can be made automatic by using a servomotor in place of the "cosine" meter, though this has not been done in the instrument shown.

We understand that the value of the instrument in "tuning" a system, diagnosing faults and in routine checks on components has become very obvious in the course of test work on automatic positional control. Pick-ups have been designed to work in conjunction with the test gear. By their use it can be used to deal with displacements, velocities, or pressure differences as the input or output quantities.

One of the principal exhibits on the stand of Messrs. Muirhead and Company, Limited, Elmers End, Beckenham, Kent, is the Muirhead-Pametrada wave analyser illustrated in Fig. 4. This instrument is suitable both for vibration measurements and for analysis of electrical wave forms. It covers a range of 19 cycles to 21 kilocycles per second with a frequency accuracy of $\pm$ 0·5 per cent. Variable selectivity and bandwidth facilities are provided, the latter being particularly useful when measuring fluctuating frequencies, such as those encountered in the testing of rotating machinery. The associated equipment includes a battery-operated pre-amplifier, which allows almost any type of vibration pick-up to be used with the analyser; and a low-frequency modulator, which extends the lower frequency limit of the instrument to 2 cycles per second. Other exhibits on this stand are resistance-capacitance oscillators employing the decade principle of tuning, with the development of which the firm has been closely associated for many years. Of these, one covers a frequency range 0·1 to 20,000 cycles with an accuracy of $\pm$ 0·5 per cent. or better, and is intended for specialised applications. Another is a re-designed version of the well-known Muirhead-Wigan decade oscillator and covers a range of 1 to 111,100 cycles with an accuracy of $\pm$ 0·2 per cent. $\pm$ 0·5 cycles per second. The same firm are also showing an improved direct-current potentiometer for general purpose laboratory use and a miniature tuning fork and amplifier, mounted on a chassis so that it can be incorporated in other equipment where a compact standard of audio-frequency is required.

The Powder Metallurgy Division of Messrs. Murex, Limited, Rainham, Essex, are illustrating the developments which have taken place during the last twelve months in the production of zirconium, by showing a large sheet of this metal about 15 in. wide and 4 to 5 ft. in length, as well as examples of tube drawn in the same material. They are also exhibiting various parts fabricated in tantalum, molybdenum and tungsten, including discs of tungsten for rotary-anode X-ray tubes, which can now be made with a diameter of 5 in. Fig. 5, on page 426, shows one of their sintered composite magnets, the range of which has been extended to include shapes other than plain rings. Improved techniques have also made it possible to increase the ratio of magnetic material to soft iron for a given overall volume, thus allowing an increase in energy and a reduction in leakage.

In accordance with the practice adopted for some years past, the Cambridge Instrument Company, Limited, 13, Grosvenor-place, London, S.W.1, are limiting their display to one class only of the wide range of instruments they construct. This year, their exhibit demonstrates many of the unusual temperature problems that are put to the instrument maker, and their ultimate resolution. It is arranged in four groups: radiation and optical pyrometers; resistance thermometers; thermo-electric pyrometers; and mechanical thermometers (i.e., pressure systems). The temperature range covered by each class, the ultimate standards against which they are calibrated, and examples of the processes or uses to which they are applied are all indicated. Simple demonstrations are being given for each group and a number of photographs show the instruments in actual use. These demonstrations are subdivided into industrial and research categories.

The range of applications dealt with extends from the measurement of the roof temperatures of a steel furnace (around 1,800 deg. C.) to that of the body temperatures of flies or small animals in parasitological or physiological research. It is felt that this form of presentation may be more

EXHIBITS AT THE PHYSICAL SOCIETY'S EXHIBITION.

FIG. 5. SINTERED COMPOSITE MAGNET; MUREX, LIMITED.

FIG. 6. HIGH-POWER STROBOSCOPE; PHILIPS ELECTRICAL, LIMITED.

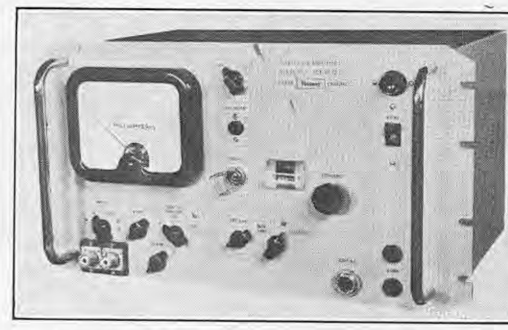


FIG. 7. SELECTIVE AMPLIFIER; PLESSEY COMPANY, LIMITED.

instructive to the student and at the same time give a more comprehensive idea of the methods and their limitations than would be possible simply by a display of instruments.

Among the instruments actually shown are a Smith's difference bridge for the standardisation of resistance thermometers, and a precision vernier potentiometer for electromotive-force measurements, as well as other more generally used types of indicators and recorders. Of particular interest are the applications for medical and physiological research and a special quick-acting recorder for the rapid measurement of billet temperatures. This recorder is used with a new rapid-response Fery radiation pyrometer with a response time of about 1 second for a temperature change of 800 deg. C.

As in the previous three years, the Company are making the Physical Society Exhibition the occasion for issuing a monograph—No. 4—of a series dealing with the co-operation of eminent men of science in the discovery and development of scientific instruments that have had a marked effect on the progress of scientific achievement or industrial development. The subject this year is "C. T. R. Wilson and the Cloud Chamber." This monograph may be obtained on the stand or from the Company.

Philips Electrical, Limited, Century House, Shaftesbury-avenue, London W.C.2, are showing a number of electronic measuring instruments, among which mention may be made of the high-powered, stroboscope illustrated in Fig. 6. This has a flash frequency of 0·5 to 250 cycles per second with a flash duration of 3 microseconds, while the light intensity can be adjusted up to 20×10^6 lumens. The apparatus produces very short periodic flashes of light the frequency of which can be adjusted and, if synchronised with the object to be studied, will cause it to appear stationary. The flash frequency can be read off directly so that the speed of engines, pulleys and fans can be measured and compared. The stroboscope, which has a built-in frequency meter and provision for external synchronisation, is suitable for use in any industry where it is desired to study an object under dynamic conditions.

The apparatus designed for the television on this stand includes a signal generator with crystal-controlled sound and vision channels. This instrument is provided with 13 video modulation patterns and variable synchronising pulses and blanking times, as well as with means for external sound and video modulation. It is also fitted with a built-in monitoring oscilloscope. With this instrument, stage-by-stage tests of a television receiver can be made; and the vertical and horizontal synchronisation, vertical and horizontal size and positioning of the television raster can be investigated. A small television pattern generator has a frequency range which can be varied between 40 and 80 megacycles per second with sound and vision. There is external video output and four video modulation patterns. It has been specially designed for servicing and adjusting television receivers.

Among the exhibits on the stand of the Plessey Company, Limited, Ilford, Essex, mention may be made of the wave-guide test-bench equipment, which has been developed under Admiralty contract for laboratory measurements in the centimetre range. Facilities are provided for linear frequency modulation and square-wave modulation on all types of Klystron with either visual presentation or selective amplification of the small resulting signals. As regards power, facilities are provided for supplies up to 12 milliamperes at 1,000 to 1,700 volts and at 0 to − 600 volts, as well as from −150 to + 750 volts for the reflector and grid electrodes to which modulation may be applied respectively. These supplies are designed for extreme flexibility with minimum tolerances on ripple voltage and stabilisation. The stability is one part in 10,000 for full load and mains variations and one part in 100,000 for ripples. A well-smoothed rectified supply provides direct-current up to 1·5 amperes at 4·0 volts or up to 1·0 ampere at 6·3 volts, as well as up to 40 milliamperes at from 250 to 500 volts for the Klystrons. The selective amplifier, of which an illustration is given in Fig. 7, gives full scale deflection for an input of 1·6 microvolts over the frequency band of 300 to 6,000 cycles, either with selective tuning, which gives an attenuation of 6 decibels for a 10 per cent. change in frequency, or in the wide-band response condition. The total noise does not exceed 3 per cent. of full scale deflection at maximum sensitivity, and inputs are provided at 5,000 ohms impedance. The modulator gives outputs of square-wave, saw-tooth and synchronising pulse.

Another instrument of interest on this stand is the Nyquist diagram plotter, which has been designed to record the phase and amplitude response of servo mechanisms on their component parts. The input signal for driving the apparatus is obtained from an oscillator, the frequency of which can be swept automatically from 1,600 to 0·16 cycles. Decades of frequency within this range can, however, be selected if the whole is not required. The rate at which the frequency is varied is automatically adjusted to suit conditions so that the record is drawn accurately without unnecessary waste of line. The output response of the apparatus under test is fed back into the plotter, where it is continuously compared in amplitude and phase with the input. The pen and polar chart are electrically driven, so that a permanent record of the response is obtained in the form of a Nyquist diagram. Although designed primarily for servo mechanisms, the plotter may be used with any apparatus in which an electrical input and output are available.

Messrs. Londex, Limited, 207, Anerley-road, London, S.W.2, are showing an electronic planimeter, the object of which is to give an immediate and accurate indication on a large dial and not simply an approximation under Simpson's rule. It comprises a luminous surface, which is viewed by a photo-cell, the latter being connected through an amplifier (which is unaffected by changes in temperature or in mains voltage or frequency) to a meter, directly calibrated in areas. The geometry is such that obscuring a given area of any part of the surface results in the same meter deflection and, as the alternating-current component only of the surface illumination is used, the equipment can operate in daylight. The instrument on view is capable of measuring areas up to 200 sq. in., but larger models suitable for determining areas up to as much as 72 sq. ft. are available. Another exhibit is a direct-current constant-speed motor of about ½ watt. This can be operated from a dry battery and is intended for use in laboratories and at unattended radio stations for sending out regular coded signals. It is also being used to operate battery-driven lights on buoys. The motor is normally fitted with a gear train which turns a cam once in 30 seconds to operate a contact system.

A local oscillator assembly for communication receivers, which is being exhibited by Messrs. Mullard Limited, Shaftesbury-avenue, London, W.C.2, consists of a pentode which is operated in an electron-coupled Hartley circuit. This valve falls into the sub-miniature class and has a very stable electrode structure. A feature of the design is that the frequency drifts due to high- and low-tension changes tend to be self-compensatory, and stabilised supplies are therefore unnecessary. Frequency changes due to variation of load reactance and to warming up have been reduced to extremely low limits. Special attention has also been paid to the reduction of frequency drift due to changes of ambient temperature and uncertainty of turret location. The tuned circuits are made up of compensated inductors and a Mullard precision variable capacitor. The turret unit consists of two castings mounted on ball races and rotated by a spring-loaded split-helix mechanism. The ultrasonic generator, which is being shown on the same stand, consists of an improved vibrator of the St. Clair type. A solid bar is excited at resonance and is arranged to have a very low mechanical damping. As a result, a large part of the input energy is transferred to the air as sound.

The pen-oscillograph equipment which is being shown by Edison Swan Electric Company, Limited, 155, Charing Cross-road, London, W.C.2, comprises multi-channel permanent-record oscillographs, high-gain low-noise amplifiers and stabilised power supply units in a complete unit. The oscillograph is made up of 1 to 4 pen motors in a magnet block;

WHYTELEAFE EXPERIMENTAL VALVE FACTORY.

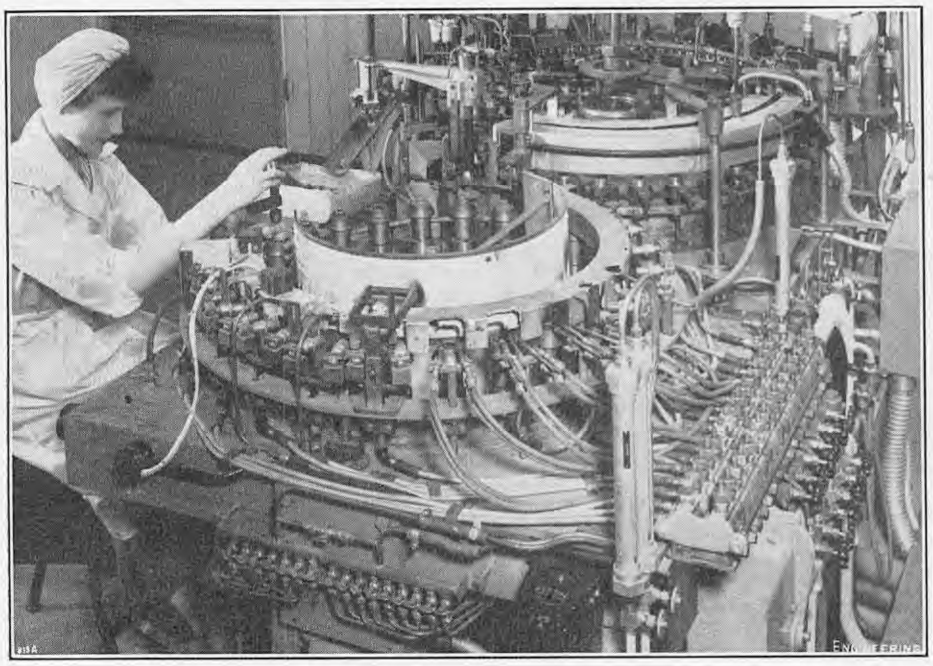


FIG. 1. SEALING AND PUMPING MACHINE.

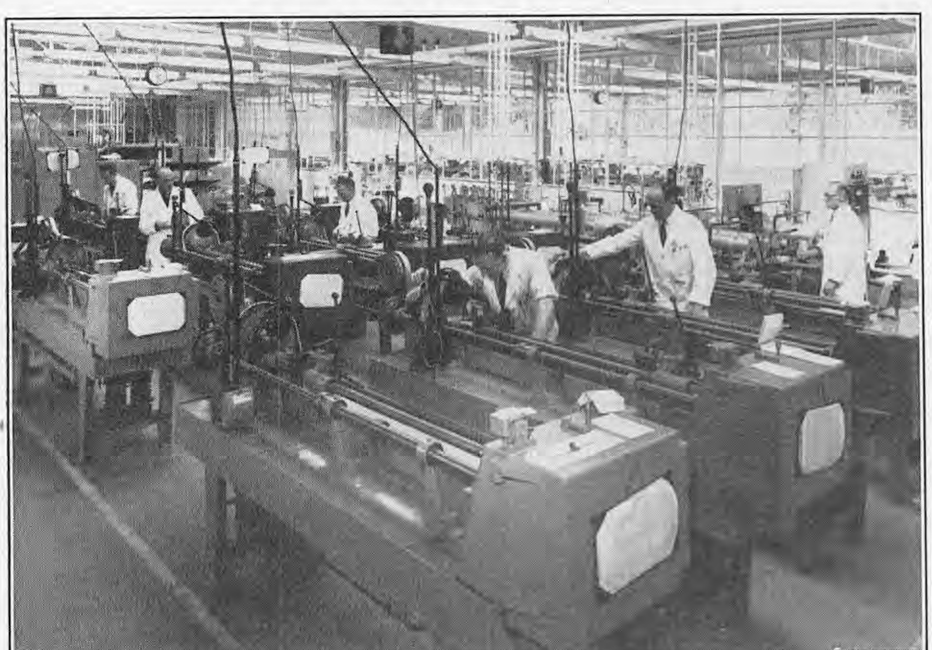


FIG. 2. GRID-WINDING DEPARTMENT.

a paper drive, provided with a three-speed gear box, ink feeds, and switching facilities. It is designed for portability. The pen motors are specially designed to give good frequency and amplitude response. The movements are borne in double-sleeve bearings and are totally enclosed, so that no magnetic dust is drawn into the gap, thus eliminating the possibility of damage to the coil. The pen arm radius is 10 cm. and the maximum peak-to-peak deflection is 2·35 cm., the sensitivity being 17·5 milliamperes per centimetre through the whole coil. The coil resistance of the pen motor is 1,450 ohms and the rating is 3 to 4 watts. A three-speed gate-change gearbox is fitted to give speeds of 1·5, 3 and 6 cm. per second with the motor running synchronously.

Messrs. Negretti and Zambra, Limited, 122, Regent-street, London, W.1, are showing a pyrometer. This has been designed for use with high-speed Diesel engines in which the exhaust gas temperatures are above the range of mercury-in-steel or bi-metal galvanometers. It is protected by anti-vibration fittings so that it can be mounted on the engine frame. The scale is 4 in. in length and the various thermocouples can be connected through a selector switch to a central point.

(To be continued.)

EXPERIMENTAL VALVE FACTORY AT WHYTELEAFE, SURREY.

AN interesting industrial experiment has been inaugurated recently by Mullard Limited, Century House, Shaftesbury-avenue, London, W.C.2, who have opened a small factory at Whyteleafe, in Surrey, specially designed and equipped for the production of miniature and sub-miniature valves for use in the Services and in industry. The new factory, which operates in conjunction with the main valve factory at Mitcham, Surrey, represents only a small fraction of the whole valve-manufacturing capacity of the Mullard organisation. Its object is to facilitate experiments and investigations on methods of valve manufacture, rather than to add materially to the large number of valves already produced. Manufacturing methods found satisfactory at Whyteleafe will, however, be adopted in the larger factories already in existence and in those that may be constructed later.

In recent years there has been a greatly increased demand for very reliable valves, since valves are now often employed in applications where a failure might have serious, or even disastrous, consequences. Examples that may be cited are aircraft, tanks, guided missiles, repeaters for submarine telephone cables, etc. In some cases also, valves must be subjected to heavy vibrations and shocks, extreme variations in ambient temperature, and other adverse working conditions. Although, in comparison with earlier productions, modern valves of normal design may be regarded as very reliable, valves specially designed and manufactured to withstand the severe conditions of service indicated above have been developed and are at present being manufactured in one of the development departments at the Mitcham factory. Later it is intended to produce these valves in large quantities at the Whyteleafe factory and at other production centres. At present, the cost of producing these valves is many times that of similar types of normal design, so that only small-scale production has been undertaken so far. It is expected that improved manufacturing methods at Whyteleafe, combined with large-scale continuous production, will result in a considerable reduction in the selling price of the specially reliable valves.

Sub-miniature valves are already being made at Whyteleafe by mass-production methods and as the main external dimensions of some of these valves, which are flat, are only 28 mm. by 8·5 mm. by 6·1 mm. it will be obvious that very careful manufacturing methods must be employed to ensure reliability and uniformity. Of the many factors which have been found to affect the question of valve reliability, those most important can be broadly classified in two categories: scientific and human. The former includes mechanisation, manufacturing methods and design; and the latter such considerations as the training of operators and supervisors and working conditions in the factory. By mechanisation it is expected to reduce the effects of variations in the skill of operators and a good example of this is afforded by one of the machines installed in the factory. This is a sealing and pumping machine, illustrated in Fig. 1, on this page, requiring only one operator and having an output of 650 valves per hour; previously several machines operated by 12 girls were used for this work, giving outputs of 600 valves per hour. Improvements have also been made in the machines used for making grids for miniature and sub-miniature valves. The grids are made in lengths of a few feet by winding very fine molybdenum wire on a pair of stout nickel wires which act as supports. The machine applies the correct number of turns for a single grid and leaves gaps at intervals, the whole length being cut through in the gaps in other machines to form the individual grids. To fix the fine molybdenum wires firmly, small nicks are formed in the support wires, the sides of the nicks being closed over to clamp the fine wires. A photograph of the grid-winding department is reproduced in Fig. 2, on this page. Very close tolerances are obviously essential in making these grids, but one of the latest cutting machines installed produces them at the rate of 2,400 per hour.

In the assembly room at Whyteleafe some interesting examples of mechanisation are to be seen. The filament in sub-miniature hearing-aid valves consists of a tungsten wire less than eight microns in diameter, the wire being coated with oxides to give the emission. The assembly of these minute components is facilitated by the use of special jigs. Those parts which have to be connected electrically are joined by the use of welding tweezers in a convenient and expeditious manner. The two blades of the tweezers are insulated from each other and are connected to the opposite poles of a direct-current supply, so that when two small metal parts are pinched between them the parts are welded almost instantaneously.

In setting up the Whyteleafe factory, the Mullard Company have paid special attention to the question of human relations, realising the influence the individual operator has upon the final product, particularly when this consists of "reliable" valves. Most of the operators are girls who are selected, in the first place, for nimbleness, dry hands and good eyesight, but they are also required to show enthusiasm for the work; otherwise they would hardly be likely to appreciate the importance of any particular operation affecting reliability. Similar conditions apply to the selection and training of supervisors, who must also be in full sympathy with the various incentive schemes and fatigue-reducing experiments carried out. All operators are trained in an assembly school, for which a section of the assembly room is set apart. The full training period is about 26 weeks, but we understand that a new entrant frequently attains practically the full output required after about eight weeks' training. The quality of the work done, of course, does not depend solely upon the skill of the operators, but also, to a material extent, upon their comfort. Particular attention has therefore been paid to heating, lighting and ventilation. Cleanliness of the working spaces is also of great importance, as the smallest speck of dust or lint in a valve will have a deleterious effect upon its performance. For this reason the components are kept covered in the factory until they are actually assembled in the valve. The operators are provided with overalls and head scarves of nylon, which, being non-fibrous, does not create dust. No food may be brought into the assembly room, which is vacuum-cleaned each evening, and traffic through this room is restricted as far as possible.

An interesting feature of the Mullard organisation is that the system of team work, introduced by them some five years ago, is being used at all their factories and has been found to give higher outputs and better results generally than could be obtained when each operator made up the complete electrode structure of a valve. Under the new system, each operator works in a team with three or four other girls selected to have about equal working speeds. The effects of absenteeism, which would appear to react unfavourably on the results, are avoided by the provision of replacement, or "first aid" operators, who are specially selected to be able to adapt themselves quickly to any of the operations involved and are thus able to maintain the output of the team when one of the normal members of it is away. Payment is by piecework and experiments with new systems and incentives are being carried out continually. The question of fatigue is of particular importance in connection with operators working on the sub-miniature valves and some experiments are now being conducted at Whyteleafe to determine those working conditions which reduce fatigue to a minimum.

In conclusion, it should be emphasised that the Whyteleafe factory is a new one, so that some of the initial problems have still to be solved. The Mullard Company are convinced, however, that, when set for operation on a full-scale mass-production basis, it will be one of the most efficient valve-producing plants in the world.

OPTIMUM CRUISING CONDITIONS FOR JET-PROPELLED AIR LINERS.

THE technique to be adopted in operating jet-propelled air liners in cruising flight—a subject of considerable topical interest in view of the new Comet air-liner service which is to open on May 2—was discussed in a paper on "Some Aspects of Civil Jet Aircraft Performance," presented by Mr. D. R. Newman at a meeting of the Royal Aeronautical Society in London, on Thursday, March 27. With piston engines, Mr. Newman said, it had been the practice to cruise at constant altitude and, in long-range flights, to reduce power and speed progressively, as fuel was consumed, in order to maintain the most economical speed, at or near to the maximum lift-to-drag ratio, appropriate to the aircraft weight.

With jet aircraft, such a technique would not give the optimum range, which was generally obtained when the product of the lift-to-drag ratio and the forward speed was a maximum. For the jet-engined aircraft, it could be shown that if the engine revolutions were varied while the altitude was held constant, the optimum-range condition occurred at a speed a little over 1·3 times the minimum-drag speed. If in the stratosphere, however, the engine revolutions were held constant while the altitude was varied, the optimum-range speed was a little below 1·2 times the minimum-drag speed. This meant, in effect that the pilot held the aircraft at a constant angle of incidence, reducing the indicated airspeed as fuel was consumed, in accordance with a predetermined curve of speed plotted against weight. In either case, it paid to fly as near to the absolute ceiling as possible, which implied the use of the highest engine speed consistent with reasonable length of overhaul life. The lecturer then showed a slide demonstrating that the constant-r.p.m. varying-altitude technique offered an appreciable advantage in range at a slightly higher average speed as compared with the most economical technique compatible with constant-altitude cruising. Changes in ambient temperature, moreover, had less effect on cruising speed and range. When cruising at constant incidence, the Mach number increased as the ambient temperature fell, and, in order to avoid flying at speeds above the critical Mach number for the aircraft, it might be necessary to instruct the pilot to fly at constant Mach number at air temperatures below a certain value. The use of a variable-altitude cruising technique would add to the difficulty of air-traffic control. Vertical separation of aircraft would no longer be practicable and, since aircraft flying on reciprocal courses at speeds of 500 m.p.h. would have a relative speed of 17 miles a minute, some form of collision warning would be required.

The speed of a jet aircraft was from two to four times as sensitive to engine speed as that of a piston-engined aircraft. At engine revolutions above, say, 85 per cent. of maximum, therefore, a much higher standard of accuracy of engine-speed measurement would be required, particularly in the case of test work. More accurate fuel-contents gauges and fuel-flow meters were also required, since a 1 per cent. error in weight estimation could result in an error of nearly 1 per cent. in speed and ½ per cent. in specific range (miles per lb. of fuel). Fuel quantity and flow measurements were complicated by the wide variation over which the fuel temperature ranged during a flight; it might be above 40 deg. C. at the beginning, falling to, say, − 35 deg. C. towards the end of a long flight.

Neglecting Reynolds Number effects, the performance of a jet engine could be specified in non-dimensional form. At the altitudes likely to be used in civil operation, Reynolds Number effects were probably not important, and the drag variation due to Reynolds Number was not great during cruising flight. This meant that the variation of jet-engine output with temperature was much more easily predicted than that of a piston engine. The author thought, therefore, that tropical trials on jet-propelled aircraft could be considerably reduced. The presentation of jet-propelled aircraft performance data was greatly simplified by the "non-dimensional behaviour" of the jet engine.

DE HAVILLAND "HERON" AIR LINER.—The first production Heron air liner, constructed by the de Havilland Aircraft Co., Ltd., Hatfield, Hertfordshire, made its initial flight at Hatfield on February 19. It will shortly be flown to New Zealand for demonstration flights.

LIGHT-ALLOY PRESSURE DIE-CASTING FOUNDRY: ERRATUM.—On page 297 of our issue of March 7 we described and illustrated the pressure die-casting foundry of Messrs. High Duty Alloys, Ltd., at Slough. We now learn that the figures for pressure applied to the metal, contained in the second column of the table, were erroneously supplied to us as being in tons per square inch. The figures given are the total injection pressures available in tons.

ELECTRIC TRAIN-DESCRIBER SYSTEM.

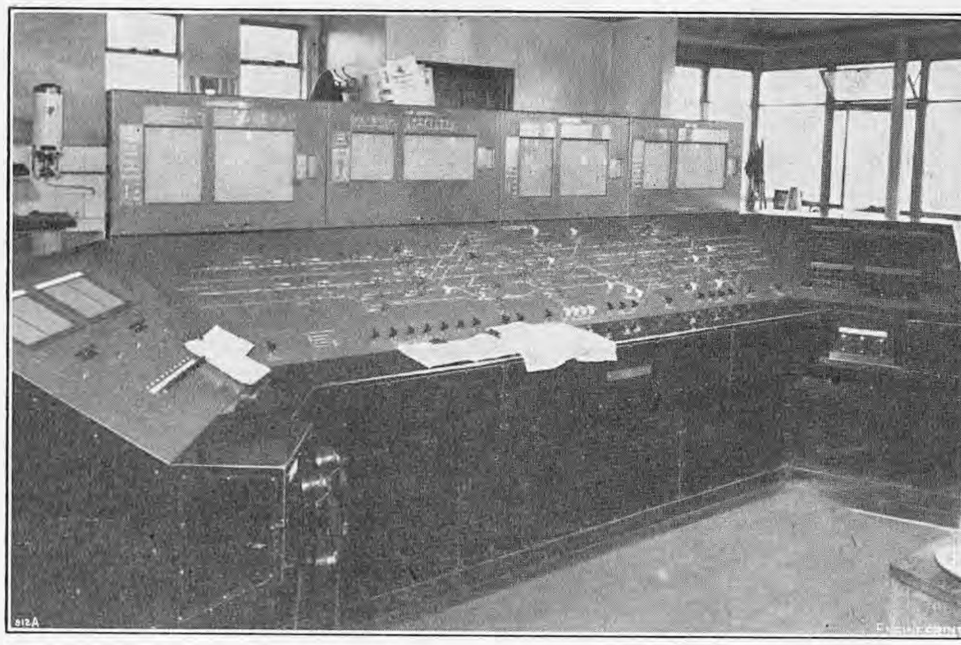


FIG. 1. DISPLAY INSTRUMENTS AND SET-UP PANEL AT GOODMAYES.

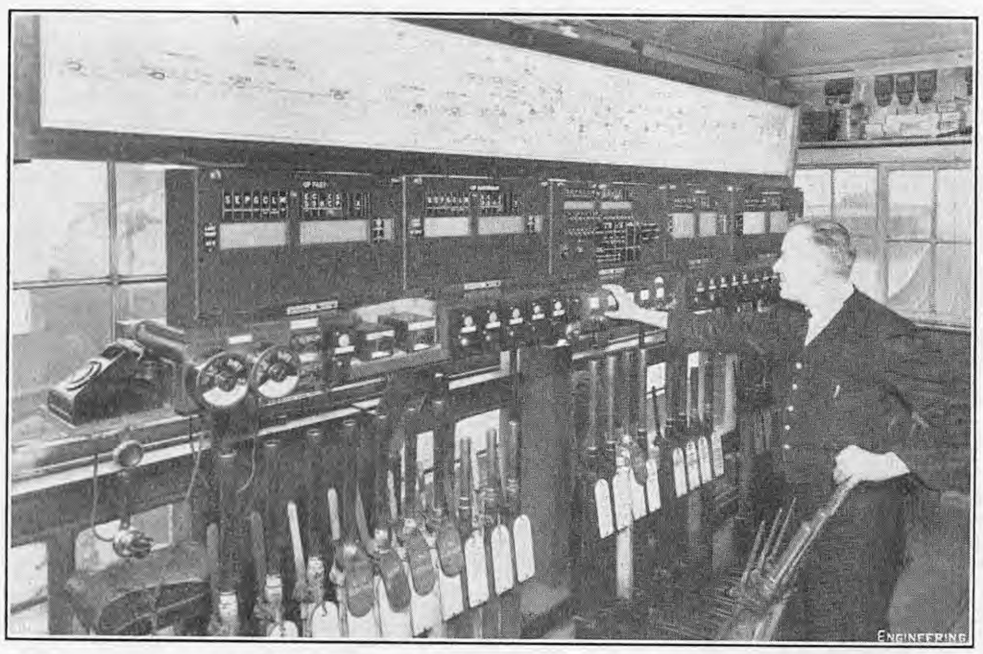


FIG. 2. DESCRIBER APPARATUS AT HACKNEY WICK.

TRAIN-DESCRIBER SYSTEM ON LIVERPOOL STREET-ROMFORD RAILWAY.

THE four-track section of line between London (Liverpool Street) and Gidea Park in the Eastern Region (British Railways) was equipped with four-aspect colour signalling and the necessary track circuits at the time when electric traction was introduced in September, 1949.* A train describer system has now been brought into service in connection with this signalling, and operates over the section between Liverpool Street and Romford, as well as over the four-track section between Bethnal Green and Hackney Downs, the double-track branch from Bow Junction to Gas Factory Junction and two additional tracks between Liverpool Street and Bethnal Green. A view of the display instruments and set-up panel which form the principal parts of this installation on the colour-light section is shown in the Goodmayes signal box in Fig. 1; and that at Hackney Wick, where mechanical signalling is still in use, is illustrated in Fig. 2, above.

The description of a train, which is initiated at Liverpool Street or Romford, is transmitted automatically from signal box to signal box in step with the progress of its journey. For this purpose, each signal box is provided with a transmitter and "last

* See ENGINEERING, vol. 168, page 325 (1949).

ELECTRIC TRAIN-DESCRIBER SYSTEM.

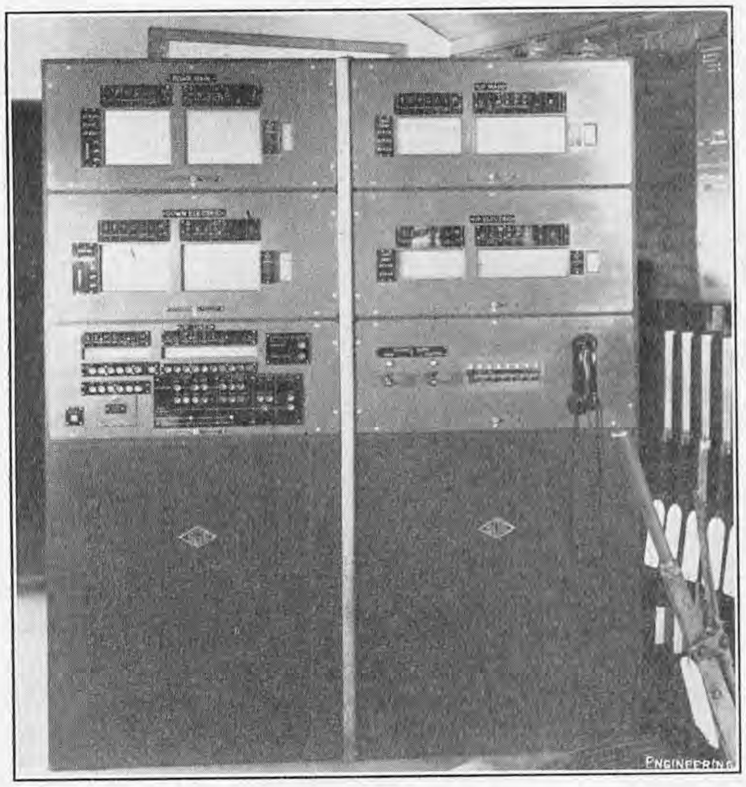


FIG. 3. PEDESTAL CABINET AT ROMFORD.

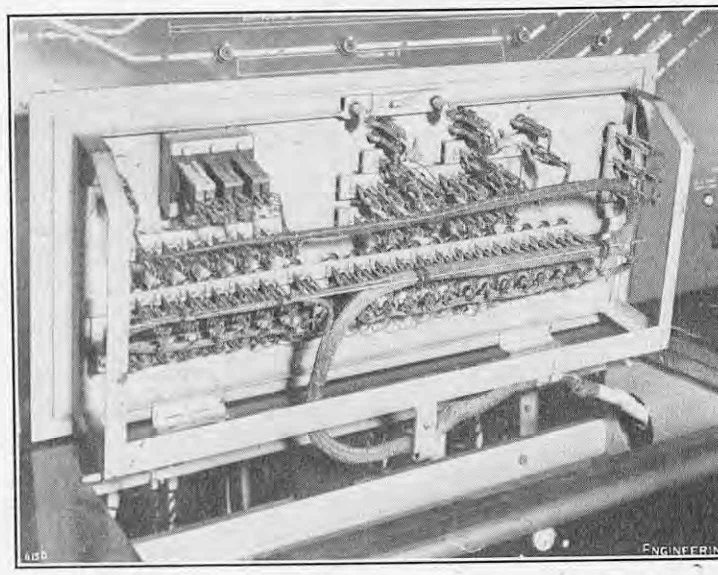


FIG. 4. INTERIOR OF DESK-TYPE DESCRIBER UNIT.

sent" indicator for each track leading away from it; and with a receiver indicator for each track approaching it. Generally speaking, the receivers consist of rows of indicating lamps, varying from 11 to 29, which are arranged horizontally, as can be seen in Fig. 1. The bottom row is labelled "Third in Section" and those above it "Second in Section"; "First in Section"; "At Signal X"; "At Signal Y"; "At Signal Z"; and "Last Sent" in ascending order. Each vertical row of lamps thus represents the train which appears third, second or first in the section (depending on how many trains are between the signal box in question and that in rear), and subsequently arrives successively at each of the signals controlled by the box until it finally reaches the "Last Sent" position, showing that it has passed into the section ahead.

The vertical rows of lamps are divided into two groups, of which the left-hand consists of seven vertical columns headed "S, E, P, G, C, L and M." The illumination of one, two or three of these lamps indicates the class of train. The right-hand group of lamps denotes the destination of a train. A train is therefore fully described by the illumination of one or more of the seven lamps plus a destination lamp; and this illuminated description moves up the panel as the train passes from signal to signal. The units for setting up the required train description and destination can be seen in Figs. 1 and 3, and consist of panels equipped with push keys. There are 12 description keys in each signal box, but the number of destination keys varies according to its position on the route. There are also "interpose" and "clearing keys" for introducing or clearing descriptions at certain signals, while further keys are provided for cancelling the last train transmitted to the box ahead.

If any part of the train describer equipment fails, the control devices can be cut out by the signalmen and the apparatus converted to manual operation. Train descriptions are then transmitted from signal box to signal box by interposing them into the "last sent" register, which transmits them to the box ahead. Meanwhile, the register itself flashes until a check is received from the forward instrument that the description has been correctly received. The trains are also cleared from the "in section" part of the instrument by operating a key labelled "clear first in section." As will be seen from Fig. 1, which illustrates the signal box at Goodmayes, where control panels are in use the set-up equipment is mounted on the desk in front of the panel. Where lever frames are employed the equipment and display panels are mounted in cabinets, which form wings to the lever frame. This arrangement is shown in Fig. 2, which illustrates the interior of the signal box at Hackney Wick, and in Fig. 3, which shows the signal box at Romford. A desk-type describer is shown in Fig. 4. The coding apparatus for operating the system is housed in metal cubicles in the relay rooms of the signal boxes.

As regards operation when a train leaves Liverpool Street, Gas Factory Junction, Hackney Downs or Romford and enters the area covered by the new system, the signalman sets up the appropriate description and interposes it into the signal position next ahead of the train. The operation of the overlap track circuit of this signal passes the description forward from box to box, until the train leaves the area covered by the describers. As the sections on this line are comparatively short, the signalmen might not receive sufficient warning of the approach of a train if transmissions of a description were delayed until it had reached the overlap circuit of the last controlled signal. An "early re-transmission" feature has therefore been introduced which permits the transmission of a description when the train is passing through the intermediate signal registers, provided that all signals ahead of it are clear. That this early transmission has taken place is indicated by a light, which appears alongside the description on the display panel and is transmitted forward with it.

In the case of trains to Liverpool Street, the destination indication ceases at Bethnal Green, only the description being transmitted to the terminus. When this particular re-transmission takes place, a buzzer is sounded on the time-keeper's desk in the Bethnal Green signal box and the number of the platform into which the train is to be directed by the Liverpool Street signalmen can then be set up. These numbers appear alongside the train description on the display panel at Liverpool Street. If the overlap track circuit of the last controlled signal becomes occupied when there is no relevant description in the register, a "not described" indication is exhibited on the display panel and an alarm bell sounds continuously until both are cut off by the appropriate key. The signalman must then transmit the description of the train by interposing it into the "last sent" register. The two carriage lines between Bow Junction and Stratford are signalled for use by traffic in both directions, and the two terminal signal boxes of this section are equipped with both a transmitter and a receiver. The train description and destination are combined in one indication by non-automatic apparatus.

In general, all the uni-selectors and relays used on the system are operated by direct-current at 50 volts, and the indication lamps are supplied at 12 volts through 110/12-volt transformers. The uni-selectors are of the latest single-coil type and are fitted with both forward and backward drive magnets. The codes used for transmission consist of 25 impulses, which are divided into two groups separated by a short pause. Positive impulses are used for descriptions and negative for destinations, the two being sent alternately at the rate of 11 per second. The total time occupied in transmitting and checking back a full description is about four seconds. The codes are sent from box to box on the "constant total" impulsing system, thereby eliminating the delays which arise when elaborate check-back circuits are used. The display lamps are in duplicate, one in each pair on the description indicators being undercut. Power is obtained from 50-volt lead-acid batteries, the capacity of which depends on the size of the installation at a particular box. These batteries are charged from the power supply circuits of the signalling system.

The equipment used in this installation was manufactured by Siemens and General Electric Railway Signal Company, Limited, Wembley, Middlesex, to the requirements of Mr. A. Moss, Signal and Telecommunications Engineer, Eastern Region.

CONTRACTS.

DURING February, the British Electricity Authority placed contracts for equipment for power stations, transforming stations and transmission lines amounting, in the aggregate, to 10,764,167*l*. The principal orders include a 60,000-kW turbo-generator, and feed-heating and condensing plant, for Brunswick Wharf power station, with the METROPOLITAN-VICKERS ELECTRICAL CO., LTD., also 3,300-volt switchgear, with the ENGLISH ELECTRIC CO., LTD.; two 60,000-kW turbo-generators for Marchwood power station, with the BRITISH THOMSON-HOUSTON CO., LTD., also generator transformers, with FERRANTI, LTD.; one 30,000-kW turbo-generator, feed-heating and condensing plant for Northampton power station, with the BRUSH ELECTRICAL ENGINEERING CO., LTD.; one 60,000-kW turbo-generator for Nottingham power station, with the METROPOLITAN-VICKERS ELECTRICAL CO., LTD.; condensing and feed-heating plant for three 60,000-kW turbo-generator sets for Hams Hall "C" power station, with WORTHINGTON-SIMPSON, LTD., also transformers with the GENERAL ELECTRIC CO., LTD.; twelve 150,000-lb. per hour boilers for Walsall power station, with BABCOCK AND WILCOX, LTD.; two 60,000-kW turbo-generators for Ince power station, with the GENERAL ELECTRIC CO., LTD., also 3,300-kV and 415-V auxiliary switchgear with the ENGLISH ELECTRIC CO., LTD.; one 60,000-kW turbo-generator, feed-heating and condensing plant for Skelton Grange power station, with C. A. PARSONS & CO., LTD., also 132-kV generator transformers with the HACKBRIDGE AND HEWITTIC ELECTRICAL CO., LTD.; a 200,000-lb. per hour boiler for Thornhill power station, with MITCHELL ENGINEERING, LTD.; condensing and feed-heating plant for two 30,000-kW turbo-generators, for Huncoat power station, with HICK, HARGREAVES & CO., LTD.; 132-kV, 2,500 MVA switchgear for Sundon substation, with the ENGLISH ELECTRIC CO., LTD.; the Rayleigh-Chelmsford and Braintree 132-kV overhead line, with WATSHAM'S, LTD.; two 30-MVA 120. 7/11-kV transformers and earthing transformers for Shirley substation, with the BRITISH ELECTRIC TRANSFORMER CO., LTD.; the Felinfoed-Ammanford and Ystradgynlais 132-kV overhead lines, South Wales, with BRITISH INSULATED CALLENDER'S CONSTRUCTION CO., LTD., and 132-kV 2,500-MVA switchgear for Creyke Beck substation, with A. REYROLLE & CO., LTD., also 30-MVA 132/22-kV transformers and auxiliary transformers, with FERRANTI, LTD.

THE BRITISH ELECTRIC TRANSFORMER CO., LTD., in connection with the change of frequency scheme to be carried out by the Southern Region of British Railways, have received an order for two 45-MVA three-phase 50-cycles, 66/33-kV, star/delta-connected ON/OFB outdoor-type transformers with fully automatic on-load tap-changing equipment. The firm is also supplying two earthing transformers for use with the main transformers.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

ROYAL TECHNICAL COLLEGE EXTENSIONS.—The annual report of the Governors of the Royal Technical College, issued on March 26, states that nearly 240,000*l*. has now been received from, or promised by, industrial concerns, as well as public bodies and individual well-wishers, in response to the appeal for 350,000*l*., launched last year, to help in the erection and equipping of an extension to the College. Considerable progress has been made with the extension works. When completed, the extension will be occupied by the departments of civil and mechanical engineering and mining. A major programme of re-equipment has been planned for the civil and mechanical engineering departments to replace much obsolescent equipment.

REVIEW OF APPRENTICESHIP QUESTION.—On March 25, the Advisory Council on Education in Scotland issued a report on further education in which they suggested that the time is ripe for the whole question of apprenticeship to be reviewed by a body representative of all the interests concerned. They recommend that the Secretary of State should take the initiative in calling them together. The report comments on "a decline in the craft element." Copies of the report (price 5*s*.) are obtainable from H.M. Stationery Office, 13a, Castle-street, Edinburgh.

S.S. "ATLANTIS" TO BE BROKEN UP.—The former Royal Mail liner Atlantis (ex Andes) was towed to Faslane, on the Gareloch, on March 27, where she is to be broken up by Metal Industries (Salvage) Ltd. The scrap recovered will be a welcome addition to raw material supplies for steelmaking in Scotland, while re-rolling firms expect to receive boiler plates, boiler stay bars and ships' davits for re-rolling into heavy sheets and bars. The Atlantis, a triple-screw turbine steamer of 15,363 tons gross, was built by Harland and Wolff, Ltd., Belfast, in 1913.

SALE OF THE "KING EDWARD" AND "DUCHESS OF ARGYLL."—The steamers King Edward and Duchess of Argyll, two vessels of the Clyde fleet, have been sold by British Railways. The former, built by William Denny and Brothers, Ltd., Dumbarton, in 1901, and the first commercial vessel in the world to be propelled by steam turbines, will be transferred to Belgian ownership, while the Duchess of Argyll, built by the same firm in 1906, will be used for Admiralty experiments, to be carried out off Portland.

RESEARCH ON DETECTION OF COSMIC-RAY PARTICLES.—It is reported that a group of physicists from the University of Bristol, under the direction of Professor C. F. Powell, are to visit Scotland very shortly. The purpose of their visit is to release large balloons carrying apparatus for the detection of cosmic-ray particles. The balloons are made from a plastic material 0·0015 in. thick. It is believed that the magnetic field of the sun plays some part in determining the energies of incident cosmic-ray particles, and if this is the case it is expected that the effect would be more noticeable where the effect of the earth's field is least, i.e., at high altitudes. It is for this reason that the team are visiting Scotland to study the problem.

THE LATE SIR JOHN H. IRVIN.—The death of Sir John Hannell Irvin, K.B.E., a leading member of the Scottish fishing industry, occurred in Aberdeen on March 26. Sir John, who was 78, had played an active part in the development of Aberdeen as a port and fishing centre. He joined the Aberdeen Harbour Board 50 years ago, and for over 40 years had been chairman of the Finance Committee. He was governing director of Richard Irvin and Sons, Ltd., owners of various kinds of fishing vessels. Sir John was also a director of Irvin and Johnson (South Africa), Ltd. The business began on Tyneside, where his father and uncle were mayors of Tynemouth. He was created a K.B.E. in 1917.

EXTENSION OF BUNANUISG POWER STATION.—The Secretary of State for Scotland (the Rt. Hon. James Stuart, M.P.) has approved a scheme for the construction of an extension to the existing Diesel generating station at Bunanuisg, near Bowmore, on the Isle of Islay. This will comprise 2,400 kW of plant, bringing the capacity of the station up to about 3,000 kW.

THE LATE MR. DAVID DRUMMOND.—The death of Mr. David Drummond is reported from his home in Vancouver. Mr. Drummond was a Glasgow man who was formerly Orient manager of Canadian Pacific Steamships, Ltd. On completing his education he joined the staff of the former Allan Line in Glasgow, and was subsequently appointed secretary to the chairman of Canadian Pacific Steamships, Ltd. After a period of service in the war of 1914-18, Mr. Drummond became the company's manager at Southampton.

CLEVELAND AND THE NORTHERN COUNTIES.

CHINESE TANKER AT MIDDLESBROUGH.—The S.S. Yung Che, an oil tanker of 6,769 registered tonnage, owned by the China Tanker Co., Ltd., took on 6,000 tons of creosote at Middlesbrough and left on March 24 for Vancouver by way of the Panama Canal. She is stated to be the first Chinese ship, entirely manned and officered by Chinese, to dock at Middlesbrough. The vessel was built and engined by Howaldtswerke, Kiel, in 1914, and, after 1918, was owned in the United States. She was purchased by her Chinese owners in 1946.

COLLIERIES TO BE OPENED AT CROOK AND WEST BRANDON.—Three new drift mines in Co. Durham, equipped with the latest types of machinery and furnished with pit-head baths, canteens, and other amenities, will be opened and producing coal during the next six months. Two of the collieries are at Crook and the third is at West Brandon, the latter being the largest; it is situated over an isolated deposit of coal estimated to contain 2,000,000 tons. The three mines will eventually employ 520 men and produce some 4,000 tons of coal a week. The new pits will absorb all men made redundant by the gradual working out of neighbouring collieries.

LANCASHIRE AND SOUTH YORKSHIRE.

"RATIONING" OF AUSTRALIAN IMPORTS.—The High Commissioner for Australia, Sir Thomas White, speaking at the Cutlers' Feast at Sheffield, on March 21, said that Australia was not letting the Empire down but was merely introducing a rationing of imports that would soon rectify itself. He appreciated the feelings of Sheffield manufacturers inasmuch as Australia imported from Sheffield last year 1,250,000*l*.-worth of cutlery and 1,900,000*l*.-worth of hand tools and a multitude of other articles. It has been announced that imports into Australia are to be cut by four-fifths.

CUTLERY COMPETITION.—Samples of German and Italian scissors received in Sheffield are being sold in the Far East at prices a third cheaper than British scissors. One agent has reported that many German cutlery goods are 50 per cent. below Sheffield prices. Silver-plated Japanese teaspoons are being sold in the Far East at less than one-eighth of the price of the cheapest British plated teaspoons. German firms are reported to offer delivery of cutlery within 12 weeks, whereas British firms' delivery dates vary from six to twelve months on account of shortages of materials.

DELAYS DUE TO INSPECTION.—The Master Cutler, Mr. G. M. Flather, considers that the Services should trust steelmakers to observe only the highest standards in their products. Time and labour were being wasted and production held up because only one of the Services thought the men on the job knew best how it should be done. In his view, the reputations of steelmakers meant more to them than all the inspectors' stamps in the world, and if inspection were abolished man-power could be saved.

ALTERNATIVE FUELS FOR OPEN-HEARTH FURNACES.—Three of the five steel-melting furnaces at the Stocksbridge works of Samuel Fox & Co., Ltd., are oil-fired, as are many others in Sheffield, including all those at Templeborough; but a representative of the United Steel Companies Ltd., which control both Samuel Fox & Co. and Steel, Peech & Tozer, Ltd., states that the company always have in mind the possibility of reverting to gas. Recent progress in furnace design at Stocksbridge is a factor likely to influence the reversion. The furnaces at Stocksbridge changed from gas to oil in 1946 and the 14 furnaces at Templeborough in the following year. Since then, the price of fuel oil has advanced considerably.

LOSS OF ENGINEERING OPPORTUNITIES.—At a meeting in Sheffield of the Incorporated Sales Managers' Association, Mr. S. G. Sloan, of Darlaston, complained of loss of engineering opportunities because demands on steel mills were based on an obsolete standard. They were bound by a 1946 criterion. Wonderful new engineering opportunities throughout the world, he said, were being nipped in the bud because demands on the mills could not be altered from what they were in 1946. Sales managers of raw-materials firms were not able to give the flexibility needed for creative sales planning.

THE MIDLANDS.

DEVELOPMENT OF WOLVERHAMPTON.—The development plan for the borough of Wolverhampton, which has now been published, envisages the spending of 47,310,000*l*. over a period of 20 years. The population of the town is to be reduced from 163,000 to 141,000, which will be effected by re-housing people outside the borough boundaries. Industry will be concentrated largely on a strip of land running from south-east towards the centre of the town and then dividing to turn north and north-west. The industrial zone is roughly that at present occupied by the town's factories, but there are isolated examples of industry in areas scheduled for residential purposes, and the plan provides for the gradual re-siting of these factories. Questionnaires were sent to industrialists in the borough in 1950 and from the replies received it was obvious that an increase of about 20 per cent. in the industrial area would be necessary. The plan therefore provides for 840 acres of land to be scheduled for industry, against the present acreage of 700. Some of the land required will be obtained by demolishing sub-standard houses in the present industrial area.

THE COST OF ELECTRICITY.—Alderman W. S. Lewis, chairman of the Midlands Electricity Board, speaking at a luncheon in Birmingham on March 26, claimed that electricity tariffs in the Midlands, for both commercial and domestic consumers, were lower than in any other part of the country. He said that the average cost of a unit of electricity to a consumer was now 1·02*d*., as compared with 1·112*d*. before the war.

WATER SUPPLIES.—Major A. H. S. Waters, chairman of the South Staffordshire Waterworks Co., speaking at the company's annual general meeting at Birmingham on March 27, said that there was still a need to conserve water. Last year, the daily consumption of water in the company's area had increased by 1,250,000 gallons, as compared with 1950, and the new construction works which were in hand to increase supplies had been delayed by labour and materials shortages. Major Waters reported, however, that reasonable progress had been made on all large construction works and that the supply position might soon be eased. A new source of supply is being developed at Churchill, near Kidderminster, Worcestershire, where work on boreholes has already commenced.

ROAD HAULAGE IN DUDLEY.—The Dudley (Worcestershire) sub-area of the Road Haulage Association has decided to raise its rates by 10 per cent. as from April 1. The Association states that the increase is due to the rise in the price of petrol and oil.

SOUTH-WEST ENGLAND AND SOUTH WALES.

NEW CARDIFF-DUBLIN AIR SERVICE.—Mr. S. Kenneth Davies, chairman of the Welsh Advisory Council for Civil Aviation, announced during the week that a new passenger air service between Rhoose aerodrome, near Cardiff, and Dublin is to be inaugurated on June 10. The conversion of Rhoose aerodrome, which was used by the R.A.F. in the last war, into a civil airport has been approved by the Glamorgan County Council planning committee, subject to safeguards in respect of highways in the vicinity. The Minister of Transport and Civil Aviation has stated that if the new service to Dublin proves successful in operation, Rhoose would probably be developed as the future airport for Cardiff and South Wales.

SUPPLY OF METHANE TO GAS BOARD.—Negotiations between the Wales Gas Board and the National Coal Board concerning the price to be paid for the supply of methane gas from the South Wales pits are reported to be entering a final stage. Reference has recently been made to the sources of methane in the South Wales coalfield capable of economic use. Experiments are being carried out at the Windsor Colliery, near Caerphilly, by the National Coal Board and at other pits in the coalfield.

RHONDDA DECISION ON SATURDAY WORKING.—A surprise development in the South Wales movement to ban Saturday working in the coalfield as a protest against the cuts made in the social services, has been the decision, reached in the past week by the colliers engaged at the Parc and Dare pits, in the Rhondda, to resume Saturday work forthwith. These were the men who initiated the movement some weeks ago. They have gone even farther and, at a mass meeting, decided to support the continuation of the voluntary shift after the present agreement expired.

MINERS' PENSION SCHEME.—Efforts to get miners to participate in the pension scheme are to be intensified in South Wales. A meeting of the area executive council of the National Union of Mineworkers was told that the latest figures showed that approximately 68 per cent. of the miners in the coalfield had joined the pension scheme, as against 66·3 per cent. of miners for the country as a whole.

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.

INSTITUTE OF ECONOMIC ENGINEERING.—*Glasgow Branch:* Saturday, April 5, 10.30 a.m., Christian Institute, 70, Bothwell-street, Glasgow. "The Paperwork of Production," by Mr. P. M. Fleming. *Birmingham Branch:* Saturday, April 5, 2.30 p.m., Chamber of Commerce, 95, New-street, Birmingham. "Some Reflections on the Productivity Teams' Reports," by Dr. Noel Branton.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Lancashire Branch:* Saturday, April 5, 2.45 p.m., Engineers' Club, Albert-square, Manchester. "The Observation and Control of Dust in Foundry-Dressing Operations," by Mr. W. B. Lawrie; accompanied by a film on "Dust Flow." *Newcastle Branch:* Saturday, April 5, 6 p.m., Neville Hall, Westgate-road, Newcastle-upon-Tyne. Annual Meeting. *West Riding of Yorkshire Branch:* Saturday, April 5, 6.30 p.m., Technical College, Bradford. Presentation of the paper awarded the S. W. Wise Memorial Prize. *Sheffield Branch:* Monday, April 7, 7.30 p.m., Sheffield College of Technology, Pond-street, Sheffield, 1. Short Paper Competition. *Birmingham and West Midlands Students' Section:* Wednesday, April 9, Dudley and Staffordshire Technical College, Dudley. "Modern Trends in Cupola Design, with Special Reference to Hot-Blast Cupolas," by Mr. E. Hunter.

INSTITUTE OF PACKAGING.—*Northern Area:* Monday, April 7, 6.30 p.m., Grand Hotel, Manchester. "Engineering a Package: The Fundamentals of Package Design and Mechanisation," by Mr. E. D. S. Baker and Mr. J. L. Winfield.

INSTITUTION OF ELECTRICAL ENGINEERS.—*North-Eastern Centre:* Monday, April 7, Royal Station Hotel, Newcastle-upon-Tyne. 6.15 p.m., Annual Meeting (For corporate members and Associates only). 7.15 p.m., Informal Conversazione. *South Midland Centre:* Monday, April 7, 6.30 p.m., James Watt Memorial Institute, Birmingham. Education Discussion Circle. Discussion on "The Position of the Cathode-Ray Oscillograph in Electrical Engineering," opened by Dr. W. Wilson. *Southern Centre:* Monday, April 7 6.30 p.m., The Guildhall, Southampton. Faraday Lecture on "Sound Recording: Home, Professional, Industrial and Scientific Applications," by Dr. G. F. Dutton. *Radio Section:* Wednesday, April 9, 5.30 p.m., Savoy-place, Victoria embankment, W.C.2. Symposium on "Microwave Links." (i) "Microwave Radio Links," by Dr. A. T. Starr and Mr. T. H. Walker; (ii) "Circuit Technique in Frequency-Modulated Microwave Links," by Mr. H. Grayson, Mr. T. S. McLeod, Mr. R. A. G. Dunkley and Mr. G. Dawson; and (iii) "Microwave Technique for Communication Links," by Mr. G. King, Mr. L. Lewin, Mr. J. Lipinski and Mr. J. B. Setchfield. *Scottish Centre:* Wednesday, April 9, 7 p.m., Heriot-Watt College, Edinburgh. "The Design and Performance of Surge Diverters for the Protection of Alternating-Current Systems," by Mr. T. F. Monahan.

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—*Scottish Centre:* Monday, April 7, 7.30 p.m., Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow, C.2. "Chassis Frame Construction and Repair," by Mr. C. F. Cunningham.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS. —*Sheffield Branch:* Monday, April 7, 7.30 p.m., Royal Victoria Station Hotel, Sheffield. "Control of Machine Tools," by Mr. K. M. Swash. *North-East London Branch:* Monday, April 7, 8 p.m., Angel Hotel, Ilford. "Power Station Engineering," by Mr. H. D. Watson. *Bolton Branch:* Tuesday, April 8, 8 p.m., The Balmoral Hotel, Bradshawgate, Bolton. "Refrigeration," by Mr. A. Crowshaw. *Bradford Branch:* Wednesday, April 9, 7.30 p.m., Midland Hotel, Bradford. Film Display, introduced by Mr. L. Bruce.

INSTITUTION OF CIVIL ENGINEERS.—*Maritime and Waterways Engineering Division:* Tuesday, April 8, 5.30 p.m., Great George-street, Westminster, S.W.1. "Model-Tests on the Bellmouth-Spillway and Outfall of the Fassideri Project," by Mr. E. S. Crump.

CHEMICAL ENGINEERING GROUP.—Tuesday, April 8, 5.30 p.m., Geological Society's Apartments, Burlington House, Piccadilly, W.1. "Heat Transfer to Boiling Liquids at Low Temperatures and Elevated Pressures," by Mr. A. G. Monroe, Mr. H. A. S. Bristow and Mr. J. E. Newell.

INSTITUTE OF MARINE ENGINEERS and INSTITUTION OF NAVAL ARCHITECTS.—Tuesday, April 8, 5.30 p.m., 85, The Minories, E.C.3. "Some Recent Studies of Human Stress from a Marine and Naval Viewpoint," by Dr. N. H. Mackworth.

ILLUMINATING ENGINEERING SOCIETY.—Tuesday, April 8, 6 p.m., Lighting Service Bureau, 2, Savoy-hill, W.C.2. "Photo-Luminescence as Applied to Lighting," by Mr. H. G. Jenkins and Mr. A. H. McKeag.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, April 8, 6.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. Annual Meeting. Report of the Council for 1950-51 Session. "Ship Structural Members: Part V," by Mr. A. G. Hadjispyrou and Mr. H. Lackenby.

INSTITUTION OF WORKS MANAGERS.—*Preston Branch:* Tuesday, April 8, 7 p.m., Starkie House, Starkie-street, Preston. Film on "Factory Planning," followed by a discussion.

INCORPORATED PLANT ENGINEERS.—*Edinburgh Branch:* Tuesday, April 8, 7 p.m., 25, Charlotte-square, Edinburgh. "The Development of Modern Lubricating Oils," with film, by Mr. D. T. McHutchison. *East Lancashire Branch:* Tuesday, April 8, 7.15 p.m., Engineers' Club, Albert-square, Manchester. "Mechanical Stokers and Coal-Handling Plant," by Mr. R. F. W. Guy and Mr. J. P. Lauder. *South Wales Branch:* Tuesday, April 8, 7.15 p.m., South Wales Institute of Engineers, Park-place, Cardiff. Various short papers and discussions. *East Midlands Branch:* Wednesday, April 9, 7 p.m., The Welbeck Hotel, Nottingham. "Ironstone and Iron," by Mr. W. Corns. *Kent Branch:* Thursday, April 10, 7 p.m., The Queen's Hotel, Maidstone. Demonstration and films illustrating "Toughened Glass. *Newcastle Branch:* Thursday, April 10, 7.30 p.m., Roadway House, Oxford-street, Newcastle-upon-Tyne. "Applications of Hydraulics," by Mr. D. V. Rowles.

NEWCOMEN SOCIETY.—Wednesday, April 9, 5.30 p.m., Science Museum, South Kensington, S.W.7. "The Scientific Basis for Leonardo da Vinci's Work in Technology; An Appreciation," by Dr. Ivor B. Hart.

INSTITUTE OF PETROLEUM.—Wednesday, April 9, 5.30 p.m., Manson House, 26, Portland-place, W.1. "Some Observations on Corrosion in Engineering," by Dr. S. F. Dorey, F.R.S.

LIVERPOOL ENGINEERING SOCIETY.—Wednesday, April 9, 6 p.m., 9, The Temple, 24, Dale-street, Liverpool. Annual Meeting.

BRITISH INSTITUTION OF RADIO ENGINEERS.—*North-Eastern Section:* Wednesday, April 9, 6 p.m., Neville Hall, Westgate-street, Newcastle-upon-Tyne. "Very High Frequency Broadcasting: The Case for Amplitude Modulation," by Mr. J. R. Brinkley. *Scottish Section:* Thursday, April 10, 7 p.m., at the works of Metropolitan-Vickers Electrical Co., Ltd., Watling-street, Motherwell. "X-Ray Equipment and Its Control Gear," by Mr. C. S. Norton.

INSTITUTION OF MECHANICAL ENGINEERS.—*Southern Branch:* Wednesday, April 9, 7 p.m., Physics Lecture Theatre, University College, Southampton. Joint Meeting with the *Southern Branches* of the INSTITUTION OF CIVIL ENGINEERS and the ROYAL AERONAUTICAL SOCIETY. "Wind Excited Oscillations of Suspension Bridges," by Mr. C. Scruton. *London Graduates' Section:* Wednesday, April 9, 6.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Marine Propulsion," by Mr. P. R. Christopher. AUTOMOBILE DIVISION.—Tuesday, April 8, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Long-Distance Diesel 'Buses on the European Continent," by Mr. J. Steenman.

STOKE-ON-TRENT ASSOCIATION OF ENGINEERS.—Wednesday, April 9, 7 p.m., Midland Electricity Board's Lecture Hall, Back Glebe-street entrance, Stoke-on-Trent. "Design and Production of New Motor-Vehicle Prototypes," by Mr. J. R. Rix.

INSTITUTION OF PRODUCTION ENGINEERS.—*London Section:* Thursday, April 10, 7 p.m., Royal Empire Society, Northumberland-avenue, W.C.2. "How Production Engineers Can Be Helped by Metallurgists," by Dr. J. Jevons.

INSTITUTE OF FUEL.—*North-Western Section:* Wednesday, April 16, 2 p.m., Engineers' Club, Albert-square, Manchester. Annual Meeting. "Thermal Factors in Furnace Design," by Professor R. J. Sarjant and Mr. W. Hulse. (Preceded by luncheon at 1 p.m.) *East Midland Section:* Thursday, April 17, 6.15 p.m., East Midland Gas Board's Showrooms, Nottingham. "Developments in Gas Manufacture in the Area of the East Midland Gas Board," by Dr. M. Barash and Mr. A. W. Elliott. *Scottish Section:* Friday, April 18, 7 p.m., Royal Technical College, Glasgow. Annual Meeting.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—Wednesday, April 16, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "The Fell Diesel Mechanical Locomotive," by Lieut.-Col. L. F. R. Fell.

INSTITUTION OF WATER ENGINEERS and INSTITUTE OF SEWAGE PURIFICATION.—Thursday, April 17, 3 p.m., Chamber of Commerce, 95, New-street, Birmingham. "The Rivers (Prevention of Pollution) Act, 1951: A Commentary," by Mr. Ll. Jones and Mr. D. H. A. Price.

JUNIOR INSTITUTION OF ENGINEERS.—Friday, April 18, 6.30 p.m., 39, Victoria-street, Westminster, S.W.1. "Some Modern Submersible Pumping Applications," with film, by Mr. W. L. Gardiner.

PERSONAL.

SIR HENRY TIZARD, G.C.B., A.F.C., F.R.Ae.S., F.R.S., retired on March 31 from the position of chairman of the Defence Research Policy Committee held by him since 1946, latterly on a part-time basis. His successor is SIR JOHN COCKCROFT, F.R.S., who will also be chairman on a part-time basis and will continue to serve as director of the Atomic Energy Research Establishment.

SIR RICHARD SNEDDEN, general manager of the Shipping Federation, 52, Leadenhall-street, London, E.C.3, has been granted, by H.M. The Queen unrestricted permission to wear the insignia of Commander, Second Class, of the Order of the Dannebrog, conferred upon him by the King of Denmark in recognition of services rendered during the war. Sir Richard has also been made a Commander of the Order of the Finnish Lion by the President of the Republic of Finland.

MR. W. H. HODGETTS, production manager of Imperial Chemical Industries Ltd., Witton, Birmingham, has been elected chairman of the Birmingham District Advisory Committee for the Midland Regional Board for Industry, in succession to MR. J. A. HUNT, general manager of the Hymatic Engineering Co. Ltd., Redditch.

MR. FRANK SWIFT, M.B.E., for 25 years manager of the steel foundry of the Darlington Forge Ltd., Darlington, has retired after over 50 years of service.

MR. ROGER FALK, O.B.E., lately director-general of the British Export Trade Research Organisation (B.E.T.R.O.) has joined the staff of Production Engineering, Ltd., to take charge of the marketing side of their organisation work.

DR. L. T. M. GRAY, J.P., B.Sc., has been appointed a director of the British Rollmakers Corporation Ltd.

MR. F. L. LEVY, a director of George Cohen, Sons & Co. Ltd., and associated companies, has been elected President of the London and Southern Scrap Iron and Non-Ferrous Metal Merchants Association. This office was held for a number of years by his father, MR. LAWRENCE LEVY.

MR. A. E. PEATFIELD, A.M.I.Mech.E., A.M.I.Struct.E., formerly resident engineer with the Ministry of Transport and Air Ministry Works Directorate, who joined the civil and general engineering department of the Anglo-Iranian Oil Co. Ltd., in 1943, has now been made standards engineer to that company.

MR. STANLEY BELL has been elected to the board of Bowaters Sales Co. Ltd., in succession to the late MR. E. L. FIFOOT and MR. C. G. CULLEN has been appointed an additional director. Mr. Cullen has also succeeded Mr. Fifoot as chairman of Bowaters Building Boards Ltd., of which MR. J. H. SMITH has been elected a director. The chief engineer, MR. G. R. ROBERTS, and the secretary, MR. C. G. RYE, have been appointed directors of the firm's three paper-mill companies and MR. H. M. ARCHIBALD has been made a director of Bowater's Lloyd Pulp & Paper Mills Ltd.

MR. P. W. ELLIS, general manager, area No. 1 (Worksop), North-Eastern Division, National Coal Board, since vesting day, retired on March 25. His successor is MR. N. HULLEY, hitherto production manager, area No. 1 (Worksop), who, in turn, is succeeded by MR. E. J. KIMMINS, deputy-production manager of sub-area "B," area No. 3 (Rotherham) of the North-Eastern Division.

MR. A. FORBES SMITH, stores superintendent, Eastern and North Eastern Regions, British Railways, King's Cross, has been appointed chief officer (stores), Railway Executive Headquarters, London.

MR. V. E. HUGHES informs us that his new permanent address is: 115, St. George's-square, London, S.W.1. (Telephone: TATe Gallery 8292.)

TEMPLE INSTRUMENTS LTD., Chevron Works, Temple-street, Wolverhampton, have built a new works in Sharrocks-street, Wolverhampton.

COLUMBUS LIMITED and R. G. DIXON & CO. LTD., Capitol Works, Empire-way, Wembley, Middlesex, hitherto associated companies, are to form a single marketing organisation, to be known as COLUMBUS-DIXON LTD., as from April 1.

The name of BOUND BROOK BEARINGS (G.B.) LTD., manufacturers of oil-retaining and other bearings, Trent Valley Trading Estate, Lichfield, has been changed to BOUND BROOK BEARINGS LTD.

THE MCGRAW-HILL PUBLISHING CO. LTD., and their affiliated companies, are to move from Aldwych House, Aldwych, London, W.C.2, and other addresses to larger premises to be renamed McGraw-Hill House, at 95, Farringdon-street, E.C.4. The move should commence at a date in mid-April, to be fixed, and should be completed by the end of May.

D. NAPIER & SON LTD., Acton, London, W.3 (a subsidiary of the English Electric Co. Ltd.), have purchased the factory and plant of BRITISH SALMSON AERO ENGINES LTD., Raynes Park, London, S.W.10, in order to expand manufacturing facilities for the development of new types of aeroplane and marine engines.

REINFORCED-CONCRETE BUILDING FOR RUBBER AND PLASTICS FACTORY.

(*For Description, see Page 437.*)

Fig. 1. Interior of Drug Room.

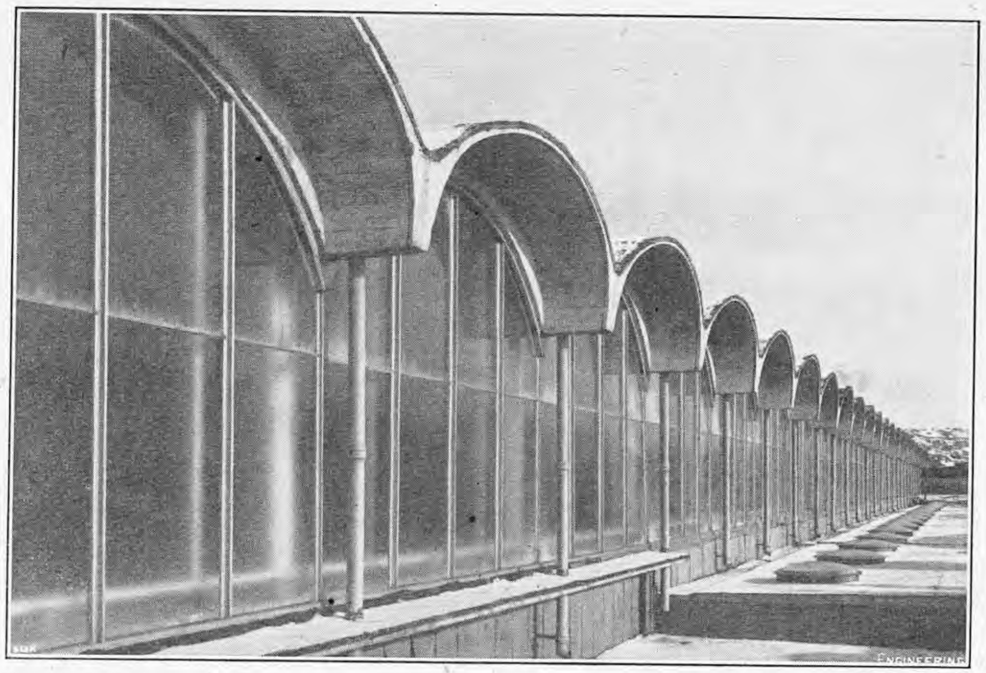


Fig. 2. Clerestory Section of Drug Room.

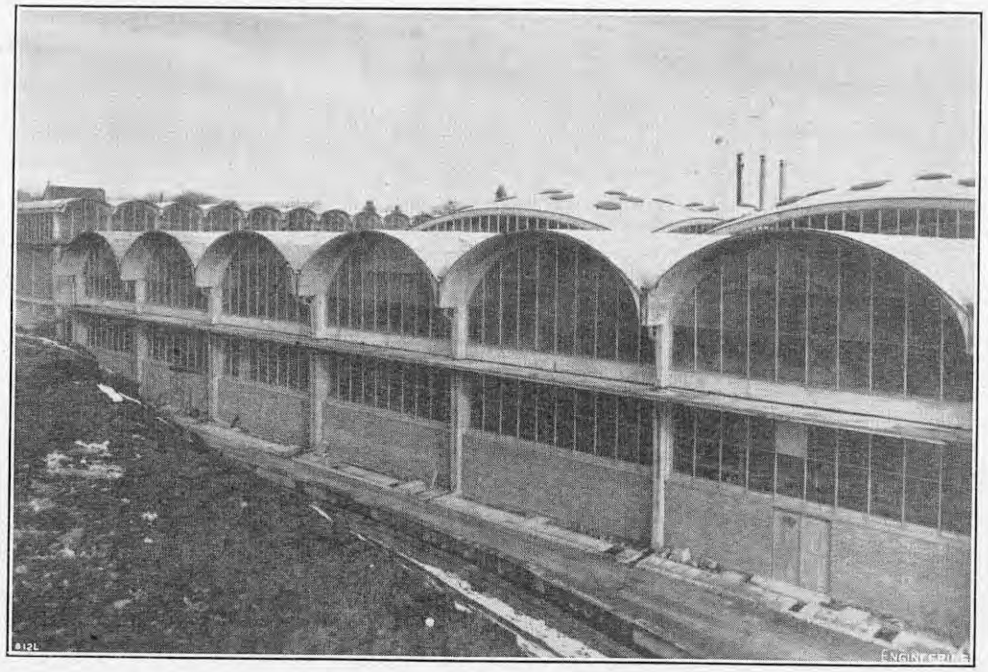


Fig. 3. Mill Room, with Production-Area Domes Beyond.

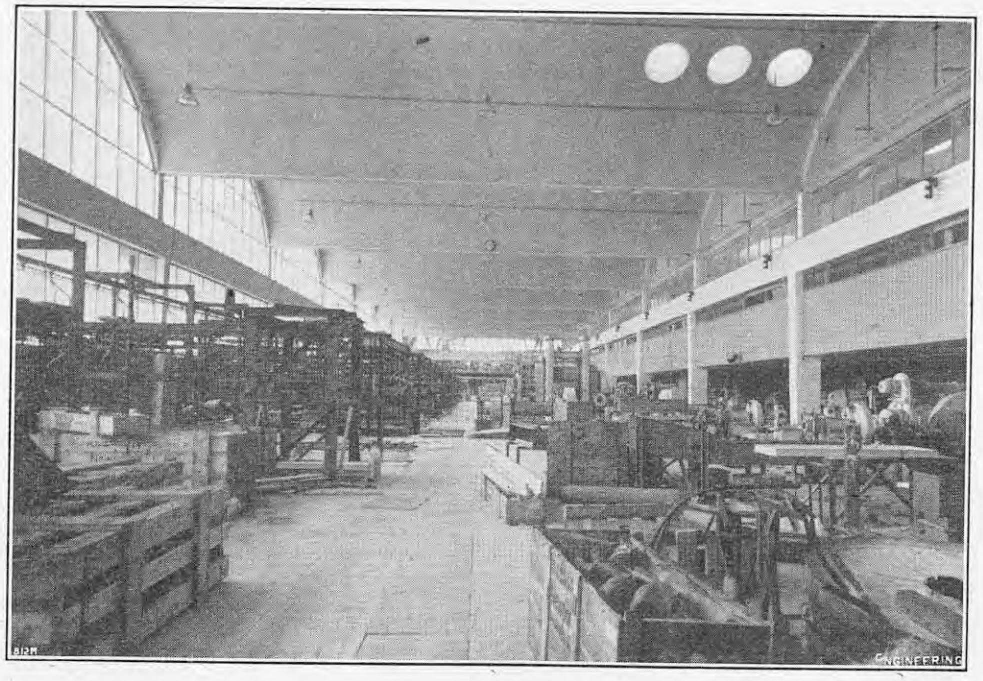


Fig. 4. Mill Room, Looking Towards "Banbury" Corner.

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ENGINEERING

FRIDAY, APRIL 4, 1952.

VOL. 173. No. 4497.

THE NAVAL ARCHITECTS' SPRING MEETING.

THERE is no annual conference in London quite like the Spring Meeting of the Institution of Naval Architects. The venue has changed more than once in the past 30 years or so, from the Royal Society of Arts to the Royal United Service Institution; on at least one occasion—we write from memory—the hall of the Institute of Marine Engineers; and, more recently the headquarters ship, the Wellington, of the Honourable Company of Master Mariners. The make-up of the programme, however, has altered little and the conduct of the proceedings hardly more, if as much. The 1952 meeting, which began on the morning of Wednesday, April 2, on board the Wellington, and concludes this afternoon, followed the familiar pattern: first, the submission of the Council's annual report, then the announcements of the Council election results—arrived at by proportional representation, the nomination of scrutineers for the following year, the presentation of awards, and the President's address. Finally comes the first paper of the three day programme. This year there was an additional item, the presentation of a gold wristwatch and a cheque to Mr. P. J. Shilham, the former assistant secretary, after 32 years' service. That was exceptional, but in all else the meeting conformed to tradition; nor were the members disappointed in their usual expectation that there would be something of note in both the President's address and the opening paper.

There have been occasions in the past, notably before 1914 and between the world wars, when the keynote of the meetings was predominantly naval; but matters naval are now mainly "on the secret list," and only two papers—those to be presented at this morning's session—are concerned with Her Majesty's ships, and only one of those with conditions on active service. At the present time, however, the problems of merchant-ship construction and operation, and especially those of liner tonnage, are sufficiently serious to warrant all the attention that they were given by Viscount Runciman in his presidential address, and by Mr. Basil Sanderson in his review of "Britain's Deep Sea Liner Trade, 1945-51." The reference by the President to the investigation, mentioned also last year, and still proceeding, into the methods of tonnage measurement, was one of the most important points, and it is to be hoped that some satisfactory basis for international discussion and eventual agreement will be found eventually, and without too much delay. The question has been discussed before, notably by Sir Murray Stephen in a presidential address to the Institution of Engineers and Shipbuilders in Scotland. The geared turbine brought it into considerable prominence, and the compact marine gas-turbine further emphasises the anomalies of the existing legislation and their adverse influence on design.

Mr. Basil Sanderson's paper, in certain respects, was a continuation of that delivered by Mr. Walter Warwick in 1944, on "Post-War Merchant Ships from the Owner's Point of View." It showed that whereas, at the outbreak of war in 1939, the total of world tonnage was slightly under 61½ millions, it had risen to nearly 75 millions at the close of 1949 and to more than 77 millions a year later, without taking into account more than estimates, known to be incomplete, for Germany, Japan and Russia. The British share in the total has undergone some significant changes, from 50·4 per cent. in 1905 to an estimated 18 per cent. in 1945, and a more certain 21·9 per cent. in 1948 and 1949, and 21·6 per cent. in 1950. The growth in total world tonnage, as Mr. Sanderson pointed out, might be supposed to indicate a corresponding expansion of world trade; but this generalisation may be misleading, even when allowance has been made for the tonnage laid up or under repair at any given period. The greater time now taken in turning ships round in port is a factor of importance; but another, of equal moment, is the rate of replacement and its influence on the age and efficiency of fleets in service. In 1939, the percentage of liners over 20 years old was 24, but it had risen to 27 per cent., in 1950, and the cost of replacement is now something like four times what it was in 1937-39.

The mention of this disparity brought Mr. Sanderson to what shipowners would probably regard as the most important topic discussed in his paper, namely, the incidence of a taxation system that was designed initially for a more or less stable economy, but which is clearly inadequate to meet a condition in which the value of money is changing as rapidly as it has done in the period covered by the paper. The technical points on which Mr. Sanderson touched—the possibility of changes in the design of ships to facilitate cargo-handling, the loss of cargo space represented by the insulation of refrigerated holds, and the increase in fuel consumption that is caused by underwater fouling—aroused evident interest among the audience and induced some useful contributions to the discussion, which we hope to report in due course; but the taxation problem, so forcibly presented in comparatively few words by a shipowner who could speak from experience, was shown in what was probably a new light to many. Mr. Sanderson's conclusion was that, "failing the introduction of some logical system of taxation which faces up to realities, the British merchant navy will dwindle steadily in size over the years until, within measurable time, it is unable to fulfil its duty towards the country."

IRON AND STEEL IN 1951.

For the iron and steel industry of Great Britain the year 1951 will stand out in memory as the year that opened with indecision about nationalisation and closed with indecision about de-nationalisation. The vesting date was February 15, 1951, but, only eight days before, the House of Commons had debated an Opposition motion of censure on the proposed nationalisation. Though the motion was defeated and, on the due date, the securities of 80 of the largest iron and steel companies were transferred to the Iron and Steel Corporation, eight months later the new Government was in power. Throughout the period the British Iron and Steel Federation appear to have retained the initiative, and, indeed, their annual report for 1951* deals not so much with the high-level discussions and negotiations which took place during the year as with the direct problems of expanding production, reducing exports to meet increased home demands, re-introducing distribution control, overcoming raw-materials difficulties, intensifying the steel-scrap drive, and generally dealing with the problems of a most complex industry. How complex probably few outside the industry appreciate, such is the impression of a simple, basic raw material created in the lay mind by the words "iron and steel."

In 1945, the Federation formulated the development plan which provided for the annual steel production to be raised from about 13 to 15½ million tons by 1950-52. More than three-quarters of the work involved is now either completed or under construction, and last year the output was again over 15½ million tons, in spite of a drastic reduction in supplies of scrap from Germany. Meanwhile, by 1948 it had become clear that the steel and steel-using industries would have to carry an even larger share of the burden of the export drive than had been expected, and the capacity target was therefore raised to 18 million tons, to be reached in 1954. The major production development last year was the official opening, in July, of the new melting shop and hot strip mill at the Abbey Works of the Steel Company of Wales, Limited. The cold reduction mill for sheets, at the Abbey Works, and the cold reduction mill for tinplate at Trostre are now having their trial runs, and when the whole plant is in full production wide-strip rolling capacity in this country will be increased by a million tons per annum. Good progress has also been made with the construction of many other plants in various parts of the country, and, as a result, it has been possible to take steps to close down less economic steel-melting plants with a total ingot capacity of 750,000 tons per annum, and the Development Committee are now considering a second development plan.

Steel production during 1951 was actually smaller than in 1950—15·64 million ingot tons, compared with 16·29 million tons—but by reducing exports from 3·25 million to 2·65 million tons, and by effecting a greater reduction in producers' stocks than had been achieved in 1950, home deliveries rose from 14·18 million tons in 1950 to 14·54 million tons in 1951. Imports remained practically constant (0·56 million tons in 1950 and 0·55 million tons in 1951); so, also, did second-hand and re-usable material (0·48 million and 0·50 million tons, respectively). The volume of outstanding orders, for both home consumption and export, increased throughout the year, largely owing to the Korean war; at the beginning of 1951 it amounted to 7·42 million tons and at the end it was 9·52 million tons. Faced with the impossible task of satisfying the needs of the home market (much of which, after manufacture, was destined for export), and of the direct export market, the Federation sought the guidance of the Government, with the result that, at home, priority was given to re-armament items distinguished by the symbol "D.O." and to selected civilian requirements with the symbol "P.T."; and, in the export market, deliveries were progressively curtailed until, at the beginning of October, the Board of Trade revoked all bulk licences for countries other than the Commonwealth and Bilateral countries, thus making any exports to these markets subject to individual licensing. Meanwhile, the Government decided it was necessary to re-introduce distribution control. The Federation favoured a simpler form of control than that in force up to May, 1950; they recommended a system based on broad allocations to direct users only, employing existing statistics, but, in the event, the Government decided to revert to the old system. It came into operation, for both carbon and alloy steel, on February 4, 1952.

The chief difficulty in importing iron ore was the severe shortage of shipping caused by the Korean war. A welcome offer of a number of American ships, to load iron ore for the United Kingdom before returning home in ballast after delivering coal at Mediterranean ports, helped to ease the situation, and, indeed, in July, the record figure of 973,000 tons of iron ore was unloaded at British ports. Steps have since been taken to safeguard the industry's long-term ore supplies by securing control of part of the shipping required. A new joint company, Ore Carriers, Limited, was formed by B.I.S.C. (Ore), Limited, and Messrs. Houlder Brothers and Company, Limited, to acquire and operate six specially-constructed ore-carrying ships, which are to be delivered in 1953-4. A second scheme, resulting from an offer of early shipbuilding berths, was an agreement between B.I.S.C. (Ore), Limited, and the Denholm/Lithgow syndicate, under which the latter are to build two specialised ore carriers on their own account. B.I.S.C. (Ore), Limited, have undertaken to provide continuous employment for these two ships for 15 years from the date of delivery. To ensure future sources of iron ore, various schemes have been promoted and agreements reached at several places overseas. The Federation therefore expect the record 1951 figure of 8·6 million tons of imported iron ore to be exceeded this year. At home, too, the production of ironstone is expanding.

The scrap drive, which has been the subject of much publicity since it was started in January, 1951, produced additional supplies during the year, estimated at 325,000 tons. Though steelmakers themselves achieved more than their expected increase, the home-bought contribution was disappointing, in spite of the great efforts made by the industry.

In times of steel shortage, the Federation have the unenviable task of co-operating in the economical use of steel. Various measures recommended by the Government's steel economy committee, on which the Federation are represented, have come into operation, particularly in building and civil and constructional engineering, where higher working stresses have been adopted and the use of welding has been extended. The details of a scheme for co-ordinating the whole range of existing British Standard, Service and other specifications, are being examined, and work is proceeding on a steel designers' handbook—a comprehensive reference work on advanced methods of design.

The British Iron and Steel Federation are certainly alive to their responsibilities and opportunities. When users of steel, large and small, have occasion to deplore the obstacles to obtaining their requirements, they may derive some comfort from the reflection that the Federation have to plan to meet the needs of all users, several years hence, under conditions that few would attempt to prophecy and with capital equipment that involves millions of pounds and takes years to design and build.

* *Annual Report*, 1951. British Iron and Steel Federation, Steel House, Tothill-street, London, S.W.1.

NOTES.

The Institution of Naval Architects.

As noted on the previous page, the 1952 spring meeting of the Institution of Naval Architects opened on the morning of Wednesday, April 2, the President (Viscount Runciman of Doxford) taking the chair. The meeting is being held once again on board the Wellington, headquarters ship of the Honourable Company of Master Mariners, by permission of the Master and Wardens of that Company. The annual report for 1951, which was presented and adopted, showed that the membership had increased during the year from 3,436 to 3,512, though the number in the grade of Member fell slightly, from 1,241 to 1,238. The biggest increase was in the grade of Associate-Member, from 1,134 at the end of 1950 to 1,217 in 1951. The election of members of Council resulted in the election as vice-presidents of Sir Wilfrid Ayre, Mr. V. G. Shepheard, C.B., R.C.N.C., and Sir A. Murray Stephen, M.C.; and as members of Council, of Mr. A. Aikman, O.B.E., Dr. J. F. Allan, Mr. John Baird, Mr. George Barrie, Mr. R. W. L. Gawn, O.B.E., R.C.N.C., Vice-Admiral (E) The Hon. Sir Denis Maxwell, K.C.B., C.B.E., Mr. J. A. Milne, C.B.E., Mr. A. R. Mitchell, M.B.E., M.C., Mr. D. E. J. Offord, R.C.N.C., Mr. H. B. Robin Rowell, C.B.E., A.F.C., Mr. H. E. Steel, and Mr. James Turnbull, O.B.E. The three Associates who were elected to the Council were Mr. Alexander Belch, C.B.E., Vice-Admiral Earl Mountbatten of Burma, K.G., P.C., D.S.O., and Captain F. G. Spriddell, C.B.E. The scrutineers nominated for the ensuing year were, for the Council, Dr. J. F. Allan and Dr. S. Livingston Smith and, for the members, Mr. H. A. Lyndsay and Mr. F. McAlister. Instructor Rear-Admiral Sir Arthur E. Hall, K.B.E., C.B., was re-elected treasurer. The Institution Gold Medal was awarded to Mr. Mark L. Ireland, Mr. H. W. Semar and Mr. N. L. Mochel for their joint paper on "Higher Steam Conditions for Ships' Machinery," presented to the International Conference of Naval Architects and Marine Engineers; and Institution Premiums were awarded to Professor C. W. Prohaska, for his paper on "Influence of Ship Form on Transverse Stability," and to Mr. John C. Niedermair for his paper on "Ship Motions," both of which papers were also presented at the International Conference. The Samuel Baxter Prize for 1951 was awarded to Mr. H. E. Skinner, O.B.E., R.C.N.C., for his paper on "The Safety of Small Ships." The Duke of Northumberland Prize was awarded to Mr. T. N. Stephens, of the Royal Technical College, Glasgow, and a special prize to Mr. R. S. Young, of Birkenhead Technical College. It was announced by the President in the course of his address that the Council proposed the election as an honorary member of the distinguished Italian naval constructor, General G. Rota, and that the diploma of honorary membership would be presented to him in Rome during the Autumn Meeting, which it was being arranged to hold in Italy towards the end of September.

The Institution of Mechanical Engineers.

Sir David Pye, C.B., F.R.S., was inducted into the presidential chair by the retiring President, Mr. A. C. Hartley, C.B.E., at the annual general meeting of the Institution of Mechanical Engineers on Friday, March 28. The names of the elected members of Council are as follows: vice-presidents, Mr. A. Roebuck and Mr. A. H. Lloyd, M.B.E.; members of Council, Dr. H. Roxbee Cox, Mr. G. Nelson Haden, O.B.E., B.Sc., Mr. A. T. Holman, O.B.E., Sir Ewart Smith, M.A., Mr. G. Varley, M.Sc., Air Marshal C. W. Weedon, C.B., C.B.E., and Mr. A. D. S. Carter (associate member of the Institution). The past-presidents serving on the Council are Mr. A. C. Hartley, Dr. S. F. Dorey, C.B.E., F.R.S., Dr. H. J. Gough, C.B., M.B.E., F.R.S., and Captain (E) William Gregson, R.N.R., M.Sc.; and the chairmen of the Automobile Division (Mr. C. B. Dicksee) and local branches also serve. Prior to the induction of the new President, the meeting discussed and then adopted the Council's annual report for 1951. Two days before, on Wednesday, March 26, Mr. and Mrs. Hartley attended the coming-of-age dinner and dance of the Southern Branch of the

Institution at the Polygon Hotel, Southampton. The branch was founded in 1931, and of the members of the original committee only one—Wing-Commander T. R. Cave-Browne-Cave, C.B.E.—was able to be present at the dinner. The toast of "The Institution of Mechanical Engineers" was proposed by Councillor Mrs. M. Cutler (Mayor of Southampton) and acknowledged by Mr. Hartley, who referred to a proposal to form a new branch to cover Oxfordshire, Bedfordshire, Cambridgeshire, Norwich and East Anglia. Mr. J. H. Jellett (chairman of the Southern Association, Institution of Civil Engineers), proposed the toast of the branch. Referring to the distinction between civil and mechanical engineering, he said that 50 years ago it might have been said that mechanical engineering dealt with dynamics and machines, and civil engineering with statics and structures, but he was not so sure that that was true to-day. What of "the aerodynamic stability of suspension bridges"? Wing-Commander Cave-Browne-Cave, replying to this toast, recalled the early days of the branch. The toast of "The Ladies" was proposed by Professor E. J. Richards and acknowledged by Mrs. Hartley.

The "Super-Priority" Scheme.

At a Press conference held on Wednesday, March 28, the Deputy Secretary of the Ministry of Supply, Mr. F. C. Musgrave, C.B., said that the Government had decided that super-priority should be given to the production—including equipment and ammunition—of the Hawker Hunter and Vickers-Armstrongs Swift single-seat fighter aircraft, the all-weather two-seat fighter aircraft which has still to be selected by the Royal Air Force from the de Havilland 110 and Gloster GA5 prototypes; the English Electric Canberra tactical bomber and reconnaissance aircraft, the Vickers-Armstrongs Valiant heavy bomber, and the Fairey Gannet general reconnaissance and anti-submarine aircraft; ammunition for aircraft; equipment for the radar chain; the Centurion tank; guided weapons; and certain items of the anti-mine programme. The Minister of Supply, Mr. Duncan Sandys, was notifying the main contractors concerned of the contracts to which super-priority applied. Where it was necessary to ensure prompt delivery of materials and components for these contracts, the contractors were to quote to sub-contractors the contract number preceded by the words "Super-Priority," enclosing a copy of the Minister's letter. The same procedure was to be adopted by sub-contractors to ensure prompt deliveries. Within the next two years, there would be a considerable extension of sub-contracting. The scheme was intended to be voluntary, and, provided that it was not abused, its effect on production for the export trade should not be serious. To guard against abuse of the scheme, contractors were being asked to keep a list of the firms that they had authorised to use the super-priority symbol. The principal trade associations concerned were being informed of the implications of the scheme, and local labour exchanges were to help in contracting labour for super-priority work. The immediate need was to get production under way, and the principal requirement, particularly in the aircraft industry, was for more skilled workers; in the modern fighter aeroplane, there was involved about eight times the amount of machining necessary on a fighter of the Second World War. About 75,000 additional workers would be required in the aircraft industry by early 1955, when aircraft production was expected to reach its peak; the electronics programme still required some 1,500 technicians and 10,000 workers, and 5,000 more workers were required for tank production. Arrangements had been made by the Ministry of Housing and Local Government for houses to be built in "super-priority" localities where recruitment of personnel was held up.

"Brabazon I" and "Princess" Aircraft.

The report of the Comptroller and Auditor General, in the Civil Appropriation Accounts (Class IX, Supply, Food and Miscellaneous Services) for 1950-51, published by H.M. Stationery Office, contains a summary of expenditure on the Bristol Brabazon I air liner and the three Saunders-Roe Princess flying boats. When two Brabazon prototypes were ordered in 1944, for experimental purposes, it was expected that eventually there would be orders for about 12 aircraft from the operators. No orders had been received when the specification of the second prototype was altered in 1945 to provide for propeller turbines instead of piston engines. By the end of 1950, the British Overseas Airways Corporation had decided that no production orders would be placed, but it was decided that the second prototype should be completed at an estimated further cost of 2,000,000*l*. In May, 1951, the Ministry of Supply told the Public Accounts Committee that valuable knowledge of the aerodynamic behaviour of large aircraft was being gained by regular experimental flights on the Brabazon I aircraft. The second prototype, with propeller turbines, would not be fully tested until 1954. If the tests were satisfactory, the Ministry thought that the Brabazon might yet be a successful operational aircraft on the Atlantic or Empire routes. By March 31, 1951, expenditure on the main contract for the Brabazon I and II prototype aircraft, excluding engines, amounted to 4,157,506*l*. The total cost of the project, including the runway and assembly building at Filton, originally estimated at 8,000,000*l*., is now expected to exceed 14,000,000*l*. Three Saunders-Roe Princess flying boats, to be fitted with propeller turbines, intended for operational use by the British Overseas Airways Corporation, were ordered in May, 1946; the Ministry of Supply tentatively estimated the cost, including engines, at 2,800,000*l*. By the end of 1947, the estimated cost had risen to 4,500,000*l*., because the engines originally selected were not available and the airframe design had, consequently, to be modified. British Overseas Airways Corporation lost interest in the project, but British South American Airways Corporation reported favourably on the possibility of operating eight Princesses, and the Government decided that their construction should continue. British Overseas Airways Corporation, with whom the British South American Airways Corporation had become merged, agreed, in October, 1949, to purchase from the Ministry of Civil Aviation the three airframes under construction at 700,000*l*. each, and to hire engines from the Ministry. In June, 1950, the Ministry of Supply estimated the cost of the three aircraft at 10,800,000*l*., of which 4,200,000*l*. was mainly for the development and manufacture of the engines and propellers. In March, 1951, the House of Commons was informed that it had been decided that British Overseas Airways Corporation would not use the flying boats and that the three Princesses should be completed for use by the Royal Air Force. In December, 1951, the Air Ministry withdrew their request that the aircraft should be completed. The Minister of Supply made a statement on the position of the Brabazon and Princess aircraft in the House of Commons on Monday, March 17. It had been intended, he said, that the Bristol Brabazon II and the three Princess aircraft should be fitted in the first instance with Bristol Proteus II propeller-turbine engines. However, as the work proceeded, it became evident that great economy would be achieved by waiting for the production of the more powerful Proteus III engines, which were not yet available. It had, therefore, been decided to postpone, for the time being, work on the second Brabazon and the second and third Princesses. In the meantime, the first Princess flying boat, now nearing completion, would be fitted with Proteus II engines, so that experimental test flights could proceed. There was no intention of abandoning these important development projects, on which much money had already been spent.

The Passenger and Cargo Liner "Kenya Castle."

The s.s. Kenya Castle, of the Union Castle Line, left London on Monday, March 31, on her maiden voyage round Africa. She is the fifth passenger and cargo vessel to be added to the company's fleet since the war, and, according to Mr. F. H. Keenlyside, of the Union Castle Line, she has been designed for the "new poor." An inspection, however leaves the impression that she will be equally attractive to the "new rich." She is the second of three similar vessels to be provided for this service, the first, s.s. Rhodesia Castle, having been completed in November, 1951; the third will probably sail later this year. The Kenya Castle is a twin-screw turbine steamer of about 17,000 tons gross, and was built at Belfast by Messrs. Harland and Wolff, Limited. She has an overall length of 576 ft., a moulded breadth of 74 ft., and a moulded depth of 35 ft. 6 in. There are four complete steel decks and a lower deck forward and aft of the machinery space, as well as promenade and boat decks. The hull is divided into ten watertight compartments; and there are two cargo holds forward and three aft of the machinery space, with corresponding accommodation between decks to the underside of the upper deck. One-class accommodation is provided for 530 passengers, and the public rooms include a dining saloon with seating for 280 passengers, a lounge, smoke rooms and library. There are also extensive open and covered promenade spaces and a swimming bath. The propelling machinery consists of Parsons-type triple-expansion turbines, which operate twin screws through double-reduction gearing. The ahead turbines are of the all-reaction type, but the high-pressure and low-pressure astern turbines, which are incorporated in the intermediate and low-pressure ahead turbine castings, respectively, are of the impulse type. Steam is supplied at a pressure of 450 lb. per square inch and a temperature of 750 deg. F. from oil-fired water-tube boilers made by Messrs. Babcock and Wilcox, Limited. There is a comprehensive installation of radio, radar, direction-finding and echo-sounding equipment.

Electrical Development in Uganda.

The fourth annual report of the Uganda Electricity Board, for the year ended December 31, 1951, records that satisfactory progress was made with the Owen Falls hydro-electric scheme, in spite of some delays due to the abnormal rainfall. The cofferdam for the power house, to protect the first four sets, was completed and de-watered in March, and that for the other six sets was finished before the end of the year. Concreting of the power station was started in May and that of the main dam in September. As a result of investigation, it was decided that the river banks could be treated as natural earth dams and that extensive cut-offs would not be required, thereby effecting considerable savings in both cost and time. A financial estimate for the period 1948 to 1956 provides for the installation of six 15-MW sets. Concurrently with this large hydro-electric development, the Board have been engaged upon the completion of a second thermal station at Jinja, and by the end of the year eight of a total of eleven 940-kW sets had been placed in commission. The electricity generated increased from 16,454,623 kWh in 1950 to 28,552,900 kWh in 1951. The plant installation kept pace with the demand and at the end of the year there was an approximate surplus of 25 per cent. It is hoped that this will be adequate to meet requirements until the Owen Falls scheme, comes into commission. That considerable generating capacity will be needed is shown by the fact that a number of capital development schemes costing 225,512*l*., have been approved and that the connection of a number of large power consumers may be expected.

Survey of Sulphur Position.

As is now generally known, there is a world shortage of sulphur, an important industrial raw material, as, directly or indirectly, it is needed in the rayon, rubber, dyestuffs and wood-pulp industries, and also in agriculture. It is pointed out in "A Survey of the Sulphur and Sulphuric Acid Position," by Mr. R. Ashton, Mr. A. L. Thorogood, and Mr. D. Neville-Jones (issued by the Intelligence Division of the Department of Scientific and Industrial Research, and published, price 1*s*. 6*d*., by H.M. Stationery Office) that the United States is the chief source of crude sulphur. That country exported some 900,000 tons of this material in 1951 and about 50 per cent. of this quantity came to the United Kingdom. Natural sulphur occurs also in Italy and other countries, but not in any great amount. Other sources of sulphur include pyrites, mainly iron disulphide, containing up to 50 per cent. of sulphur and from which sulphur dioxide is recovered by roasting for the production of sulphuric acid. Pyrites are imported into this country mainly from Spain and Cyprus, but large deposits exist also in Portugal, Canada and the United States, although, in the last two countries, they have not yet been developed on a large scale. In Great Britain, the only important mineral available for the manufacture of sulphuric acid is anhydrite or calcium sulphate. Very extensive deposits of this material exist at Billingham-on-Tees and in Cumberland and Furness. In the production of sulphuric acid from anhydrite, a Portland-cement clinker is produced as a by-product and only an adequate market for the cement makes the process an economic possibility. The present capacity of the sulphuric-acid plant at Billingham is 100,000 tons of acid per annum, and this is to be extended by 73,500 tons. Recently, a new company, the United Sulphuric Acid Corporation, has been formed by 11 British firms, and it is planned to erect a plant, probably on Merseyside, for the production of 150,000 tons of sulphuric acid per annum from anhydrite. It will be some years, however, before this plant will come into operation. The flue gases of power stations constitute an important potential source of sulphur. It is estimated that some 300,000 to 400,000 tons of sulphur a year are burned with the 30 million tons of coal consumed by power stations in the United Kingdom. Hitherto, it has proved too costly to recover this, but the Fuel Research Station have erected a pilot plant for the removal of the sulphur by washing.

CLOSING OF THE KINGSWAY TRAMCAR SUBWAY.

Owing to the replacement of tramcars by 'buses on certain routes in London, the Kingsway subway will be closed to traffic on the night of Saturday/Sunday, April 5/6. This link between the northern and southern tramway systems has had a not uneventful history. It was first opened between Theobald's-road, in the north, and Aldwych, in the south, on February 24, 1906, there being an intermediate station at Holborn; and was extended to the Victoria Embankment on April 10, 1908. At the northern end, the entrance was by an open incline, 170 ft. long and 20 ft. wide, which fell on a gradient of 1 in 10. This led to twin cast-iron tunnels, 14 ft. 5 in. in diameter and 255 ft. long, which carried the tracks under two pipe subways and a branch of the Fleet sewer beneath Holborn. The subway then rose on a gradient of 1 in 10 to Holborn station, after which the tracks were laid in a single 20-ft. wide tunnel of rectangular section with a roof of steel troughing, just below the level of the street, to Aldwych station, a distance of 1,800 ft. The line next turned westward and dipped on a gradient of 1 in 20 to pass under the Strand. The roof of this section, which was 440 ft. long, consisted of brick arches, followed by a single cast-iron tube, 250 ft. long, which curved under Wellington-street and ended at the first of the brick piers of the viaduct leading to Waterloo Bridge. The final section of the work involved the underpinning of 360 ft. of this viaduct, which consisted of 16 arches carried on brick piers built on timber frames resting on soft ground and mud. Openings were made in the viaduct to accommodate a single tunnel, 20 ft. wide, from which access was given to the Victoria Embankment through a 22 ft. 6 in. diameter archway. This part of the work involved careful planning and execution to prevent failure of the piers of the bridge. The usefulness of the original subway was impaired by the fact that it could only accommodate single-deck cars. Nevertheless, it was not enlarged for 21 years, an operation which was then carried out in the short time of 11 months, the new subway being opened for traffic on January 15, 1931. The necessary extra headroom was obtained by raising the roof of the tunnel on a short section at the northern end and by lowering the rail level elsewhere. The two cast-iron tubes and brick arches north of Holborn were replaced by concrete side walls with a steel roof after the Fleet sewer had been diverted into the Kingsway sewer. The lower segments of the twin tubes under the Strand were removed in short lengths and replaced by concrete walls, the upper segments being temporarily supported on timbers. When the new Waterloo Bridge was built the extreme southern end of the subway was aligned to bring the portal immediately beneath the bridge.

OBITUARY.

THE RT. HON. SIR ANDREW DUNCAN, G.B.E.

WE regret to record the death of Sir Andrew Duncan, which occurred in London on Sunday, March 30, in his 68th year. Sir Andrew was well known both in electricity supply and iron and steel circles as an able administrator-industrialist; while the same qualities, which had led to his success in private enterprise, also served him well as President of the Board of Trade and Minister of Supply during the 1939-45 war.

Andrew Rae Duncan was born at Irvine, Ayrshire, in 1884 and was educated at Irvine Academy and Glasgow University. While he was a schoolmaster he studied law and became a partner in a Glasgow firm of solicitors, who specialised in industrial work. During the 1914-18 war he served as secretary to the Merchant Shipbuilding Advisory Committee to the Shipping Controller (Lord Maclay) and as joint secretary to the Admiralty Shipbuilding Council. In both these posts he was able to exercise his talents as a conciliator, and the same qualities

THE LATE SIR ANDREW DUNCAN.

were brought into play in 1919 when he was appointed Coal Controller and undertook tne task of supervising the transfer of the mines from public control back to private ownership. In 1920, he was called to the Bar and during the next few years served as chairman of the Advisory Committee of the Coal Mines Department and on various other commissions and committees, including the Royal Commissions on National Health Insurance and the coal industry of Nova Scotia.

In 1926, he was appointed the first chairman of the Central Electricity Board, a body which had been given powers under the Electricity (Supply) Act of that year to erect a network of high voltage transmission lines throughout the country, and to operate the generating stations which they connected on a national basis. The provisions of the Act were far from palatable to certain sections of the electricity supply industry, but, although the Board possessed compulsory powers, the new chairman and the general manager (the late Sir Archibald Page) wisely decided that this weapon should only be used as a last resort. That this policy was correct is shown by the fact that, within the short space of five years, it was possible to erect 4,430 miles of transmission line, 3,039 miles of which were for operation at 132 kV; and to inaugurate a scheme of generation which enabled the plant available to be utilised at the highest efficiency and considerably reduced the amount of spare equipment it was necessary to install. The value of the grid was also amply demonstrated during the war.

In 1934, Duncan became independent chairman of the Executive Committee of the British Iron and Steel Federation, but remained a member of the Central Electricity Board until 1940. In this position his main duty was to co-ordinate conflicting interests, a task which he performed with ability until 1939, when the Federation was merged in the Ministry of Supply as the Iron and Steel Control. In 1940, he was appointed President of the Board of Trade in the Chamberlain Government and was elected as a National Government Member for the City of London. Later in the same year he was transferred to the Ministry of Supply, but returned to the Board of Trade in 1941 and again to the Ministry of Supply in 1942, where he remained until the end of the war. He retained his seat in Parliament until 1950, and, having resumed the chairmanship of the British Iron and Steel Federation, played an active part in opposing the nationalisation of the iron and steel industry and in advocating that the great steel firms should maintain their identities.

Duncan received the honour of knighthood in 1921 and was appointed a Knight Grand Cross of the Order of the British Empire in 1938, becoming a Privy Councillor two years later. He was the recipient of honorary degrees from Glasgow and Dalhousie (Canada) Universities and was elected an honorary member of the Institution of Electrical Engineers in 1941. He was also an honorary member of the American Iron and Steel Institute and an honorary Fellow of the Society of Engineers. He had been a director of the Bank of England and of a number of industrial concerns, including the North British Locomotive Company.

LETTER TO THE EDITOR.

THE COLLECTION OF A REPRESENTATIVE FLUE-DUST SAMPLE.

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with interest the article by Messrs. Fitton and Sayles with reference to flue-dust sampling published in your issues of February 22 and 29, on pages 239 and 261. While I think the work will provide valuable information on this relatively unexplored subject, it is a pity that the studies have led the investigators to believe that a throat or nozzle is superior to a plane disc or rectangular baffle. The outstanding advantage of this type of baffle is that it can be incorporated in a butterfly mounting so that it can be turned out of the way when not actually required during a sampling test, and thus imposes no permanent restriction on the system. While few power-plant systems can tolerate a permanent restraint, the objections to a slight increase in P.D. for short periods are much less severe. Further, the disc or plate baffle gives a zone of mixing independent of the position of the sampling point relative to the axis of the duct, and this zone does not have to be determined by pre-calibration.

It is observed that Messrs. Fitton and Sayles have tested a centrally-placed baffle and have recorded a sampled concentration lower than the mean. I think that this may be due to the fact that their test sampling duct is horizontal, which is not to be recommended. This is borne out by the fact that their recommended mixing nozzle still gives very variable concentrations across the duct at the recommended plane of sampling, ranging from 31 per cent. to 190 per cent. of the mean, in spite of the fact that it has fortuitously given a value of 105 per cent. at the centre point. Surely the only safe result would be that in which the concentration over the whole of the cross-section, at the preferred sampling plane, is reasonably uniform, as given by the half-area disc (see ENGINEERING, vol. 152, page 141 (1941)).

Yours faithfully,
C. J. STAIRMAND.

Imperial Chemical Industries, Ltd.,
Billingham, Co. Durham.
March 25, 1952.

REINFORCED-CONCRETE BUILDING FOR RUBBER AND PLASTICS FACTORY.

(*For Description, see Page* 437.)

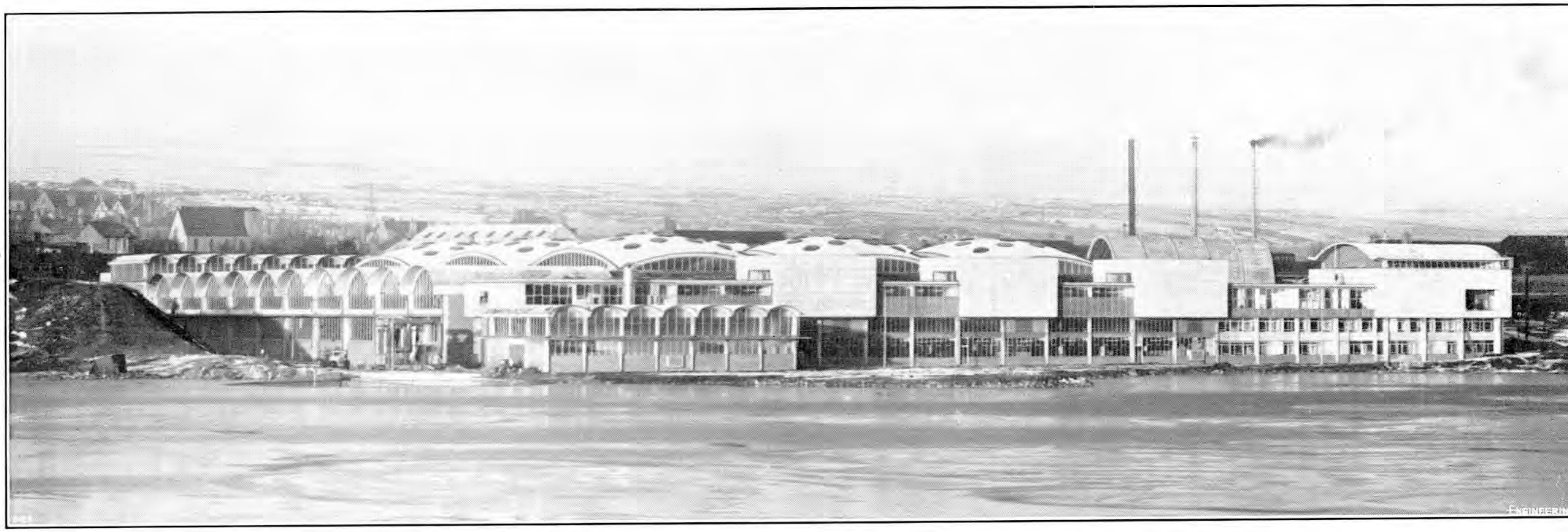


Fig. 5. View from the South-West across the Frozen Reservoir.

Fig. 6. Domed Roof of Main Production Area.

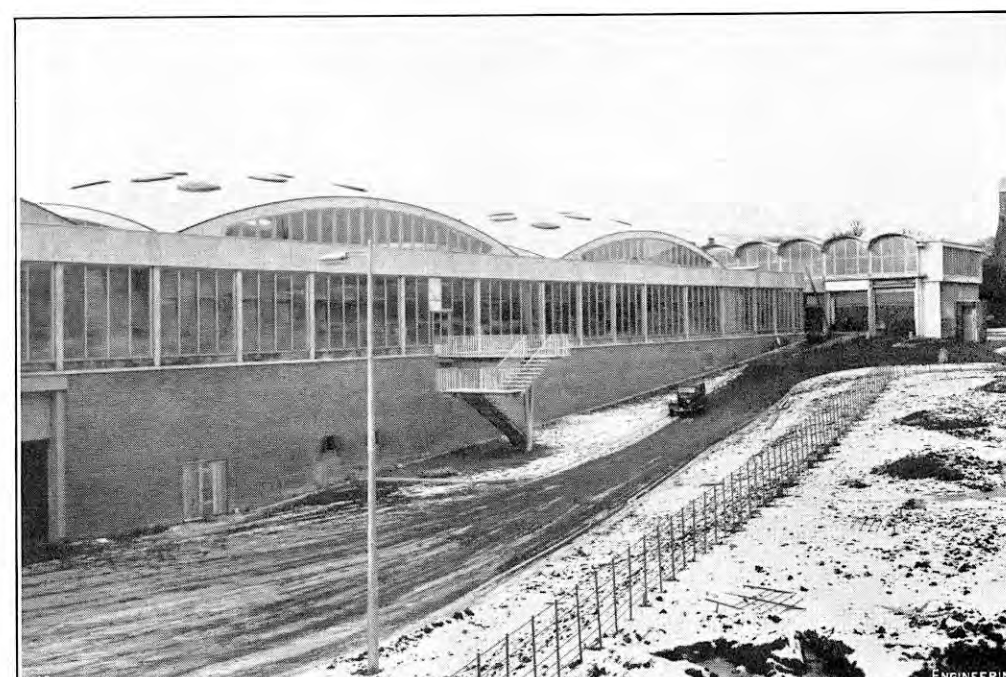
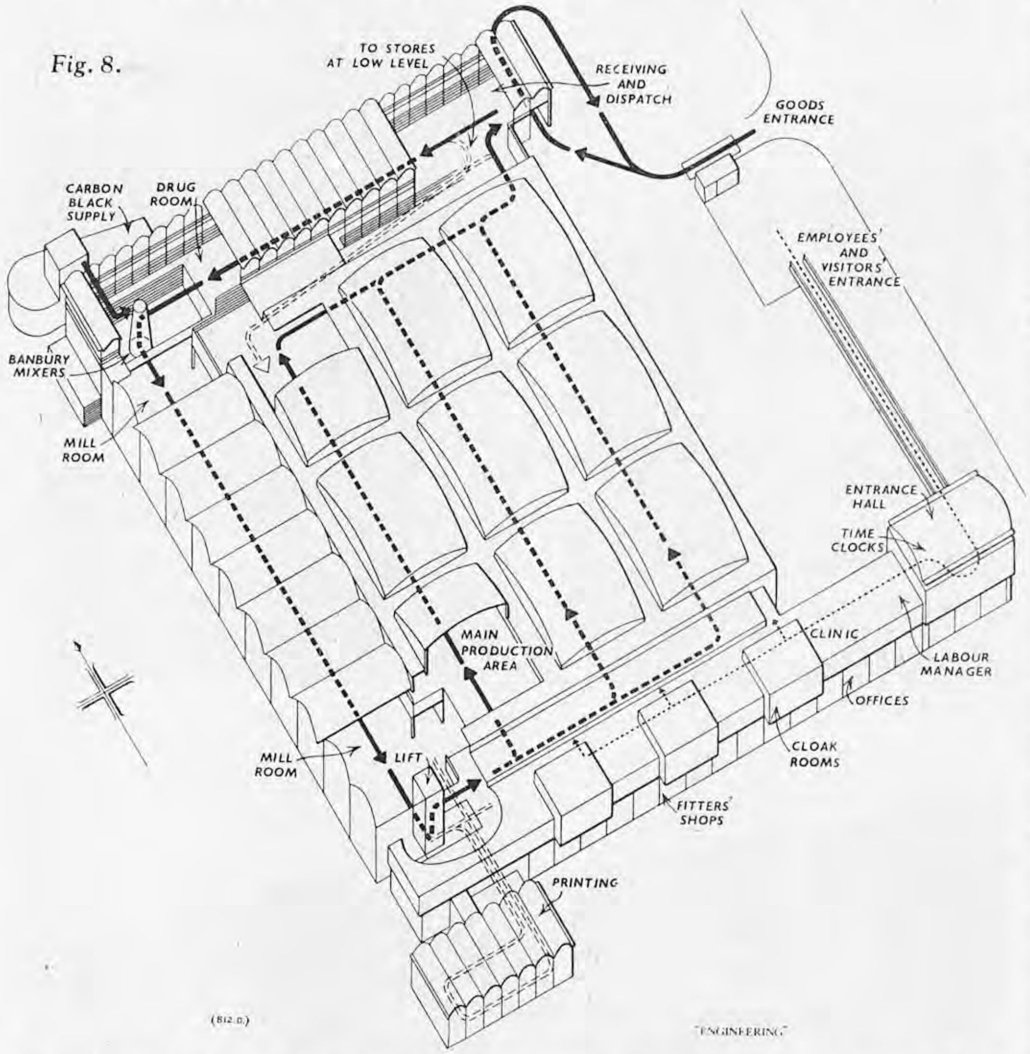


Fig. 7. East Elevation of Main Production Area.

RUBBER AND PLASTICS FACTORY.

Fig. 8.



RUBBER AND PLASTICS FACTORY IN REINFORCED CONCRETE.

FROM an engineering point of view, the design of the new factory of Brynmawr Rubber, Limited, at Brynmawr, South Wales, is significant for two reasons; firstly, because of the use of reinforced concrete, particularly in the form of domes and barrel vaulting for roofs, and flat slabs for floors; and, secondly, because of the factory layout, which not only accords with modern practice in matching the production flow but also makes good use of the natural slope of the site. The factory is illustrated in Figs. 1 to 4, on page 432, Figs. 5 to 7, on Plate XIX, and Figs. 8 to 12 on this and the following pages.

Fig. 8, on this page, which is an isometric view of the main building, shows the route followed by raw materials of manufacture, from the receiving bay at the north-east corner through the drug and mill rooms (where they are prepared and stored in a semi-processed state), to the main production area where finished articles are made, and thence back to the loading bay for dispatch. In the drug and mill rooms the accommodation is planned specifically for the plant involved, since the processing up to this stage is unchanged whatever the end products of the factory, but the main production area is treated simply as a large clear floor space, with the minimum of obstruction, so that the plant can be changed or re-arranged to suit market demands. The basement is used for stores.

The building is supported on concrete piles, cast *in situ*, and columns on these piles carry the roof. The factory has been built for Wales and Monmouthshire Industrial Estates, Limited, who have leased it to Brynmawr Rubber, Limited, a subsidiary of Enfield Cables, Limited. The consulting engineers for the reinforced concrete and other structural work were Messrs. Ove Arup and Partners, 8, Fitzroy-street, London, W.1, and the architects were the Architects' Co-operative Partnership, 34, Gordon-street, London, W.C.1. To enable an early start to be made on the construction, the scheme was divided into six contracts. The foundation work was carried out by the Cementation Company, Limited, Doncaster; from there up to the flat-slab mushroom column tops below the main production area the contractors were Messrs. Holland & Hannen and Cubitts, Limited, 1, Queen Anne's-gate, London, S.W.1, who were also responsible for the boiler house and the subway connecting it to the main building. All remaining work was done by the principal contractors, Messrs. Gee, Walker and Slater, 100, Park-lane, London, W.1.

The factory has been designed to house a large general rubber and plastics manufacturing business in which rubber and rubber latex, with various plastics, powders, oils and dyestuffs, are the chief raw materials used. Finished products will include moulded goods, sheet rubber, plastic products, insulating tape and latex-dipped and foamed-latex articles. It was planned for Brynmawr Rubber, Limited, but it is to the foresight and initiative of the parent company, Enfield Cables, Limited, that the factory owes its origin. About 1,000 men and women will be employed. One factor leading to the selection of the site of the new factory was the abundant water supply from a disused reservoir, the 18-acre Waen Pond, which forms part of the 37-acre site. The site is on the southern edge of Brynmawr, a town with a population of about 6,000 on the borders of Breconshire and Monmouthshire. It lies at the head of one of the seven South Wales valleys, with easy communication east and west as well as to the south. The north-south Brynmawr to Newport road on which the factory depends for the transport of all the raw materials and finished goods—of everything, in fact, except coal—actually bisects the site. To the north the land is bounded by the steeply-embanked railway which crosses over the highway at this point. Below part of the site, galleries still remain from the Nineteenth Century mine workings, and precautions were therefore necessary against subsidence. To fill the voids 500 tons of cement in the form of grout were pumped into the old workings.

LAYOUT OF THE FACTORY.

The whole main building, a general view of which is given in Fig. 5, Plate XIX, covers a rectangular area about 325 ft. by 450 ft. About half of this (77,000 sq. ft.) is taken up by the main production area, which to the north is flanked by the drug room, to the west by the mill room and to the south by a block containing the entrance hall, administration offices, welfare department, cloakrooms and lavatories, etc. Over the whole area there is a considerable slope from north to south and to a lesser extent from east to west. The main factory building, which occupies the lower part of the site, west of the road, stands rather below the highway level. The boiler house, an entirely separate building, is on the opposite side of the road and at a higher level. This siting places the factory alongside the water of the old reservoir and the boiler house next to the railway on which it depends for coal. By the arrangement of the various departments at different floor levels the slope of the site has been overcome and turned, so far as possible, to the advantage of the production flow.

From the production point of view, the factory is divided roughly into two principal sections, as already noted: the drug and mill rooms area, where the raw materials are prepared and stored in a semi-processed state, and the main production area, where finished articles are made. Reserves of raw materials and finished goods are kept in the large storage space below the production floor, which also houses the sprinkler pumps and pressure tanks, the sub-station and transformer rooms, garaging, charging and batteries, and other general equipment. The plant used in production is light and liable to be changed frequently, and for reasons of flexibility the services for machines are suspended from the ceiling of this basement store. They can be brought up at almost any point through 7-in. square holes cast 6 ft. $4\frac{1}{2}$ in. apart in both directions over the whole floor slab. Cast-iron covers set flush with the floor fit into the holes that are not in use. The entrance hall, cloakrooms and lavatories, which are contained in the south block, are all level with the main production floor. A mezzanine immediately below, with extensions along the west and north sides of the storage area, holds most of the heating and ventilating plant. Below this and on the lowest level are offices, engineer's stores and accommodation for fitters.

Incoming raw materials (other than carbon black, which is dealt with separately) enter the building at the loading bay at the east end of the drug room, and either go to the storage area below the production floor or pass by way of the drug room and mill room through the various preparatory processes to the main production area. Between the preparatory and finishing stages some material is treated in the printing and spreading department situated at the south-west corner, a section with a heavy fire risk, which is therefore isolated. All the products finally arrive in the finished state at the inspection-room end of the main production area, and from there go either to the store below or straight to the loading bay for dispatch. Carbon black, a material liable to spread its blackening influence everywhere unless strictly controlled, is kept in a small store at the north-west corner, separated from the main building by a covered lorry way. From there the black is introduced into the manufacturing process by a closed mechanical conveyor at the point where it is needed. All raw materials arrive and all finished goods leave the site by a single traffic entrance. Personnel enter and leave by another entrance, and both are arranged so that they can be supervised and controlled from the same vantage point.

The most interesting structural feature is the thin shell concrete roofing, particularly that to the main production area. The nine rectangular domes over this section are thought to be a new type of dome and are certainly larger than anything of their kind constructed before. With shell concrete roofing, there are few projections or ledges to harbour dust which must be avoided in the rubber industry. Flat-slab construction, used to form the floor of the production area, is specially suitable for this purpose, and the absence of beams considerably simplifies the conveying of services and ventilation ducts below. As the basement is chiefly for storage, the relatively close spacing of mushroom-headed columns is no disadvantage. In all the working areas heating is by warmed air and ventilation is mechanical; in the south block, the heating is by hot-water radiant floor panels and the ventilation is natural.

THE MAIN BUILDING.

The whole structure rests on piled foundations driven through strata of variable soils to a bearing mainly of sandstone. The piles, which are 15 in. and 19 in. in diameter, with a working load of 40 tons and 60 tons, respectively, are cast *in situ*. Generally, lengths of up to 25 ft. were necessary, but in some places less was sufficient. Mushroom-headed columns supporting the flat slab floor of the production area each stand on a single pile, but all the more heavily loaded supports, including those to the domed roofs, are carried on groups of piles. The flat slab, a 7½-in. thick floor increasing to 11 in. at the drop panels, is designed for a general superimposed loading of 240 lb. per square foot and axle loads of 5 tons on mobile cranes. The columns are spaced regularly 19 ft. 1½ in. between centres in both directions.

The domes over the main production area are illustrated in Figs. 6 and 7, Plate XIX. Each of the nine domes covers a rectangular area of about 82 ft. by 63 ft. and rises about 8 ft. from springing to crown. These thin slabs, which for the most part are only 3 in. thick, are generated by a vertical circle 82 ft. 9 in. in diameter moving on a circle 108 ft. in diameter. The domes are designed to carry a superimposed loading of 15 lb. per square foot, and, except for some tension across the corners, the stresses are entirely compressive. Two layers of hard-drawn steel wire, of 6-in. mesh and about 3 lb. weight per square yard, were used for the main reinforcement, with supplementary ½-in. mild-steel bars placed across the corners. Each dome is supported along its four edges by a reinforced-concrete bowstring truss with the top boom following the thin shell dome curvature and the bottom boom the horizontal. Both booms are nominally 9 in. thick and are connected to each other at regular intervals by 4-in. by 2-in. reinforced-concrete hanger members, pre-cast and built in. The open spandrel formed by these girders is glazed and provides the main source of natural light to the interior. This clerestory lighting, supplemented by 6-ft. circular glass domes in the shell roofing, gives a minimum daylight factor at working level of 5 per cent. Where the longer and shorter span girders meet at the corners the main reinforcement from each extends into the other to form a continuous tie all round. Except for an area at the intersections where four domes meet, the flat walk-way slabs in the valleys between the domes are cast integral with the lower boom of the bowstring truss. Here the construction is considered to be sufficiently flexible in itself to accommodate thermal and other movement; the amount involved, which in any case is only slight, is taken up by relative movement between the top and bottom booms of the girders.

At the intersections where the top and bottom booms join and trusses of opposite spans meet, however, structural stiffness increases, and to avoid restriction of movement at that point, independent cruciform-shaped areas of walk-way are introduced. These free areas of roofing extend about 10 ft. along the dome sides in all four directions. They are separated from the lower boom by expansion jointing and from the rest of the walk-way by rebated jointing. Support is afforded by the rebated bearing at the end edges and also by the horned extensions projecting from the bowstring girders, the bearing here being a sliding one. At each dome corner the roof structure receives support from a column of rectangular cross-section set to an inclination of about 15 deg. from the vertical, placed immediately below the 82-ft. major span girder and constructed to the same width. Pairs of inclined columns supporting adjoining domes converge towards floor level, as shown in Fig. 9, on this page, and below are carried on a T-sectioned support of 7 ft. flange-width and 9-in. thickness with a 12-in. by 18-in. rib. The inclination of the columns was adopted primarily to reduce obstruction of the working floor, and the direction of the slope was chosen to suit the directional flow in production.

The formwork for these large curved concrete surfaces was made of aluminium-alloy and steel scaffold tubes and steel decking plates. The nine domes were constructed with only three sets of scaffolding and two sets of plates. The steel tubes, curved to the required radius and supported on diagonally-braced verticals, were used to form main trusses at approximately 6-ft. centres parallel to the short span. On these were laid the aluminium tubes in pairs, 4 in. apart and 2 ft. from centre to centre of pairs. The decking plates, which were mainly 2 ft. square, were placed on these tubes and clamped to them with ordinary scaffold clips to prevent uplift by wind during construction. The structure so formed was supported throughout on steel jack shores to allow for final adjustment of curvature and to simplify the striking. Concreting was carried out in the following order: bottom booms of the trusses and the adjacent portions of the walk-way slab; top booms and the first 10 ft. of the dome; then the remainder of the dome, which was normally completed in one operation. These last two operations, both of them involving the dome, were always carried out in two whole working days. The concrete for the domes was made with rapid-hardening Portland cement and the formwork struck ten days after placing. Concreting of the first dome began on April 7, 1949, and by early August the ninth had been completed.

DRUG ROOM AND MILL ROOM ROOFS.

The roofs to the drug and mill room sections, which are illustrated in Figs. 1, 2, 3 and 4, on page 432, are of long-spanning thin-shell concrete barrel vaulting, three-centred in both cases. In the first, a series of 26 vaults, each with a chord width of 12 ft. 9 in. makes up the total length, and spans the

REINFORCED-CONCRETE FACTORY BUILDING.

FIG. 9. PAIRS OF RAKING COLUMNS SUPPORTING ADJOINING DOMES.

FIG. 10. ESCAPE STAIRWAY OF REINFORCED CONCRETE.

REINFORCED-CONCRETE FACTORY BUILDING.

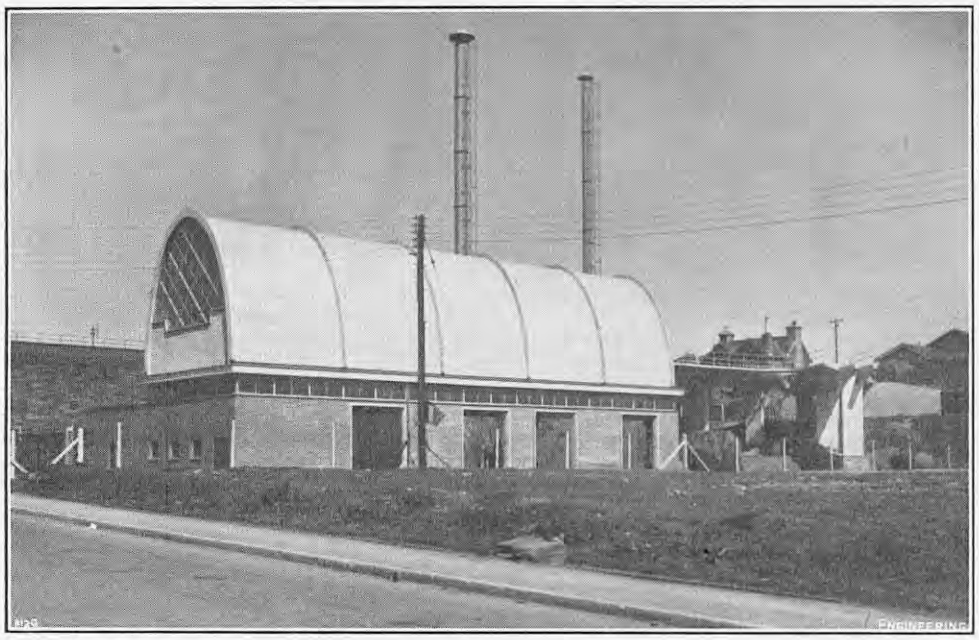


Fig. 11. Boiler House.

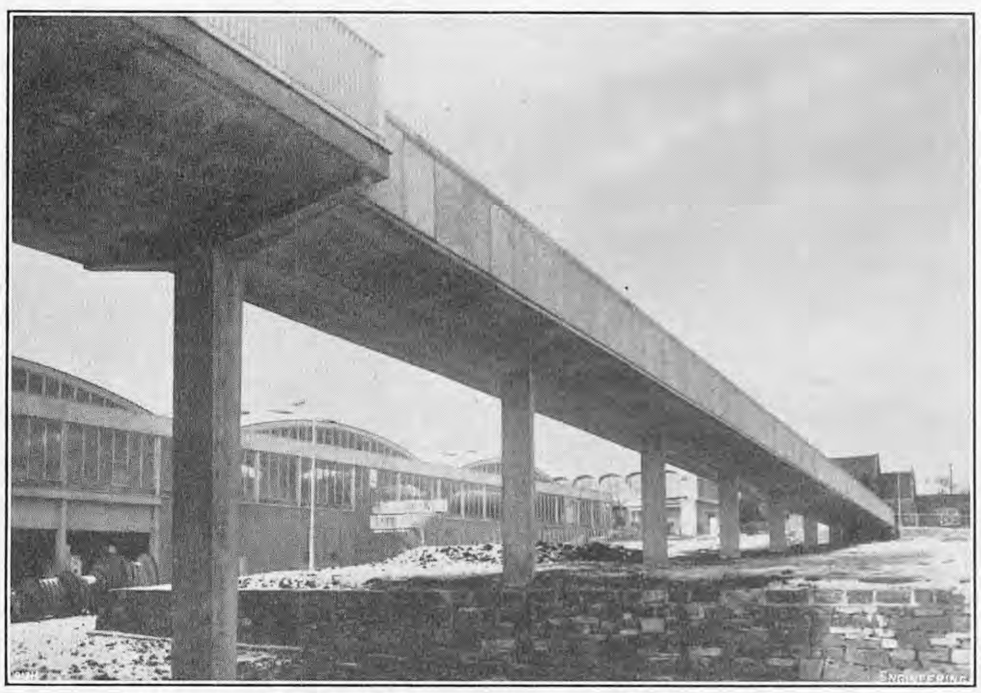


Fig. 12. Entrance Ramp.

44 ft. 7½ in. width transversely. In the mill room, ten vaults each of 30-ft. chord width make up the length and, in this case, span the 63 ft. 9 in. width. Arch ribs projecting downwards from the curved under surfaces and springing from the supporting columns give the necessary gable stiffness. In the drug-room section the thin curved shell cantilevers 2 ft. 6 in. beyond these ribs at each end, and in the mill-room section 4 ft. 6 in. beyond, but at only one end. Up to the level of the longitudinal beams, which in the drug room carry the rails of a 5-ton travelling crane, the rectangular columns support the beams and the loads transmitted by the crane together with those of the roof. The columns on the north side, which are designed to take eccentric loading from the crane and the wind, are larger than those opposite and taper from the base upwards. Above crane rail level the construction lightens considerably. Here the columns are circular with a diameter of 8 in. on the south side; those on the north side, that take the wind load, are 12 in. by 8 in. in section and elliptical in section. Horizontal thrust from the vaults is taken at one end by a wall and at the other by a pair of larger columns, and the whole roof structure between is made flexible enough to accommodate all the temperature and shrinkage movement likely to occur. Concrete hinges formed at the crown of the ninth and 18th vaults, and designed always to be under compression, with corresponding joints for expansion in the crane-rail beams inside, divide the drug-room section into three parts. During construction, before the roof was complete and while the external end restraints to horizontal thrust were non-existent, temporary resistance had to be provided. Formwork for only four complete vaults was used for the whole of the roof, and the concreting therefore proceeded in stages. Beginning at the loading-bay end, the first, second and third vaults and half the fourth were concreted first, and after they had gained sufficient strength, temporary diagonal struts were inserted from the column heads between vaults 3 and 4 to the bases of those between vaults 4 and 5. When these were in place, the formwork to the three complete vaults was removed and re-erected for the fifth, sixth and seventh. From there on, two whole and two half vaults were concreted at each stage, and at each stage diagonal strutting was placed in the last bay. At the end, only one vault and one half remained and these were treated as a separate stage. All the concreting was carried out in 3-ft. wide strips beginning at both verges simultaneously and proceeding inwards to about mid-span.

The mill-room roof of ten vaults was constructed with two expansion joints, one between the third and fourth vaults and the other between the seventh and eighth. These joints extend into and divide the columns below into twin supports and so separate the structure into three independent sections. Here the horizontal roof thrust is shared between two columns through steel tie-rods, 1¼ in. in diameter, which are inserted from head to head of columns in the end bay of each of the three sections and are masked by the bars in the glazing.

At the " Banbury room " corner, where the roofs of the drug and mill rooms meet, the last five vaults over the drug room are carried at one end on a reinforced-concrete Warren girder, 64 ft. long, which spans across the mill room. The girder is about 13 ft. deep and 2 ft. wide, and carries not only these five vaults but, in addition, the loads from the drug-room crane rails, a walk-way and the low curved section of the roofing that links the drug and mill room areas.

South Block.

Unlike other parts of the building, the south block is mostly a three-storied beam-and-column framed structure with solid slab floors and, except for the thin shell vault to the entrance hall, flat roofed. On the top storey, cloakroom and lavatory sections alternate, the cloakroom section projecting upwards above the lavatory roofs and outwards in front of the main building face. These projecting sections have been treated as open-ended reinforced-concrete box elements, with solid side walls and floor and roof slabs, cast integral with the framing members and cantilevered forward about 6 ft. Four expansion joints, three of them coinciding with the west walls of the cloakroom sections, and the other between this portion of the building and the entrance-hall wing, separate the supporting members, where they occur, into twin columns and twin beams and divide the total length into four parts. The entrance hall, which is at the same floor level as the cloakrooms, is cantilevered out beyond the general face of the building. Its thin shell roof, of unusual design, is a single vault spanning 57 ft. between the supporting solid-wall end frames and cantilevering between 5 ft. and 6 ft. beyond them at each end. Instead of the more usual edge beam, a flat extension of the slab tilted slightly upwards from the springing resolves the conditions obtaining at the vault edge.

The chord width is 37 ft. 7 in., the radius of curvature 28 ft. 8½ in., and the total rise 7 ft. 2 in. Calculations showed that, with a roof of this form, deflection, downwards and outwards, would occur at both the long edges, while at the crown the vault would remain level from end to end of its length. On the extreme vault edge the expected maximum deflections were 1·32 in. vertically and 0·5 in. horizontally, gradually diminishing both ways towards zero at the crown and supports. In constructing the roof, this deflection was taken into account and the formwork, which was supported on adjustable steel jack shores, was carefully cambered in anticipation of the ultimate deformation. The observed deflections were in almost exact agreement with those calculated, and from the slightly cambered form in which it was cast the roof edge, on release, assumed the horizontal; a condition which was essential to permit the fixing of the standard glazing frames of the clerestory windows.

The spreading department, with its roof of seven vaults, is in most respects similar in construction to the drug room. Expansion joints, besides being used to sub-divide individual sections of the factory into several parts, are constructed between the main sections themselves so that each is structurally isolated from the other.

External Stairs and Ramp.

Two seemingly minor features, both projecting outwards from the main body of the building, are of interest: namely, the escape stairway from the production floor of the factory, and the ramp that leads up to the main entrance hall. The stairway, which is illustrated in Fig. 10, on page 438, is in the centre of the east elevation, as shown in Fig. 7, Plate XIX, and provides an emergency link between the factory floor and the forecourt below. It is a ramped concrete slab, 3 ft. wide and 8 in. thick—a reinforced ribbon bent and doubling back under itself in its rise from the ground to the level of the upper floor. At the top, where the floor and slab join, and again at the ground, there is structural fixity. At about midway in the length the structure poises on a V-shaped support, cast homogeneous with the slab itself but hinged at the toe where it is supported from the ground. The ramp, which is illustrated in Fig. 12, on page 439, is a long trough-shaped beam rising in a straight line from the ground to the floor it serves. The base of the trough forms the deck slab; in cross-section it is plain on top and tapering on the underside from a central thickening towards the two edges. The sides are the balustrade walls, which are monolithic with the base. A central row of columns supports the ramp.

BOILER HOUSE.

By comparison with the factory building, the boiler-house is quite a small structure; it is shown in Fig. 11, on page 439. It stands well away from the main factory and a little above the level of the road. It is a two-storey building connected to the main factory by a subway from below, and at the upper level to the nearby railway goods yard. An extension to an existing siding, thrust forward to link the steeply-embanked railway with the building, is carried over the intervening gap on reinforced-concrete bridging. Along this elevated track, trucks pass inside the building, there to be discharged straight into coal-storage hoppers on the upper floor. These hoppers feed directly into boilers at ground level. A semi-elliptical vault 4 in. thick, and with a minor axis of 29 ft. as base and half the major axis of 25 ft. as height, encloses the upper storey. Two end and four intermediate ribs, each 6 in. wide and projecting 10 in. outwards from the curving surface, give added stiffness. The intrados remains unbroken. Vault, floor and hopper sides are homogeneous and all structurally functional so that beams as such become superfluous. This upper structure is elevated on two rows of inset columns, recessed about 6 ft. in from the outside longitudinal faces. Walling of brick, with a continuous strip of glazing along the top, encloses the ground-level boiler-room.

CONCRETE AND FINISHES.

Most of the concrete used in the construction was a 1 : 2·4 mix (by volume) of crushed whinstone, sand from Newport Sand and Gravel Company (dredged channel sand) and ordinary Portland cement. For the thin slab vaults and roof domes the concrete was different, with mix proportions about $1 : 2\frac{1}{2} : 3\frac{1}{4}$, in this case made with uncrushed $\frac{3}{8}$-in. gravel from Herefordshire, a coarser sand from Kidderminster, and rapid-hardening Portland cement. Minimum specified strengths for the concrete were 2,000 lb. per square inch at seven days or 3,000 lb. per square inch at 28 days using ordinary Portland cement, and 3,000 lb. per square inch at 7 days using rapid-hardening Portland cement.

The domed and vaulted roofs are finished on the outside and made waterproof with a two-layer covering of bituminous felt. The felt is stuck with adhesive mastic to the concrete itself and sprinkled over on top with white marble chippings to reflect light and reduce heat absorption from the sun. The same covering is used on the flat roofs, but here a 2-in. thickness of insulating foamed concrete is laid over the structural concrete before the waterproofing is applied. Thermal insulation of the domes and vaulting is derived mainly from the finish to the inside: a $\frac{1}{2}$-in. thickness of sprayed asbestos. Calculated U values for these two roof treatments are respectively 0·20 and 0·35. Most of the external walling is simply panels of infilling material fitted between the structural members, but in several places, principally on the south block and in small areas elsewhere, some is of reinforced concrete. Where reinforced concrete walling occurs it is cast integral with the framing members and functions structurally.

LABOUR NOTES.

MR. R. A. BUTLER, the Chancellor of the Exchequer, and Sir Walter Monckton, the Minister of Labour and National Service, met members of the economic committee of the Trades Union Congress at the Treasury on Tuesday. The meeting lasted for about an hour and a half, during which problems arising from the country's general economic situation and the Government's Budget proposals for dealing with them were discussed. It is understood that the Chancellor emphasised that the need for restraint in the making of new wage claims remained urgent and that any advances in wage rates should be accompanied by a corresponding increase in productivity. The response of the committee is believed to have been, on the whole, helpful but reserved. In its views on the Budget, published a week ago, the T.U.C. adopted a distinctly critical tone but showed an appreciation of the dangers of the situation and a willingness to accept measures to rectify it.

An official announcement issued after Tuesday's meeting, stated that the Chancellor attached great importance to the views of the T.U.C. While accepting the fact that there was room for differences of view on details, he believed that the Budget was already having a beneficial effect in the balance-of-payments crisis, and gave reasons for that opinion. He suggested that it should now be possible for the T.U.C. and the Government to examine jointly the country's future economic prospects. He reaffirmed the Government's hope that it might be possible to do this in a spirit of full co-operation between the two bodies. Both parties agreed that such meetings were valuable and that further meetings should take place from time to time.

Further criticism of the Budget by Mr. Arthur Deakin, C.H., C.B.E., general secretary of the Transport and General Workers' Union and chairman of the Trades Union Congress, is contained in the April issue of his union's journal, the *Transport and General Workers' Record*. In the course of an article entitled "The Banker's Budget," he expresses the view that the Budget means a return to the traditional method of controlling the economy of the country through a financial and monetary policy operated by the bankers. He considers that the estimate of the Chancellor of the Exchequer that the Government's cuts in subsidies will mean a rise of not more than four and a half points in the retail prices index shows great optimism. It is his opinion that the Budget will give "a savage twist to the upward spiral of wages and prices."

With an increase in the general price level, it is obvious, Mr. Deakin states, that there will be demands for increases in wages. He considers that no amount of exhortation can prevent demands being made by rank-and-file members of the unions. They will definitely require the executive councils of their unions to take whatever steps are essential to the safeguarding of their standards of living. Mr. Deakin contends that the greatest danger to the national economy arises from the increase of the bank rate to 4 per cent. and comments that dear money will inevitably lead to higher operational costs and have a serious effect on Britain's export trade.

Loyalty to the trade-union movement and its alternative, the toleration of opposition views by a minority, are discussed in an article by Mr. Tom Williamson, the general secretary of the National Union of General and Municipal Workers, in the April issue of the union's *Journal*. In a review of the parliamentary conduct of certain labour leaders, Mr. Williamson states that those involved have claimed that toleration should be exercised. Toleration, however, is no remedy for the actions of organised minority groups which reserve to themselves the right to act independently whenever it may be convenient to do so. Mr. Williamson regards disciplinary action as distasteful and suggests that it can be avoided if those who find themselves in serious conflict with party policy take the honourable way out. He adds: "Contempt for loyalty to majority decisions can have no place in our conception of democratic organisation."

Restrictive practices for political ends were condemned by Mr. Arthur Baddeley, the President of the Midland area of the National Union of Mineworkers, in an address to delegates at the annual conference of the Midland area, which took place at Stafford on Monday last. He urged all who might be inclined to advocate the taking of industrial action because the Government had passed legislation which was unpalatable to them to think again. Any such action could only lead to anarchy and chaos. It was sheer folly and madness to talk of strike action or of any kind of restrictive practices while the country was in its present economic straits.

Apprentices in the engineering and shipbuilding industries, who have been on strike in support of an application for an increase in their wages, returned to work in most instances during the past week, principally as a result of advice given by their trade-union leaders. Engineering apprentices in Manchester, where a strike had been in progress for nearly a fortnight, held a mass meeting on March 28 to discuss the situation. About a thousand young men attended. Mr. A. Jones, the district secretary for the Manchester area of the Amalgamated Engineering Union, and Mr. H. Scanlon, the union's organiser for the same area, addressed the apprentices, and advised an immediate return to work to enable negotiations for a settlement of the wage demand to be continued. The men agreed by an overwhelming majority to adopt this course and return to work on Monday last. It was decided, however, that the apprentices' strike committee should continue to function and that it should hold another meeting at an early date.

Engineering and shipbuilding apprentices involved in strike action in Edinburgh, some of whom had been absent from work since March 18, voted unanimously at a mass meeting on March 28, to return to work on Monday last. In Glasgow, a national conference of representatives of the apprentices in both industries, who had been on strike, was held on March 30, and, after much discussion, it was decided to recommend all apprentices to resume work as from last Wednesday. The resolution passed by the meeting stipulated that there should be no victimisation of the strikers and that all apprentices who took part in the dispute should be re-employed. Another resolution recommended that apprentice and youth committees should be established at factories and shipyards and that these committees should be as representative as possible of all young persons engaged in the two industries. It was agreed to communicate these decisions to apprentices' representatives in Manchester, Liverpool and Sheffield.

Advice given by the district committee for the Glasgow area of the A.E.U. no doubt contributed to the decision of the conference to return to work. The committee passed on to the apprentices an instruction from the union's national executive council that they should resume their duties immediately. The claim for an all-round increase of 20*s*. a week for young men engaged in the engineering and shipbuilding industries was presented some time ago to the Engineering and allied Employers' National Federation by the apprentices' unions, through the Confederation of Shipbuilding and Engineering Unions, and the employers' reply is expected shortly. At their Glasgow conference, the apprentices also decided that if no response to the demand was received from the Federation by April 16, or that should an award be made which was deemed "unsatisfactory," the national conference should meet again on April 20. It is estimated that, for a brief period, the number of apprentices on strike in support of the wage demand reached a total of some eighteen to twenty thousand, but the stoppage did not have union support and no official strike pay was given. Last week many lads had been returning to their employment on their own initiative. Edinburgh, Glasgow, Manchester, Liverpool and Sheffield were the principal places affected.

Wage claims were presented to the National Coal Board in October last by the National Association of Colliery Overmen, Deputies and Shotfirers, on behalf of some 33,000 colliery overmen and allied employees in British coalfields. Negotiations on the demands were commenced at a joint meeting between representatives of the N.C.B. and the union in London on November 20, but a settlement has been delayed owing to the introduction of new mining regulations, which will involve some re-grading of these employees. As some compensation for this delay, to avoid the spread of unrest, and to prevent possible stoppages of work, the Board last week made a token payment of 15*l*. to each man concerned in the claim.

This payment has been accepted by the union without prejudice to the main claim. The 15*l*. paid to the men will be deducted when a final settlement is made. It is expected that whatever amount may be awarded will be antedated by some months. The union has asked the Board to introduce full wage uniformity throughout Great Britain for this class of mining operative. In brief, the union has claimed that Grade I deputies shall be paid 2*l*. 5*s*. a shift, that Grade II deputies shall receive 2*l*. 2*s*. a shift, that certificated shotfirers shall be classed as Grade II deputies and paid as such, and that non-certificated shotfirers shall be paid 1*l*. 15*s*. a shift. A further meeting between representatives of the Board and the union took place yesterday. The union's national conference is due to open at Carlisle on April 22 and it is expected that a settlement of the men's claim will be reached before that date.

DREDGING CRAFT.

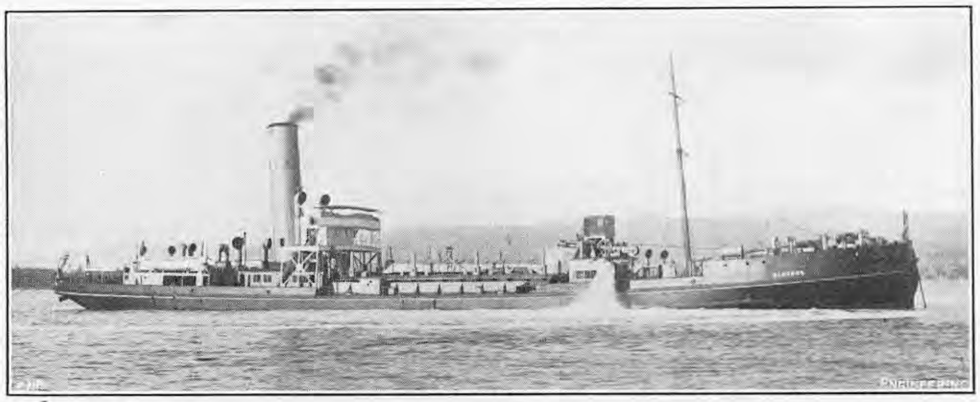


FIG. 12. BOW-WELL SUCTION HOPPER DREDGE "BLESBOK."

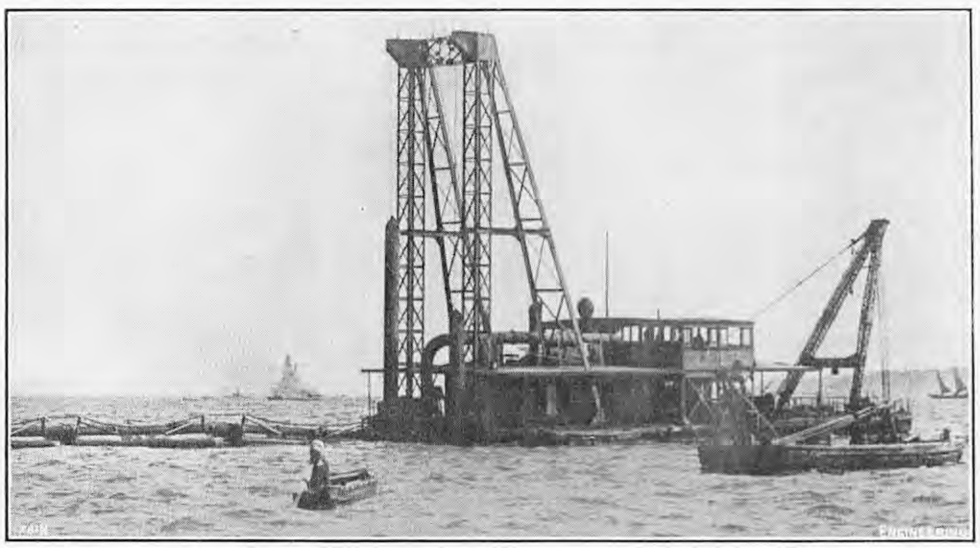


FIG. 13. 22-IN. CUTTER SUCTION DREDGE "YOKOHAMA."

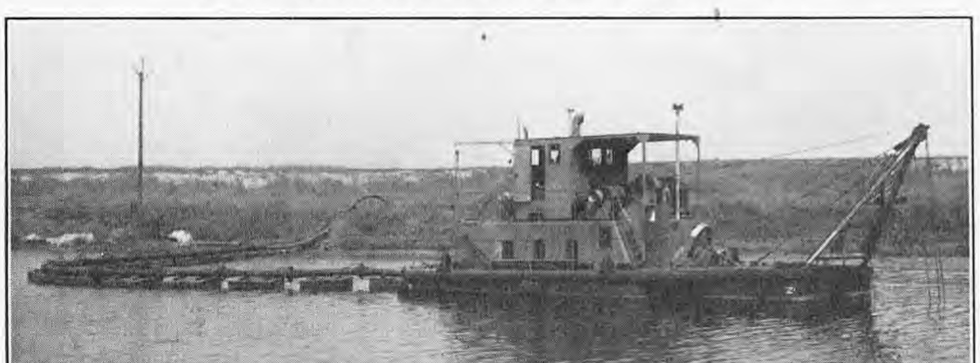


FIG. 14. 8-IN. CUTTER SUCTION DREDGE.

DREDGING CRAFT.*

By D. W. Low, O.B.E., M.I.Mech.E.

(*Concluded from page* 411.)

To conclude these observations on sea-going suction dredges, reference should be made to the type known, for lack of a better name, as a hole-digger. Several large and successful dredges of this type have been built for service in conditions where the material flows freely to the suction head and where there is a considerable depth of material to be removed. At the commencement of dredging, the suction pipe is lowered to the bottom and the process of excavating a large hole is conducted by feeding the suction pipe downward to maintain contact with the bottom. This type is, in certain respects, akin to that shown in Fig. 11, page 410, *ante*. Sea bars at the entrance to navigable waterways and composed of loose free-running sand are ideal working sites for these craft. With short hauls to deposit the spoil at sea, the ability to pump large quantities of bar sand efficiently and, in some instances, to clear a passage through a sea bar which has been closed by siltation, these vessels have proved very satisfactory. The suction pipe may be fitted in a forward or an after well-way or at the ship's side but, for work on an open sea bar or channel subject to high seas and swells, it is equipped with a special arrangement of flexible jointing, so that the effects of the ship's liveliness on the dredging performance are reduced to a minimum.

Fig. 12, herewith, shows a dredge having closed bows and a forward well-way, in which the suction pipe is accommodated with the suction head at the fore end. Between the well end and the hopper is the pump room in which two 42-in. sand pumps are fitted, mounted one at each end of the pumping engine and arranged so that, while one pump is in service, the other may be overhauled. Discharge pipes are led to the hopper and to overboard connections, and the pumping power is adequate for discharge to a distance of 2,500 ft. from the dredge. Records from this craft show that in routine service the hopper is loaded comfortably in 45 min., an output rate of 4,700 tons per hour. The main particulars of this dredge are: length between perpendiculars, 304 ft.; breadth, moulded, 54 ft.; depth, moulded, 23 ft.; hopper capacity, 2,600 cubic yards; dredging depth below waterline, 65 ft.; loaded service speed, 12 knots.

The river and harbour suction dredge is not fitted with a hopper, but is arranged to pump spoil directly from the bottom, through floating and shore pipe lines, to a deposit site. By preference, and as a general rule, these dredges are non-propelling, but instances do arise where propulsion equipment is considered necessary and can be arranged. Land reclamation is frequently effected by spoil disposal through a pipe line and, where areas are available and the spoil suitable, it is an excellent and economic system. Spoil disposal by means other than a floating and shore pipeline is sometimes required and one method, successfully applied, incorporates an overhung pipe system discharging overboard either to one or both sides. These dredges, on occasion, are required to work in rough waters, and for this condition the design of the floating pipeline and the joints merits particular attention.

The cutter-suction principle is applied in some form to all dredges of this type. The hull is invariably box-shaped, with the bows cut back in plan view, and has a well-way at the forward end in which the suction frame is partly housed. This frame, which is anchored at a pivoting point at the after end of the well-way, carries the suction pipe, the line of shafting driving the cutter, the cutter head gear, and the revolving cutter, which is located at the forward end of the suction frame, substantially overhanging the bows of the dredge. The revolving cutter has greatly widened the scope of this type to include the dredging of clay and other hard-digging materials. The cutter is usually driven independently, but in small craft a combined drive is sometimes used. Power for driving the cutter varies with the dredging duty and the size of the dredge, but American practice far outstrips British practice to the extent that, at normal rating, 1,000 h.p. is transmitted on occasion through the cutter, with allowance for momentary peak loads of 2,000 h.p. The design should correlate the cutter speed and traversing speed of the dredge and the cutting angle of the blades for efficient action and minimum wear.

For manœuvring, it is customary to fit a multi-barrel manœuvring winch. In a headline dredge, one barrel raises and lowers the suction frame, another operates the headline and four others the sidelines. In a spud dredge, five barrels are used, one for the suction frame, two to raise and lower the after spuds, and two to operate the forward sidelines. A headline dredge is suitable only for easy dredging conditions, but the introduction of spuds is essential for hard digging and high outputs. The spuds are located at the stern, one on each side of the longitudinal centre line of the dredge. The forward sidelines traverse the dredge back and forth across the cut and keep the revolving cutter into the dredging face when undercutting on the digging swing. The return swing, or overrun, is usually done at a higher speed and by skimming over the ground surface. In traversing the dredging face the cutter describes an arc about one grounded spud while the second spud remains suspended. Stepping the dredge ahead into the next cut is effected by a simple manipulation in which both spuds play a part and assistance is given by the sidelines.

There are several well-known designs of cutter suction dredge: equipped with spuds; with mooring lines only; with swinging suction frame; with multiple suction frames and forward feed; and with rotating bucket. The first type is easily the most popular. In the United States, it is used as an all-purpose dredge and the development in driving power is remarkable. Diesel-powered installations having direct drives of 1,600 to 2,000 h.p. on the sand pump are commonplace. Above these powers, Diesel-electric equipment has many operative attractions, but the capital outlay is high. In large powerful dredges, discharging through a pipeline, steam plant is popular; in two typical dredges, the sand pump, having a 34-in. suction and 28-in. discharge pipe, is driven by a turbine rated at 5,000 h.p. on nominal load and 6,250 h.p. on overload. Turbo generating plant supplies electric power for the auxiliaries. A large part of the pumping power is devoted to overcoming friction loss in the pipeline, in which velocities of 17 to 21 ft. per second are general practice. Fig. 13, herewith, shows a 22-in. cutter-suction dredge equipped with spuds and having a dredging motor of 1,000 h.p. Fig. 14 shows a small 8-in. cutter-suction dredge without spuds The rotating-bucket design is of recent date and has had, so far, limited application.

The purpose of the reclamation dredge is to pump dredged spoil from hopper barges and deliver it to a reclamation site. Where several dredges are employed in harbour work, and it is essential to carry the dredged spoil by hopper barge, which barge loads may not be deposited within a reasonable distance from the dredging site, the reclamation dredge can pump to a derelict area through a shore pipeline. Usually, two sand pumps are fitted, to operate singly or in series so that long discharge pipelines may be used. Fig. 15, on page 442, illustrates a reclamation dredge, designed for tropical service, in which two 27-in. sand pumps operate in series to deliver spoil through a pipeline 6,000 ft. in length. Usually, these craft are non-propelling, but a few special-service vessels are self-propelled, as in this instance.

* Paper entitled "Considering Dredging Craft," read before the Institution of Engineers and Shipbuilders in Scotland, in Glasgow, on March 11, 1952. Abridged.

Dredge types have altered little in 50 years, but substantial improvement in detail design of equipment, and in refinements of accommodation, ship services and control gear have occurred. Installed powers have increased, but not comparably with dredge practice in the United States. Modern dredges are definitely more efficient and their ability to withstand harsh operating conditions has improved immeasurably. Wear-resisting materials and welding have been an immense boon. A large field remains, however, for further research, both in dredging and in the propulsion of these odd-shaped craft with peculiar, but necessary, appendages to and recesses in the hull form. Although progress has been made with Diesel and Diesel-electric installations, steam plant—in particular the steam reciprocating engine—retains a firm grip. So far as the author is aware, only one geared-turbine dredge has been dispatched from this country. This prime mover, offering best results in the higher range of powers, would appear to have a future in dredge practice. Dredging is a rugged job and dredges are frequently operated by personnel unversed in the finer techniques of Diesel and Diesel-electric machinery. They can, however, maintain simple steam plant at work and therefore could be readily trained to turbine practice. This robust simplicity of steam plant is economically important.

APPENDIX.

SUMMARY OF SUCTION DREDGING RESULTS.

Dredge.	R.	A.	C.	S.
Hopper capacity, cub. yd.	1,400	1,400	470	470
Sand-pump bore, in. ..	24	24	16	16
No. of tides worked ..	146	131	108	126
No. of tides lost—for weather	17	16	47	48
No. of tides lost—for repairs	7	11	11	—
No. of tides lost—for other causes	14	27	8	4
Total hopper load for period, cub. yd. ..	169,660	1 50,380	43,430	57,150
No. of hopper loads ..	128	112	95	118
Average hopper load, cub. yd.	1,320	1,340	456	485
Total pumping time, hours	149·5	129·7	111·3	129·4
Time lost in clearing suction head, hours ..	10·8	6·7	—	—
Net pumping time, hours	138·7	123·0	—	—
Ratio: $\frac{\text{Net pumping time,}}{\text{Total pumping time}}$ per cent.	93	95	—	—
Average pumping time per load, hours ..	1·17	1·17	1·17	1·10
Average pumping rate, cub. yd. per hour ..	1,130	1,130	390	440
Average mixture pumped, per cent.	25	25	—	—
Best time to fill hopper to capacity, min. ..	45	50	50	45
Average time to empty hopper, min.	25	30	11	10

The results given in the above table were recorded under regular service conditions and extend over a period of five autumn and winter months. Note the large number of tides lost by the small vessels due to weather conditions. This reflects the ability of the large vesels equipped with cylindrical hopper valves to work in conditions unfavourable to the small vessels fitted with hopper doors. Dredging was conducted between 30 ft. and 45 ft. below water level.

DREDGING CRAFT.

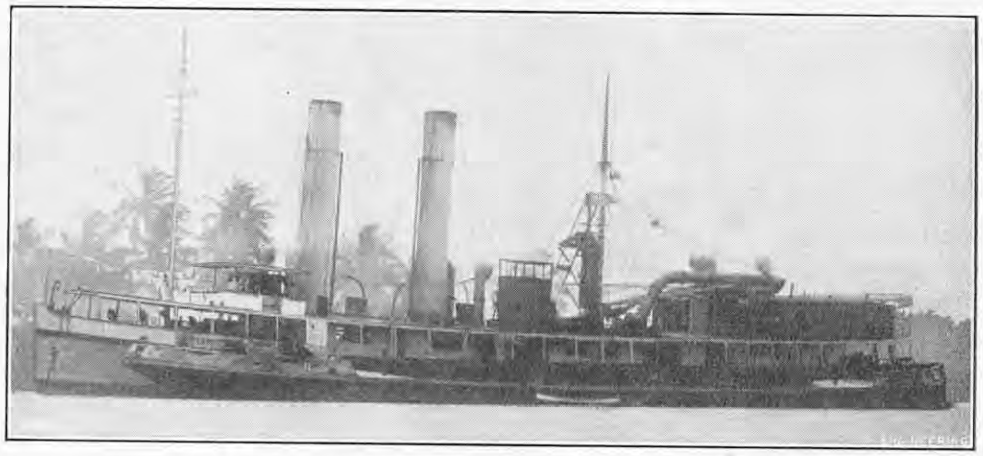


FIG. 15. RECLAMATION DREDGE "LADY THOMSON."

HIGH-SPEED SALIENT-POLE ALTERNATORS FOR WATER-POWER PLANTS.*

By E. M. JOHNSON, M.Sc. Tech., and C. P. HOLDER, B.A.

HIGH-SPEED alternators are defined as those having a normal peripheral speed of about 15,000 ft. per minute or more, with rotational speeds of 300 to 1,000 r.p.m. They are usually constructed with salient poles, which, in the larger sizes, are more than 8 ft. long, 2 ft. wide and 1 ft. deep and weigh about 3 tons. The centrifugal force on such a pole and coil at the turbine speed may exceed 3,000 tons. The design of the rotor body and the salient pole, the attachment of the latter to the body and the construction and support of the field coils constitute the major problems of this type of machine. As the rotor construction is determined by the peripheral speed at the maximum runaway speed of the turbine (and this may be 1·8 to 2·2 times the normal value), it is customary to employ factors of safety, as low as 1·5, which are based on the yield point of the material.

High-speed salient-pole alternators may have rotor bodies or magnet wheels up to 12 ft. 6 in. in diameter and 15 ft. long. A number of different designs are in common use, of which those illustrated in Fig. 1, opposite, are representative. A characteristic of all these designs is that the body is subdivided not only to ensure homogenous materials, but to make transport possible. The component parts may be of rolled, forged or cast steel. In Fig. 1 (*a*) a number of relatively thin discs are spigoted and bolted together and then pressed or shrunk on to the shaft. This is a convenient design where the rotor has not to be assembled in the factory for test or where transport facilities permit it to be shipped to the site with the discs in position. These limitations do not apply to the design shown in Fig. 1(*b*), in which the pressed-in shaft is replaced by two bolted-on stub shafts. The torque may be transmitted from the stub shafts to the discs by axial dowels and from disc to disc by radial dowels inserted at the periphery. Loose-fitting bolts are used to hold the discs and stub shafts together, so that dismantling for shipment and re-assembly on site presents no serious difficulties. If stresses permit, the centres of the discs can be cut away, as shown, to reduce the rotor weight.

Fig. 1 (*c*) shows a variant of Fig. 1 (*a*) in which air is admitted to the middle of the rotor—an advantage with long cores. The shaft is fluted and the discs are shrunk on with spaces between them. Air enters the flutes at each end of the rotor and is thrown out radially at the periphery. As an alternative to fluting the shaft, a small radial-armed spider is sometimes interposed between the shaft and the discs. This spider can either be pressed on the shaft or bolted to stub shafts at its ends. The admission of air to the middle of the rotor assists the cooling of both rotor and stator; but the amount of air that can be admitted in this way is relatively small, and where factory tests are required, the design of Fig. 1 (*c*) is open to the same objections as is that of Fig. 1 (*a*). Fig. 1 (*d*) shows a design in which the admission of air to the middle of the rotor is combined with the advantage of easy dismantling obtained with the design of Fig. 1 (*b*), and with minimum weight. Transport is not affected, because the discs are shipped separately. In all the types of rotor body described above the individual component discs are in one piece. This is advantageous for generators operating at high peripheral speeds. Provided that the rotor body can be taken to pieces for shipment, transportation difficulties are not likely to arise with diameters up to about 12 ft. 6 in. The largest high-speed alternators so far built have rotor body diameters within this limit.

Alternators of the size and type considered have relatively large radial air-gaps. Solid poles may therefore be used without causing undesirable pole-face losses. The solid pole, either cast or machined from a forging, has an advantage over the laminated pole, since it results in a more uniform distribution of centrifugal force along the length of the pole and rotor body. The intensity of such force in the case of an average laminated pole is about 60 per cent. greater at the ends than in the middle. Larger rotor diameters are therefore practicable with solid poles for the same limits of stress; and larger outputs are in consequence obtainable. Solid poles are generally more costly; they may obviate the need for a damper winding, but their principal use is to extend the permissible limits of output.

A number of different methods of attaching the poles to the periphery of the rotor body are in common use. They are all applicable to any one of the types of rotor-body construction described above. The method of attaching the poles is of great importance, since, with rotor bodies built up of solid discs, the limiting stress usually occurs in the pole fixing. The two most common methods involve the provision of suitably-shaped projections on the base of the poles, which engage with slots machined in the periphery of the rotor body. In one case the projection is of dovetail shape and is pressed with a slight interference fit into the slot; in the other case the projection is a loose fit in the slot and is secured by tapered keys driven from the ends. The latter type of construction has the advantage of facilitating the assembly and removal of the poles. The projections are conveniently in the form of T-heads, and there may be from one to four of them per pole. An alternative to dovetails or T-heads is the "comb" construction, in which projections on the underside of the pole interleave with corresponding rings formed by machining circumferential grooves in the rotor body. The centrifugal force on the pole body is taken by tightly fitting axial bolts in shear. In a recent variation of the design the interleaving takes place within the pole tip, which is made deeper than normal in order to accommodate the axial bolts. There is little to choose, on the score of strength, between the different methods of attaching the poles. From the point of view of convenience, both for the manufacturer and for the user, the advantage would however, seem to lie with T-heads and tapered keys. As regards cost, generalisations are difficult, but the concensus of opinion indicates a balance in favour of T-heads.

The field coils of large high-speed alternators are almost invariably made of copper strap, which may be as much as 4 in. wide and from 0·1 in. to 0·4 in. thick. Until recent years all field coils made of strap were wound on a former. Nowadays large coils are fabricated by some makers from straight lengths of copper without any bending, and there is also a tendency for this method of construction to be adopted for the smaller sizes of coil. The joints at the corners of the coil are usually made by punching the ends of the straight lengths to the correct shape and brazing them after assembly. Several important advantages are gained by the fabrication of field coils in this way. The first is the elimination of the tendency of the strap to thicken at the inside of the bends when wound on a frame. The use of strap having high width-thickness ratios is therefore possible, which is a valuable asset in the electromagnetic design. The provision of projecting turns, or fins, which improve heat dissipation is also facilitated. A further advantage is that hard or silver-bearing copper can be used instead of soft annealed copper.

The general tendency nowadays is to use asbestos for the interturn insulation of large field coils. This is usually applied in several thin layers which are suitably bonded together and to the copper. The coil is then electrically heated to about 150 deg. C., and, while hot, is consolidated by pressure. The thickness of the insulation between turns may be about 0·01 in. To insulate the field coil from the pole body a spool of insulation, usually mica with a cloth backing, is bonded to the inside of the coil and to insulating washers at the top and bottom. Another way is to wrap micafolium around the pole body, consolidating the layers by ironing and heating in an oven, using a shellac or similar bond. A third method is to use moulded insulation and flat insulating boards of cotton or glass fabric bonded with a synthetic resin, which are inserted between the pole body and the coil. This method is particularly suited to fabricated coils which have flat ends and square corners. Heavy washers of a similar material are usually placed between the coil and the pole tip and rotor body, respectively. To prevent the sides of the coils bulging away from the

* Paper read before the Supply Section of the Institution of Electrical Engineers on Wednesday, March 26, 1952. Abridged.

ALTERNATORS FOR WATER-POWER PLANTS.

Fig. 1. TYPES OF ROTOR BODY.

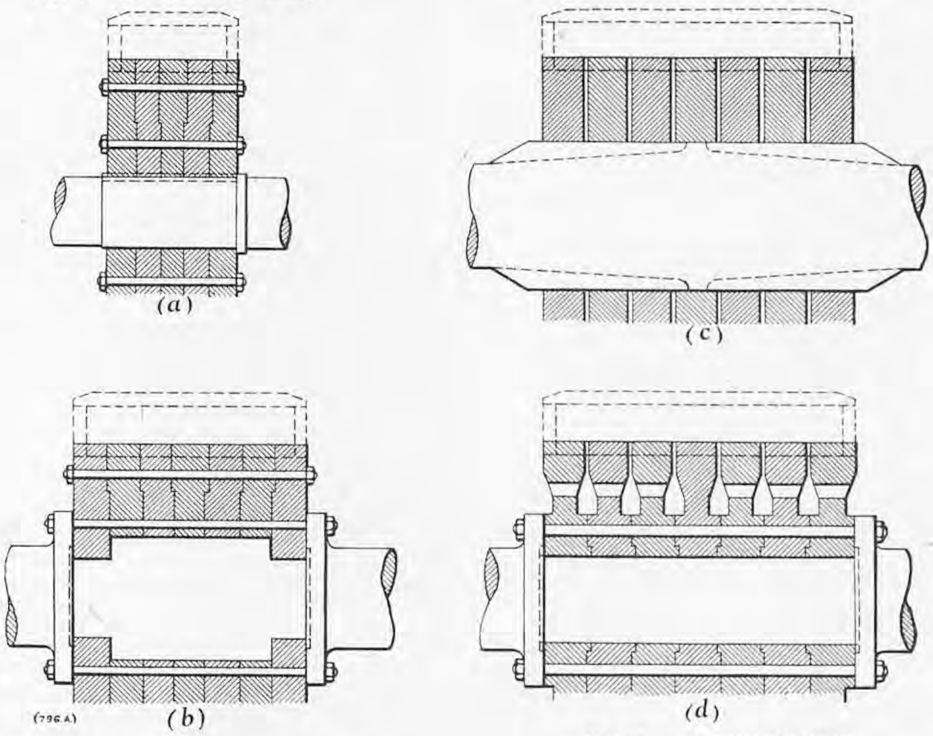


Fig. 2. TYPICAL V-CLAMPS FOR FIELD COILS.

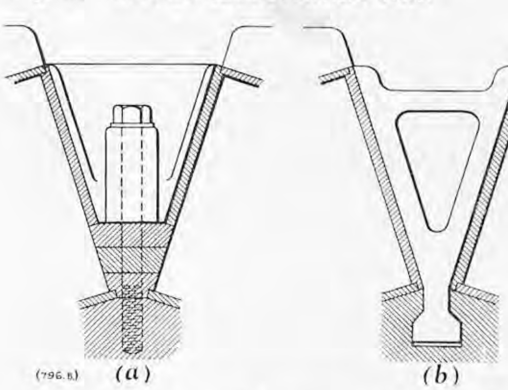
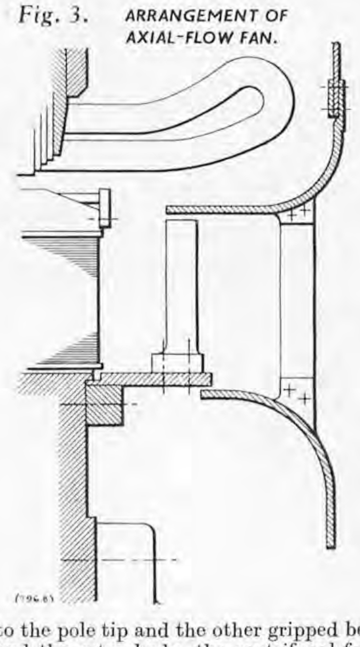


Fig. 3. ARRANGEMENT OF AXIAL-FLOW FAN.



poles, under the tangential component of the centrifugal force, V-shaped clamps located between them are usually employed. These clamps must be designed, so as to offer the minimum of obstruction to the free flow of air. With ventilation from both ends of the rotor, a single clamp at the middle of the core length offers no appreciable obstruction, since the air has no axial velocity at this point. A solid clamp such as that shown in Fig. 2 (*a*) is frequently employed in such cases. The clamp is secured by two or more bolts and is made of steel, bronze or an aluminium alloy. Where the stress in the copper is such as to necessitate more than one clamp, three are generally preferred to two, since they are then smaller and the middle one causes little obstruction. In this case the type of clamp shown in Fig. 2 (*b*) is better. It is usually of steel, either flame-cut from thick plate or cast; and the tongue fits into a slot in the periphery of the rotor body.

The limits of core length and peripheral speed beyond which field-coil clamps become necessary, can be raised in certain cases by the use of wider copper for the coils; fabrication of the field coils is then an advantage. Alternatively the coils can be so designed that the tangential component of centrifugal force is reduced to a minimum. One way of doing this is to taper the pole body, so that its sides are almost radial. Another method achieves a similar result with parallel-sided poles by so shaping the field coils that the turns in the side portions lie in tangential planes. The extra cost of these special designs of pole and field coil, merely as a means for improving ventilation by the omission of clamps, is rarely justified. In some cases, however, the avoidance of field-coil clamps has other advantages. It enables the poles to be removed with the rotor in position in the stator. In such cases, if clamps cannot be avoided altogether, either of the types shown in Fig. 2 can be arranged for manipulation from the ends of the machine. Alternatively, the clamps may be replaced by straps which can be tightened by a form of turnbuckle and have one end attached to the pole tip and the other gripped between the pole and the rotor body, the centrifugal force on the coil being resisted by the tension in the strap. This type of fixing has the advantage that it is inserted and removed with the pole, but it also has the disadvantage of being much weaker than the more usual V-type clamp, in which the load is carried chiefly in compression.

A low-resistance squirrel-cage damper winding is desirable on high-speed machines for unbalanced or rectifier loads, and to give the maximum possible pull-in torque for re-synchronising after a disturbance. It also reduces to a minimum the transient over-voltages which may occur owing to an unbalanced short-circuit and might otherwise attain dangerously high values, particularly if the alternator is connected to a long transmission line. A further advantage is the damping of small pulsations of torque originating in the regulating mechanism of the prime mover; but in many cases a damper winding consisting of copper rods in the pole-faces without a connection between poles is found to be adequate. Damper rods are usually distributed uniformly across the pole-face; but sometimes they are omitted from the pole tips, the span of the rods then covering rather less than the width of the pole body. This has the advantage of reducing stress concentrations in the pole tips; it also provides, if the rods are connected between poles, effective damping in the quadrature axis, while maintaining the direct-axis subtransient reactance and the negative-sequence reactance at higher values than are possible with a complete squirrel-cage. The ends of the damper rods are brazed to copper-ring segments, which may be spigoted or bolted, or both, to the pole end-plates. Adjacent segments are joined by bolted fish-plates to form a connection between poles. For high peripheral speeds the centrifugal force on the bolted joint is opposed by a steel tie-rod attached at its inner end to the rotor body.

The core length of a salient-pole alternator having a normal peripheral speed of 15,000 ft. per minute may measure 10 ft. or more. For such lengths an axial-flow fan mounted at each end of the rotor, and consisting of a number of spirally-shaped blades mounted on the periphery of a ring attached to the rotor body, has particular advantages. If the blades are correctly shaped, very efficient ventilation can be obtained. It is important, however, that the tips of the blades should be shrouded, and it is advantageous if a shroud is also provided at the base of the blades. The shrouds serve to guide the air into the fan in a smooth stream and to reduce to a minimum the parasitic windage losses due to the rotor body and shaft. A typical arrangement is shown in Fig. 3.

The stator frames of large high-speed alternators (usually fabricated, but sometimes cast in steel) are frequently subdivided, either to facilitate transport or to permit removal of the rotor. In the latter case, the core is correspondingly sectionalised, but where the frame is subdivided for transportation reasons only, the core may be built on site as a complete ring. Some designers consider the resulting elimination of core joints to justify the inconvenience of core building on site. Alternators so built cannot, however, be factory tested, and experience has shown that the potential difficulty of making and maintaining satisfactory core joints can be overcome if they are accurately prepared and dowelled to ensure correct assembly. In a horizontal-shaft alternator having basement air-ducts or coolers, heavy flanges on the horizontal diameter tend to restrict the free flow of ventilating air from the top half to the bottom half. The desire to avoid this restriction has led some designers to divide such machines at a vertical plane. In the authors' opinion the horizontal division is in every way to be preferred. The stator feet are usually integral with the frame, but in some designs for horizontal alternators they are separate, to allow the stator to be rotated for ease of access to the windings in the lower half, the necessary rollers being mounted on jacks. It is doubtful whether the advantage gained is sufficient to justify the considerable cost of such arrangements.

The method of construction of the stator core is generally similar to that adopted for high-speed turbo-alternators and for large low-speed water-turbine-driven alternators. The relatively big radial air-gap in large high-speed alternators enables open stator slots to be used without disadvantage. Consequently, the two-layer diamond type of winding is generally adopted, since as compared with the concentric (or chain) winding it has the merit of lower reactance, better cooling, identical interchangeable coils and not more than half the number of joints. These coils are characterised by a pitch of at least 2 ft. 6 in. and an overall length up to 12 ft. or more. Each conductor is subdivided in depth to limit eddy-current losses; but in order that the cross-section of copper may be a maximum it is desirable that subdivision of the strands in the width of the conductor should be avoided if possible. The conductor width usually exceeds 0·3 in. The insulation on the individual strands is preferably applied after the coil has been formed to shape, since otherwise the strains imposed on the insulation during the forming process may lead to a breakdown in service. The strand insulation most generally favoured for such coils is mica tape. Sometimes, however, about 5 per cent. of the available copper space is deliberately sacrificed and the conductor is subdivided in the width as well as in the depth. In such cases the width of the component strands may be less than 0·3 in. and their insulation can then consist of glass braid or asbestos serving, applied before the coils are formed; for experience has shown that with strands up to 0·3 in. wide there is little risk of these types of insulation being damaged during the forming process, if the necessary precautions are taken. The subdivision of the copper in the width makes the coil more flexible. This is an advantage from the point of view of assembly and removal, but it necessitates more rigid bracing of the end-windings.

An alternative method of facilitating the handling of large heavy-section coils is to form and insulate the two sides separately and join them at both ends after assembly in the slots; the need for flexure of the coils is eliminated by this method. In general, however, whole coils, up to the limit of size that can be formed and handled conveniently, are less costly than half coils jointed at both ends, even if the whole coil has to have the straps divided for flexibility and particularly if the coil has more than one turn.

Most large high-speed alternators in water-power stations operate at voltages between 6 and 15 kV and are solidly connected to step-up transformers. The latter serve to protect them against switching surges, and surge diverters and shunt capacitors are added, where necessary, to protect them against lightning. Consequently, the insulation levels of the stator windings need rarely be extreme. Security against breakdown, particularly under sustained peak loads, is, however, of great importance and calls for particular attention to the quality of the insulation. The insulation of a stator coil may be considered as made up of three parts: the insulation between the individual strands of the conductor, the insulation on the conductor itself and the external insulation between the coil and earth and between coil and coil. The strand insulation may consist of mica tape or, in certain circumstances, of glass braid or asbestos serving. With a properly transposed winding the voltage between adjacent strands is small and the insulation need do little more than ensure separation of the strands. Mechanical rather than electrical strength is here required, and it is for this reason that asbestos serving is usually confined to strands of smaller cross-section than is permissible with glass braid. The strands must be securely bonded together, particularly in the slot portion of the coil. With glass or asbestos insulation a phenolic-resin bond is frequently employed for the slot portion; mica tape, on the other hand, is usually bonded by impregnation under pressure with a bituminous compound, the coil having first been dried in a vacuum. If a coil has more than one turn, the turn insulation is almost invariably of mica tape, backed by glass, silk or paper. The bonding medium applied to the layers of tape may have a natural resin or a bituminous base, according to the type of main insulation which is to be employed.

The finishing of the coils usually follows the same lines whatever type of slot insulation has been employed. The ends are preferably protected by a layer of tough and flexible tape such as braided glass, and then coated or sprayed with a synthetic-resin varnish having oil-resisting properties. The slot portion, to a distance of an inch or two beyond the core at each end, is advantageously provided with a semi-conducting surface for the prevention of corona. This sometimes consists of a butt-layer of asbestos tape; alternatively the surface of the coil is given a coat of semi-conducting paint. In certain instances, specially graded coats of such paint have been extended to cover portions of the end-windings. Experience has shown, however, that with adequate spacing of the coils, and well-consolidated insulation, the use of anti-corona paint on the end-windings (introducing, as it does, an element of risk) is unjustifiable at normal voltages.

The bracing of end-windings to resist short-circuit forces becomes a matter of great importance where the forces tend to be large and the coils, because of the high peripheral speed, have a wide pitch and an extensive overhang. In the very largest machines the design of bracing tends towards steam turbo-alternator practice in the use of specially-shaped non-magnetic supporting brackets to which both layers of the end-winding are secured by insulated bolts. In the majority of cases, however, a less rigid bracing is adequate. The most common method is to brace the two layers separately by insulating blocks fitted tightly between adjacent coils on the straight and sloping portions and, if necessary, at the coil noses. The outer layer of the end-winding is firmly lashed (for example, with glass cord) to one or two non-magnetic rings supported from the core end-plates. Cross-connections and terminal leads are usually secured in bolted clamps with suitable spacing blocks of insulating material (such as Bakelised fabric) to promote ventilation, and with micanite sleeves to reinforce the insulation where it is under pressure.

Vertical-shaft alternators running at high peripheral speeds are usually provided with two guide bearings, one above and the other below the rotor. If the turbine is of the Pelton type the wheel is sometimes mounted overhung on a downward extension of the alternator shaft; but, in general, and particularly if it is of the Francis type, the turbine has its own guide bearing, making a total of three for the unit. The thrust bearing is mounted above the rotor, since if it were placed below the rotor it would not be sufficiently accessible because of the relatively small diameter of the alternator and turbine. It is often convenient to combine the thrust bearing with the upper guide bearing by forming the journal of the latter on the upper part of the thrust-bearing collar. This simplifies the lubrication and cooling of the upper guide bearing; but at speeds of 500 r.p.m. and over it may be desirable to reduce the losses in this bearing by mounting it on the alternator shaft below the thrust bearing where it can be of smaller diameter. This, however, complicates the lubrication and may increase the height of the alternator.

With the thrust bearing above the rotor, it is necessary to remove the thrust collar from the shaft before the rotor can be lifted out of the stator, and to replace it after the rotor has been put back. If the dismantling is occasioned by a breakdown, it may be of great importance to get the machine into service again with as little delay as possible. One way of easing the operation is to make the thrust collar a relatively light fit on the shaft, but this has been known to introduce troubles in service owing to fretting corrosion. On the other hand, very serious difficulty may be experienced in attempting to separate collar and shaft if the fit is too tight. A method has recently been developed whereby thrust collars having a heavy interference fit may be mounted on, and, if necessary, removed from and replaced on, a shaft in a small fraction of the time previously required, and with much less risk of damage to the surfaces in contact. The procedure is illustrated in Fig. 4, which shows a section through a typical thrust collar. The bore of the collar and the seating on the shaft have a small taper. In assembly the collar is lowered on to the seating and a moderate

Fig. 4. METHOD OF ASSEMBLING AND REMOVING THRUST COLLAR.

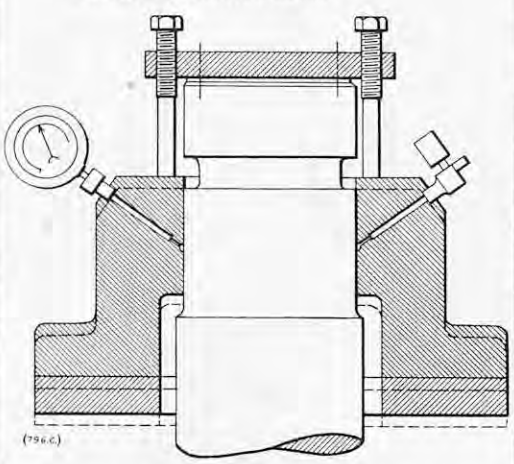
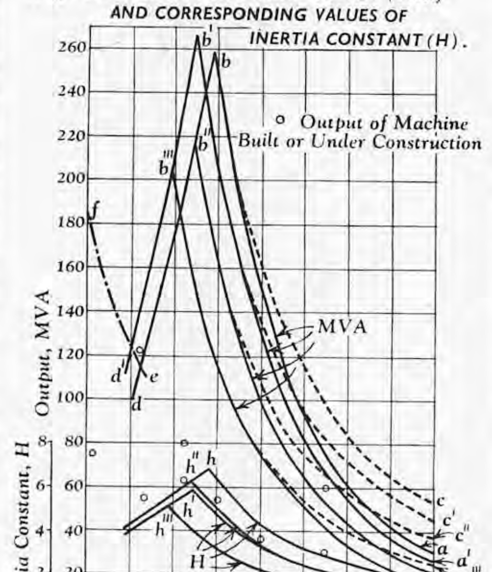


Fig. 5. MAXIMUM VALUES OF OUTPUT (MVA) AND CORRESPONDING VALUES OF INERTIA CONSTANT (H).



axial pressure is applied to it by forcing screws. Oil under pressure is then introduced into a circumferential groove in the bore of the collar. As the pressure builds up, the forcing screws are gradually tightened. The oil pressure expands the collar uniformly and enables it to mount the taper seating under the axial thrust of the screws. Removal of the collar is carried out by a similar process. Thrust collars having interference fits exceeding 0·0015 in. per inch of bore diameter have been successfully assembled and dismantled by this method. The thrust load is transmitted from the shaft to the collar by keys.

The design of vertical-type thrust and guide bearings is, in general, the same for high- as for low-speed machines. An important innovation is the use of direct water-cooling for thrust bearings of the fixed-pad type. There is also a tendency towards the use of direct water-cooling for the journal bearings of large high-speed machines. The effectiveness of this method arises from the fact that the cooling medium is in direct contact with the hottest part of the bearing, which may have a temperature of about 65 deg. C., instead of with the lubricating oil which may have a temperature of 50 deg. C. or less as it reaches the external coolers. The quantity of water required is thus considerably reduced, and a great deal of costly lubricating equipment, including pumps, motors, coolers, sump tank, valves and pipework, is eliminated.

The apparently large output of high-speed alternators recently built or under construction for water-power plants mostly fall far short of what is, in fact, attainable. If the occasion arose, some of the present maximum outputs could be exceeded several fold. This is illustrated in Fig. 5, which shows the maximum outputs that could be achieved at speeds from 300 to 1,000 r.p.m. with normal materials and with the methods of construction described in the paper. In these curves it is assumed that the runaway speed is 1·8 times normal, that the maximum core length to pole-pitch ratio is 4·5, that the power factor is 0·8, and the short-circuit ratio unity. It is also assumed that the yield point for the forged steel used for the solid poles and pole end plates is 30 tons per square inch and for the rolled steel used for the rotor-body discs 25 tons per square inch, the maximum factor of safety on yield point being 1·5. The machines of which the outputs are shown in curves a, b, d and h had solid poles and aluminium field coils; those shown in curves a', b', d' and h' had solid poles and copper field coils; those in curves a'', b'', d'' and h'' laminated poles and aluminium field coils; and those in a''', b''', d''' and h''' laminated poles and copper field coils. The curves may serve to correct the view that considerable increases in output can only be achieved by radical departures from normal design.

As will be seen, the electrical and mechanical characteristics assumed as a basis for the output curves are in no way extreme, and the qualities of steel are those normally obtainable. The curves show the effect on maximum output of using solid instead of laminated poles and the effect of using aluminium field coils. It would be permissible to continue $a\,b$, $a'b'$, $a''b''$, $a'''b'''$ beyond the points b, b', b'' and b''', respectively, if stress were the only consideration. However, this would necessitate a rotor-body diameter greater than 12 ft. 6 in., which is, in general, a limiting size both for manufacture and for transport. The curves $b\,d$ and $b'd'$ correspond to this rotor-body diameter, the output, pole pitch and peripheral speed falling with the speed of rotation until a point is reached at which the stresses permit sectionalising of the rotor. The curve $e\,f$ shows how sectionalising of the rotor enables the diameter to be increased almost indefinitely at constant peripheral speed, so that the limiting output rises as the speed of rotation is further reduced. The curves $c\,b$, $c'b'$, $c''b''$, $c'''b'''$ show to approximately what extent the output could be increased at the higher rotational speeds, if the first critical speed of the rotor were allowed to be below the runaway speed. The necessity of keeping the first critical speed above the runaway speed involves a limitation in the length of core for a given diameter and speed of rotation. The permissible core length cannot be expressed in general terms without considerable approximation, since the critical speed depends to some extent on the dimensions and bearing arrangement of the turbine. The output curves in Fig. 5 are therefore only approximate at speeds above 600 r.p.m., and slightly higher values may well be attainable.

The use of aluminium field coils produces effects in two opposite directions. The first is an advantage resulting from the fact that, at high peripheral speeds, the centrifugal force of the pole and field coil is the determining factor in the alternator design. The lower specific gravity of aluminium as compared with copper permits an increase of about 20 per cent. in the rotor diameter with laminated poles and of about 13 per cent. with solid poles. A corresponding increase in core length (limited by considerations of critical speed and ventilation) also results. On the other hand, the lower conductivity of aluminium leads to a loss of about 18 per cent. in specific output. The gain in output due to the increased diameter and length, however, more than offsets the reduction in specific output; hence, as shown in Fig. 5, the maximum outputs obtainable with copper field coils can be exceeded, for the same limits of stress, by the use of aluminium. It should be noted, however, that whenever the required output can be obtained with copper field coils they are always to be preferred to aluminium, since the specific output is greater and the machine dimensions are therefore less.

ZINC-RICH PAINTS.—The Corrosion Committee of the British Iron and Steel Research Association, 11, Park-lane, London, W.1, have issued the following statement concerning zinc-rich paints: "The use of the term 'zinc-rich paint' should be restricted to paints containing a sufficiently high percentage of zinc pigment to ensure direct electronic contact between the metallic particles in the dry paint film. There are theoretical reasons for believing that in the simplest case this will not occur unless the metallic zinc constitutes 92/95 per cent. by weight of the dried paint film—the exact value depending on the specific gravity and other properties of the vehicle."

VARIABLE-DELIVERY HYDRAULIC PUMP.

DOWTY EQUIPMENT, LIMITED, CHELTENHAM.

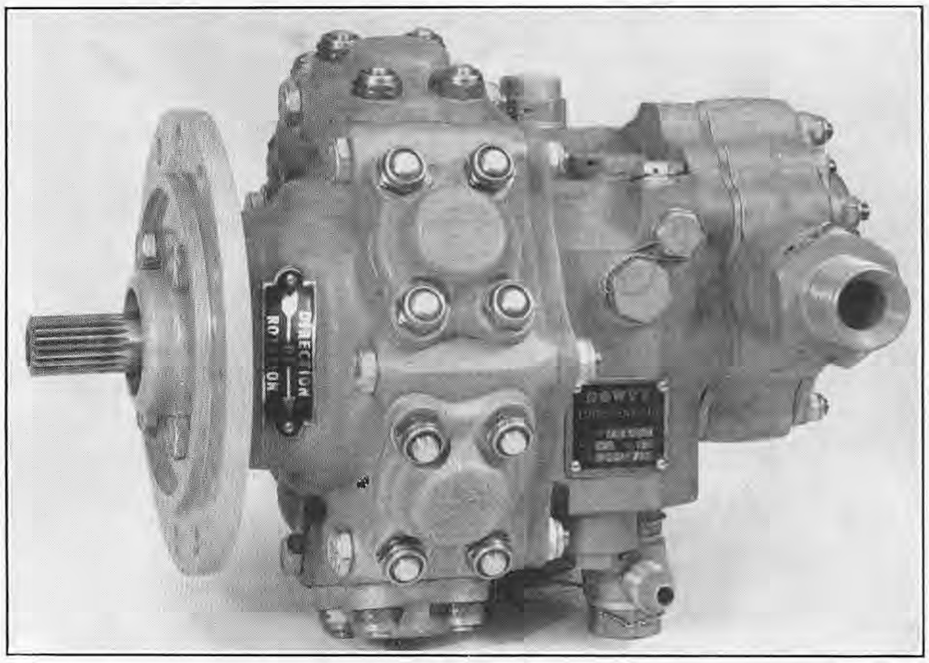
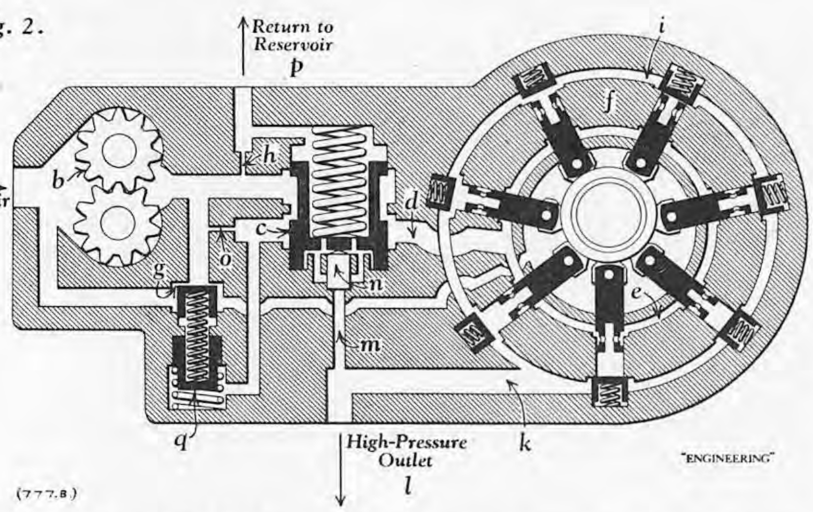


FIG. 1. "VARDEL" PUMP.

Fig. 2.



HIGH-PRESSURE HYDRAULIC PUMP WITH AUTOMATICALLY VARIABLE DELIVERY.

FOR supplying fluid under pressures up to 4,000 lb. per square inch to aircraft hydraulic circuits, Messrs. Dowty Equipment, Limited, Arle Court, Cheltenham, Gloucestershire, have developed a two-stage pump, known as the Vardel, the delivery flow of which is automatically varied to suit the demands of the system. It is designed for an output of 5 gallons per minute at a speed of 3,000 r.p.m., and has a dry weight of 13·5 lb. which, it is claimed by the manufacturers, is appreciably less than that of older types of pumping unit depending upon an automatic cut-out valve and a hydraulic accumulator for pressure regulation. Fig. 1 illustrates the Vardel pump. The first-stage pump is a conventional gear pump, the driving gear of which is coupled to an extension of the driving shaft of the second-stage pump, which is a rotary piston pump comprising seven radially-disposed cylinders and pistons actuated by an eccentric shaft. The gear-pump output is greater than the capacity of the second-stage pump, and the excess fluid is recirculated in the first-stage circuit through a pressure-relief valve. The sequence of operations, devised to regulate the output to meet varying demands, may be followed by referring to the diagram reproduced in Fig. 2.

Fluid from the hydraulic reservoir is drawn through the inlet *a* by the first-stage pump *b*, which delivers at low pressure through the port controlled by the slide valve *c* and the passage *d* to the inlet annulus *e* of the second-stage pump *f*. The excess output from the gear pump is recirculated through the pressure-relief valve *g*; in order to maintain uniform temperature and viscosity, a limited quantity of fluid is pumped through a restrictor orifice *h* to the reservoir. The second-stage pump delivers fluid at high pressure through the outlet annulus *i* and the passage *k* to the outlet *l*. The system pressure is communicated through the oilway *m* to a piston *n* which acts against the spring load on the slide valve *c*.

As the system pressure approaches the maximum value, the piston *n* overcomes the spring force and shifts the slide valve *c* to close the ports, shutting off the main fluid supply to the second-stage pump. A small flow is maintained, however, through the orifice *o*, a by-pass annulus and the passage *d*, until the maximum pressure is attained in the high-pressure circuit, by which time the piston *n* has uncovered the escape ports in the channel *m*, through which high-pressure fluid can escape by way of the spring housing and the passage *p* to the reservoir. The suction created in the inlet annulus *e*, and its communicating passage, when the second-stage pump is idling, acts on the underside of the piston *q* and thereby increases the opening of the relief-valve port *g*, so that the main volume of fluid re-circulates through the first-stage circuit at a lower pressure than the normal "on-load" setting of the relief valve.

For a given demand, the pump delivery is constant at any altitude from sea-level to 60,000 ft. Less than 1 h.p. is required to drive the pump when it is idling at 3,000 r.p.m. and 4,000 lb. per square inch. On load, the pump absorbs just under 14 h.p., and has an efficiency of over 85 per cent. The valve mechanism responds rapidly to pressure changes and, it is claimed, is free from dangerous surging. The unit is designed for easy servicing; each set of second-stage pump pistons and cylinders is accessible for replacement by removing four nuts and a cover plate, and the gear pump, in its casing, can be detached by removing seven nuts. The suction and delivery connections are at the opposite end of the unit from the mounting flange and the splined driving shaft.

Although the pump has been designed primarily for aircraft hydraulic circuits, it is suitable for other high-pressure systems where automatic pressure regulation is required, and has been used successfully for operating plastics moulding and extrusion presses and to provide controlled pressure between calender rolls used in processing paper.

POWER GENERATION BY WIND.*

By C. W. MARSHALL, B.Sc., M.I.E.E.

PARTISANS of wind-power development periodically draw attention to the vast supplies of energy which could be obtained from the winds in many parts of the world, and there are some hundreds of thousands of small windmills in service in regions where other sources of energy are difficult and expensive to obtain. Existing wind machines are small—normally less than 1 kW in capacity if used for generating electricity, and of only a few horse-power in the more usual application to pumping water. Much pioneer work has been done by U.S.S.R. engineers with machines up to 100 kW capacity. A 100-kW machine, erected at Yalta in 1931, is a classic in its way. It is manually-controlled from a small room, and must have provided much valuable information as to the local wind potential.

The largest experimental wind plant known was a 1,250-kW machine installed on Grandpa's Knob, Vermont, U.S.A., which failed due to blade fracture caused by vibration after generating 3,600 kWh in 838 hours of operation in parallel with an alternating-current power system. This experience, unfortunate as it was financially, showed that it is practicable to supplement the power of an electricity supply system by means of wind-driven generators. It also revealed that the danger of vibration of the propeller blades is the greatest hazard to such installations. Against this unfortunate occurrence there is, as an economic counterbalance, the fact that one manufacturer of small windmills in the United States sells some tens of thousands of wind machines every year.

French engineers have built highly scientific plants up to 40 kW capacity and, in spite of much early discouraging experience, continue to play a leading part in designing large aero-motors. Denmark, in 1944, used 88 wind-driven electric generators, mostly for the production of direct current. The energy generated by these machines in that year was $3{\cdot}01 \times 10^6$ kWh. The largest of the direct-current machines was rated at 30 kW, with a wind speed of 10 m. per second, or about 22 m.p.h. It had a four-blade propeller, 59 ft. in diameter. A 50-kW alternating-current generator was driven by a two-blade propeller about 58 ft. in diameter. In this case, the rated wind speed was 24 m.p.h. The Danish effort in the production of energy from wind, prompted mainly by absence of fuel during war, constitutes the finest example of its kind.

There is, in short, little experience with wind motors which would encourage anyone to invest heavily in wind-power developments, especially on large-scale plants. The large commercial sailing ship has, most regrettably, been completely superseded by engine-driven vessels, and only yachts and small craft remain to use the energy of the wind.

In spite of all such discouraging evidence, wind-power research is being fostered at high level in Great Britain. The justification for this research seems to lie primarily in the fact that, on the long-term view, it will become essential to eke out our diminishing irreplaceable fuel resources by all available means. It also seems probable that wind energy might be used particularly economically in this country because of the high average wind speeds on the west coast, and because all energy could be absorbed conveniently through the medium of the national electricity transmission system, the grid. Medium-capacity machines could also be of great value in the Western Isles.

Preliminary research into wind power and energy distribution has been carried out energetically and expeditiously by the Electrical Research Association. Adequate findings have been reached in respect of the amount of energy which may be obtained at certain particularly favourable sites. Among the sites which have been surveyed are Costa Head on the island of Orkney, and Mynydd Anelog on the Caernarvon coast. The Electrical Research Association wind surveys conducted at these sites have indicated that an annual output of 4,000 kWh of energy per kilowatt of installed power should be obtained from a scientifically designed

* Excerpt from a paper entitled "Supplementary Sources of Power: Wind, Volcanic Heat, Sun and Tide," delivered at a meeting of the Royal Society of Arts, held in London on March 19, 1952. Abridged.

and constructed wind-driven generator. The British Electricity Authority, on their side, have indicated that energy without firm associated power would be worth 0·4*d*. per kilowatt-hour, delivered at 11 kV to the national supply network.

Guided by experience abroad, and with the benefit of advice from specialists in the fields of aerodynamics, structural engineering and electrical engineering, the Electrical Research Association have reached a tentative conclusion that the most economical capacity of a wind-driven generator for operation in conjunction with the British grid system would lie between 1,000 and 2,000 kW. It is, however, a significant fact that no wind machine of anything approaching this power has been successfully operated for a long period. The reason is that a wind motor which is sufficiently light and cheap to provide electrical energy at low cost, and which can withstand the maximum stresses imposed by gale conditions, has not yet been constructed. Several designs which purport to provide a satisfactory basis of construction have, however, been produced. Much can be, and is being, done to assist designers by measuring rates of change of wind speed and direction, maximum speeds, and associated phenomena, but it has long been evident that there is little or no possibility of making real progress other than by experiments with actual wind-driven generators of adequate capacity. The question arose: what constitutes adequate capacity for a prototype wind-driven electric generator which will serve as a satisfactory guide to the design of the most economical capacity of machine ?

On the electrical side, there is now no problem of a seriously difficult nature, as the American 1,250-kW machine delivered power successfully to a synchronous alternating-current system. The structural engineering problems, although special in respect of the stresses imposed on the supporting tower by the wind wheel, come mainly within the compass of well-proved theory and practice. The propeller, however, brings in so many special factors, notably vibration problems, methods of speed regulation, and of protection against failure in high winds, that even the most expert aerodynamic specialists could not be expected to predict with high accuracy the performance of a prototype unit. The aerodynamical experts' attitude is that it will be essential to envisage the provision of more than one propeller, whatever the size which may be chosen, before the best design can be produced. There is, fortunately, a great fund of knowledge of aircraft propellers which will ensure that even preliminary models should be reasonably efficient, and will make it possible to reduce trial and error processes to tolerable limits. Taking into account all factors, it has been agreed that propellers of the order of 60 to 80 ft. in diameter are sufficiently large to provide all the design data for future wind-driven generators of any capacity likely to come into consideration for adoption on a commercial basis.

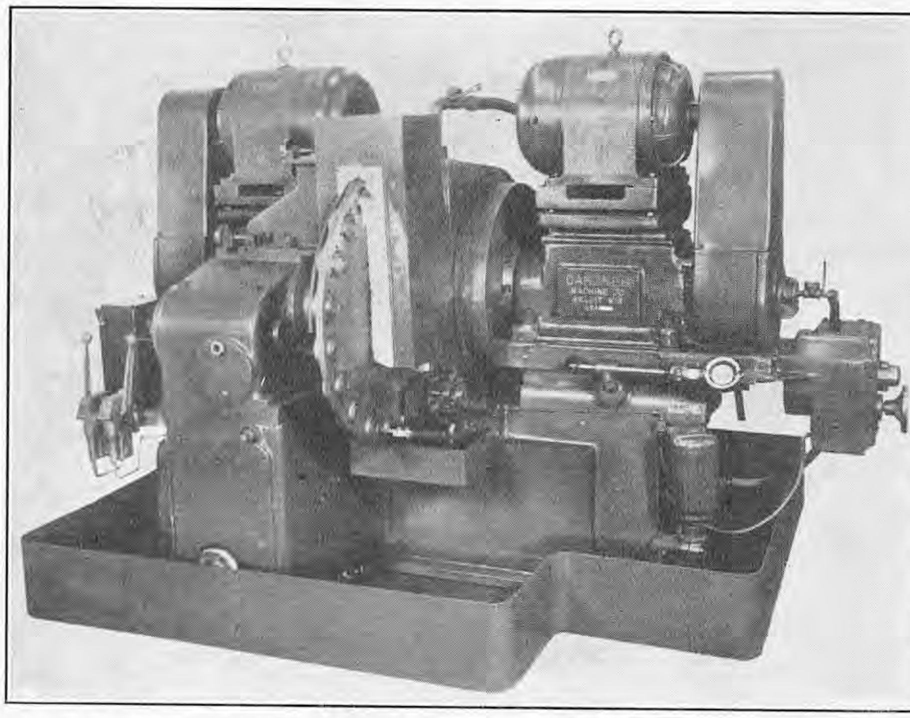
To establish a fixed point on which to base designs of experimental prototype wind-driven generators, an electrical output of 100 kW was specified. This output has to be obtained at a wind speed of 30 m.p.h. Two experimental generators of this capacity are on order. One of these, the property of the North of Scotland Hydro-Electric Board, has been erected on the Costa Head site in Orkney; the second, ordered by the British Electricity Authority, will be erected on the Mynydd Anelog site in Caernarvonshire, after it has undergone preliminary tests near St. Albans. The machine will be completed in the course of this year, and will be transferred to its permanent site during the light-wind period of 1953, if the rated output is attained and if all controls function satisfactorily.

The North of Scotland Hydro-Electric Board machine is a 100-kW geared unit, with a three-bladed propeller and an asynchronous generator. The British Electricity Authority machine is of the Andreau type, with pneumatic transmission and a synchronous generator. It will weigh 35 tons, that is, 770 lb. per kW, as compared with about 22 lb. per kW for a steam power station of the coal-fired type; but the latter class of station uses coal at the rate of about 4,000 lb. per annum per kW, so that the comparison on the basis of weights is by no means unfavourable to the wind plant. As already stated, the wind plant must produce energy at a cost of 0·4*d*. per kWh to be competitive with coal-fired plant in this country. The performance of these two machines will provide evidence regarding the potentialities of wind power which should decide our wind power research and development policy for the next decade or more. About 3,000 sq. ft. must be swept by a propeller to obtain 100 kW from a 30-m.p.h. wind; if we design to get maximum efficiency at this wind speed, then the structure has to be able to withstand at least ten times normal stresses once every year or so. Starting an efficient propeller presents a special problem which can be solved economically when there is a separate source of power always available, or it can be done by means of an auxiliary propeller.

Several of the most competent aircraft propeller designers are working intensively on the design of wind-driven generators embodying all the refinements essential to efficiency at all operating speeds, and the means for ensuring the safety of the installation under extreme wind conditions. Their success with aircraft provides justification for expecting equally good results in the new domain, which may provide work for the propeller factories to replace the losses of business brought about by jet-propulsion developments. Successful operation of the pilot plants will mean a possibility of obtaining at least as much energy from the wind as is now being obtained from British hydro-electric plant south of the Clyde-Forth line.

DOUBLE-SPINDLE GRINDING MACHINE.

GARDNER MACHINE COMPANY, BELOIT, WISCONSIN, U.S.A.



DOUBLE-SPINDLE GRINDING MACHINE FOR FINISHING BEARING-ROLLER ENDS.

THE machine illustrated above has been designed to finish-grind both ends of anti-friction bearing rollers simultaneously. A circular carrier, with holes to take the rollers, is rotated between the two grinding heads, and with rollers 1⅝ in. in diameter and 1¾ in. long the average stock removal is 0·006 in. to 0·008 in. per pass. Two passes are necessary, each performed at the rate of 18 pieces per minute, and production tolerances are 0·001 in. on parallelism and 0·002 in. on squareness and uniformity. The machine is made by the Gardner Machine Company, Beloit, Wisconsin, U.S.A., for whom the agents in Great Britain are Messrs. Burton, Griffiths and Company, Limited, Mackadown-lane, Marston Green, Birmingham.

The Gardner 125-26 in. double-spindle grinder, to give it the makers' name, consists of a heavy cast-iron base, supporting the heads on dovetailed slides mounted on ball-bearing ways. The heads can be pivoted to the correct angle for optimum grinding resuts. Two 4-in. spindles, running in anti-friction bearings, carry heavy-duty abrasive discs. The drive to the rotary carrier, at the front of the machine, can be varied to give a range of speeds of which the limits are in the ratio of 3 to 1. The carriers are interchangeable to suit the size of the workpiece. As the rollers enter and leave the space between the abrasive discs they are directed by guides with micrometer adjustment. They are loaded manually but unloaded automatically by an ejector.

SAFE FRONTIER TRANSIT OF SCIENTIFIC INSTRUMENTS.—To protect delicate standard scientific instruments from damage and delay in delivery when being transported across national frontiers, Unesco has proposed to member states that the instruments should be inspected at the laboratories from which and to which they are being dispatched, under competent supervision, instead of at customs depots at the frontiers or terminals. Each participating government is to name the laboratory or laboratories in its country which it wishes to include in the scheme. Unesco will periodically circulate a list of such laboratories. Such information reaching Unesco, 19, Avenue Kleber, Paris (16e), by June 1 will be included in the first circular. A similar scheme already exists between a few laboratories, among which are the National Physical Laboratory, the United States National Bureau of Standards, and the U.S.S.R. Institute of Metrology. Unesco hopes to extend the arrangement to other institutions as part of its campaign to reduce administrative and other barriers to the passage of educational and scentific materials between countries.

FOUNDERS' COMPANY FELLOWSHIPS.—The Worshipful Company of Founders of the City of London, to which Ordinances were granted as long ago as July 29, 1365, awards Fellowships so as to give facilities for advanced education to men who have already completed their normal course of training in chemistry, physics, metallurgy and allied sciences. Previous practical foundry training and experience, and the Diploma of the British Foundry School, are considered to be advantages by the selection committee. The course to be followed by the Fellow, in all cases, will be chosen with the object of adding to his scientific knowledge that which appears to be most necessary for adapting him to some branch of the founding industry. The normal value of the Fellowship is 300*l*. per annum and one Fellowship is granted each year. The Fellow will be expected to devote his whole time to work approved by the Company and to submit periodical reports of progress, if required. Candidates should not be less than 21 years of age on September 1, from which the tenure of a Fellowship dates. Applications must be received not later than May 1 by the Clerk of the Company, Founders' Hall, 13, St. Swithin's-lane, London, E.C.4, to whom all inquiries should be addressed.

CALENDAR.—The Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, have sent us a monthly tear-off wall calendar, which is current from April, 1952, to March, 1953, inclusive.

THOMAS GRAY MEMORIAL TRUST.—The Council of the Royal Society of Arts have awarded the prize of 50*l*., offered in 1951 under the Thomas Gray Memorial Trust, to Mr. J. Home Dickson, of Teddington, Middlesex, for his "instrument which makes it possible to navigate a ship in fog by means of a direct comparison of a large-scale chart and a Radar Plan Position Indicator." The competition was open to any person of British nationality who might bring to the Council's notice an invention, publication, diagram or other device which, in the opinion of the judges, was considered to be an advancement in the science or practice of navigation, proposed or invented by himself in the period from January 1, 1946, to December 31, 1951. The objects of the Thomas Gray Memorial Trust, which is administered by the Society, are "the advancement of the science of navigation and the scientific and educational interests of the British Mercantile Marine." The prize of 50*l*. offered for a "Deed of Professional Merit" was not awarded, as none of the submissions was considered sufficiently outstanding.

ELECTRONIC TELEPHONE EXCHANGES.

IN a paper on "Electronic Telephone Exchanges," which was read by Mr. T. H. Flowers at a meeting of the Institution of Electrical Engineers on Thursday, March 13, a description was given of the preliminary steps that had been taken to determine the practical forms such exchanges might assume and how they might compete with existing electromagnetic systems. The problem of the form which an electronic exchange might take was not adequately solved simply by substituting electronic for electromagnetic switches, since the characteristics of the two were quite different. Moreover, the greater operating speed of electronic devices made possible switching systems which were impracticable with electromagnetic apparatus.

The requirements of speech transmission involved the consideration of overall loss, attenuation distortion, non-linearity and noise and cross-talk attenuation; and in these respects electronic exchanges would differ from electromagnetic exchanges. For example, metal-to-metal contacts produced little attenuation, attenuation distortion or non-linearity in transmission. These effects were, however, always present in electronic switches and their reduction to acceptable values was one of the design problems. The simplest element switches were vacuum valves, rectifiers and gas-discharge tubes; and these could be formed into connector switches of any size. About 40 such element switches were required for speech transmission per subscriber's line if they could transmit in both directions. Vacuum valves could, however, transmit in one direction only, so that this number would have to be doubled for both-way transmission. They could therefore be ruled out as uneconomic. On the other hand, gas-discharge tubes provided both-way transmission and consumed no power except when conducting. Their economical use, however, depended on how cheaply the large numbers required could be made. Speech transmission through vacuum valves was satisfactory, but as the circuits within the switches were electrically unbalanced satisfactory cross-talk attenuation was dependent on the spacing of the conductors and on screening. Speech transmission through gas-discharge or rectifier switches suffered attenuation which might be serious and had to be made up by amplification with two-wire transmission. Four-wire transmission might therefore be necessary, thus doubling the number of unit switches. Gas-discharge-tube conduction was also liable to introduce noise and attenuation distortion, although this might be negligibly small. It must therefore be concluded that although "multiplied element" switches, more particularly those using gas-discharge tubes, might be employed in very small exchanges in larger exchanges multiplex types of switches were the more attractive.

One type of multiplex switch was known as the frequency-division switch and consisted of a number of audio-frequency circuits, each comprising a transmitting and receiving channel. Each transmitting channel modulated one of a number of carrier frequencies. These modulated frequencies were then applied to a common channel to which the receiving channel was connected through a de-modulator. Any number of receiving circuits could be connected to the receiving channel; and switches constructed in this way might be used very much as the 100-point selectors of existing systems. In another type of multiplex switch, known as the time-division switch, the modulators and de-modulators were replaced by pulse modulators and the carrier frequencies by trains of pulses. The pulse modulators were operated by trains of pulses, which were fixed in time relative to the multiplex cycle and spaced so that the channels were connected to the common transmitting channels in order. Any transmitting circuit could thus be connected to any receiving circuit and both speech and signal transmission could readily be provided.

The power capacity of whatever form of electronic connector switch was adopted would only be one or two milliwatts. This was insufficient for ringing a magnetic bell and operating a meter. As there were great advantages in retaining the present types of subscribers' apparatus and meters, equipment must be provided which would link these with the new switches. This could be done by using the output of a transformer which was resonant to a signal intended to ring the subscriber's bell, to fire a cold-cathode gas-discharge-tube relay in the anode circuit of which was a second transformer and a direct-current biassed 17-cycle power supply. When the tube was discharging, sufficient power was supplied to the line to ring the bell. The meter was similarly operated by 50-cycle current from a third transformer. Selection of the required circuit, as a result of signals originating from the calling subscriber, consisted of three basic operations: the selection of a group of called circuits; the selection of a free circuit in the selected group; and the connection of the selected called circuit to the calling circuit. In a wholly electronic system, group selection implied the production of an electric signal, which "marked" a group of circuits, and free-circuit selection implied the marking of a free circuit in the selected group. Examples of group selection circuits described in the paper required one or two gas-discharge tubes per marker lead, but more economical arrangements might be used in appropriate cases.

When the required group of circuits had been selected, the condition—free or engaged—of each circuit in the group was indicated over a test lead so that a free circuit could be selected and marked. The apparatus used for this purpose took many forms and included gas-discharge tubes with their cathodes connected to a common resistor, so arranged that if one tube fired the others were prevented from doing so. The connection of the calling circuit to the selected called circuit could be effected relatively simply either by vacuum valves, gas-discharge tubes or frequency-division switches, so that any number of calls could be set up simultaneously without mutual interference. It was doubtful, however, whether electronic exchanges with connector switches of any type could compete in cost and size with any existing type.

Electronic exchanges would make no difference to the fundamental problem of planning the telephone system, but might compel, or at least encourage, changes in practice. The transmission through electronic exchange-switches would introduce extra possibilities of and variations in overall loss, reflections and distortions. There were, however, more than compensating advantages. Where one-way amplifiers were included in the transmission paths, the gains would be such as to make the loss through the connector switches zero. The variation of overall loss would generally be more than offset by the greater gain that could be employed in the line repeaters. In addition, a subscriber's line connected to four-wire switches, including amplifiers in the four-wire channel, would have an exchange termination which did not vary with the connections. Side-lane balance at the instruments might then be improved, with a corresponding improvement in transmission. There should be a saving in the cost of generation and exchange line plant, owing to the greater number of amplifiers in use and a consequent reduction in the copper in the transmission circuits. Finally, frequency-division and time-division exchange switches offered opportunities for carrying these types of transmission into local and short junction networks. It was not difficult to visualise, for example, the present unattended automatic exchanges being replaced by multiplex terminals, connected by coaxial cable to a larger exchange in which all the switching for an area of considerable size was installed.

Little information was available regarding either the capital or maintenance costs of electronic exchanges. The equipment might, however, be expected to be much less expensive than electro-mechanical apparatus. The number of parts required was a mere fraction of that necessary in the Strowger system, so that standardisation and mass production would be facilitated. No new system would, however, be adopted in place of existing systems unless the labour cost was much less. Labour would be mainly limited to finding and replacing faulty valves, which with a valve life of one year would work out at about 50 a day for a 10,000-line exchange. At least a five-year life was necessary for fully economic working, and there was no reason to think this could not be achieved. A further point was that the power consumption of an electronic exchange would consist of a fixed load plus a smaller load proportional to the traffic. At an estimated power of three watts per line, 25 kWh would be consumed per line each year. For a 10,000-line exchange, the base load would be about 60 kW.

In conclusion, the author said that the evidence available to date was sufficiently encouraging to justify proceeding with the development of electronic exchanges. Even if the other signs were not as propitious, the possibilities of improving network design and construction were enough to stimulate progress.

PROBLEMS OF THE SHIPPING INDUSTRY.—The 81st annual report of the North of England Shipowners' Association again draws attention to the effects of high taxation, the man-power difficulties of the shipping industry, and the increasing competition from other countries that are building up merchant fleets. On the taxation question, the report asserts that the present system is penal in its effect on the private shipowner and, while it continues, no owner could view the position with anything but disquiet. Because of the man-power shortage, ships were being sent to sea without a full complement of certificated engineers. This resulted in frequent breakdowns, major repair bills and loss of freight. The report states that the number of countries increasing their merchant tonnage is growing. This, coupled with the tonnage owned and building in Germany and Japan, must result in serious competition with Britain.

BRITISH STANDARD SPECIFICATIONS.

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

Dimensions of Toroidal Sealing Rings.—A new specification, B.S. No. 1806, dealing with the dimensions of toroidal sealing rings, has been prepared and issued at the request of the Ministry of Defence. Toroidal sealing rings, sometimes referred to as "O" seals, are used as packings for reciprocating mechanisms and as gaskets for static purposes for light and medium general engineering applications. These sealing rings are not intended for use at pressures in excess of 1,500 lb. per square inch. For use as packings in reciprocating mechanisms, 73 sizes are specified in the range of ⅛ in. to 8 in. internal diameter, and, for static purposes, 96 sizes in the range of ⅛ in. to 15½ in. internal diameter. The latter range includes the 73 sizes intended for reciprocating mechanisms. Recommendations regarding the recesses into which the rings are to be fitted are also included, but it is emphasised that there should be close collaboration between the designer and the manufacturer of the sealing rings to ensure satisfactory operation and service. [Price 2*s*. 6*d*., postage included.]

Marking System for Grinding Wheels.—A uniform system of marking grinding wheels to indicate their relative hardness and grit size has been established in a new specification, designated B.S. No. 1814. The system is based on the agreed practice of British grinding-wheel manufacturers, and the sequence in which several symbols are used gives a general indication of the hardness and grit size of any wheel as compared with another. It will be appreciated, however, that the widely differing conditions under which grinding wheels are used make it impracticable to state that wheels of similar marking, made by different manufacturers, will necessarily give the same grinding action. The system does not apply to diamond wheels, or to such products as scythe and tool-sharpening stones. [Price 2*s*., postage included.]

LAUNCHES AND TRIAL TRIPS.

M.S. "LONDON GLORY."—Single-screw oil tanker, built by Sir James Laing & Sons, Ltd., Sunderland, for London and Overseas Freighters, Ltd., London, W.1. First vessel of a series of three. Main dimensions: 475 ft. between perpendiculars, by 67 ft. 4½ in. by 37 ft. 4 in.; deadweight capacity, about 15,300 tons on a draught of 29 ft. Four-cylinder opposed-piston oil engine, constructed by William Doxford & Sons, Ltd., Sunderland. Speed, 12½ knots. Trial trip, March 1 and 2.

M.S. "TABOR."—Single-screw cargo vessel, built by the Caledon Shipbuilding and Engineering Co., Ltd., Dundee, for the Moss Hutchison Line, Ltd., Liverpool, for the company's eastern Mediterranean trade. Main dimensions: 360 ft. between perpendiculars, by 55 ft. by 32 ft. 6 in. to shelter deck; deadweight capacity, about 5,000 tons on a draught of 21 ft. 9 in.; gross tonnage, 3,417. Hawthorn-Doxford four-cylinder two-stroke airless-injection oil engine, developing 4,400 b.h.p. in service, constructed by R. and W. Hawthorn, Leslie & Co., Ltd., Newcastle-upon-Tyne. Speed, 15 knots. Trial trip, March 5.

M.S. "CEARA."—Single-screw oil tanker, built by the Blythswood Shipbuilding Co., Ltd., Scotstoun, Glasgow, for the Brazilian Tankers Purchasing Commission. Main dimensions: 510 ft. between perpendiculars, by 69 ft. 6 in. by 37 ft. 3 in.; deadweight capacity, 16,700 tons on a draught of about 29 ft. 9 in. Barclay Curle-Doxford five-cylinder combined-stroke Diesel engines, developing about 5,600 b.h.p., constructed by Barclay, Curle & Co., Ltd., Glasgow. Mean speed on trial, 14½ knots. Trial trip, March 12.

S.S. "HACKNEY."—Single-screw collier, built by S. P. Austin & Son, Ltd., Sunderland, for the British Electricity Authority, London, W.1. Last vessel of a series of three. Main dimensions: 257 ft. by 39 ft. 6 in. by 18 ft. 6 in.; deadweight capacity, about 2,700 tons on a draught of 17 ft. 1 in. Triple-expansion steam engine of North Eastern reheat design, developing 800 i.h.p. at 78 r.p.m., constructed by George Clark (1938), Ltd., Sunderland, and one coal-burning three-furnace boiler. Speed, 11 knots. Trial trip, March 12.

S.S. "ROONAGH HEAD."—Single-screw cargo vessel, accommodating twelve passengers, built and engined by Harland and Wolff, Ltd., Belfast, for the Ulster Steamship Co., Ltd. (Managers: G. Heyn & Sons, Ltd.), Belfast. Main dimensions: 430 ft. between perpendiculars, by 59 ft. 3 in. by 39 ft. 4 in. to shelter deck; gross tonnage, about 6,200. Double-reduction geared turbines developing 5,000 s.h.p. in service, and two Babcock and Wilcox boilers, also constructed by the shipbuilders. Trial trip, March 18 and 19.

NOTES ON NEW BOOKS.

The Cornish Engine: A Chapter in the History of Steam Power.

By H. W. DICKINSON, Eng.D., M.I.Mech.E. Art and Technics, Limited, 58, Frith-street, Soho, London, W.1. [Price 7s. 6d. net.]

THIS little manual, produced as a description of the series of films of Cornish engines made some five years ago by the Shell Film Unit with the co-operation of the Cornish Engines Preservation Society, of which the late Dr. Dickinson was a vice-president, is described as a "revised edition," but, in fact, is virtually a first edition, as publication of the original was suspended in order that certain necessary corrections could be made. The films were made as a record of some of the last Cornish engines to remain at work in Cornwall, and the book, in addition to containing descriptions of those engines, presents a concise review of the development of the type and the manner of its operation. It is well illustrated with sectional diagrams and with reproductions of views of the engines filmed, and is supplemented by a short bibliography. As most of the works cited also contain bibliographies, this book forms a useful starting point for anyone who is taking up the study of the subject for the first time.

The Concealed Coalfield of Yorkshire and Nottinghamshire.

By W. EDWARDS, M.A., Department of Scientific and Industrial Research, Geological Survey of Great Britain. Third edition. H.M. Stationery Office, York House, Kingsway, London, W.C.2. [Price 22s. 6d.]

THE concealed coalfield which underlies parts of Yorkshire, Nottinghamshire, Derbyshire, Lincolnshire and Leicestershire, comprises the eastern and larger part of the great East Pennine coalfield, from which more than a third of the total output of coal in Great Britain is obtained. Bounded on the west by a line between Leeds and Nottingham, the concealed field extends eastwards under a gradually thickening cover of younger rocks at least as far as Market Weighton, Lincoln and Grantham. No eastern boundary for the coal measures has been found so far, though the area already proved covers approximately 2,000 square miles. Since the publication in 1926 of the second edition of this memoir, 50 collieries have been in active production along the western side of the field, three new collieries have been established in Nottinghamshire, and 19 deep coal-borings have been sunk in the concealed area. In addition, over 330 boreholes have been put down by the D'Arcy Exploration Company and the Anglo-American Oil Company in their search for oil. As a result of these activities and of researches in stratigraphical palæontology, knowledge of the eastward extension of the coalfield has so increased as to necessitate the complete rewriting of the subject-matter of earlier editions. The new volume, of 285 pages, is principally a record of facts of economic importance. The first 80 pages are devoted to a concise description of the coal measures, short informative chapters follow on coal-measure palæontology, and Permo-triassic and Jurassic rocks, and the last 160 pages are devoted to stratigraphical sections taken from colliery shafts and borehole logs. A short glossary of mining terms is appended and the entire work is of the usual high standard associated with Geological Survey memoirs.

The A.S.E.E. Guide to the I.E.E. Regulations for the Electrical Equipment of Buildings.

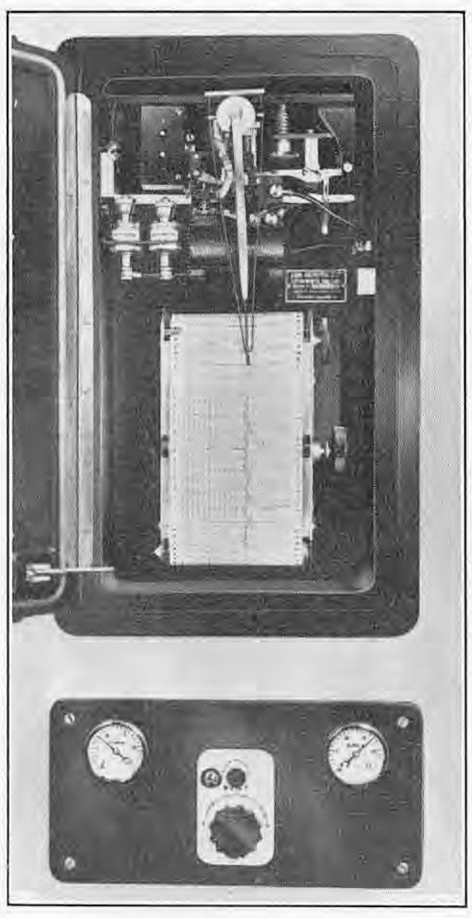
The Association of Supervising Electrical Engineers, 54, Station-road, New Barnet. [Price 3s. 9d., post free in paper covers; 5s. 3d., post free in cloth covers.]

THE well-known Regulations for the Electrical Equipment of Buildings published by the Institution of Electrical Engineers cover a great deal of ground and are necessarily subject to periodic revision, in accordance with the dictates of experience and as new applications come into use. As a result, they form a portentous body of material, not all of which is required by workers in a particular field. The Association of Supervising Electrical Engineers therefore conceived the useful idea of preparing a "Guide" to the Regulations. This, being intended for trained electricians, omits certain portions which do not normally concern the operative. An attempt to secure greater clarity is made by using diagrams to illustrate some of the regulations. A certain amount of re-wording has also been undertaken and some explanatory matter has been added. Where this has been done, the fact is indicated in bold type. Once again clarity is the object, although examination shows in certain cases this is almost superfluous. The present Guide is related to the twelfth and latest edition of the Regulations and, of course, follows the changes which were made in that edition. Certain regulations previously omitted have, however, been included, and all the tables in the main work now find a place. The Guide will be very useful to those for whom it is intended and great credit is due to those responsible or its compilation.

CONTROLLER FOR GAS CALORIFIC VALUE.

SINCE the war, the demand for gas has generally speaking increased more rapidly than holder capacity. The gas therefore passes through the holder more quickly than previously and variations in its calorific value are not smoothed out so effectively. Closer control of its calorific value before it enters the holder is therefore necessary; and the same is true when it is fed into a grid system directly from coke ovens. To effect this control, a new calorimeter, illustrated herewith, has been developed jointly by the Sigma Instrument Company, Limited, Letchworth, and Messrs. George Kent, Limited, Luton, and is being marketed by the latter firm.

The apparatus consists of two basic parts: a Sigma Mark 2 calorimeter and a Kent Mark 20 pneumatic-control unit. The calorimeter is made up of a gas-flow regulator, measuring instrument and recording mechanism. The regulator supplies gas to the measuring instrument at a rate which would be constant if reduced to the standard pressure and temperature of 30 in. of mercury and 60 deg. F. It also automatically compensates for changes in the specific gravity of the gas and in the ambient temperature. From the regulator, the gas passes to a burner in



the measuring instrument and the products of combustion then flow upwards to the atmosphere through a vertical steel tube. This tube is concentrically mounted within a second steel tube, the lower ends of the two being rigidly connected, while the upper end of the outer tube is fixed to the instrument case. The relative expansion and contraction of the inner tube, which are directly dependent on the calorific value of the gas being burned, are transmitted through a bar at its upper end to a recording linkage. The effect of changes in the ambient temperature is, however, excluded, since both tubes respond equally to them. The relative movement of the inner tube is magnified many times by the linkage, so that adequate motion is given to the pen of the recorder. The slight zero errors, which are sometimes associated with large changes in barometric pressure, are compensated.

The Kent control mechanism is contained in the instrument case and consists of a setting pointer, which is mounted concentrically with the recording pen. Any deviation between the positions of the pen and the pointer causes a change of air pressure in the controller system, with the result that a value in the diluent gas main is moved and the calorific value of the gas is corrected. The controller is also designed, so that the calorific value is returned to that corresponding with the control setting without overshoot. The control valve is usually of the butterfly type and is operated by a power cylinder.

BOOKS RECEIVED.

The Aeroplane Directory of British Aviation, Incorporating Who's Who in British Aviation, 1952. Temple Press, Limited, Bowling Green-lane, London, E.C.1. [Price 15s. net.]

Marine Steam Engines and Turbines. By W. J. FOX and S. C. MCBIRNIE. George Newnes, Limited, Tower House, Southampton-street, Strand, London, W.C.2. [Price 35s. net.]

Railway Commercial Practice. By H. F. SANDERSON. Volume I. *General and Passenger.* Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 25s. net.]

Uganda Electricity Board. Fourth Annual Report and Accounts for the Year Ended 31st December, 1951. Offices of the Board, P.O. Box 550, Johnson-street and Wilson-road, Kampala, Uganda. [Price 1s.]

Ten Steps to Power. A National Fuel and Power Policy. By GERALD NABARRO. The Saint Catherine Press, Limited, 39, Parker-street, London, W.C.2. [Price 3s.]

Ministry of Fuel and Power. Coal Mines Act, 1911. *Regulations and Orders Relating to Safety and Health.* 1951 edition. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 4s. net.]

Thermal Properties of Buildings. By N. S. BILLINGTON. Cleaver-Hume Press, Limited, 42a, South Audley-street, London, W.1. [Price 25s.]

Grundlagen der technischen Winkelmessungen. By DR.-ING. KURT RÄNTSCH. Carl Hanser-Verlag, Leonhard-Eck Strasse 7, Munich 27, Germany. [Price 14.80 D.M.]

Werkstattkniffe. No. 10. *Aus der Praxis der Werkzeugmachers in der Stanzerei.* By ERNST BOSSE. Third enlarged edition. Carl Hanser-Verlag, Leonhard Eck Strasse 7, Munich 27, Germany. [Price 3.80 D.M.]

Theoretische Elektrotechnik. Volume III. *Grundzüge der Theorie elektrische Maschinen.* By PROFESSOR KARL KUHLMANN. Verlag Birkhaüser, Basle, Switzerland. [Price 68.65 Swiss francs in paper covers, 74.90 Swiss francs cloth bound.]

International Statistical Institute. Bibliography of Basic Texts and Monographs on Statistical Methods. Offices of the Institute, The Hague, Holland. [Price 5s.]

Department of Scientific and Industrial Research. Report of the Road Research Board with the Report of the Director of Road Research for the Year 1950. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 3s. 6d. net.]

TRADE PUBLICATIONS.

High-Torque Squirrel-Cage Motors.—Details of the "Trislot" high-torque low-current squirrel-cage motors manufactured by Laurence, Scott and Electromotors, Ltd., Norwich, are given in a brochure recently received.

Flexible Electric Cords.—The first catalogue dealing with flexible electric cords to be issued by them since the war has been received from W. T. Henley's Telegraph Works Co., Ltd., 51, Hatton Garden, London, E.C.1. It covers heat-resisting flexible cords and motor-car cables in addition to the firm's standard range of C.M.A. and medium insulation flexible cords.

Materials-Handling Equipment.—A booklet issued by Lansing Bagnall, Ltd., Basingstoke, illustrates and briefly specifies a wide range of materials-handling equipment, including industrial tractors, pallet trucks, fork trucks, stillage trucks, paper-reel trucks, tin-plate trucks, die-handling trucks, trailers, pallets, stillages and a side-loading combined platform and fork truck.

Glass-Bulb Mercury-Arc Rectifiers and Inverters.—Complete details, with a number of excellent illustrations, of the various types of mercury-arc rectifiers and inverters manufactured by them are given in a brochure published by the Nevelin Electric Co., Purley Way, Croydon, Surrey. Data regarding the cubicles, transformers, control gear and auxiliaries made for use with this equipment are also given.

Mass-Impregnated Non-Draining Cables.—Full particulars of the mass-impregnated non-draining cables, designed by them to overcome the difficulties associated with mass oil-rosin impregnated paper cables on installations involving vertical runs and steep gradients, are given in a publication received from British Insulated Callender's Cables, Ltd., Norfolk House, Norfolk-street, London, W.C.2.

Flow Meters.—Details of variable-area type flow meters manufactured by Solway Flowrators, Ltd., Abbey-road, Park Royal, London, N.W.10, are contained in a well-illustrated and informative catalogue, No. 51 N, recently issued by the company. Instruments are available which indicate or record either instantaneous rates of flow of liquids and gases or total flows over a period of time. The company also manufacture remotely-recording flowmeters and automatic controllers. The meters are suitable for pipe lines of up to 2-in. bore.