

250-TON AND 125-TON LADLE
CRANES FOR JOHN
SUMMERS'S STEELWORKS.

Two cranes of 250-tons lifting capacity for handling casting ladles, and two of 125-tons capacity for charging hot metal into furnaces, have been designed, built and installed by the Wellman Smith Owen Engineering Corporation, Limited, for the new No. 3 steelworks at the Hawarden Bridge Steelworks of Messrs. John Summers and Sons, Limited, Shotton, near Chester. Each 250-ton crane weighs approximately 500 tons without load, and therefore the maximum rolling load, when fully laden, is

bay of the new melting shop and are intended for carrying the ladle when receiving molten steel from the furnaces and when teeming the steel into ingot moulds. The cranes are of the four-girder type, where the main trolley runs on the two main girders forming the bridge of the crane, each of

building columns at each side of the shop is 3 ft. The gantry rail is situated at an elevation of 54 ft. above the shop floor and the headroom clearance from the rail to the underside of the roof principals is 21 ft. The minimum approach of the main hooks to the centre line of the gantry girders at the furnace

TABLE I.—LOADS, SPEEDS AND MOTORS OF 250-TON CRANES.

	Loads and Speeds.	Motors.
Main hoist	250 tons at 9 ft. per min.	2-125 h.p. at 605 r.p.m.
Main cross traverse	250 " 75 "	70 " 580 "
Auxiliary hoist	50 " 30 "	125 " 605 "
Auxiliary cross traverse	15 " 50 "	70 " 580 "
Long travel	50 " 125 "	20 " 590 "
	250 " 200 "	2-100 " 650 "

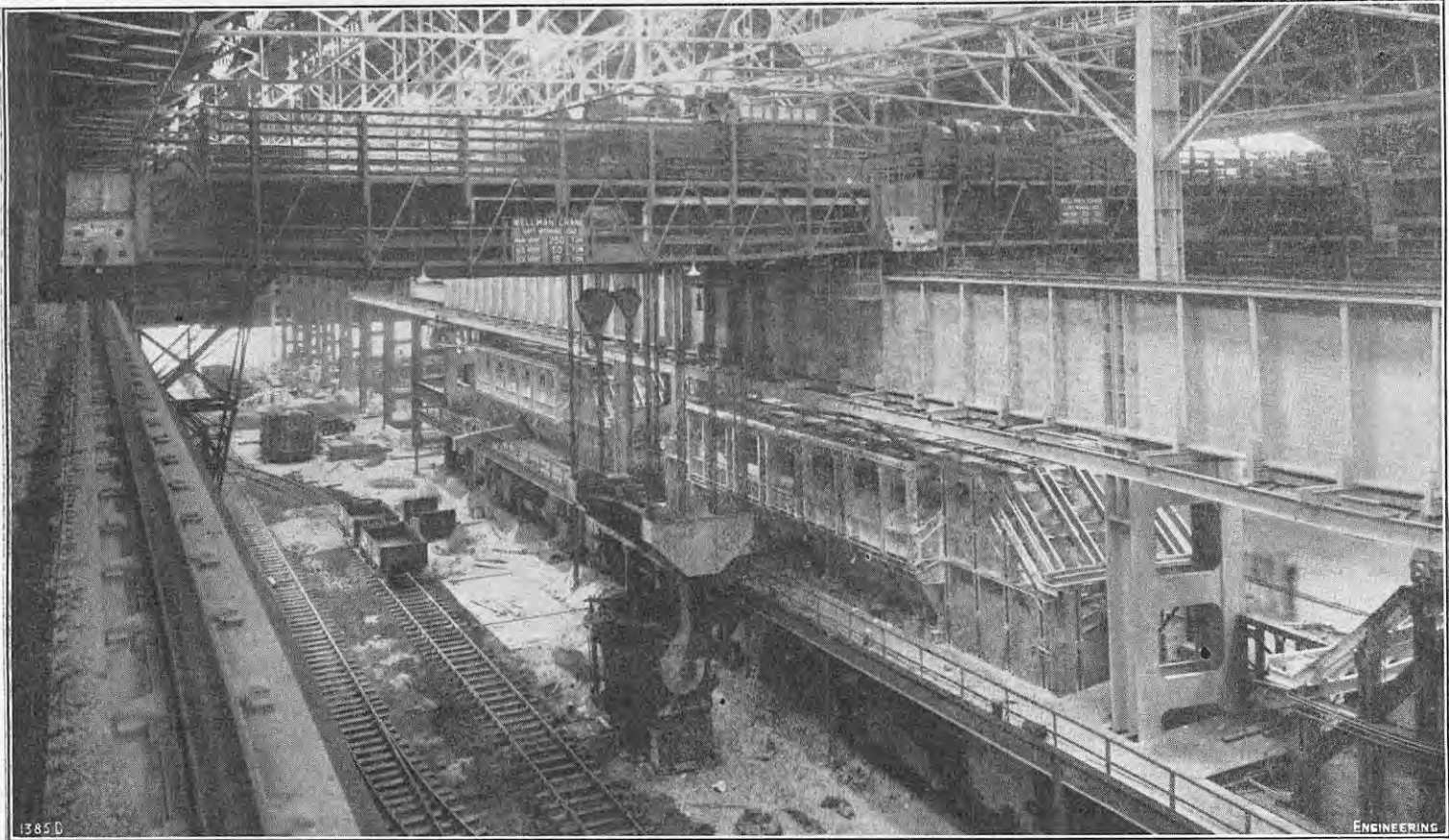


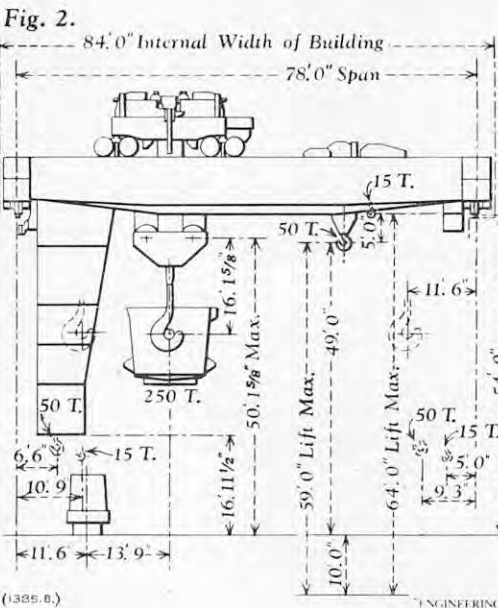
FIG. 1. 250-TON AND 125-TON LADLE CRANES.

750 tons. With the maximum load, and with the main trolley as close as possible to one side of the shop, the total load on the gantry, due to one crane, amounts to 542 tons. The maximum individual wheel loads are then 68½ tons at one end of the crane, i.e. at the driver's cab, and 67 tons at each of the other four wheels. The cranes have been constructed for continuous service in the steelworks, and represent an advanced design as a result of co-operation between the builders and user. In Fig. 1 a 250-ton crane is shown on the left and a 125-ton crane on the right, in the adjacent bay.

250-TON LADLE CRANES.

The 250-ton cranes, which are shown in Figs. 5 and 6, on Plate VIII, will lift the load of 250 tons, maximum combined weight of ladle and molten metal, by means of a ladle beam arranged for four-point suspension from the main trolley, and from which depend the two ladle hooks, these being situated at 15 ft. 6 in. centres for engaging the ladle trunnions, as shown in Fig. 10, on Plate IX. The auxiliary trolley is provided with two independently-operated hoisting motions, one of 50-ton capacity, required primarily for tilting the ladles, and one of 15-ton capacity for general service. The operating speeds and motors for the various motions are given in Table I.

The 250-ton cranes are installed in the casting



these girders having an outrigger girder, with a full-length platform both sides of the crane. The auxiliary trolley is also provided with independent girders. The crane span is 78 ft., centre to centre of the gantry-track rails, and the end clearance from the centre line of the rail to the face of the

side is 11 ft. 6 in., and at the opposite side 10 ft. 9 in. Some dimensions are given in Fig. 2.

The main girders are of the double-web plate type, braced laterally to the outrigger girder by horizontal and diaphragm bracings which form a lattice-box construction for carrying the platforms and long-travel motors and driving gear. The auxiliary trolley girders, which are between the main girders, are also of the double-web plate type. The platforms alongside each span girder provide ready access to either trolley and to the rigid T-bar cross conductors which carry current to the motors on the trolleys, the conductors being mounted above platform level behind wire-mesh guards. In addition, extensive platforms are provided on the trolleys themselves, and platforms for access to the long-travel wheels and axle bearings are arranged under the girders at each end of the crane; they are guarded from the main collector gear and down-shop conductors at one side of the shop. The crane cab has five decks. The lower compartment for the driver, which houses master controllers and auxiliary switchgear, is insulated and sealed for the future installation of air-conditioning equipment.

The cranes are carried on 16 steel-tyred travelling wheels, 3 ft. 6 in. in diameter; four wheels at each corner of the crane are disposed symmetrically about the abutment of the main-trolley girders.

LADLE CRANE AT JOHN SUMMERS'S STEELWORKS.

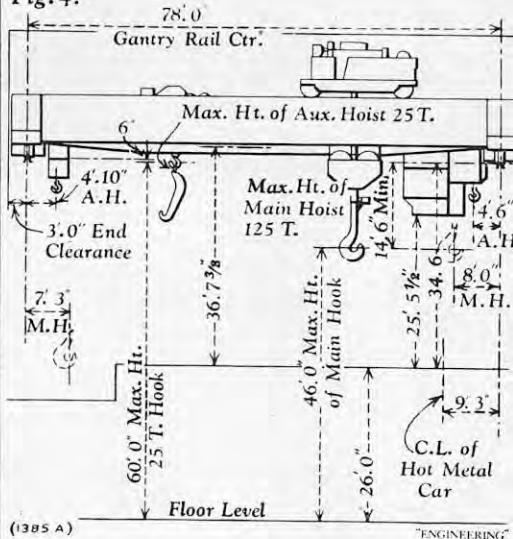


FIG. 3. 125-TON HOT-METAL LADLE CRANE.

The wheels are mounted on live axles running in bronze bearings lubricated by Armstrong oilers. They are arranged in pairs in compensating bogies, and the method of compensation between each pair of bogies is unique, in that it is accomplished by means of massive rocker levers arranged so that, on jacking up the crane, both bogies can be run out without removing the heavy pins forming the main pivots of the compensating gear. One wheel of each of the four outer bogies is driven, through an end gear reduction mounted on the bogie itself, from a motor and reduction gear situated at the centre of the span on each side of the crane. The main trolley is carried on eight 3-ft. diameter steel-tired cross-traverse wheels mounted in two-wheel compensating bogies; two of these wheels are driven from the cross-traverse motor through enclosed spur gearing, the construction being substantially similar to the drive for the long-travel motion. Figs. 8 and 9, on Plate IX, show the construction of these bogies.

The main hoisting gear, shown in Fig. 7, on Plate IX, is driven by two motors driving through inter-connected first-motion and second-motion enclosed reduction gears to four steel hoisting drums, 4 ft. in diameter, arranged in pairs with right-hand and left-hand grooving for coiling the hoisting ropes. The load is carried on 32 parts of rope, return sheaves being rigidly mounted on the trolley, and the standing ends of the ropes arranged for independent adjustment to take up any inequalities in stretch. An auxiliary trolley is provided with two hoisting motions, one of 50-ton and another of 15-ton capacity, each independently operated by an electric motor driving through enclosed spur reduction gearing with steel hoisting drums of 3 ft. 1½ in. and 2 ft. 6 in. diameter, arranged for eight and four falls of rope, respectively. The trolley is carried on four runners, 2 ft. in diameter,

Fig. 4.



which are mounted on through axles running in self-lubricating bronze bearings.

125-TON HOT-METAL LADLE CRANES.

The 125-ton cranes, one of which is shown in Fig. 3, on this page, are for charging hot metal into the furnaces. The maximum lift of 125 tons is suspended from the main trolley in a manner similar to that of the 250-ton cranes, with four-point suspension of the ladle beam, the two ladle hooks

being spaced at 13 ft. 4 in. centres to suit the hot-metal ladles. The auxiliary trolley for tilting the ladles is of 25-ton capacity. These cranes are also of the four-girder type. The operating speeds and motors are given in Table II.

The crane span is 78 ft. and the end space is 3 ft. from the centre of the rail to the face of the building columns; the gantry rail level is 60 ft. above floor level, with 21 ft. 4 in. headroom. The main hook approach is 7 ft. 3 in. at the furnace side and 8 ft. at the opposite side of the shop. Some of the main dimensions are shown in Fig. 4. The girder construction is substantially similar to that described for the 250-ton cranes, the main girders being of the double-web plate type, but these cranes have a short cab, situated at a comparatively high level and giving good visibility when pouring. The control gear is housed in the girders. The travelling gear is driven by a single motor and reduction gear, situated at the centre of the span on one side of the crane opposite the cab, which drive two of the eight steel-tired travelling wheels, 3 ft. 6 in. in diameter, which are mounted in pairs in compensating bogies, the four bogies being disposed one under each main girder abutment.

The main trolley is carried on four steel-tired cross-traverse wheels, 3 ft. in diameter, which are mounted on live axles running in bronze-lined bearings of the run-out type. The main hoist gear is driven by a single motor through enclosed gears, the second-motion train being divided to drive two

TABLE II.—LOADS, SPEEDS AND MOTORS OF 125-TON CRANES.

	Loads and Speeds.		Motors.	
Main hoist	125 tons at	10 ft. per min.	125 h.p. at	605 r.p.m.
Main cross traverse	125 "	75 "	30 "	590 "
Auxiliary hoist	25 "	30 "	70 "	580 "
Auxiliary cross traverse	25 "	125 "	15 "	660 "
Long travel	125 "	225 "	125 "	605 "

250-TON LADLE CRANE AT JOHN SUMMERS'S STEELWORKS.

WELLMAN SMITH OWEN ENGINEERING CORPORATION, LTD., LONDON.

(For Description, see Page 417.)



FIG. 5. TWO 250-TON LADLE CRANES IN STEELWORKS.



FIG. 6. 250-TON CRANE, SHOWING MAIN AND AUXILIARY TROLLEYS.

250-TON LADLE CRANE FOR JOHN SUMMERS'S STEELWORKS.

WELLMAN SMITH OWEN ENGINEERING CORPORATION, LTD., LONDON.

(For Description, see Page 417.)

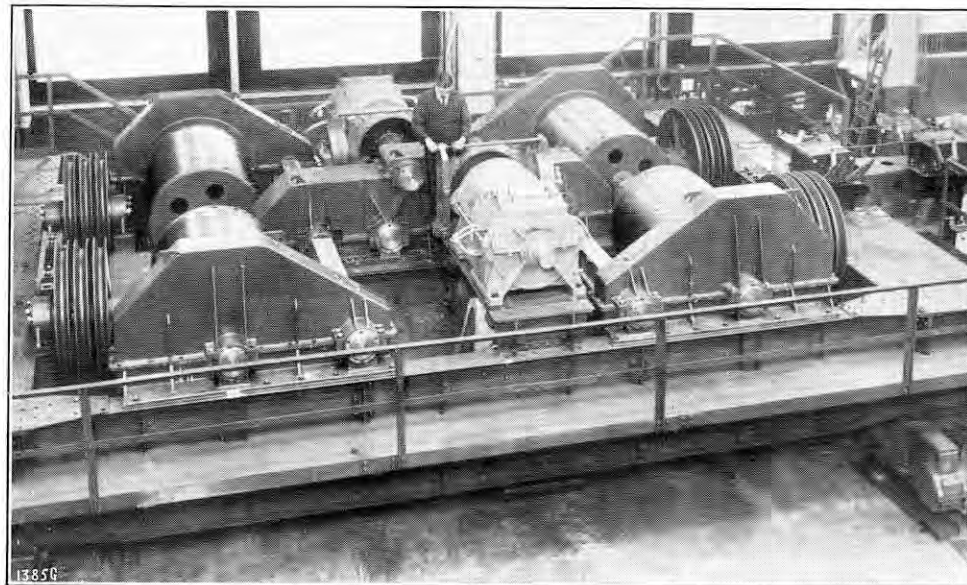


FIG. 7. MAIN TROLLEY UNDER CONSTRUCTION.

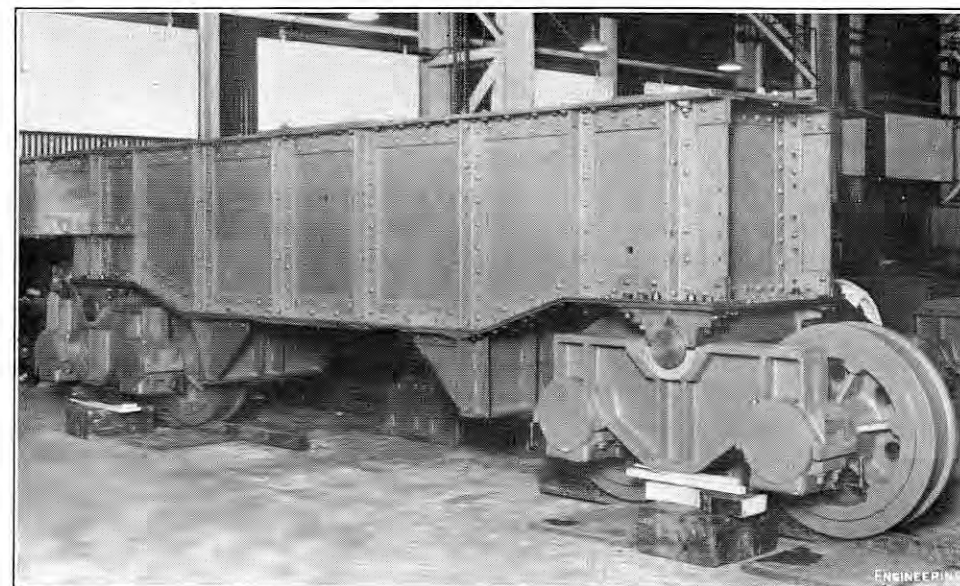


FIG. 8. SILL GIRDER AND BOGIES OF MAIN TROLLEY.

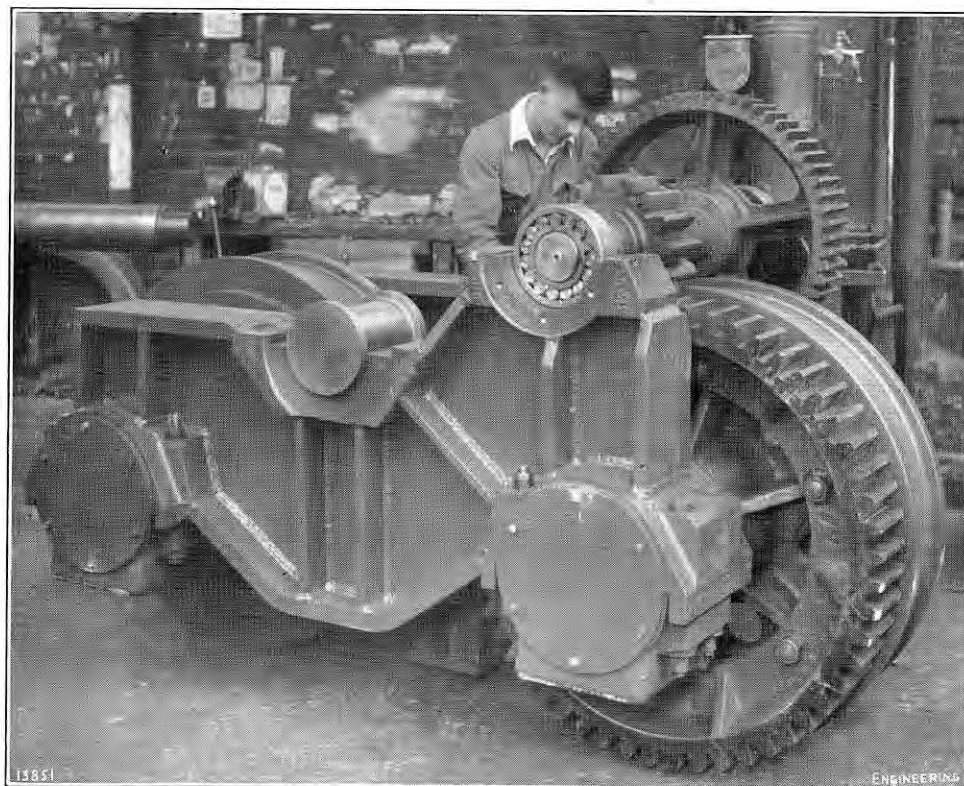


FIG. 9. TWO-WHEEL BOGIE FOR MAIN TROLLEY.

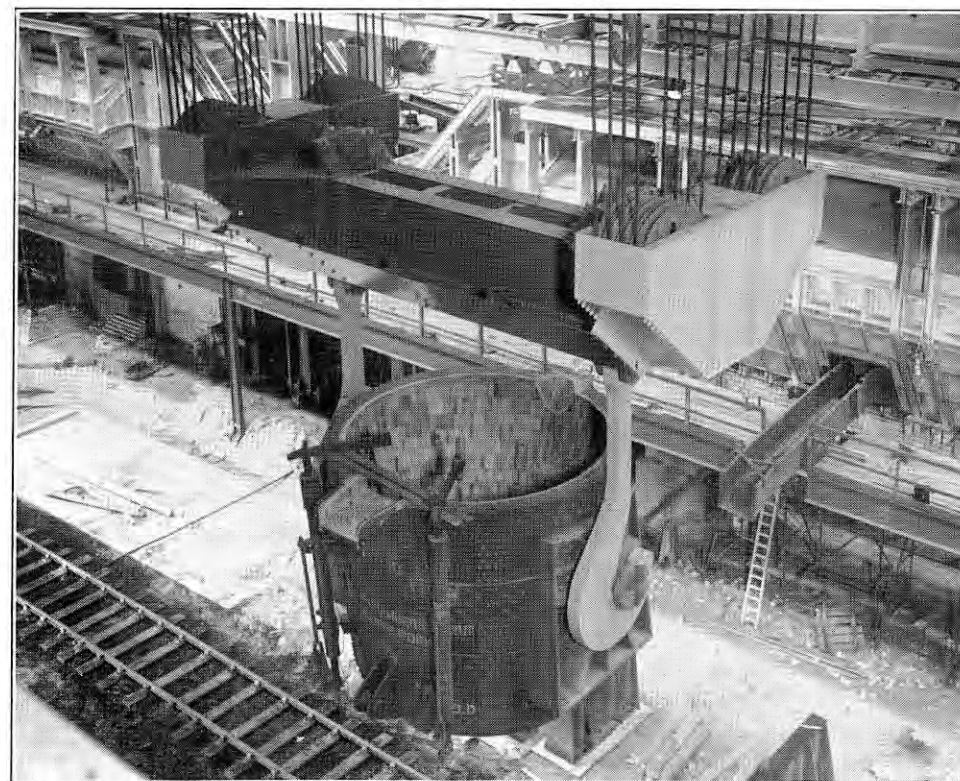


FIG. 10. LADLE BEAM AND HOOKS.

steel hoisting drums (3 ft. 6 in. in diameter) for coiling the 16 falls of rope, the system of return sheaves and rope anchorages being arranged as for the 250-ton crane. The auxiliary-trolley hoisting motion is of 25-ton capacity, with eight falls of rope; the steel hoisting drum is 2 ft. 11 in. in diameter. The trolley runs on steel-tyred cross-traverse wheels with through-axles mounted in bronze bearings. The unladen weight of the 125-ton crane is approximately 260 tons, or 385 tons when carrying full load, and the maximum individual wheel load on the gantry is approximately 71 tons.

ELECTRICAL EQUIPMENT.

All electrical equipment is arranged to operate on a 220/230-volt direct-current supply. The motors are Laurence Scott "Super-Mill" type, series wound and one-hour rated, the horse-power and running speeds being as indicated in the table of operating speeds. All motions are controlled by means of contactor control gear, with the exception of the auxiliary X.T. motions, which have heavy-service steelworks-type drum controllers, giving plain series control in each direction except on the lowering side of the hoisting motions, which are arranged for potentiometer control with dynamic braking. Protective devices for all motor circuits are contained in a separate protective panel. An electro-mechanical brake of the Igranic "M" type is fitted to the motor extension shaft of each drive, and an overwinding switch of the Igranic Palmer type, with dynamic braking stop, is provided on the hoisting motions.

LITERATURE.

History of the Second World War: Works and Buildings.

By C. M. KOHAN, O.B.E., M.A. H.M. Stationery Office, York House, Kingsway, London, W.C.2; and Longmans, Green and Company, Limited, 6 and 7, Clifford-street, London, W.1. [Price 32s. 6d. net.]

IN compiling the official history of the last war, it was wisely decided to exercise the minimum amount of control over the individual authors. The outcome was a happy one in the present instance. Despite the lengthy and factual treatment of the chosen theme—the co-ordination of the Government's building programme during a critical decade, and its impact on the building industry in this country—the resulting book is surprisingly readable. This is partly due to the author's practice of punctuating his narrative with short, but illuminating, summaries of what has gone before. It might be well, perhaps, if the underlying rule were better known: "Tell them what you are going to tell them; then tell them; then tell them what you have told them." Apart from the general interest which the book as a whole should have for engineers, many will turn with particular interest to the chapters which describe the particular activities in which they had a part; when, undoubtedly, the verdict will be that the mass of facts and figures to which the author had official access have been presented faithfully and with discrimination.

Broadly speaking, the book deals in turn with three different facets of the immensely complex problems and relationships—bedevilled throughout by the violent ebb and flow of war-time economy—which confronted the Government and the building industry between the years 1935 and 1945. The first two parts deal chronologically with the period from 1936 to 1942; the two succeeding parts analyse the resulting problems of control and co-operation, first as between the Government and the industry, and then as between ten or more separate Government departments, each with its own tradition of self-sufficiency. Part V attempts to bring the story into some sort of focus, and describes the steps taken to bridge the gap between

war and peace. Finally, the supporting documents and other detailed information, necessary to a proper understanding of the main contents, are included in a series of notes and appendices. A key to the official history of which this book forms a part appears on the dust-cover. It is a pity this was not incorporated in the book itself; is it too late to suggest that this practice should be adopted in future volumes?

Much of the first three parts is concerned with the swing from control by priority to control by allocation, back again to priorities, and forward again to allocations, now called "ceilings." The arguments for and against the two types of central control are brought out clearly by the author, and leave no excuse for any similar vacillations in major policy in the future. One of his thumb-nail summaries appears on page 66: "The building industry—let it once more be stressed—was not at any time well-knit or highly organised; its great size, the multiplicity of its trades, the diverse character and quality of the 80,000 or more firms of which it was made up, were intractable factors. The separate and parallel organisation of the civil engineering industry brought in a further complication." On page 260, the author suggests that the reorganisation of the Army Works Service, following official censure (later qualified) of the conduct of the militia-camp programme, resulted in a "less flexible, more cumbersome" machine. It could be argued against this verdict that there was, in effect, no machine at all before the reorganisation, and that the new machine was not cumbersome in relation to the magnitude of the work to be done. In any case, it was soon to be put to the test by the immense "Bolero" programme. The impression thus far created, of able men wrestling with events of overwhelming size, complexity and speed, is greatly strengthened in reading the detailed accounts of the work which fell to be done by the other two Services, and by the various Civil Departments and Directorates. The size and weight of the Admiralty programme alone will come as a surprise to many, totalling as it did nearly 25½ million by 1945.

Fortunately for the reader, the personalities taking part in these events are not entirely excluded from mention, and the pages are enlivened here and there by direct references to their views. Three examples must suffice. On page 114: "The Prime Minister laid it down as fundamental that offence came before defence and that precedence was to be given to works which improved the striking power of the forces." On page 109: "The Director General of the Ministry of Works insisted that '... the problems cannot be solved by the statisticians talking globally and making precise deductions from approximate data which contain large errors'..." On page 111: "In the words of Lord Reith... 'I cannot understand why there should be introduced between myself and P.E. (the Production Executive) a new Minister, in order that he may have information on strategy and policy which could (and I think should) be available either to Bevin or me.'"

It is to be hoped that this and other fully documented accounts of administrative frameworks, tested sometimes to the point of failure and often to the point of fatigue, will point the way to improved patterns of large-scale organisation, for peace as well as war, which will at least avoid the more obvious errors of the past. The means for systematic study exist in the various Government and civilian management research organisations which are now reaching maturity. The country cannot continue to rest on "administrative innovations and patient diplomacy," coupled with voluntary acceptance of irksome controls. It is true that such methods, in the hands of devoted men, have often brought order out of disorder in the past—as instanced in the volume under review—but at what cost?

ELECTRIC-TRACTION BRAKING.—III.*

By T. F. WALL, D.Sc., M.I.E.E.

Braking on a Level Track.—Suppose that a train is on a level track running at a speed of $v_{\max}$ metres per second. It is then braked to a standstill, and it will be assumed that the retardation of b metres per sec.² remains constant throughout the braking period. Then the time T seconds required for the complete braking operation will be related to the speed as follows. Since the retardation is of constant magnitude, the ratio $\frac{dv}{dt}$ will be constant, and reference to Fig. 5, page 420, will show that for any point such as c , the equation is,

$$\frac{ao}{cd} = \frac{T}{T-t}$$

so that,

$$\frac{T-t}{T} = \frac{v}{v_{\max}},$$

from which it follows that

$$\frac{t}{T} = 1 - \frac{v}{v_{\max}} \quad (10)$$

Consequently, when $t = 0$, $v = v_{\max}$, and $v_{\max} = 2v_{\text{mean}}$.

The power developed in the braking operation will then be given by the rate of loss of the kinetic energy; that is,

$$W = -\frac{dv}{dt} \quad (11)$$

and the numerical value of this power can be derived from expression (9), on page 324, *ante*.

If expression (9a), of Part II, is differentiated with respect to the time t , and if the result is inserted in place of the right-hand side of equation (11) it will be found that the following equation will be obtained:

$$W_{\text{Brake (max.)}} = \left[10^3 \left(1 + \rho \right) - 9 \cdot 81 \frac{w}{b} \right] v_{\max} \quad (12)$$

watts per ton,

where $v_{\max}$ metres per second is the speed of the train at the moment when the braking action begins, and ρ is the percentage to take account of the moment of inertia of the rotating parts of the train.

It is seen, therefore, from the expression (12), that the initial braking power will increase proportionally with the speed.

If expression (9), of Part II, is used to derive the braking power, it will be seen that,

$$W_{\text{Brake (max.)}} = \left[278 \left(1 + \rho \right) - 2 \cdot 7 \frac{w}{b} \right] V_{\max} \quad (13)$$

watts per ton weight,

where $V_{\max}$ km. per hour is the speed of the train at the moment when the braking operation begins.

Since, in equation (13), the retardation factor b will usually be much greater than the quantity $2 \cdot 7 w$, the initial braking power will be very closely proportional to $v_{\max}$. The mean power during the braking period may then be taken to be,

$$W_{\text{Brake (average)}} = \frac{1}{2} W_{\text{Brake (max.)}} \quad \text{watts per ton weight of train.} \quad (14)$$

Braking on an Incline.—Reference to Fig. 6, page 420, will show that, for the braking conditions on an inclined track, the following equation will hold: potential energy in kg. metres is

$$U = [l 10^3 M_{\text{Tons}} \sin \alpha - w b M_{\text{Tons}}] \text{ kg.m.,} \quad (15)$$

where l metres is the length of the track, and w in kg. per ton is the retarding force of the rail friction and windage per ton weight of the train.

In practice it is usual to define the incline $\sin \alpha$ in the form, s unit per 1,000, i.e., 10 ft. per 1,000 ft.,

* Part II appeared on page 324, *ante*.

so that $\sin \alpha = \frac{h \text{ ft.}}{l \text{ ft.}} = s \text{ per 1,000}$. If, for example,
 $s = 22$, $\sin \alpha = \frac{h}{l} = 0.022$. . . (16)

If the length of an incline is given as L km., the length in terms of l is $l = 1,000 L$ and the equation (15) can be re-written in the form,

$$U = L \times 10^3 \times M_{\text{Tons}} (10^3 \sin \alpha - w) M_{\text{Tons}},$$

so that

$$U = L \times 10^3 (s - w) \text{ metre kg. per ton weight of the train.}$$

Then $U = L \times 10^3 (s - w)$ metre-kg. per ton weight of train or, since 1 watt hour = $0.102 \times 3,600$ metre-kg.

$$U = L \times \frac{10^3}{360} (s - w)$$

watt-hours per ton weight of train on an incline of L km. The potential energy of the train is then

$$U = 2.7 (s - w) \text{ watt-hours per km. of incline per ton weight of train.} \quad (17)$$

This expression shows that, in the case of a steep incline, the brake energy is approximately proportional to the slope s . For small values of s (less than about 10 per 1,000) the effect of the rail and windage friction factor w , becomes appreciably important.

Braking Power on an Incline.—In view of the treatment already considered for the braking power on an inclined track, the following relationships can be stated. If T seconds is the time taken for the train to travel a distance of L km. on the inclined track, the braking power will be

$$W_{\text{Brake}} = \frac{U}{T},$$

and, substituting for U from expression (17), it is seen that

$$W_{\text{Brake}} = \frac{2.7 (s - w)}{T}, \quad (18)$$

watt-hours per km. of incline per second per ton-weight of train.

Numerical Example.—A train on a level track is running at a speed of 60 miles per hour. and is to be brought to a standstill in 1,000 yards. Find the magnitude of the constant braking force which must be applied for this purpose.

$$\text{Sixty miles per hour} = \frac{60 \times 1.6 \times 1,000}{3,600} \text{ m. per}$$

second, that is, 26.6 m. per second; 1,000 yards is 915 m. The mean value of the speed during the braking period is $\frac{1}{2} \times 26.6 = 13.3$ m. per second, so that the time required to bring the train to rest is

$$T = \frac{915}{13.3} = 68.6 \text{ seconds.}$$

The retardation is, therefore,

$$b = \frac{26.6}{68.6} = 0.388 \text{ metre per sec.}^2$$

so that the required retarding force is

$$Q = \frac{M_{\text{Tons}} \times 10^3 \times 0.388}{9.81} = 39 \text{ kg. per ton, or}$$

$$86 \text{ lb. per ton.}$$

FORCE OF ADHESION.

The force of adhesion between the wheels of the train and the track accounts for the grip which is exerted between the rotating wheels and the rails. The magnitude of this force is eventually the determining factor which limits the magnitude of the braking action that can be applied. In accordance with the extensive investigations made by Metzkwow, the range of values of the adhesive factor μ_s for normal conditions of the rails lies between 0.17 and 0.26. These limits only hold for the case of rotating wheels. If the brake action locks the wheels very objectionable flats will be

developed on the tyres and the adhesive factor will be appreciably reduced.

In order that the wheels of a long train should not become locked by braking, the German State Railways adopted as the value of the adhesive factor, the quantity, $\mu_s = 0.15$ ton per ton weight of train. Accepting this as the limiting value of the adhesive factor, it is possible to derive some numerical conclusion regarding the magnitude of the retardation b_{max} , which may be allowed in practice. It is also possible to determine the number of axles which should be used for braking purposes. Thus, if G tons is the weight of the whole train, and G_B tons is the weight of that part of the train which corresponds to the number of axles to which the braking action is to be applied, then

$$b_{\text{max}} = \frac{9.81 (B + W)}{G (1 + \rho)} \text{ metres per sec.}^2, \quad (19)$$

where B kg. is the total braking force, and b m. per

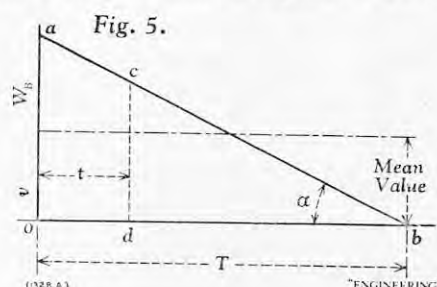
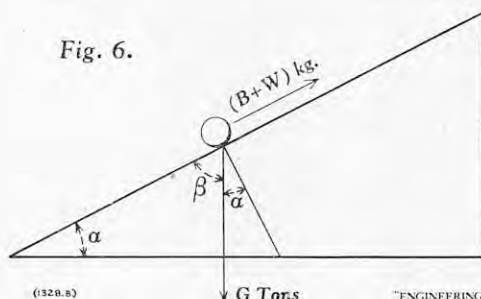


Fig. 6.



second² is the retardation of the train per ton, W kg. is the total force of rail and windage friction and

$$B = \mu_s G_B 10^3 \text{ kg.,} \quad (20)$$

that is,

$$\mu_s = \frac{B}{G_B 10^3}$$

Further, the rail and windage friction braking effect will be $W = w G$ kg. m., where w is in kg. per ton.

Hence, from expressions (19) and (20)

$$b_{\text{max}} = 9.81 \times \frac{(\mu_s 10^3 G_B) + w G}{G (1 + \rho)},$$

metres per second² per ton weight of train. That is, the retardation of the train will be given by the expression

$$b_{\text{max}} = 9.81 \left[\frac{(\mu_s 10^3 \frac{G_B}{G}) + w}{1 + \rho} \right], \quad (21)$$

metres per sec.² per ton weight of train.

For dealing with problems of railway traction, the following fundamental dynamical relationships will be found indispensable.

(i) Linear Motion.

Driving-force in dynes = mass in grammes $\times$ acceleration in cm. per sec.²

Driving-force in kg. $\times 9.81 \times 10^3$ = mass in grammes $\times$ acceleration in cm. per sec.²

Force in kg. $\times 9.81 \times 10^5 = 10^3 \times$ mass in kg. $\times 10^5 \times$ acceleration in km. per sec.²

Accelerating force in kg.

$$10^3 \times \text{mass in kg.} \times \text{acceleration in kg. per sec.}^2 = \frac{\quad}{9.81}$$

Force in kg.

$$= \frac{\text{mass in kg.} \times \text{acceleration in metres per sec.}^2}{9.81} \quad (22)$$

(ii) Rotary Motion.

Accelerating torque in kg-metres, that is

$$\tau_{\text{kg-m}} = \left\{ \frac{\text{Moment of inertia } J \text{ in kg. m.}^2 \text{ units}}{9.81} \right\} \times \left\{ \text{acceleration } \frac{d\omega}{dt} \text{ in radians per sec.}^2 \right\}$$

that is

$$= \frac{J \text{ in kg.m.}^2 \text{ units}}{9.81} \times \frac{d\omega}{dt} \quad (23)$$

The moment of inertia of a rotating mass is

$$J = \frac{1}{2} M R^2 \text{ kg.-metre}^2 \text{ units,} \quad (24)$$

where M is in kg. units and R m. is the radius of the rotating mass.

For the rotor of an electrical machine which has p pairs of poles, the following relationship holds:

$$\text{Angular acceleration } \ddot{\theta} \text{ in electrical radians} = p \frac{d\omega}{dt}$$

Kinetic energy of a rotating mass =

$$\frac{1}{2} \frac{J \omega^2}{9.81} \text{ kg.m.} \quad (25)$$

The retarding force in kg. =

$$\frac{(\text{mass in kg.}) \times (\text{retardation in metres per sec.}^2)}{9.81}$$

The braking-power in kW =

$$\frac{\text{braking force in kg.} \times \text{speed in metres per sec.}}{10^3} \quad (25a)$$

Now, if an appropriate value be assumed for the factor w in kg. per ton weight of train, and also assuming a value for ρ per cent. as usually found in practice, the safe limit for retardation as usually applied to railway traction is

$$b = 1.5 \text{ metres per sec.}^2 \quad (26)$$

This value, however, assumes that all the axles of the train are braked. When this is not the case, the retardation limit will be about in the proportion $\frac{G_B}{G}$, where G_B is the weight of that portion of the train which corresponds to the braked axles, and G is the total weight of the train.

The maximum permissible braking power will then be,

$$b_{\text{max}} = \frac{\left[\left(\mu_s \times 10^3 \times \frac{G_B}{G} \right) + w \right] \times 9.81}{(1 + \rho)} \text{ metres per sec.}^2 \text{ per ton.} \quad (27)$$

From calculations made for normal types of trains, it is found that the weight ratio $\frac{G_B}{G}$ is related to the permissible retardation b_{max} , as shown in the following table.

b_{max} metres per sec. ²	0.5	0.7	1.0	1.2	1.5
$\frac{G_B}{G}$	35	49	70	80	105

From Fig. 6, it is seen that, in order to obtain constant speed when braking on an incline, the rail and windage friction, plus the total braking force, must be equal to that component of the mass G , which is resolved in the direction of the incline, viz.,

$$10^3 G \cos \beta = B + W,$$

where,

$$B = \mu_s G_B 10^3 \text{ kg. } W = w G \text{ kg.,}$$

and

$$\cos \beta = \frac{B + W}{10^3 G}.$$

But $\cos \beta = \sin \alpha$, so that,

$$\frac{s}{1,000} = \sin \alpha = \cos \beta = \frac{B + W}{10^3 G},$$

and substituting from expressions (19) and (20), gives

$$\frac{s}{1,000} = \left[\frac{(\mu_s G_B 10^3) + W G}{10^3 G} \right] \times 1,000,$$

that is,

$$s \text{ per } 1,000 = \left[\frac{(10^3 \times \mu_s \times G_B) + W G}{10^3 G} \right] \times 1,000,$$

or

$$s \text{ per } 1,000 = \left(\frac{10^3 \mu_s \times G_B}{G} \right) + W. \quad (28)$$

The following table shows the permissible values of the ratio $\frac{G_B}{G}$ for a series of values of the slope of the incline. In deriving this table, it has been assumed that the adhesive factor, $\mu_s = 0.15$, and that the braking action of the rail and windage friction is $w = 5$ kg. per ton weight of the train.

s per 1,000	10	15	20	25	30	35	40
$\frac{G_B}{G}$ per cent.	3.3	6.66	10	13.3	16.7	20	23.3

Thus, if s per 1,000 = 15, then from expression (28) it follows that

$$\frac{G_B}{G} = \frac{s \text{ per } 1,000 - W}{w_s \times 10^3} = \frac{15 - 5}{0.15 \times 10^3},$$

that is,

$$\frac{G_B}{G} = \frac{10}{150} = 6.66 \text{ per cent.}$$

For main line railways, friction-braking is easily the predominant method, and, within its limits, the block-brake occupies the dominant position.

Electric Braking.—An obvious method of electric braking is to use the motors as generators and to convert either the whole or a part of the stored kinetic energy into electric power. In this way, the disadvantages of friction braking can be eliminated, and the inherent advantages of electric braking can be realised. The electric energy generated in this way may be dissipated as heat energy in resistances, thus giving resistance braking, or it can be fed back into the supply network, thus giving the so-called regenerative braking.

When electric braking is used, the adhesive force between the wheels and the rails can be used to its limiting value, because if any tendency develops for the wheel to slip, the generator action simultaneously falls away, so that locking of the wheels is impossible when electric braking is used.

Of special importance is the very slight demand on the wheel tyres and brake blocks in the case of trains which have to stop frequently, and also when running down inclines, since almost the whole of the brake energy is then converted into electric energy. In this way, the nuisance of the brake-block dust is avoided, and, particularly for suburban trains, the avoidance of dust production is a very valuable feature, since such dust will contaminate the carriages and general equipment of the train. A further advantage of electric braking is that loose wheel tyres and flats on the tyres are avoided.

When frequent braking is required, as in the case of suburban trains, and also when long periods of braking are necessary, as in the case of mountain railways, the brake energy is so great that it is profitable to feed this energy back into the supply network. This regenerative method of braking is particularly important because, in addition to the other advantages of electric braking, the recovery and utilisation of the brake energy is possible, and the recovery of this energy provides an important means for improving the efficiency of the railway system.

For electric braking, supplementary switchgear and regulating apparatus are required, and the motor power will have to be increased in order to cope with the increased power needed when the train is to be braked on an incline.

From a consideration of the aspects of the extra costs involved when electric braking is used, and also in view of the various advantages of this method of braking, certain conclusions can be reached with regard to the influence of the different methods of braking on the economic efficiency. It may be said here that electric braking on main-line railways will only be profitable when the stopping places or long inclines are sufficiently numerous.

OCCUPATIONAL RISKS OF FIREMEN.

A QUESTION of some interest to the factory owner who has the misfortune to have a fire on his premises was recently discussed before, and decided by, a judge of assize. It was this: if a fireman is exposed to unexpected danger, and suffers in consequence, can the owner be held liable? The case (*Mornington v. Ironbridge Metals Works, Limited, and Others*) is noted in the *Law Times* of December 12, 1952, page 309. The defendants occupied a factory in which they recovered aluminium from aluminium foil, in the course of which process quantities of fine dust, containing aluminium and carbon particles, were created. This dust lay in thick deposits all over the factory, and no steps were taken to remove it. While lighting a fire at the factory, the plaintiff, in the course of his duties as a part-time fireman, was injured by a dust explosion caused, as was alleged, "by the exceptional and unnecessary dangers of fire and explosion which the defendants have created and maintained on the premises."

In an action by the plaintiff, claiming damages for negligence, the defendants denied liability and pleaded, *inter alia*, that the plaintiff attended the fire with knowledge of the attendant risk or injury to himself and voluntarily incurred that risk. Mr. Justice Hallett, in the course of his judgment, referred to the maxim *volenti non fit injuria*, which normally applies in every case where a man must be taken to have accepted the risk incident to any kind of employment. He said, however, that it would only apply to excuse the consequences of an accident in this case if the plaintiff fully appreciated the dangerous character of the physical condition brought about by the negligence of the defendants, and if the plaintiff were willing, i.e., he had consented, to assume the risk without compensation. "A man," said his Lordship, "could not be said to be *volens* unless he was in a position to choose freely, and if he was acting under the compulsion of a duty his consent should rarely, if ever, be inferred. On the facts the plaintiff was neither *sciens* nor *volens*, and he had not implicitly agreed to give up any rights which he would have had but for such agreement." He then proceeded to find that the plaintiff was entitled to succeed because there was a duty on the defendants not to have their factory in the dangerous condition in which it was, and they knew, or ought to have known, that, by lack of reasonable care, they were creating and maintaining exceptional and serious risks of fire and explosion in the factory; that, by reason of such risks, a fire was likely to occur; that, if a fire did occur, members of the fire service were likely to enter the premises to deal with it in the course of their duty; and that, if they did so, they would be exposed to an exceptional and serious risk of being injured by explosion; therefore, it was a duty of the defendants towards the firemen, not to have their factory in that dangerous condition. As the decision in this case is likely to cause some apprehension in the minds of factory owners, it is desirable to emphasise that the facts were unusual. At all events, the case could not be quoted as an authority for the proposition that the factory owner is liable to pay damages for every injury sustained by a part-time fireman when acting in the discharge of his duty. After all, a fireman must know that he is exposing himself to a certain amount of risk.

THE ENGINEERING OUTLOOK.

X.—THE LIGHT ELECTRICAL INDUSTRY, AND THE ELECTRICAL WIRE AND CABLE INDUSTRY.

FOR very large sections of the light electrical industry, particularly those making domestic appliances, marketing conditions deteriorated considerably in 1952 and there is as yet little prospect of much improvement. At home, high purchase tax and the restriction on hire purchase have accentuated the fall in sales which followed a decline in consumers' buying power. Abroad, import restrictions have been necessary in many countries (of which the most notable is Australia) to correct serious deficits in their foreign balances, and these have naturally affected consumer goods most severely. In some cases, they have meant a total ban on imports. The increase in housing construction may have sustained somewhat the output of such items as cookers and wash-boilers, but, nevertheless, these suffered quite a considerable set-back in 1952. The output of washing machines, vacuum cleaners, electric kettles, electric irons, refrigerators, etc. (as shown in Figs. 1 to 8, on page 422) fell off substantially in 1952. In the case of washing machines and refrigerators, this reverse follows a period of rapid expansion, under which, between 1949 and 1951, the output increased by 140 and 60 per cent., respectively. The only item of domestic electrical equipment produced in greater numbers in 1952 than in 1951 was television sets, but the sales of these increased only at the expense of domestic radio sets, the output of which declined by 40 per cent. (see Figs. 9 and 10).

IMPROVED EFFICIENCY AND NEW PRODUCTS.

The contraction of demand has not been entirely without its compensations for the light electrical industry; declining output has meant greatly reduced profits for even the most efficient companies and loss of employment for many workpeople, but it has also helped to prune away much inefficiency and to put the industry on a sounder footing. The more efficient companies have increased their share of the national output, while production of some of the simpler types of equipment, such as electric irons, by firms with very small manufacturing facilities (some relying upon other makers for the manufacture of their products) has been greatly reduced. Despite the set-back, one of the larger companies, at least, has been going ahead with plans to extend capacity. Morphy-Richards, Limited, have opened a new factory at St. Mary Cray in Kent, but Mr. George Wansborough, the chairman of the company, stated at the annual general meeting in November that this would not long satisfy their needs, and that they were then "actively fighting the usual battle with the Government departments concerned" for permission to complete an extension. Another company, Pye, Limited, do not think the moment inopportune to re-enter the market for domestic electric appliances. Before the war, Pye, Limited, for a short time made a range of products including refrigerators, vacuum cleaners and electric irons. Since then, however, they have concentrated on radio and television manufacture. The first product to be marketed in their new range of domestic appliances is an automatic tea and coffee maker. In the market for electrical consumer goods, it is always open to any manufacturer to create a new demand by devising a new product, so that success may be quite independent of the booms and slumps in economic activity. No manufacturer, moreover, is likely to stay in business long who does not constantly improve his products or develop new ones.

In the United States, perhaps rather more than in the United Kingdom, there has been keen technological competition. A slump in domestic appliances in the United States started in the middle of 1951, but there was some revival in the middle of 1952, though the total value of retail sales in 1952—6,000 million dols.—was slightly lower than in 1951. The revival has been accounted for almost entirely by new appliances. Sales of home freezers, fat fryers, air conditioners, dehumidifiers and other comparatively new products were all higher in 1952

than in 1951, while sales of irons, radio sets, washing machines and refrigerators, which have been established on the home market in the United States for a very long time, fell off considerably. Sales of some established items like vacuum cleaners increased, but only because new designs were supported by intensive advertising.

Because of lower consumers' buying power, it is impossible to introduce new designs and new products on the market in the United Kingdom on such a large scale as in the United States. In the United Kingdom the saturation point for refrigerators and washing machines is still a long way off, and some appliances, already extensively used in the United States, have not yet been introduced. It is interesting to note, however, that the International Harvester Company of Great Britain are to produce a new American type of "home freeze" unit. So far, the British subsidiary has not entered the market for domestic appliances, though the parent company is a leading producer of this type of equipment in the United States. A report by the Electrical Association for Women, published in October, 1952, drew attention to the need for a wide variety of electrical appliances in the United Kingdom, some of which are already available in the United States. They include apparatus for clearing ashes and sweeping chimneys, a dish washer and drier for small families, an inexpensive mixer and egg beater, and an electrically-driven perambulator. The Association assert that "Perfection depends upon a fully electrified home front," but they realise that this is an ideal, the achievement of which may be deferred for various reasons not within the control of the electrical industry. On the score of dependability, British appliances are beyond criticism, and, as the report states, "the reader cannot fail to be impressed by the records of lengthy use of the appliances." In the United Kingdom, as well as many overseas markets where the purchasing power is comparatively limited, this is at least as important a factor as rapid progress in the development of new luxury products.

EXPANSION IN ELECTRONICS.

There is nothing backward about British research and development in electronics. The use of electronic techniques in industry is still at a very early stage, and, apart from applications in radio and television, there is very little quantity production. Nevertheless, the value of the output of industrial electronic equipment is considerable. Mr. A. L. Whiteley, manager of the electronics

TABLE I.—United Kingdom Exports of Light Electrical Goods and Apparatus.

	Value (£1,000).		
	1950.	1951.	1952.
Wireless apparatus:			
Domestic radio receiving sets	2,730	4,765	4,440
Transmitting apparatus	6,496	5,707	7,905
Valves, complete	2,668	3,734	3,610
Telephone and telegraph apparatus	17,032	15,521	17,109
Electric light bulbs complete	1,235	1,569	1,360
Electric light appliances and accessories	3,659	4,430	5,317
Batteries, primary, complete	1,265	2,130	2,246
Accumulators	3,461	4,966	4,590
Electrical cooking and heating appliances	2,559	4,297	4,087
Electrical instruments	3,941	4,385	4,790
Electro-medical apparatus	1,821	2,710	2,500
Refrigerating machinery	9,846	14,000	14,117
Vacuum cleaners	2,359	3,515	2,286
Total	59,072	71,719	74,417

engineering department of the British Thomson-Houston Company, has estimated that the annual sales value of high-frequency generators for induction heating processes alone is in excess of 1l. million. The annual value of electronic motor-control systems for industrial machinery may be as large, while the output of electronic welding controllers and miscellaneous apparatus for timing and controlling processes is probably in the region of 500,000l. per annum. Electronic devices have been adopted most readily by the newer industries or by those processing newer materials. In the textile industries, a major application for electronic motor control is on modern nylon stocking knitting

machines. Some of the older industries, including steel manufacture, have failed to make wide use of electronic methods, but others, including machine tools, printing presses and paper machines, have adopted them for drive control.

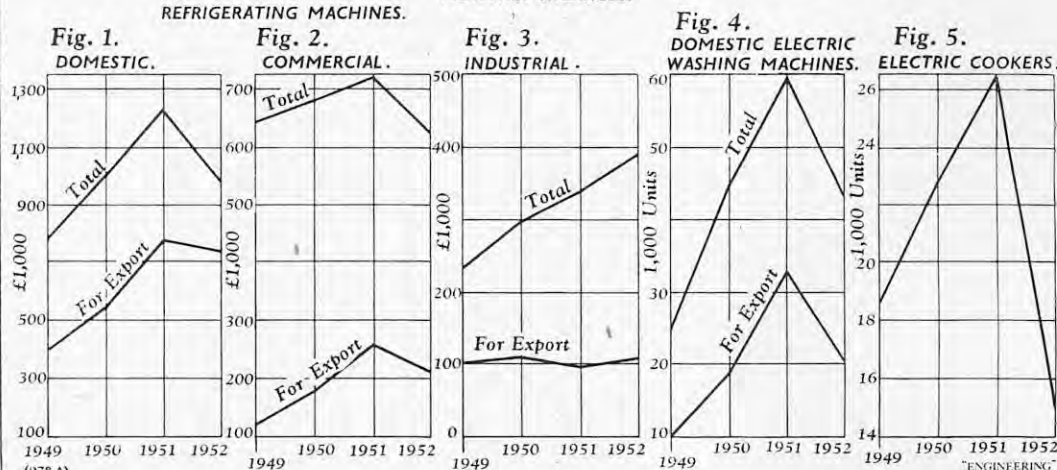
Electronic methods are still not competitive with conventional methods where only simple starting, stopping or reversing of electric motors is required. Present-day methods require expensive valve systems, but it has recently been announced that new types of crystal valves are being developed in both the United Kingdom and the United States, which have far-reaching possibilities. In the United States, it has even been claimed that television has been achieved without the use of thermionic valves other than the picture tube, but the most attractive immediate applications for the crystal valve probably lies in devices like deaf aids and electric telephone exchanges and computers, where very large numbers of valves are used which do not need to meet high standards in operational requirements. Much research and development work has

automatic screen-settling conveyors, three of which are employed, each attended by only three operatives. The total output of tubes by the ten manufacturers in the United Kingdom in 1952 is estimated to have reached nearly 1 million.

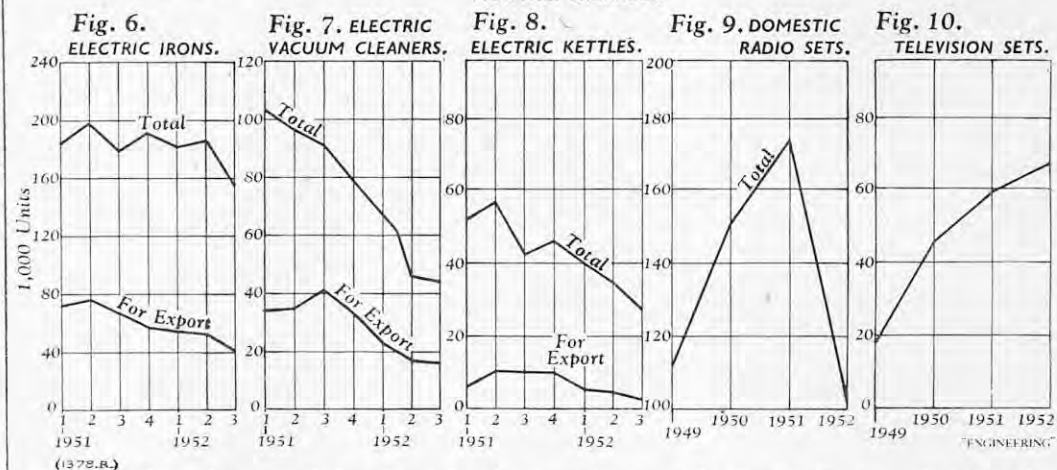
RADIO INDUSTRY CONTRASTS.

The increased demand for television sets, and re-armament orders, have resulted in an expansion of the radio manufacturing industry. The total number employed rose from 109,500 in December, 1949, to 142,000 in December, 1951. There has since, however, been a slight decline to 139,000 at the end of 1952, due partly to the cut in re-armament. Not all sections of the industry have expanded their capacity, and some makers of domestic radio receivers have been badly hit by the fall in consumer demand. During the last war, large numbers of relatively simple military radio receivers were produced on assembly lines which had formerly been used for the manufacture of domestic receivers. Under the present re-armament

FIGS. 1 TO 5, UNITED KINGDOM: PRODUCTION OF LIGHT ELECTRICAL EQUIPMENT; MONTHLY AVERAGES.



FIGS. 6 TO 10, UNITED KINGDOM: PRODUCTION OF LIGHT ELECTRICAL EQUIPMENT (CONTINUED); MONTHLY AVERAGES.



still to be done, however, before crystal valves capable of supplanting thermionic valves can be produced in quantity. One difficulty is insufficient understanding of the properties of the crystal materials, silicon or germanium. The production of germanium in quantity, of sufficient purity, is no easy task, while the mounting of the crystal and the contact element in the new valves is an operation of some precision, which will make large-scale production difficult.

Considerable progress has been made with the bulk manufacture of cathode-ray picture tubes for television sets. The demand for television sets has grown at double the rate of that for sound radio before the war, and since 1945 the tube makers have had to undertake heavy capital investment in evolving and installing machinery capable of carrying out, on a large scale, complex and delicate operations. One of the most intricate processes, the deposition of the luminescent coating, formerly had to be done by hand, and bulk production required a large number of operatives. Production has been speeded up in the works of Electric and Musical Industries, Limited, by the use of

programme, orders for receivers constitute less than half of the total orders for radio and radar equipment; many, moreover, are for very complex types, suitable for operation in fast high-flying aircraft. While, therefore, the value of these orders may be high, they have not compensated in volume for the fall in demand for domestic receivers.

The total value of re-armament orders is very high; in the middle of 1952, they amounted to 83l. millions and were being fulfilled at the rate of 2.1l. millions per month. The Royal Air Force estimate for 1953-54 for radio, radar and electrical equipment is 42l. millions. The greater part of the re-armament production comprises relatively expensive equipment, much of it for the radar defence chain of the United Kingdom, and this has made heavy demands on the capacity of manufacturers capable of handling the work. In 1951, the civil production of transmitting equipment suffered as the result of the weight of defence orders, and, as is shown in Table I, on this page, taken from the *Trade and Navigation Accounts*, exports fell from 6.5l. millions in 1950 to 5.7l. millions in 1951. In 1952, however, it was possible to achieve a high

level of production for export, substantially in excess of that of 1950. The heavy volume of work has called for large numbers of highly-skilled electronic engineers, who have been by no means easy to find. It is of considerable importance that an adequate supply of men of the highest calibre should be made available in a branch of engineering in which it is vital that the United Kingdom should remain in the forefront. The Ministry of Supply have therefore decided to double the number of apprentices at their School of Electronics at Malvern. The school, which has hitherto accommodated 120 students, has now been in existence for five years, and trains technicians, engineers, experimental officers and instrument makers, mainly to meet the needs of the Ministry's major scientific establishments and the Royal Ordnance factories. It is also intended to serve the country generally, however, and there is no obligation on the apprentices to enter Government service.

Television is rapidly becoming the mainstay of the radio industry; in 1952, 67,500 receivers were produced, 8,300 more than in 1951. This, however, does not compensate for the fall in domestic radio receivers, even assuming that capacity for their manufacture is easily switched to the making of television sets. A radio receiver has only about one-third of the components of a television set, but the fall of 71,000 in the number of radio receivers produced, in value and equivalent volume of output, was considerably greater than the increase in output of television sets. The increase in sales of television sets, moreover, was not perhaps so great as might have been expected in a year which saw the opening of two new television stations, giving a population coverage of an extra 8.5 million people. At the end of 1952, there were nearly 2 million television licences current, but, though the Kirk o' Shotts transmitter was opened in March, only 41,700 licences had been issued in Scotland. The Wenvoe station opened in August, but at the end of December only 45,300 licences had been issued in the West of England. In the London area, the percentage of licences to the population covered was 8.0, in the West of England 1.2, and in Scotland 1.0.

Differences in national and regional characteristics may account for the slower rate of expansion in the new areas, but this is not likely to be as significant a factor as the fall in consumer purchasing power. Sales are reported to have improved since December, and, after the uncertainty about purchase tax is removed on Budget Day, should be greatly stimulated by the arrangements made for special Corona-

tion programmes. Meanwhile, the British Broadcasting Corporation are planning to increase the population coverage from 78 to 88 per cent. Because of the need to restrict capital investment, the construction of the five additional medium-powered stations which will be required has been deferred, but steps have been taken to acquire sites and to prepare for building as soon as permission is granted. For the present, temporary arrangements have been made to bring the Coronation programmes to the areas which it is proposed to cover. A private concern, the Associated Broadcasting Development Company, is reported to be planning the construction of up to 50 stations for commercial television in the United Kingdom as soon as the law permits. These stations will have a radius of 10 to 15 miles, and, in some areas, will be able to serve audiences of more than 500,000 people. Altogether, at least 34 large commercial organisations, including some national newspapers, have applied for permission to operate television services.

GROWING EXPORT OPPORTUNITIES.

British exports of television transmitting equipment have been at a high level for some time, and should increase substantially in 1953. Marconi's

Fig. 11.

UNITED KINGDOM: PRODUCTION OF INSULATED WIRE AND CABLE, MONTHLY AVERAGES.

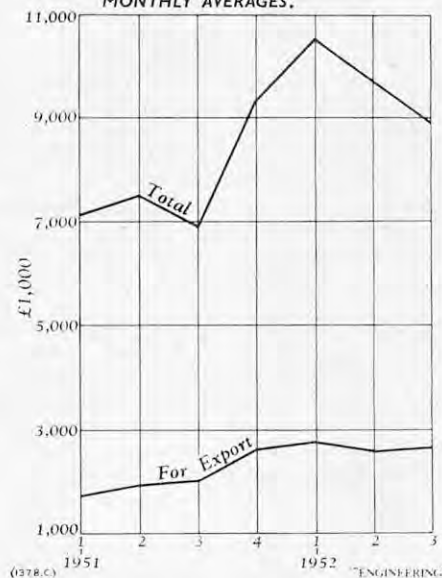


TABLE II.—UNITED KINGDOM EXPORTS OF ELECTRIC WIRES AND CABLES.

	Quantity (Tons).			Value (£1,000).		
	1950.	1951.	1952.	1950.	1951.	1952.
Telegraph and telephone cables and wires :						
Submarine	13,392	4,338	4,702	1,620	559	720
Other	35,777	21,553	26,333	7,934	5,819	8,250
Other types of wires and cables :						
Paper-insulated :						
To British West Africa	779	697	775	137	145	185
" Union of South Africa	3,154	3,080	2,457	555	590	592
" India	7,494	4,939	12,324	1,227	938	2,944
" Malaya	2,547	2,121	2,471	373	387	623
" Hong Kong	1,374	954	1,030	235	74	268
" Australia	7,252	5,350	6,933	1,226	1,049	1,643
" New Zealand	2,423	917	933	413	179	239
" Other Commonwealth countries and the Irish Republic	4,184	7,651	6,958	723	1,632	1,736
" Norway	1,323	1,006	341	227	211	88
" Egypt	1,560	1,131	802	233	223	191
" Other Foreign countries	5,308	5,061	7,877	901	1,244	2,079
Total	37,398	32,907	42,901	6,250	6,672	10,588
Rubber-insulated :						
To Union of South Africa	1,449	1,405	1,510	400	570	646
" British East Africa	816	966	664	253	466	345
" India	2,323	1,394	1,550	632	465	645
" Malaya	733	1,288	1,062	189	498	498
" Australia	576	502	648	181	135	269
" New Zealand	1,369	1,534	1,548	361	618	778
" Other Commonwealth countries and the Irish Republic	3,434	5,107	5,234	976	2,073	2,490
" Foreign countries	3,967	3,865	3,710	1,050	1,524	1,776
Total	14,667	15,861	15,926	4,042	6,349	7,447
All other :						
Cotton, silk or artificial-silk insulated	1,548	1,535	1,682	590	695	885
Enamel, glass or asbestos insulated	2,266	2,023	1,537	894	987	934
Other	4,088	5,657	6,322	1,420	2,479	3,338
Total	7,902	9,215	9,541	2,904	4,161	5,157
Grand Total	109,136	83,874	99,403	22,750	23,560	32,162

Wireless Telegraph Company have announced recently that they have received the largest export order for television equipment placed in the United Kingdom. They are to supply two 7.5-kW sets and studio equipment, valued at 300,000/., for the Italian State Broadcasting Corporation. The Canadian Broadcasting Corporation has already purchased equipment to the value of 500,000 dols. from the Marconi Company, who have also supplied equipment to the United States, South America and Thailand. Exports of television receivers have hitherto been limited, since, apart from the United States, no overseas countries have been operating television services on anything approaching the British scale. A beginning has been made, however, and, in 1952, 5,500 British television sets, valued at 365,000/., were exported. Most of these went to Canada, though some were also exported to Brazil. Prospects in Canada are very good; the first television services from Montreal and Toronto were inaugurated in September. A contract for a transmitter at Ottawa has been placed with Marconi's Wireless Telegraph Company, and stations are planned for Vancouver, Winnipeg and Halifax. Other markets in which British manufacturers of television receivers have good prospects are Italy, South America, Scandinavia and Australasia. The dollar shortage gives British exporters a considerable advantage over their only serious competitors, the United States manufacturers. British manufacturers claim that their equipment is technically superior and, in general, cheaper than that of the Americans. United States manufacturers, however, have shown their determination to build up an export trade by offering transmitters at very low prices, in the hope of being able to recoup themselves from the revenue of the stations and sales of receivers.

The market for television receivers abroad is large, but should not be overestimated. Most of the countries which are providing television services already possess well-developed radio manufacturing industries, and may be expected to undertake the manufacture, or at least the assembly, of television receivers within a comparatively short period. They are, however, likely to be dependent on imports of cathode-ray tubes and the more intricate components for a very long time. The Australian market may prove to be fairly typical. It was announced in January, 1953, that both national and commercial television services were to be permitted in Australia. The local radio industry at present meets almost the entire home demand for radio receivers, and may be expected to undertake the manufacture of chassis for television receivers without difficulty. More complex work is well within its scope; all the transmitters for the sound broadcasting service were made in Australia. Even in India, work requiring a very high degree of technical skill is to be attempted. An agreement has been signed between the Indian Ministry of Defence and the Cie. Generale de T.S.F. under which the French company will provide technical assistance for the establishment of a radio-communications industry in India. Full production of wireless equipment is to be attained in three years, and by the end of the fourth year, cathode-ray tubes are to be made.

For the light electrical industry as a whole, export prospects are, perhaps, not so bright as for television equipment. Local manufacture of the simpler items exported is growing, and very little modification of import restrictions is to be expected. For many types of equipment, Australia has been the most important market, but, though the balance of payments has been improving, import restrictions have only been slightly relaxed. Such items as washing machines, refrigerators, electric fans, cookers and floor polishers, imports of which in 1952 were restricted to 20 per cent. of the quantities imported in 1950-51, have been allotted a quota of 30 per cent. in 1953. Despite the difficulties of 1952, it may be noted, however, that the total exports of the light electrical goods and services listed in Table I increased in value, at least as compared with 1951. Exports of even those items which showed a decrease, such as radio receivers, electric light bulbs and accumulators, moreover, were still considerably higher than in 1950. On

the home market, there is still little indication of a revival in sales for a wide range of domestic appliances; much will depend on whether or not purchase tax can be reduced in the coming Budget, and upon some relaxation of restrictions on hire purchase. Since inflation at last seems to have been arrested in the British economy, the industry seems to have a strong case in pleading for more generous hire-purchase terms. So far as purchase tax is concerned, electrical equipment must take its place in the queue along with many other candidates for tax relief. The need for a reduction in purchase tax, however, is perhaps second in importance only to that for an increase in depreciation allowances.

RIISING OUTPUT OF CABLES.

With improving supplies of raw materials, the British output and exports of wires and cables increased substantially in 1952. The trend of the value of output, which in 1952 seems to have been about one-third higher than in 1951, is shown in Fig. 11, on page 423. Exports are given in Table II, taken from the *Trade and Navigation Accounts*. The principal remaining problem, so far as raw materials are concerned, is the high price of copper. Although the prices of zinc, lead and other raw materials slumped badly in 1952, copper, the principal raw material of the cable industry, has continued to increase in price; high conductivity electro-copper, delivered in the United Kingdom, in the middle of March, 1953, cost 285*l.* per ton, 57*l.* more than twelve months earlier. The price was increased at a single leap by 50*l.* per ton by the Ministry of Supply in the middle of 1952, to bring prices into line with those quoted in the United States. The difficulties and complexities of the copper supply position make the task of the Ministry of Supply an unenviable one, and it is by no means certain that bulk buying has, in fact, been the most economic way of meeting the nation's copper requirements. Certainly, some of the cable makers believe that a resumption of free trading would bring down the price of copper.

There is no danger of any slackening in demand for wires and cables from the British Electricity Authority for some time to come. In their Fourth Report and Accounts, for 1951-1952, the B.E.A. reported that extensive reinforcement of the grid system is being undertaken, and that the design of the first stage of the 275,000-volt "supergrid" was completed, while that of the remaining stage, to meet requirements up to 1960, was in hand. The construction of the first section, which is to operate initially at 132,000 volts between Staythorpe and West Melton, was completed some time ago. The total cost of all transmission schemes approved during the financial year amounted to 23*l.* millions. According to information published in the report of the Monopolies and Restrictive Practices Commission on The Supply of Insulated Electric Wires and Cables published on July 1, sales to the electricity supply industry in 1948 accounted for 27.3 per cent. of the value of the sales of the cable industry (51.5*l.* millions). Of the total sales to the electricity supply industry, 73.4 per cent. was accounted for by mains cables. Altogether, nearly 50 per cent. of the total output of the industry is sold to Government-operated public services and nationalised undertakings. This degree of dependence on a few large buyers is not without its advantages. Close co-operation between the cable makers and the public authorities has made for a high degree of standardisation, and has helped to ensure that research and development work is directed to the best advantage. The B.E.A. report that discussions were continued in 1952 with manufacturers on the design of 275-kV cables. Proposals are being examined for a cable-testing station, for trials under service conditions of up to five types of 275-kV cables at one time.

The close association of cable makers in the Cable Makers' Association and the Covered Conductors Association has also many advantages in the opinion of the Monopolies Commission. Twenty-two of the 60 concerns in the industry, accounting for about 83 per cent. of the total output of electric wires and cables, are members of these associations. A common price has always been a feature of their

operations, "but they can claim with truth to be something more than price rings." The Commission recognised that the C.M.A. has assumed responsibility for the quality of members' products, and that, as a result of regular performance tests, high standards have been achieved. This would have been impossible if members had been engaged in price competition. Price control, moreover, has not resulted in unduly high profits. The average rate of the associated companies in 1948 was only 14.9 per cent. on the capital employed, assessing depreciation on the original cost of the plant employed; if depreciation were assessed at the replacement cost of the plant, the profit would have been only 11 per cent. There could be no question of exploitation where the cable makers were trading with monopoly buyers, namely, the B.E.A. for mains and super-tension cables, the Post Office for telephone cables, and Cable and Wireless, Limited, for submarine cables. Price control, however, does not appear to have been in the public advantage so far as concerns rubber-insulated and other light wires and cables for domestic and industrial wiring. Independent manufacturers account for a larger proportion of the total output, but, nevertheless, competition seemed less effective to the Commission. The price-fixing arrangements of the associated companies seemed to them to guarantee, in some cases at any rate, a profit even to the highest-cost producer. Consequently, they recommended the termination of the present system, but thought that, as a defence against extreme price-cutting, the C.M.A. and the C.C.A. should be allowed to fix minimum prices giving no more than a reasonable profit to the lowest-cost producer of each type of cable. Costs and profits could be reviewed from time to time by "the appropriate Government department."

Another practice of the associated companies which met with the disapproval of the Commission was that of permitting one of their number to quote a lower price or better delivery than the others in order to obtain a contract. The work might, however, be allocated among any of their members without the knowledge of the purchaser. Allocation of work in this way is not in itself harmful, since it spreads the load and helps to ensure that an order goes to the cable maker most fitted to deal with it. Nevertheless, there is no sound reason why this should be done without the knowledge of the purchaser, who, in any case, should not have been given the impression that he had received competitive tenders. The effect of arrangements of this kind is to make entry into the industry difficult for a newcomer, and to limit expansion of capacity by individual concerns. These practices are not, of course, confined to the cable industry, and, if the Government is to implement the recommendations of the Commission, consideration will have to be given to the wider implications.

A strong Cable Makers' Association has served British interests well in the export markets. British manufacturers, confronted in their principal markets by the aspirations of Governments to establish local manufacture of cables, have been able to provide capital and technical assistance and to ensure that, even if export revenues decline, there will be at least partial compensation in increased dividends and royalties. The growth of local manufacture has so far merely kept pace with the increase in demand abroad, but this will not be so indefinitely. In most markets, the manufacture of high-pressure power cables has not so far been attempted, but British Australian Power Cables Proprietary, Limited, have announced that their new plant at Port Kembla will be able to meet all Australian requirements for power cables. The output will include paper-insulated cables, for which, at present, Australia is the second largest British export market. The annual output of cables will be about 500 miles.

Despite these trends, the British cable industry is assured of a high level of exports in 1953. Orders in hand from the home market, for heavier types of cables at least, are more than satisfactory. Production difficulties should be fewer than in 1952, so that the outlook is one of greater prosperity than many other branches of the engineering industry can hope to enjoy.

ELECTRICAL ENGINEERS' EXHIBITION.

THE second Electrical Engineers' Exhibition, which is organised by the Association of Supervising Electrical Engineers, was opened by Sir John Hacking at Earl's Court, London, on Wednesday, March 25, and remained open until Saturday, March 28. The display had its genesis three years ago in a small exhibition, arranged by the North West London branch of the Association, which was followed by an exhibition at the Horticultural Hall last year. Some 60 firms participated on that occasion, while this year there were just over 100 exhibitors. Emphasis was placed on distribution and utilisation equipment rather than on generation and transmission, although a number of models and drawings of heavier plant, as well as equipment for the new 275-kV and a possible 380-kV grid, were on view. Two special displays, known as "Illumination Way" and "Cooker Avenue," were also arranged. The former was 200 ft. long by 30 ft. wide, and, as its name implies, was equipped with the latest designs in lighting fittings. These were placed in rows of three at 10-ft. intervals to facilitate inspection and included some special new flood-lighting apparatus. "Cooker Avenue" was also 200 ft. long and contained 30 examples of the latest commercial and industrial apparatus.

Cable makers were well represented, their exhibits showing the increasing use that is being made of plastics as an insulating material and of aluminium for sheathing purposes. As regards the former, the Telegraph Construction and Maintenance Company, Limited, Greenwich, London, S.E.10, were showing examples of their polythene-insulated power cables for 11-kV and of their polyvinyl-chloride insulated wires for sound distribution and other general and special purposes. British Insulated Callender's Cables, Limited, Norfolk-street, London, W.C.2, were exhibiting a range of cables insulated with silicone rubber and examples of heat-resisting cables designed for working temperatures up to 120 deg. C. They were also showing specimens of mass-impregnated non-draining cables with aluminium sheaths and vulcanised-rubber insulated cables, protected by the same metal. A display of aluminium-sheathed cables was made for the first time by the General Electric Company, Limited, Kingsway, London, W.C.2, while W. T. Henley's Telegraph Works Company, Limited, London, E.C.1, exhibited oil-filled and gas-cushion cables for voltages up to 132 kV, solid type cables for voltages up to 33 kV, and samples of wires, cables and fittings for industrial purposes.

The displays of switchgear included a new panel exhibited by the Simplex Electric Company, Limited, Oldbury, Birmingham, the "bus-bar chamber" of which is provided with parallel bars arranged so as to take a variety of sliding connections. In the cubicle-type switchboards shown by Messrs. G. P. Dennis, Limited, Speke, Liverpool, 19, the high rupturing capacity switch fuses are mounted at the back of the panel and are operated by a handle which protrudes through an elongated slot. This slot is provided with a Duralumin shutter to exclude dust. Typical air-insulated switchgear for primary distribution purposes was shown on the stand of Messrs. Johnson and Phillips, Limited, Charlton, London, S.E.7. This included a circuit-breaker unit of the vertical isolation pattern, which can either be of the plain air break or arc-control type. The first has a rupturing capacity of 150 MVA at either 6.6 kV or 11 kV, while that of the latter is 250 MVA at the same voltages. Variletric, Limited, 10, Melon-road, London, S.E.15, were displaying examples of their standardised unit construction for cubicle switchgear. This has been designed to ensure both compactness and easy access, while the "Sandastee" fuse board on the stand of Messrs. William Sanders and Company (Wednesbury), Limited, Wednesbury, has been built to give lightness, combined with maximum structural rigidity. Adequate wiring space is allowed and the firm's fuse carriers for high rupturing capacity or rewirable fuses are incorporated. The new air-break starter exhibited by Messrs. J. A. Crabtree and Company, Limited,

STRESS-FINDER FOR SHIPS.

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



Walsall, has silver main contacts, while the moving section consists of buttons of the same metal. These are mounted on arms of V-section, which are recessed into the face of the crosspiece. Connections to the coil are made through phosphor-bronze strips which engage with contacts on the coil former, thus obviating the need for loose wiring.

An interesting exhibit, which may be classed under the heading of installation, was that of the Ductube Company, Limited, Regent-street, London, W.1. This consists of pneumatic tubing, which can be laid along the wiring runs of new buildings and inflated before concrete is cast *in situ* either as a structural floor or as a final screed over other types of flooring. When the concrete has set the tubes are deflated so that they can be withdrawn and smooth holes left into which cables can be subsequently drawn. In the same category, the Rawlplug Company, Limited, Cromwell-road, London, S.W.7, were demonstrating the Durium drills, which are designed for boring through masonry and are made in a number of sizes for use with both Rawlplugs and Rawlbolts. The same firm were showing their Rawlplug drill hammer, which is intended for attachment to an electric drill, the driving spindle being inserted in the drill chuck so that a rotary movement is generated to produce either light, heavy or medium blows according to the nature of the material.

Among the items to be seen in the accessories section mention may be made of the "snap-action" shuttered socket outlet which was shown by M.K. Electric, Limited, Wakefield-road, Edmonton, London, N.19, and of the ejector plug exhibited by Clang Limited, Cricklewood, London, N.W.2. The latter is designed to ensure easy and smooth withdrawal, the plug being provided with a central plunger, which is pressed before removal and thus eliminates the risk of damage to the socket. The triple socket outlet exhibited by New Day Electrical Accessories, Limited, Balsall Heath, Birmingham, 12, provides a convenient method of supplying several appliances simultaneously. Two two-ampere sockets for lighting or radio and a 13-ampere socket outlet with a fused plug for power supplies are mounted on one plate, while there is a fused spur terminal at the back.

INSTRUMENT FOR INDICATING STRESSES IN SHIPS DUE TO CARGO DISTRIBUTION.

It does not need a profound knowledge of naval architecture to appreciate the circumstance that the stresses to which a ship's hull is subjected in a seaway, and hence the possibilities of structural damage, are greatly affected by the distribution of the cargo in a longitudinal direction. If the loading is such that the cargo is placed towards the ends of the ship then severe stresses may be experienced when the ship is in the hogging condition, that is, when she is mainly supported on the crest of a wave amidships. In these circumstances, the deck may suffer undue tensile stresses and the bottom undue compressive stresses. Conversely, when the loading is concentrated towards amidships and the ship is in the sagging condition, that is, when the trough of the wave is amidships, then the above-mentioned stress conditions are reversed.

In the case of a cargo vessel which may have to make a voyage with some of its holds only partly filled, the stresses to which the hull is subjected will therefore depend on the manner in which the cargo is distributed; the same assumptions apply to a ship in the ballast condition or in the half-load condition, the design of the modern ship being such that more attention to distribution of cargo is necessary than was previously the case.

These considerations are particularly true in the case of tankers in which, when the heavier oils are carried, several cargo tanks have to be left empty or partially loaded, and the choice of these empty tanks should be such that the minimum stresses are imposed on the ship. When the tanker is in ballast, too, it is most important that the distribution of the ballast should be such that the stresses are as low as possible. There is evidently an optimum method of loading for all ships in which the stresses in both hogging and sagging conditions are the minimum. To decide, therefore, how the load shall be distributed to ensure the minimum stress in the hull is a complicated problem, for the accurate solution of which by the ship's officers, time is not often avail-

able. Many cases are on record in which injudicious cargo distribution has led to severe structural damage, or even total loss, so that considerable interest and importance attaches to an instrument designed by Mr. J. M. Murray, M.B.E., B.Sc., of Lloyd's Register, which enables the responsible ship's officer to determine easily and rapidly whether the hull stresses lie within the safe range for any proposed distribution of the cargo. Obviously, the instrument must be calibrated for any particular vessel, or class of vessel, with a full knowledge of the scantlings and the arrangement of the holds or tanks, but its general form is shown by the photograph reproduced on this page.

It is constructed by Kelvin and Hughes (Marine), Limited, 99, Fenchurch-street, London, E.C.3, and is known as the Kelvin Hughes stress finder. As will be seen, the instrument is in the form of a sloping desk, near the upper edge of which is a rotatable roller provided with three scales showing, respectively, the trim, the stress in the hull structure and the total deadweight; near the deadweight scale are figures indicating the corresponding draught. To the right of the roller is another movable scale on which the deadweight added in the form of cargo can be read, and on the desk just below the main roller is an outline diagram of the ship, on which are indicated the names and numbers of the various holds, tanks and other cargo-carrying spaces. Towards the sides of the desk are two dials on which the names and numbers of the various compartments are engraved, the dial on the right relating to spaces forward of amidships and that on the left to spaces aft of amidships. Near the periphery of each dial is a scale of loads in tons and over each a pointer, in the form of a radial line engraved on a strip of transparent material, can be rotated by means of a knob.

In using the instrument to check the stress due to the cargo distribution, the "total deadweight" and "deadweight added" scales are first set to zero by rotating the knob on the right-hand end of the desk. An indicating bead attached to a cord, which moves longitudinally over the surface of the main roller, is then set to the zero line which coincides with the left-hand end of the dark area on the roller visible in the illustration; actually, the dark spaces on each side of the helical lines on the roller, which constitute the stress scale, are coloured red. The bead is moved by turning the knob between the two loading dials on the desk. Then, for each cargo space in turn, the pointer of the loading scale is set over the zero line for that space and the dial is rotated by turning the central knob until the weight to be loaded into that particular space coincides with the pointer. The knob at the right-hand end of the instrument is then rotated until the weight to be loaded is shown on the "deadweight added" scale, the small lever on the desk just above the right-hand dial is moved to the right and the "deadweight added" scale is returned to zero. When these operations have been carried out successively for all the cargo spaces, the position of the bead relatively to the stress scale on the roller indicates the magnitude of the stress induced in the hull. If the position of the bead is within the white space on which the stress scale appears, the loading may be regarded as safe, but if to the left of this space, the sagging stresses will be excessive and if to the right, the hogging stresses will be higher than is permissible. Any subsequent modification to the loading of one or more spaces can be allowed for by adding or subtracting the effects of the spaces concerned without repeating the whole process.

The instrument can also be used to determine the effect of the cargo distribution on the trim of the vessel. The trim scale is formed by a series of equi-spaced circumferential lines near the left-hand end of the roller, the zero line being on the extreme left. The central line indicates the "even-keel" condition and the depth by which the vessel will be down by the stern or by the head is shown by the lines to the left and right, respectively, of the central line. For a trim determination, the indicating bead is first set on the zero line of the scale and a series of operations similar to those described above is carried out in succession for each of the cargo spaces in turn, except that the loads

in the spaces forward of amidships are added, while those in the after spaces are subtracted. On completing the process, the trim is shown by the position of the indicating bead on the trim scale. As in the case of stress determination, the effect of an alteration to the loading of any individual cargo space can be indicated without repeating the process.

The instrument must, of course, be used carefully, but the fact that if so used it can make an important contribution to the safe working of a ship without occupying much of the time of the officer responsible for cargo stowage should make a strong appeal to shipowners. As an example of the time required, it can be stated that an officer familiar with the instrument can make a stress determination for a given load distribution in about 5 or 6 minutes in the case of a cargo vessel having 26 holds and other cargo spaces. The results, it is claimed, are sufficiently accurate for all practical purposes.

STEAM TURBINE RESEARCH AND DEVELOPMENT.

(Continued from page 393.)

DISCUSSION.

COMMANDER (E) L. BAKER, D.S.C., R.N. (ret.), in opening the discussion, said that the series of papers might be regarded as a progress report of the nine years since the inception of the scheme. Pametrada came into being largely because the design and development functions of marine turbine manufacturers had been concentrated in the hands of a small number of people. Progress had lagged seriously behind that in other countries, but the new organisation might still fall into the same trap because of the relative lack of competition, or, put another way, because of the integration of the development and design functions. Since the war, Commander Baker said, his company had contributed some quarter of a million pounds in levies hidden in the price of its ships, and he had often been asked by owners what they got out of it. He was hard-pressed to find a satisfactory answer; far too much of the work of the research associations was kept under a veil of secrecy.

It was mainly the owners' money and diverted taxes which were spent at Pametrada, yet, as far as he was aware, the representation of owners on the Council and Committees was negligible. When it came to a compromise between capital cost and operating costs, who could decide but the shipowner? Not every shipowner had a fleet large enough to carry an engineering staff of sufficient calibre to challenge the proposals made by the shipbuilder. Indeed, his own company, on more than one occasion, had had to remind the engine builder that the customer was entitled to what he wanted, if he paid for it.

He had been impressed by Pametrada's wonderful facilities and by the keenness and enthusiasm of the staff; but he wished he could be as enthusiastic over the finished product. His company operated eight steamships with a Pametrada design of turbine. The fuel consumption of each ship, averaged over a number of voyages, varied from 0.602 to 0.557 lb. per shaft horse-power per hour. In the case of a similar number of motor ships, the engines of which were tested on the brake, the variation was very much less, being only 0.393 to 0.388 lb. per brake horse-power per hour, or about 1.6 per cent., compared with nearly 10 per cent. He could only conclude that the turbines were to blame. To shipowners, seven tons of fuel a day was important, and a considerable capital expenditure would be justified to achieve such a saving. He had gathered the impression from the papers that the need to compromise on design for the sake of production had weighed unduly in their approach to the job. Turbines were of little use to tramp ships, but the fuel economy of liners and tankers could stand an increase of capital cost. His personal experience in both naval and merchant ships led him to believe that performance testing of every turbine set would be justified, if only by eliminating such differences in performance as had been found in practice. This was not meant to imply that full-scale testing of the entire machinery installation was either

necessary or desirable, but the test should establish the steam rate at or near the service power.

Mr. Yates mentioned that gland and diaphragm clearances had remained static at 0.015 in., but neither he nor Mr. Terrell had commented on the fact that the actual clearances, as built, ranged from 0.009 in. to 0.023 in. in one set of turbines. With conditions like that, it was hardly surprising that the performance of the turbine machinery also varied.

Referring to the paper by Dr. Cameron and Mr. Newman, Commander Baker said he thought further information would be helpful in assessing the data presented; for example, the high-power efficiency curves were shown as falling above about 105 deg. F., but experience indicated that the overall efficiency was still increasing at 120 deg. F. Similarly, the data on pitting of gear teeth were not presented on the basis of any precise gear combination. It would also be interesting to know whether any systematic survey of the hardness of the gear teeth was carried out before or after failure. In a recent gear failure in a "Victory" ship, they had found that there was a significant variation in hardness along a tooth, and that the gear was soft near the point of failure. A variation of 100 in Brinell number was then found in an unused pinion from the same source. Finally, he wanted to support the plea contained in Dr. Brown's final paragraph, for more and yet more research. In addition, he asked for the early publication of results, so that all might strive to apply them. No one could blame superintendent engineers for being suspicious of advances in design when they were presented as a *fait accompli*, shorn of the applied research, development and data.

Captain (E) A. J. Tyndale-Biscoe, O.B.E., R.N., said he imagined, from Dr. Brown's opening remarks, that it was the intention, when Pametrada was set up, that the facilities should be used for the full-scale testing of steam-turbine and gas-turbine machinery for both naval and mercantile use. As far as he was aware, the only full-scale testing which had been carried out on steam machinery had been of naval designs. These tests had been of very great value to the Admiralty, not only from the point of view of giving accurate information on the performance of the machinery, but also because it had enabled them to prove the functioning and reliability of the machinery before it got to sea. They had, as a consequence, been able to make advances in design which would otherwise have been too great a risk. Mr. Yates, however, said in his paper that, because of the difference in operating conditions between merchant ships and naval vessels, the design of turbines for the former had to be treated entirely on its own, without reference to factors which entered into naval designs. Had the full-scale tests of naval machinery been of any value in advancing the design of merchant-ship machinery? If not, was there not a case for a full-scale test to be carried out on an advanced set of merchant-ship machinery? The alternative would be for the Merchant Service to adopt naval designs. There was no doubt that the United States methods achieved some results, for, if reports were to be believed, certain American merchant ships had a fuel consumption considerably lower than corresponding British ships, and also at a lower specific weight. Of course, there might be compensating disadvantages.

Commander (E) J. H. Joughin, D.S.C., R.N., said that a number of the Navy's troubles with turbines in the recent war arose from bad casing design. The low level of that design came partly from the attitude that, round a given blade path, it was easy, with a little thought, to throw a turbine casing. It was disappointing that there were still firms who thought that they could interfere, without reference to the designer, with his careful and essential arrangements; and to realise that Pametrada had not yet educated all their member firms to understand that the critical and thorough design of the casing is so vital to the satisfactory performance of the turbine that it must be approved in its entirety by Pametrada themselves. Naval war experience with impulse turbines, designed before the war, showed many blade failures due to blade vibration. The underlying lesson that ran

through these failures and through the successful war-time designs of impulse turbines was the need, first, to eliminate and reduce all discontinuities, giving impulses which could set blades vibrating; and, secondly, when there remained any possibly unavoidable source of impulses setting up vibration, to ensure that, at the resonant speed, the nominal bending stresses on the blade were small.

Mr. Yates had reported that "The blades are united in groups by shrouding and/or binding wires, arranged in designed lengths to ensure that vibration energy transferred from the steam to any one blade, owing to discontinuities in steam flow, is neutralised by the action of the same discontinuities on other blades." To convince them that this precaution would be effective, practical evidence was needed to confirm that the shrouding and binding wires did, in fact, compel the blades to move as one. Naval experience with impulse-blade failures, both in the initial and later stages, had included many cases of broken or loose shrouding, and had not been unique in that. A description of, and the results of, the tests carried out to confirm that a design of shrouding had been evolved to cure this weakness would be of great interest. To be conclusive, such tests must be carried out on blades that had been in service for some time.

Dr. Kantorowicz had recalled the device of arranging blocks of nozzles at half-pitch intervals to eliminate the condition of complete resonance when a blade passed the nozzles at a speed such that the impulses were sustained at the natural frequency of vibration of the blade. This was done in the initial nozzles of some British destroyers. In 1935, M. Paul Pons warned them of the severe limitations of this device, arguing that it achieved its purpose of eliminating one condition of critical vibration at the expense of substituting some others of less severity.

Mr. E. V. Winstanley, B.Sc. (Tech.), referring to the back-to-back testing of marine reduction gears, said that the necessity or otherwise of going to the great expense of this class of testing had exercised the minds of most manufacturers of marine and land reduction gears. Back-to-back testing of double-reduction gear boxes was open to the objection that the main wheels were loaded so that both flanks of each tooth were subjected to loads in the opposite direction and, therefore, the range of stress was double that met in the normal service for the gear unit. The first-reduction gears were loaded on one flank, as in normal service. This aspect of back-to-back testing was the subject of comment in a paper before the American Society of Naval Architects, read in November, 1952. In the testing there described, the failure was due to fatigue at the roots of the second reduction wheel. Incidentally, the term "back-to-back" was described as "front-to-front" in that paper. The deflection tests of the single-reduction gear box were of interest to the designer. It was usual to test the rigidity of the gear casing by selectively removing base-plate supports, but to measure the distortion due to the thrust on the bearing from torque transmitted was of great interest to the designer. He presumed that they regarded the particular design as satisfactory, since four times the normal load was still within the elastic range.

All engineers called upon to give guarantees would be interested in the variation of efficiency with oil temperature and load, as given in the paper for the double-reduction design; but, in the absence of any details of the bearing sizes, the grade and viscosity of the oil, and the loads, he could only accept the answers provided by the authors from the great amount of analysis that had been done, and presented in a form which could be applied by designers. He appreciated the trouble taken by the authors in separating the tooth losses from the bearing losses. It was noted that they expected to obtain a coefficient of friction for hardened and ground gears less than for normally soft gears. Could they give their reasons for this, since surface-finish measurements showed little difference, and no change could be detected after the gears had been run in? Referring to the considerable trouble taken to analyse pitting, he noted that there was a reduction when the pinion helix angle was corrected to suit 200 per cent. load. This amount of correc-

COMBINED OIL AND COAL BOILER FIRING.

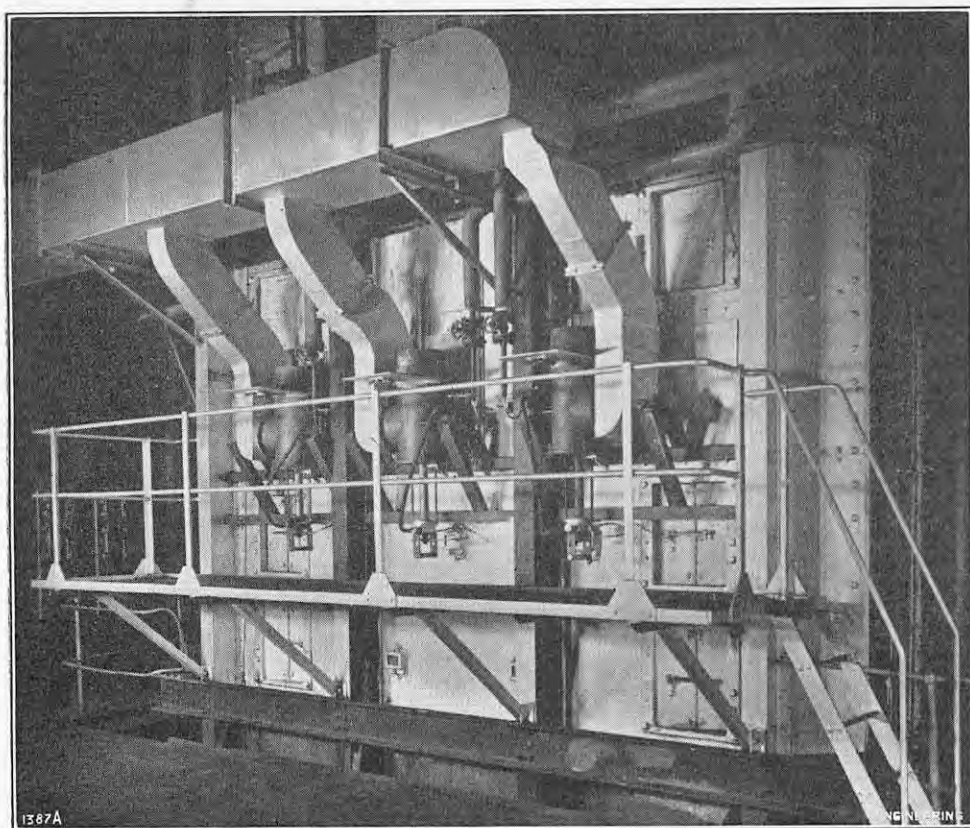
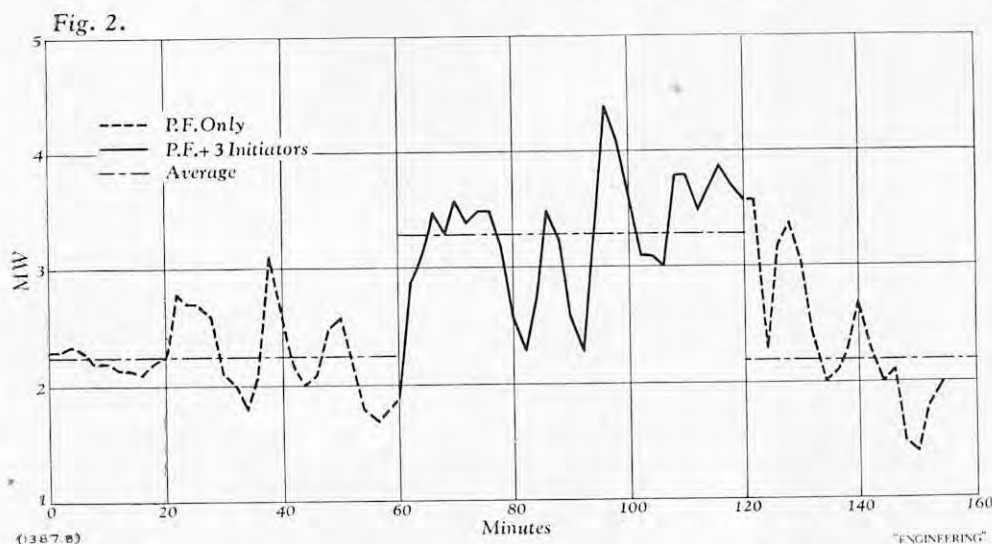


FIG. 1. INITIATORS ON PULVERISED-FUEL FIRED BOILER.



tion was easier to carry out than one intended to correct between light load and full load, but it was justifiable for the purposes of testing. In practice, there would be difficulty in implementing such a technique as the loading of the gear, and the time that it would operate at that loading was indeterminate. Apparently, to give any easement in design to minimise pitting would mean doing what was already common practice, i.e., after the first average voyage, when the markings of the teeth would show how the loading was distributed, hand scraping would be necessary to give the required easement. The value of the torque loader was amply demonstrated, one valuable feature being that it permitted the gears to be brought up to speed before heavy torques were applied, thus allowing the bearing oil films to be formed. Otherwise, the application of heavy torque might cause bearing damage at slow speeds, as at starting.

(To be continued.)

THE AMPÈRE MEDAL.—The Ampère Medal of the Société Française des Electriciens for 1953 has been awarded to M. H. André for his work in connection with the silver-zinc accumulator.

COMBINED OIL AND COAL FIRING AT ST. PANCRAS POWER STATION.

THE generating equipment in the St. Pancras power station of the London Division of the British Electricity Authority consists of four turbo-alternator sets with an aggregate capacity of 44 MW. These sets are supplied with steam at a pressure of 220 lb. per square inch and a temperature of 660 deg. or 695 deg. F. from six boilers with a total evaporative capacity of 291,000 lb. per hour. Four of these are fired with pulverised fuel, three on the bin-and-feeder and one on the unit system. The station is operated on a one-shift or two-shift basis and is out of action at the week ends, while as much of the plant is "time-expired," methods have had to be considered for increasing the steam output and overcoming the inefficient combustion and grit and smoke emission caused when starting up, owing to the lack of pre-heated air for milling. The high moisture content of the pulverised fuel has also caused smoke "puffing" and limited the boiler capacity.

These difficulties now seem to have been success-

fully overcome by the installation of oil initiators constructed by Fuel Firing, Limited, Woodley, Reading, Berkshire, as these allow higher furnace temperatures and more complete combustion to be attained with a resultant reduction in smoke and grit emission. It has also been possible, by the use of this equipment, to supply pre-heated air to the mills for drying while the boilers are being lighted up and to generate additional steam at peak periods.

Four initiators are fitted to one boiler, three to two other boilers and two to a fourth. The general appearance of one of three-unit components is shown in Fig. 1. An important point about the installation is that the initiators are retractable, as illustrated in Fig. 3, page 432, so that the precision parts of the burner are protected from radiant heat and coal and ash deposits when not in use. The burner unit itself incorporates a sprayer tube which carries an atomiser. This atomiser consists of three precision-ground plates and is designed to facilitate periodical inspection. Primary air is introduced round the atomiser to ensure stability of ignition under all furnace conditions, and for cooling purposes, so that the build-up of carbon deposits is prevented and the necessity for cleaning reduced. Secondary air is admitted through a swirler consisting of a number of blades arranged round the periphery of the burner and designed so as to create the turbulence necessary for combustion. Both supplies of air are obtained from the forced-draught fans, one of which is provided for each pair of boilers. No provision is made for variations in the output of individual burners, so that the air/fuel ratio to each initiator is constant for the designed duty. The complete burner is mounted on a shaft, which is carried in two bearings fixed to the main frame of the assembly, so that it can be rotated round a horizontal axis into and out of the furnace, as shown in Fig. 4, on page 432. The burner is shown in operation in Fig. 5, on the same page, and when it is retracted the furnace opening is closed by a plate in which an observation port is provided. At starting, the oil is ignited easily even after a prolonged shut-down, by a hand torch, interlocks being fitted to prevent the burner being retracted while it is alight. The air supply is automatically controlled by rotating the burners so that individual dampers are unnecessary.

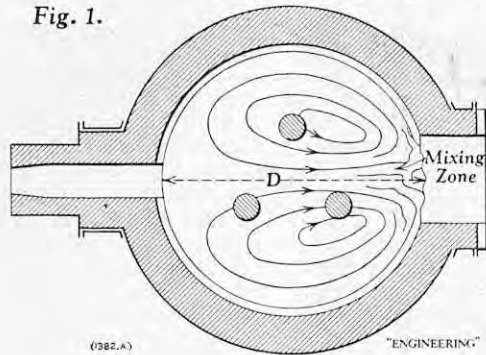
The heavy oil fuel used in these burners has a 960 second Redwood No. 1 viscosity and is delivered by road tanker into two storage tanks with a total capacity of 30 tons. Its temperature is maintained at about 100 deg. F. by steam coils and it is withdrawn by two positive-displacement type pumps and delivered to the boilers through thermostatically controlled electric heaters at a temperature of 200 deg. F. The oil range is of loop design so that the oil can be re-circulated and each contactor is supplied through individual connections controlled by stop valves. This part of the plant is illustrated in Fig. 6, on page 432.

As the result of the installation of this equipment, there has, we understand, been a marked improvement in the cleanliness of the stack and the emission of smoke and grit, while the higher furnace temperature has led to an improvement in thermal efficiency. The use of oil burners for pressure raising has given rise to more even heating, combined with a reduction of superheater-tube overheating and a finer control of the furnace temperature. The use of oil for starting has enabled the products of combustion to be used to dry the pulverised coal before filling the bins, while the furnace temperature has been increased from 2,300 deg. to 2,600 deg. F. without so far any harmful effect on the refractories. Fig. 2 shows how rapidly the load on a boiler can be increased or decreased by putting the initiators in or out of action. In fact, by their use it has been possible to increase the capacity of the station by 3 MW at a very low cost.

"MARATHON" NAVIGATION-TRAINING AIRCRAFT.—The first of 30 Marathon navigation-training aircraft destined for the Royal Air Force will be delivered shortly to the Royal Aircraft Establishment, Farnborough, Hampshire, for clearance of its navigational equipment. The Marathon trainer, constructed by Handley Page (Reading) Ltd., Woodley Aerodrome, near Reading, was described on page 348 of our 174th volume (1952).

INDUCTION STIRRER FOR ELECTRIC ARC FURNACES.

Fig. 1.



INDUCTION STIRRER FOR ELECTRIC ARC FURNACES.

It is desirable in the course of many steel-making processes to provide some means of stirring the molten metal in order to obtain good contact between the components and to ensure thorough mixing in the minimum time, as well as to equalise the alloy concentration and temperature distribution. Such stirring is particularly desirable in the case of large electric arc furnaces and in smaller furnaces of the same type, which are being used for the production of high-alloy steel. It is not surprising therefore that numerous attempts have been made to produce apparatus for this purpose, which will withstand the arduous working conditions that are naturally present. These attempts have included the employment of a ceramic-coated stirring rod manipulated by a charging machine, of a stirring coil sandwiched between the lining and the shell of an induction furnace of high frequencies, as in the Rohn and Dreyfus furnaces, and other methods. The lack of success of these attempts may be, at least in part, ascribed to non-recognition of the fact that the metal bath in an arc furnace has little inherent motion. This is not altogether surprising, for at first sight it would be expected that the electric fields set up by the large alternating currents used would provide the necessary movement. A theoretical examination of the conditions, however, shows that the operation of these forces is restricted to a shallow layer near the surface of the melt and that their value decreases as the distance from the electrodes increases. Compared with the conditions in an induction furnace, in which all the heat is generated by the current passing through the melt and not by the arc, the resultant forces are, in fact, extremely small. In addition, they tend to cause depressions under the electrodes with the result that such pressure as is set up is largely neutralised by the fall in level of the molten layer so that little or no motion occurs.

As a result of experiments, however, it has been found that the desired result can be obtained by applying a travelling magnetic field to the lower layers of the melt in such a way that they are accelerated along the bottom of the furnace and then made to flow upwards and sideways, finally returning to the starting point in wide eddies, which enclose large surfaces, as shown diagrammatically in Fig. 1. The necessary field for this purpose can be produced either by moving magnets excited by direct-current or, more practically, by a stationary winding, similar to that of an induction-motor stator, supplied by alternating current. This method has been adopted by Allmänna Svenska Elektriska A.B., Västerås, Sweden, of whom the British representatives are Asea Electric Limited, Fulbourne-road, Walthamstow, London, E.17, and has been applied to a number of arc furnaces with capacities up to 30 tons in Sweden and more recently to three 90-ton furnaces, which have been installed at the Timken Steel and Tube Division of the Timken Roller Bearing Company at Canton, Ohio. Photographs of two-phase induction stirrer for a 30-ton electric-arc furnace are reproduced in Figs. 2 and 7, on this and the opposite pages, while one of the Timken 90-ton furnaces with the stirrer in position is illustrated in Fig. 8, opposite.

As regards construction, the stirrer, as shown in Fig. 2, consists of a laminated steel yoke of the

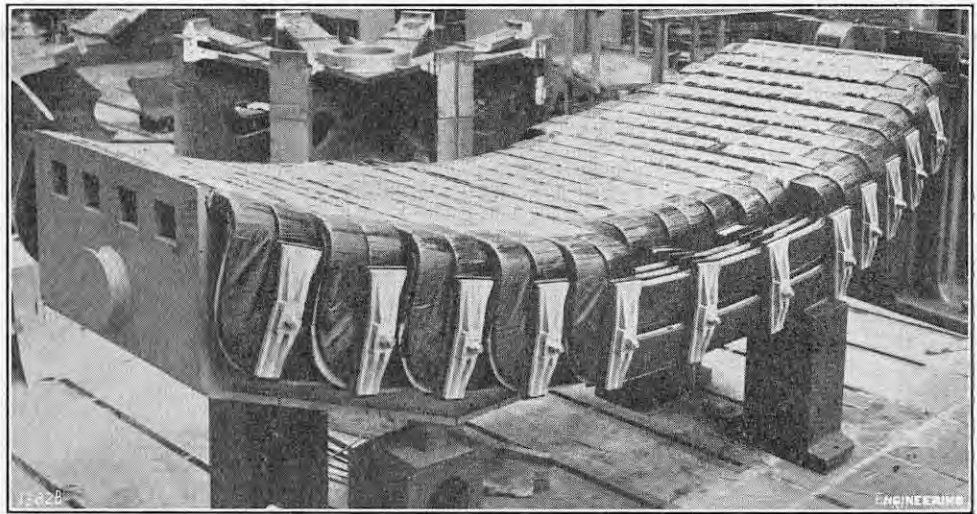


FIG. 2. TWO-PHASE STIRRER FOR 30-TON ARC FURNACE.

Fig. 3.

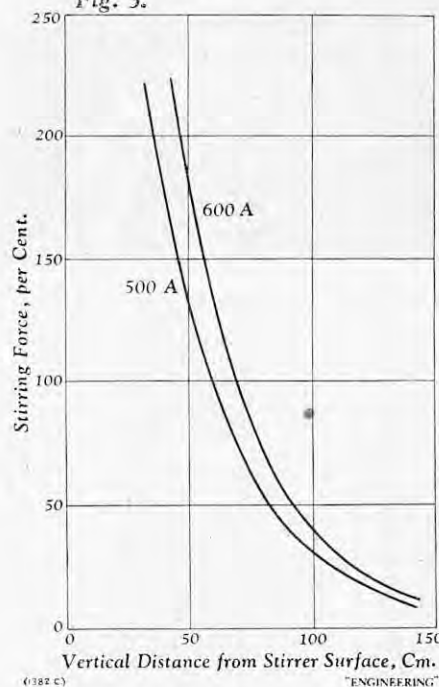


Fig. 4.

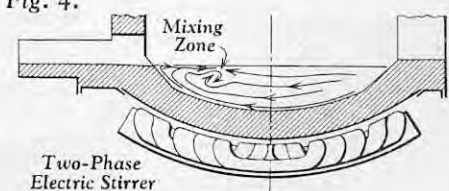
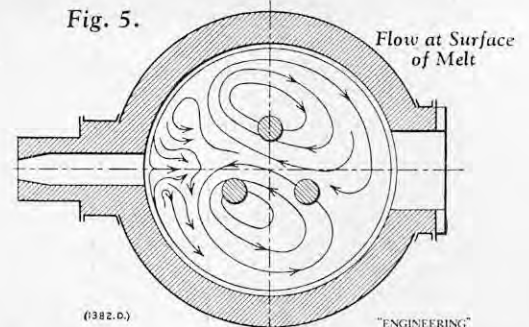


Fig. 5.



same general design as that used on an induction motor, provided with wide and deep slots for carrying the heavy conductors which form the windings. These windings are usually copper tubes through which cooling water is circulated, but air cooling by forced draught is sometimes employed as an alternative. A two-phase connection is employed and the necessary excitation is obtained from a motor-generator set consisting of an induction motor driving either one two-phase or two single-phase generators. For a 30-ton furnace, a 115-kW set operating at a power factor of 0.5 is employed, and power for the 90-ton furnace is obtained from a set consisting of a 400-h.p. 2,300-volt synchronous motor driving a 485-kVA generator. This generator supplies two-phase current at either 150 or 200 volts and at a power factor of 0.43. The frequency in both cases is of the order of 0.55 cycle, a low figure which has been chosen to avoid excessive eddy-current losses in the bottom plate of the furnace, although it is sufficiently high to ensure that the dynamic forces induced in the lower layers of the melt are sufficient to provide thorough stirring in a short time.

It is obvious that to ensure high efficiency the stirrer must be installed as close to the melt as possible and it is equally clear that sufficient heat protection must be provided between the two. In practice these conditions are fulfilled by providing the furnace with a bottom of non-magnetic material such as chromium nickel steel, shown in Fig. 6, opposite. The thickness of this bottom should not exceed 1 in. and in the larger furnaces, such as that

illustrated, is made up of strips connected by butt welds. It may perhaps be pointed out that the value of the stirring forces is effected by the thickness of the insulating lining; for instance, as can be seen from Fig. 3, the electrodynamic forces fall rapidly as the distance from the stirrer increases, a fact which limits the thickness of the lining to about 1 ft. 8 in. in small furnaces and to about 3 ft. in the larger sizes. Generally, the stirrer, which is shown complete in Fig. 7, opposite, is suspended directly from the furnace casing, a space of about 1 in. being left between its upper surface and the bottom of the furnace. To prevent any risk of damage to the stirrer in the rare event of a break through of the furnace lining, the latter is equipped with thermocouples so that an alarm is given when the temperature at any spot exceeds a certain value. Operation is effected from a central control panel on which push-buttons are provided for starting and stopping the motor-generator set and for reversing the current through the stirrer. These controls are interlocked so as to ensure correct operation. The panel also carries the usual instruments for measuring the current and voltage and for indicating the temperature at various places in the furnace bottom.

Considering a typical melt in an ordinary arc furnace, it may be pointed out that there are numerous ways in which the various processes involved are affected by the installation of a stirrer. During the melting down period stirring only begins to take effect when a molten pool forms on the bottom of the furnace, the power consumed for this purpose being small compared with that required to melt the steel. During the oxidation period the metal is stirred by the de-carbonising "boil," but the stirrer continues the agitation when this movement ceases and itself re-starts the action,

INDUCTION STIRRER FOR ELECTRIC ARC FURNACES.

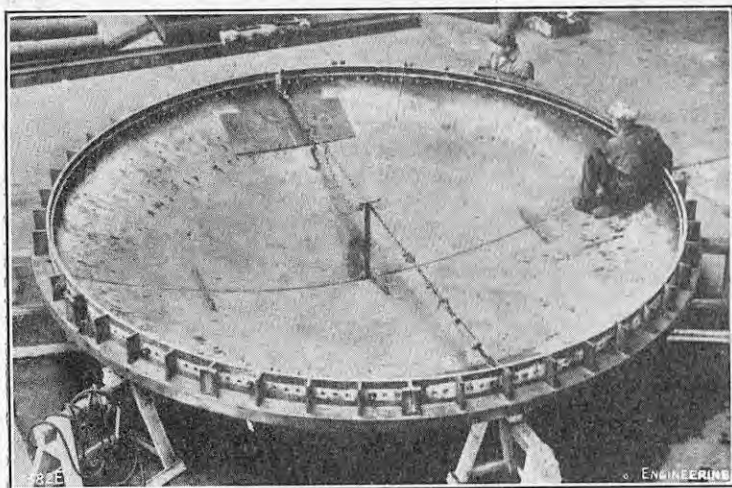


FIG. 6. FURNACE BOTTOM OF NON-MAGNETIC MATERIAL.

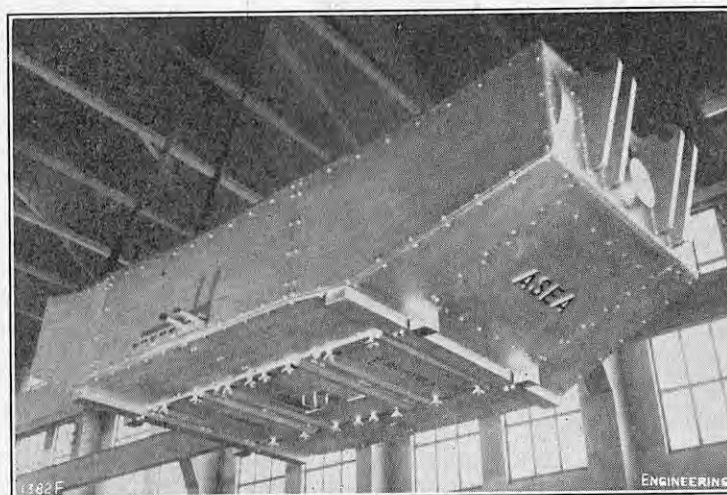


FIG. 7. COMPLETE WATER-COOLED STIRRER.

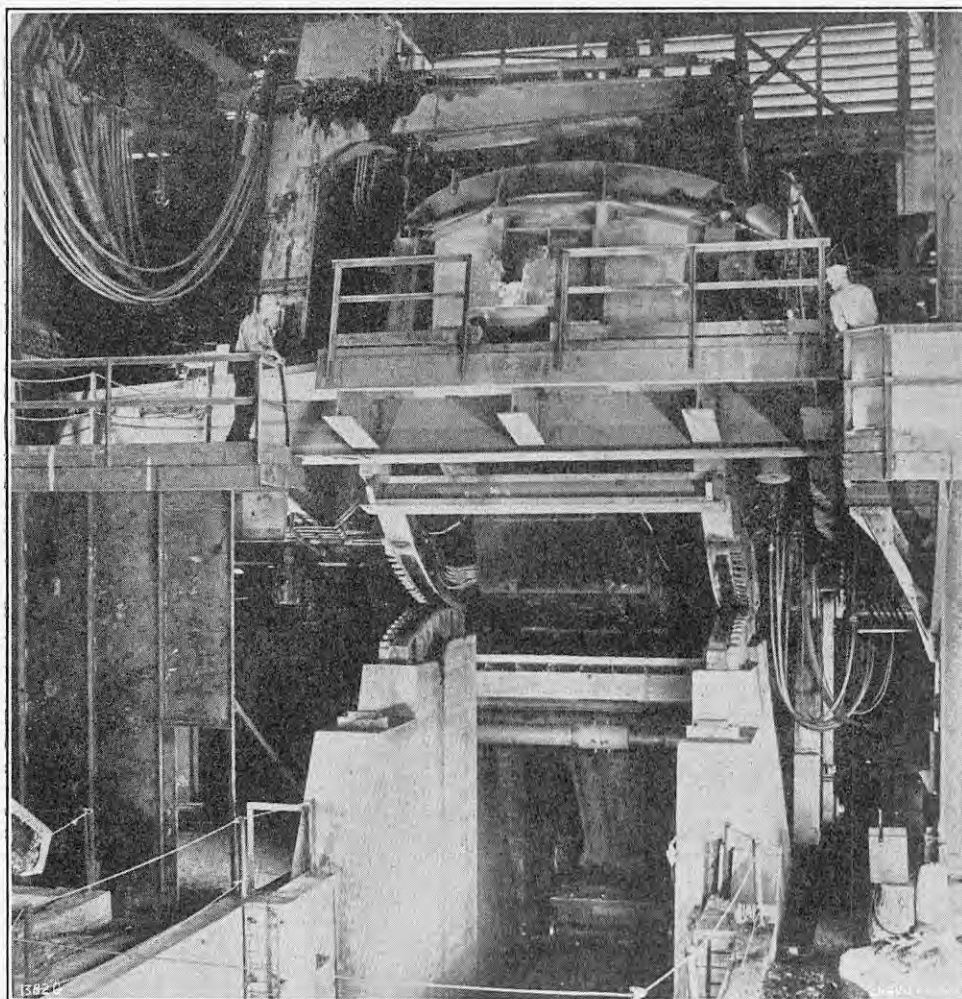


FIG. 8. STIRRER IN POSITION ON 90-TON FURNACE.

thus accelerating the rate at which de-carbonisation takes place. It is also claimed that it is possible by the use of a stirrer to obtain steels the carbon and oxygen contents of which are both low. Naturally, the effect of the stirrer is most marked during the refining period, since the active contact area between the metal and slag is increased and the chemical reactions reach equilibrium more quickly. For instance, it has been found possible to make steels with as low an oxygen content as 0.0005 per cent., and to save as much as 60 minutes in the reduction process. The times required to lower the sulphur and phosphorus contents are also reduced, the process in the case of phosphorus being assisted by the basicity of the slag.

Moreover, not only does stirring reduce the total time of the melt by some 10 to 20 per cent., but it increases the effective surface area and depth of

the bath, so that a larger charge can be taken. The steel produced is also homogenous, clean and free from porosity and inclusions, advantages which are specially noticeable when high qualities are being made. In one case, for example, the number of inclusions per surface unit during "step-down turn tests" on a steel containing 0.25 per cent. carbon, 1.0 per cent. chromium, and 0.25 per cent. molybdenum, was only one-third of the number found when an induction stirrer was not used. A further important point is that sampling is more reliable, owing to the homogeneity of the melt. As a result, it is, in fact, claimed that it is possible to reduce the time required for sampling by five or ten minutes, and the check analysis can be relied upon to represent the whole of the metal as the alloying materials spread to all parts of the bath within a short time after they have been added. Temperature

equalisation is also quickly attained, thus making control easier and eliminating local overheating.

The flow of metal in the bath when the current is reversed for slag removal is illustrated in Figs. 4 and 5, opposite, the effect being that the slag and hot surface metal are carried towards the furnace door where the former is pushed out and the latter scours the walls. This improvement in the deslagging process is a great help, especially when more than two slags are necessary. It also makes it possible to handle the large volumes of slag which are associated with the dephosphorisation of low-grade scrap.

From the economic point of view the makers estimate that the capital costs for a stirrer for a 30-ton furnace producing 4,500 tons of steel per annum, would be 38*d.* per ton. In addition, there would be a power consumption of 12 kWh per ton, costing 11*d.* per ton, while the cooling water, oil and consumable material would account for another 2½*d.* per ton, making a total of nearly 4*s.* 4*d.* per ton. Against this is an estimated saving of 50 kWh per ton, owing to the reduction in the time required for refining. This saving is equivalent to 3*s.* 6*d.* per ton, to which must be added 1*s.* 3*d.* per ton for savings in electrode consumption. The result is an overall saving of 7.6*d.* per ton of steel leaving out of account the fact that production could probably be increased by 10 per cent., owing to the shorter time necessary to complete each melt.

ISOMETRIC PROJECTOR.—Mr. Stanley Binns, Oxford-street, Heckmondwike, Yorkshire, has sent us a leaflet describing his isometric projector, designed for producing pictorial drawings directly from a plan. A stylus is used for tracing the outline of the drawing that is being projected, and a pencil attached to the instrument draws out the isometric view. Circles shown in the plan are reproduced as isometric ellipses. A scale at the centre of the instrument enables it to be reset for drawing the outline of the lower plan at a desired distance below the previously drawn view and vertical lines are added afterwards to complete the drawing; details at odd angles between the planes have to be plotted separately and have the plotted points joined together. It is claimed that the instrument is easy to operate and saves considerable time.

FLEXIBLE COUPLING.—A further range of couplings has been developed by Howard Clayton-Wright, Limited, Wellesbourne, Warwickshire, for transmitting full torque without frictional loss. They are the "Harrisflex Torflex" couplings, type A1 and A2, for shafts from ½ in. diameter to ¾ in. diameter, with a corresponding range in load from 4 in.-lb. to 90 in.-lb., and the D3 and D4 couplings, for shafts from ¾ in. diameter to 1½ in. diameter for loads from 250 in.-lb. to 825 in.-lb. The design of these couplings, it is claimed, allows angular and parallel misalignment of shafts and a cushioned drive with silence in operation. The coupling consists of a male and female cap, threaded right or left hand, to suit the direction of rotation of the shaft, and a spacer. In each cap a rubber bearing, made to suit the size of shaft, is fitted; the spacer compresses the rubber bearings when the caps are screwed together to increase the grip on the shaft.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

COAL FOUND NEAR GLASGOW.—Deep-boring operations undertaken by the Scottish division of the National Coal Board, within the Glasgow City boundary at four points surrounding the old Queenslie Colliery, near Baillieston, were described on March 25 at a meeting of the Mining Institute of Scotland in a paper by Mr. C. J. C. Ewing, M.Sc., F.G.S., assistant divisional geologist, and Mr. N. H. McLeod, B.Sc., planner, Central West area. The authors concluded that the information now available from three of the boreholes showed that a workable area of coal, the value of which was increased by its quality and geographical position, had been proved. There was still no indication, however, that the limits of its extent had been reached.

BORING FOR WATER IN LINLITHGOW.—As a sequel to a serious water shortage in West Lothian after the recent spell of dry weather, boring for water has been begun in the former bed of the river Avon in Linlithgow, which used to be famed for its wells. If the results are promising it is planned to sink a further borehole west of the town.

SCHEME FOR HEIGHTENING A GLASGOW BRIDGE NOT APPROVED.—The Ministry of Transport have declined to approve a scheme for heightening and widening the skew arch bridge over the main Glasgow-Greenock road west of Langbank. The proposal was to increase the height of the bridge, in the centre, from 13 ft. 8 in. and 6 ft. at the sides to an overall height of 15 ft. 6 in. The Railway Executive planned to carry out the work in two stages, and it was desired that the first stage, estimated to cost about 70,000l., should be included in the Ministry of Transport's estimates for 1953.

OIL HULK TO BE BROKEN UP.—The Shellfoil, the forward part of the former tanker Danmark, was towed, on March 25, from Dublin to Faslane, on the Gareloch, for breaking up. As the Danmark, the vessel was torpedoed and sunk at Kirkwall by enemy action in the early part of the war. Metal Industries, Ltd., refloated the forward portion of the ship and took it to the Clyde, where for some years it was used by the Admiralty as an oil depot ship. Later it was sold and went to Dublin as an oil hulk, being renamed the Shellfoil.

CLEVELAND AND THE NORTHERN COUNTIES.

SUNDERLAND WATER SUPPLY.—The Sunderland and South Shields Water Co. Ltd., John Street, Sunderland, are to carry out a large scheme for the construction of plant for taking water from the River Wear for the use of industrial concerns. The proposed plant will be eight miles up the river, near Lambton Castle. It is understood that the scheme will cost about 250,000l.

IMPORTANCE OF TRANSPORT ON TEES-SIDE.—At the annual dinner of the Tees-Side and District Section of the Institute of Transport, Mr. C. T. Bunner, the national President, and director and general manager of Shell-Mex and B.P. Ltd., said that the future of Tees-Side depended on good transport. The raw materials, such as ironstone and coal were near at hand, and transport was needed to bring them together. Transport charges accounted for about one-tenth of the cost of finished-steel products, and if not closely watched, could make all the difference between a profit and a loss. Mr. Bunner said that, with the exception of Australia, steel made in the United Kingdom was the cheapest in the world. This fact indicated the efficiency with which the industry operated. The demand for more steel had increased the demand for oil which offered real technical advantages to steelmakers.

LABOUR POSITION AT BISHOP AUCKLAND.—At a meeting of the Tees-side and South-West Durham Chamber of Commerce at Middlesbrough, it was stated that there was not sufficient employment for men in the Bishop Auckland area. Some men had to work outside the district, and it was felt that if full employment ceased, these men would try to obtain work locally and a serious employment situation might arise. The Chamber is to seek further information on the matter. There is already a trading estate at St. Helen's, Bishop Auckland, accommodating a number of light industries.

OLD SHIPS TO BE BROKEN UP.—The paddle tug Comet, built 77 years ago and owned by Lawson Batey Tugs, Ltd., Newcastle-upon-Tyne, is to be

broken up at Dunston-on-Tyne by Clayton & Davie Ltd. The Dunston firm have also received the 5,000-ton Panamanian ship Meridian for breaking up. This vessel was built 34 years ago.

LANCASHIRE AND SOUTH YORKSHIRE

WIGAN AND DISTRICT MINING AND TECHNICAL COLLEGE.—Stated to be one of the oldest technical colleges in the country, Wigan and District Mining and Technical College, Library-street, Wigan, Lancashire, is now in its ninety-sixth session, and celebrated Founders' Day for the first time for 15 years on Wednesday, March 25, 1953. The principal speaker was Sir Hubert Houldsworth, Q.C., D.Sc., chairman of the National Coal Board. The Principal of the College is Dr. E. C. Smith, B.Sc. (Eng.), A.M.I.C.E., A.M.I. Mech.E., A.M.I.E.E. Many distinguished guests from industry, commerce and the educational field were present, and they availed themselves of the opportunity to view the work of the College, when it was thrown open for inspection at the conclusion of the proceedings. Tribute was paid, in the proceedings, to the foresight and vision of those who founded the College, and to the contribution which the College was now making to the welfare of the country.

APPROVAL OF BURNLEY DEVELOPMENT PLAN.—The Minister of Housing and Local Government has approved, with modifications, the development plan for the County Borough of Burnley, Lancashire. The plan, as approved, will be deposited in the Council Offices for inspection by the public.

INCREASED PRICE OF GAS.—The East Midlands Gas Board which controls supplies to an area including South Yorkshire, Derbyshire and Lincolnshire states that the 5 per cent. price rise is very reasonable by comparison with the increase in its own costs. Economies have been effected to save 700,000l. a year, but these are not sufficient to offset the 650,000l. increase in costs through the coal-price rise on March 2, and an expenditure of nearly 1,000,000l. incurred by increased wages and freight charges.

EFFECTS OF AUSTIN STRIKE.—The Austin motor works strike has affected Sheffield makers of motor components. Thus, the spring department of the English Steel Corporation Ltd. has had to stop production for the Austin Company which normally takes from the Corporation, each week, about 2,000 coil springs and a similar number of laminated springs. The workpeople are being found a full week's work but only four days can be at the normal piece-work rates. Alternative work at day rates, for the fifth day, makes a loss of earnings inevitable.

IMPORTS OF CUTLERY TO BE PERMITTED.—Some concern is felt in Sheffield at the announcement that permitted imports of foreign cutlery will be raised by 10,000l. to 105,000l. in the second half of this year. The Sheffield cutlery industry is going through very lean times as is evidenced by the fact that 2,000 operatives have already left the industry, that 454 are on short time, and that 121 are wholly unemployed. A disturbing point is that cheap cutlery pays less Purchase Tax, and, even after paying duty, can be retailed at lower prices than those of Sheffield cutlery.

THE MIDLANDS.

FUTURE COAL-MINING DEVELOPMENTS.—Mr. I. W. Cumberbatch, chairman of the West Midland division of the National Coal Board, speaking at a conference of the National Union of Mineworkers at Stafford, on March 23, referred to newly-discovered coal seams north of the existing Cannock Chase coalfield. Only one borehole has so far been put down, but there are indications that two seams, 6 ft. thick, exist in an area not previously mined. Workable seams have already been proved on the east side of the area at present worked, and the new discovery gives strength to the belief that the Cannock Chase coalfield has an assured future. Developments at present taking place on the fringe of the coalfield are expected to call for an increase from 16,000 to 18,000 in the labour force employed.

ELECTRICITY CHARGES.—The Midland Branch of the National Union of Manufacturers has received numerous complaints from its members concerning the electricity charges made by the Midlands Electricity Board to small factories. The Branch has reported that the imposition of the new tariffs, based on floor area, has resulted in increases varying from 25 to 100 per cent.

ASSEMBLY FACTORY IN AUSTRALIA.—Wilkins and Mitchell, Ltd., Darlaston, Staffordshire, who manufacture power presses and domestic washing machines, have acquired premises in Bankstown, near Sydney, New South Wales, for assembling washing machines. The company had an extensive trade with Australia prior to the import restriction orders, and the new factory will enable them to resume business there. Components will be sent from Darlaston, and the company have secured a licence which will enable them to ship regular supplies of parts.

A MANSION FOR OFFICES.—The Lichfield Rural District Council have given approval to the proposed conversion of Little Aston Hall, Streetly, near Birmingham, into central offices for the Esso Petroleum Co., Ltd. The company, at present operating from offices in four different parts of Birmingham, will concentrate the whole of its Midland Division at Little Aston Hall, a large mansion, which, until recently, was in private occupation.

ASSISTANCE FOR EXPORTERS TO THE CANADIAN MARKET.—The Midlands Regional secretary of the Engineering Industries Association, Mr. Charles Dodds, has drawn attention to the fact that the Association is to open an office at Toronto in the near future, and that advice will be available regarding design and prices, tariffs, market requirements, and conditions generally. Midland engineering firms desiring information or assistance are requested to communicate with Mr. Dodds, at Dilworth House, Broad-street, Birmingham, 15.

SOUTH-WEST ENGLAND AND SOUTH WALES.

JUBILEE OF WHITEHEAD IRON AND STEEL CO.—The Whitehead Iron and Steel Co., Ltd., Newport, Mon., which, this year, celebrates its jubilee began in a Tredegar plant, abandoned by its owners and which the brothers Lionel and Arthur Whitehead, who formed the company, bought for 6,000l. From that beginning, said Mr. G. H. Latham, the managing director, speaking at the annual staff dinner and dance, the firm had grown until it "prided itself on being the largest unit in its particular line, not only in this country but the world."

COLLIERY-PRODUCTION INQUIRY.—An inquiry is to be held into the production of every coal pit in South Wales. This is the first result of the recent production and efficiency conference sponsored by the National Coal Board and the National Union of Mineworkers. A divisional joint council of representatives of the Board, the National Union of Mineworkers, the National Association of Colliery Managers, the National Association of Colliery Overmen, Deputies and Shot-firers, the Clerical and Administrative Workers' Union, and the supervisory and clerical grades of the N.U.M., has been set up.

RHOOSE AIRPORT, CARDIFF.—Work is to be speeded up in the development of Rhose Airport near Cardiff. The Ministry of Transport and Civil Aviation Estimates show that the Ministry is allocating 51,500l. for work at the airport in the next twelve months, 11,500l. more than last year.

REOPENING OF OLD TIN-PLATE WORKS.—The twelve tin-plate works, situated between Lydney and Llanelli, which the Steel Company of Wales Ltd., closed at the beginning of March on account of lack of orders in the industry reopened on Monday, March 30, with the majority in operation for at least a fortnight on a four-day basis. An official statement added that orders for tin-plate were still difficult to obtain and it was unlikely, that full working at all the works would be available thereafter. The works provide jobs for a total of 5,000 men, and are furnished with old-type equipment.

ATTEMPT TO CO-ORDINATE ROAD COMMUNICATIONS IN WALES.—The Industrial Association of Wales and Monmouthshire, meeting at Cardiff, have decided to take steps to co-ordinate, by consultation with planning authorities and other bodies, measures for improving road communications in Wales and Monmouthshire. It has been planned to draw up an acceptable and unified approach to the Ministry of Transport. Each locality, said Mr. R. B. Southall, director and general manager of the National Oil Refineries, Ltd., Llandarcy, wanted its own problems attended to. An attempt must be made to get matters out of their local setting and to make a case based on economic factors which would dictate not only what was good for one locality or district but would benefit the whole of the area served.

NOTICES OF MEETINGS.

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

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, April 7, 6.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. Annual Meeting. "The Fatigue Strength of Marine Shafting. Part II.—Large-Scale Investigation of the Effect of Fillet Radius on the Torsional Fatigue Strength of Marine Shafting," by Mr. T. W. Bunyan and Dr. H. H. Attia.

INCORPORATED PLANT ENGINEERS.—*Edinburgh Branch:* Tuesday, April 7, 7 p.m., Heriot-Watt College, Edinburgh. "Elementary Industrial Electronics," by Mr. J. H. Jones. *East Midlands Branch:* Wednesday, April 8, 7 p.m., Welbeck Hotel, Nottingham. "Peak Steam Demands and Thermal Storage," by Dr. E. G. Ritchie. *Newcastle-upon-Tyne Branch:* Thursday, April 9, 7.30 p.m., Roadway House, Oxford-street, Newcastle-upon-Tyne. "Oil-Injection Method of Separating and Uniting Joints on Shaft Couplings," by Mr. C. S. Clarke. *London Branch:* Tuesday, April 14, 7 p.m., Royal Society of Arts, John Adam-street, Adelphi, W.C.2. "The Maintenance of Process Plants," by Mr. G. C. Allfrey. *East Lancashire Branch:* Tuesday, April 14, 7.15 p.m., Engineers' Club, Manchester. "Vibration in Buildings and Structures," by Mr. F. de Bass. *Western Branch:* Wednesday, April 15, 7.15 p.m., Grand Hotel, Bristol. "The Generation of Industrial Power from Process Steam," by Dr. E. G. Ritchie.

INSTITUTION OF WORKS MANAGERS.—*Sheffield Branch:* Tuesday, April 7, 7.30 p.m., Grand Hotel, Sheffield. "The Bones of Industry," by Mr. A. Elson. *Tees-Side Branch:* Wednesday, April 8, 7.30 p.m., Vane Arms Hotel, Stockton-on-Tees. Annual Meeting. *Manchester Branch:* Monday, April 13, 6.45 p.m., Grand Hotel, Manchester. Annual Meeting.

INSTITUTION OF PRODUCTION ENGINEERS.—*Luton Graduate Section:* Tuesday, April 7, 7.30 p.m., Peahen Hotel, London-road, St. Albans. "Standardisation and the Utilisation of Materials," by Dr. E. L. Diamond. *Leicester Section:* Thursday, April 9, 7 p.m., Bell Hotel, Leicester. "Gear Finishing," by Mr. H. Pearson. *London Section:* Thursday, April 9, 7 p.m., The Royal Empire Society, Northumberland-avenue, W.C.2. "Building a Steam Turbine," by Mr. A. C. Annis. *Liverpool Graduate Section:* Friday, April 10, 7.30 p.m., Exchange Hotel, Tithebarn-street, Liverpool. Film Evening. *West Wales Section:* Friday, April 10, 7.30 p.m., Central Library, Alexandra-road, Swansea. "Advanced Science and the Production Engineer," by Professor Llewellyn Jones. *Western Graduate Section:* Monday, April 13, 7.30 p.m., Grand Hotel, Bristol. Lecture Competition. *Birmingham Section:* Wednesday, April 15, 7 p.m., James Watt Memorial Institute, Birmingham. "The Contribution of Human Skills to Productivity," by Mr. W. D. Seymour. *Cornwall Section:* Wednesday, April 15, 7.15 p.m., Cornwall Technical College, Trevenon Park, Pool. "The Application of Induction Heating," by Mr. S. R. Tones.

INSTITUTE OF FUEL.—*North-Western Section:* Wednesday, April 8, Engineers' Club, Manchester. 2 p.m., Annual Meeting. 2.30 p.m., "A National Fuel Policy," by Captain (E) W. Gregson. *East Midlands Section:* Thursday, April 9, 6.15 p.m., Gas Showrooms, Nottingham. "Investigations in Power Stations Concerned with Boiler Fouling and Corrosion," by Dr. H. E. Crossley. *South Wales Section:* Friday, April 10, 6 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Some Aspects of Domestic Heating," by Mr. E. Brooks.

INSTITUTE OF PETROLEUM.—Wednesday, April 8, 5.30 p.m., Manson House, 26, Portland-place, W.1. "The Present Status of the Art of Cracking," by Mr. W. C. Dickerman, Junr.

BRITISH INSTITUTION OF RADIO ENGINEERS.—*North-Eastern Section:* Wednesday, April 8, 6 p.m., Neville Hall, Newcastle-upon-Tyne. Annual Meeting and Demonstration of Stereophonic Reproduction. *London Section:* Wednesday, April 8, 6.30 p.m., London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. "Lens Aerials for Centimetric Wavelengths," by Lieut.-Col. J. P. A. Martindale. *Scottish Section:* Thursday, April 9, 7 p.m., 39, Elmbank-crescent, Glasgow, C.2. "Remote-Control Devices and Servomechanisms," by Mr. A. E. W. Hibbitt. Thursday, April 16, 7 p.m., The University, Edinburgh. "The Principle and Applications of the Telescribe," by Mr. C. A. Gilbert.

STOKE-ON-TRENT ASSOCIATION OF ENGINEERS.—Wednesday, April 8, 7 p.m., Offices of the Midlands Electricity Board, Back Glebe-street, Stoke-on-Trent. "Gears and Their Applications," by Mr. H. J. Watson.

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—*East Midlands Centre:* Wednesday, April 8, 7.30 p.m., Mechanics' Institute, Nottingham. "Rear Axles," by Mr. R. H. Wilson. *Western Centre:* Thursday, April 9, 7.30 p.m., Grand Hotel, Bristol. Annual Meeting and

Film Display. *South Wales Group:* Friday, April 10, 7 p.m., South Wales Institute of Engineers, Park-place, Cardiff. Annual Meeting.

INSTITUTION OF THE RUBBER INDUSTRY.—*Southampton Section:* Wednesday, April 8, 7.30 p.m., Polygon Hotel, Southampton. Annual Meeting and Film Display. *Merseyside Section:* Monday, April 13, 7 p.m., Electricity Showrooms, Whitechapel, Liverpool. Annual Meeting. *Preston Section:* Monday, April 13, 7.15 p.m., Bull and Royal Hotel, Church-street, Preston. Annual Meeting and Film Display. *London Section:* Tuesday, April 14, Manson House, 26, Portland-place, W.1. 6.30 p.m., Annual Meeting. 7 p.m., Films on "Basic Principles of Lubrication," and "Krilium." *Scottish Section:* Tuesday, April 14, 7.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. Annual Meeting. "Bonding Rubbers to Synthetic Fabrics," by Mr. T. H. Messenger and Dr. W. C. Wake.

INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, April 9, 5.30 p.m., Victoria-embankment, W.C.2. "Special Effects for Television Studio Productions," by Mr. A. M. Spooner and Mr. T. Worswick. *South Midland Centre:* Thursday, April 9, 7 p.m., College of Technology, Birmingham. "The Devising of Examination Questions," by Professor G. W. Carter. *Radio Section:* Monday, April 13, 5.30 p.m., Victoria-embankment, W.C.2. Discussion on "The Relative Merits of Broad-Band Transmission by Beam, Cable and Waveguide," opened by Mr. E. C. H. Organ. *North-Western Centre:* Tuesday, April 14, 6.15 p.m., Engineers' Club, Manchester. "The London-Birmingham Television-Cable System," by Mr. T. Kilvington, Mr. F. J. M. Laver and Mr. H. Stanesby. *East Midland Centre:* Tuesday, April 14, 6.30 p.m., Offices of the East Midland Electricity Board, Derby. "The First Stage of the Electrification of the Estrada de Ferro Santos a Jundiai (Late Sao Paulo Railway)," by Mr. R. J. B. Chatterton and Mr. D. H. Rooney.

ILLUMINATING ENGINEERING SOCIETY.—*Manchester Centre:* Thursday, April 9, 6 p.m., Offices of the North Western Electricity Board, Town Hall Extension, Manchester. "Glass," by Mr. P. M. Davidson.

INSTITUTION OF CIVIL ENGINEERS.—*Midlands Association:* Thursday, April 9, 6 p.m., James Watt Memorial Institute, Birmingham. Open Discussion Evening. *Hull and East Riding Branch:* Friday, April 10, 6.15 p.m., Electricity Showroom, Ferensway, Hull. Annual Meeting. Vernon Harcourt Lecture on "Practical Methods of Flood Protection," by Mr. W. E. Doran.

LIVERPOOL METALLURGICAL SOCIETY.—Thursday, April 9, 6.30 p.m., 9, The Temple, Dale-street, Liverpool. Annual Meeting. "Basic Processes Involved in the Tempering of Plain-Carbon and Low-Alloy Steels," by Dr. W. S. Owen.

INSTITUTE OF WELDING.—*South London Branch:* Thursday, April 9, 6.30 p.m., Caxton Hall, Victoria-street, S.W.1. Annual Meeting. Debate on "Standardised Inspection Tests in Welded Work." *North-Eastern (Tyneside) Branch:* Thursday, April 9, 7 p.m., Neville Hall, Newcastle-upon-Tyne. Annual Meeting. "Welding of Deck Houses," by Mr. W. Muckle. *Birmingham Branch:* Friday, April 10, 7 p.m., James Watt Memorial Institute, Birmingham. Annual Meeting and Film Display. *Sheffield Branch:* Monday, April 13, 7.15 p.m., College of Commerce and Technology, Pond-street, Sheffield, 1. Annual Meeting.

INSTITUTE OF MARINE ENGINEERS.—*Junior Section:* Thursday, April 9, 7 p.m., 85, The Minories, E.C.3. Discussion on "So You Want to Build a Ship."

INSTITUTE OF BRITISH FOUNDRYMEN.—*Lincolnshire Branch:* Thursday, April 9, 7.15 p.m., Lincoln Technical College, Lincoln. Short Paper Competition. *Tees-Side Branch:* Friday, April 10, 7.30 p.m., Head Wrightson & Co., Ltd., Teesdale Ironworks, Thornaby-on-Tees. Annual Meeting. "Flow of Metal," by Mr. F. Hudson. *Lancashire Branch:* Saturday, April 11, 3 p.m., Engineers' Club, Manchester. Annual Meeting. "Is Mechanisation Worth While?" by Mr. J. Gardom. *Newcastle Branch:* Saturday, April 11, 6 p.m., Neville Hall, Newcastle-upon-Tyne. Annual Meeting. *East Midlands Branch:* Saturday, April 11, 6 p.m., College of Arts and Crafts, Derby. Annual Meeting and Short Paper Competition.

INSTITUTION OF MECHANICAL ENGINEERS.—Friday, April 10, 5.30 p.m., Institution of Civil Engineers, Great George-street, S.W.1. Joint Meeting with the INSTITUTION OF CIVIL ENGINEERS and the INSTITUTION OF ELECTRICAL ENGINEERS. "The Athlone Fellowship Scheme for the Practical Training in Industry of Canadian Engineering Graduates in Great Britain," by Dr. W. Abbott.

INSTITUTION OF STRUCTURAL ENGINEERS.—*Western Counties Branch:* Friday, April 10, 6 p.m., The University, Bristol. Annual Meeting.

JUNIOR INSTITUTION OF ENGINEERS.—Friday, April 10, 7 p.m., Townsend House, Greycoat-place, S.W.1. "Developments in the Design of the Steam Locomotive," by Mr. D. M. Hunter.

PERSONAL.

SIR GEORGE GATER, G.C.M.G., K.C.B., D.S.O., chairman of the Building Apprenticeship and Training Council since 1947, has tendered his resignation to the Minister of Works. His successor, as from April 1, is **SIR FREDERICK LEGGETT, K.B.E., C.B.**

SIR JOHN DALTON has been elected chairman of W. T. Henley's Telegraph Works Co. Ltd., as from March 31, in succession to **SIR MONTAGUE HUGHMAN**, who is, however, retaining his seat on the board.

SIR HAROLD YARROW, C.B.E., is to have the honorary degree of LL.D., conferred upon him by the University of Glasgow, on Commemoration Day, June 17.

MR. R. D. G. RYDER has been elected President of the Machine Tool Trades Association, Victoria House Southampton-row, London, W.C.1, for 1953-54. **MR. H. P. POTTS** has been elected vice-president and **MR. G. E. HICKMAN**, honorary treasurer.

MR. R. O. HERFORD, O.B.E., for many years managing director of the Renold and Coventry Chain Co. Ltd., 28, Deansgate, Manchester, 3, retired from that office on March 29, but remains a director of the company. **MR. O. BERTOYA** has been appointed managing director in succession to Mr. Herford, and **MR. W. S. C. TULLY, C.B.E.**, has been made deputy managing director. **MR. W. V. FOLEY** has been appointed general sales manager in succession to Mr. Bertoya.

MR. GEORGE BARRIE is retiring from the chairmanship of Barclay, Curle & Co. Ltd., Clydeholm Shipyard, Whiteinch, Glasgow, W.4, as from tomorrow, April 4. **MR. JAMES GILCHRIST**, the present vice-chairman, has been elected to succeed Mr. Barrie as chairman.

MR. A. R. NEELANDS has been appointed chairman of the Cementation Co. Ltd., 39, Victoria-street, London, S.W.1, and relinquishes his appointment as managing director. **MR. W. A. PICKERSGILL** and **MR. P. D. TOLHURST** have been appointed to the board, the former being made managing director.

MR. ALFRED BLOUNT, hitherto general manager of Vandervell Products Ltd., has been appointed a member of the executive board of the Plessey Co., Ltd., Ilford, Essex. **MR. R. I. HUGHES, A.C.I.S.**, has resigned his appointment as managing director of the Ford Motor Co. of India to join the administrative establishment of the Plessey Co.

MR. S. G. CUSTANCE, works manager of the Fairey Aviation Co. Ltd., at Heston, has retired after a service of 48 years in the engineering world.

MR. JOHN NEILL and **MR. M. WOOSNAM** have relinquished their appointments on the board of the North Eastern Marine Engineering Co. (1938) Ltd., and **MR. E. DALE, MR. A. H. W. DAWSON, MR. C. GREY, MR. G. L. HUNTER, MR. J. M. IRELAND, MR. F. W. MATTHEWS** and **MR. A. STOREY** have been elected directors.

MR. FRANK FOSTER, M.Sc., A.M.I.E.E., has been appointed general manager of the "Cyc-Arc" stud-welding division of Crompton Parkinson Ltd.

MR. G. B. JUDD has been elected to the board of Whessoe Ltd., Darlington, in succession to the late **MR. H. CLAYTON**.

MR. D. G. B. MOUNTFORD, formerly in charge of the export sales department, the Hymatic Engineering Co. Ltd., Redditch, Worcestershire, has been made assistant production controller. His successor as export manager is **MR. D. H. V. FEREDAY**.

MR. MICHAEL ROLLING, 94, London-road, Southend-on-Sea, has been appointed representative, for the Eastern Counties, of Peter Stubs Ltd., Warrington.

MR. ALAN BROWN has been appointed sales representative in North-East England, Cumberland and Westmorland of Hadfields Ltd., Sheffield, in succession to **George M. Carter (Agencies) Ltd.**

BRITISH INSULATED CABLES LTD. have acquired, as from April 30, the cable and wire business of **PHILLIPS ELECTRICAL WORKS LTD.**, Canada. Through a new Canadian company, **PHILLIPS ELECTRICAL CO. (1953) LTD.**, they will carry on this business as a going concern at the existing Brockville (Ontario), and Montreal factories. The chairman of the new company will be **MR. W. H. MCFADZEAN**.

WHITE'S MARINE ENGINEERING CO. LTD., Prince Consort-road, Hebburn-on-Tyne, County Durham, announce that the former owners of the company, **DURHAM CHEMICALS LTD.**, have sold the complete shareholding of the company to private shareholders. **MR. J. M. BAZIN** is to continue as managing director, but there will be additions and changes to the board.

THE GENERAL DESCALING CO. LTD., have removed from 289, Hanover-street, Sheffield, 3, to more modern premises in Worksop. Their new address is: Worksop, Nottinghamshire. (Telephone: No. 3211.)

FISHER & LUDLOW, LTD., Material Handling Division, Bordesley Works, Birmingham, 12, have opened a new northern headquarters at Clifton Lodge, Park Crescent, Victoria Park, Manchester, 14. The manager is **MR. R. H. TAYLOR**.

OIL AND COAL BOILER FIRING AT ST. PANCRAS POWER STATION.

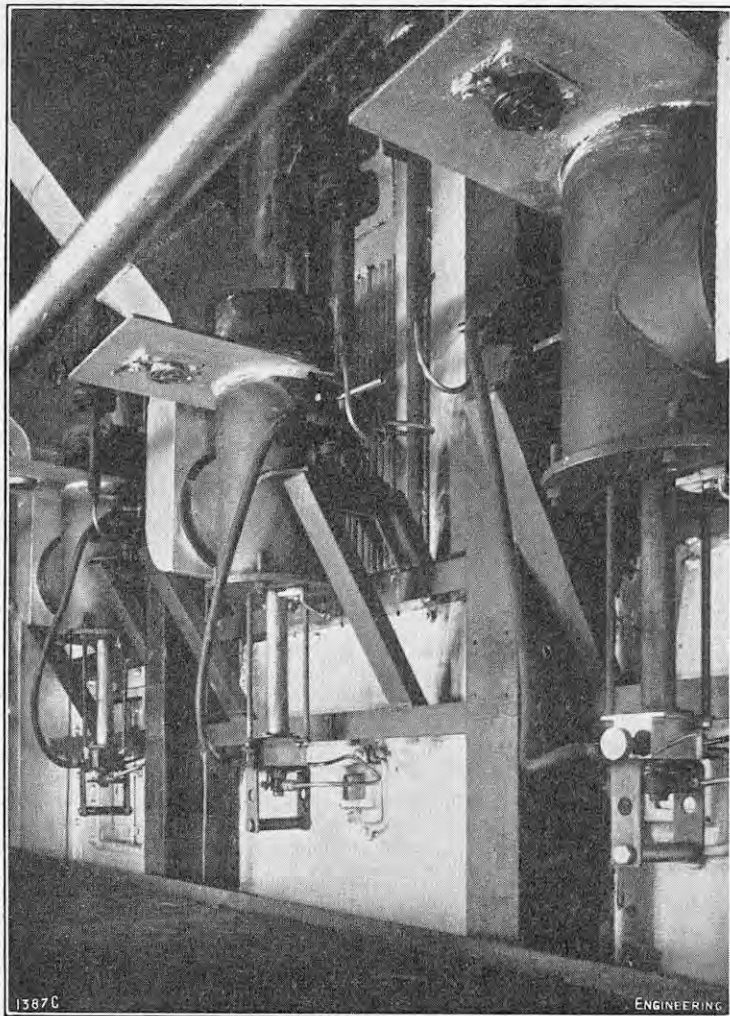
(For Description, see Page 427.)

FIG. 3. INITIATOR FULLY RETRACTED.

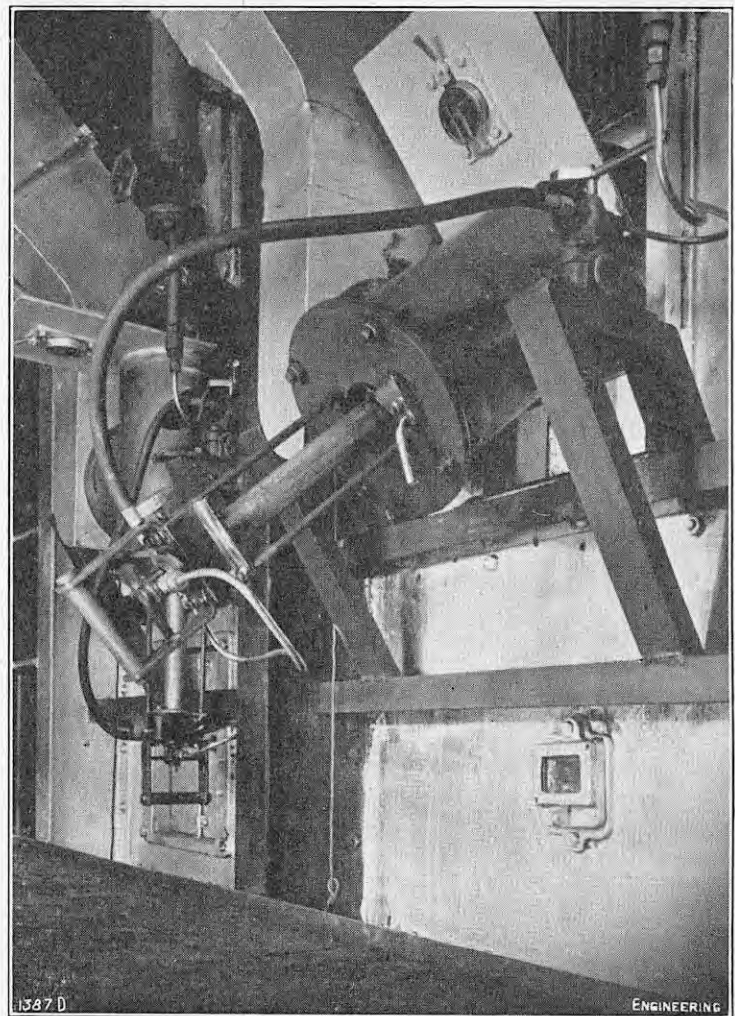


FIG. 4. INITIATOR ENTERING FURNACE.

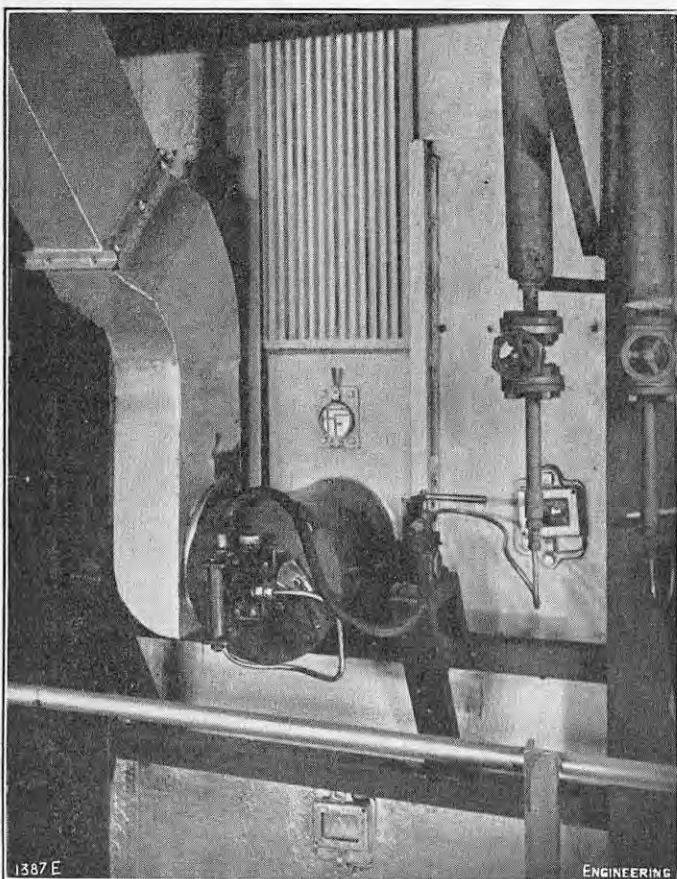


FIG. 5. INITIATOR IN OPERATION.

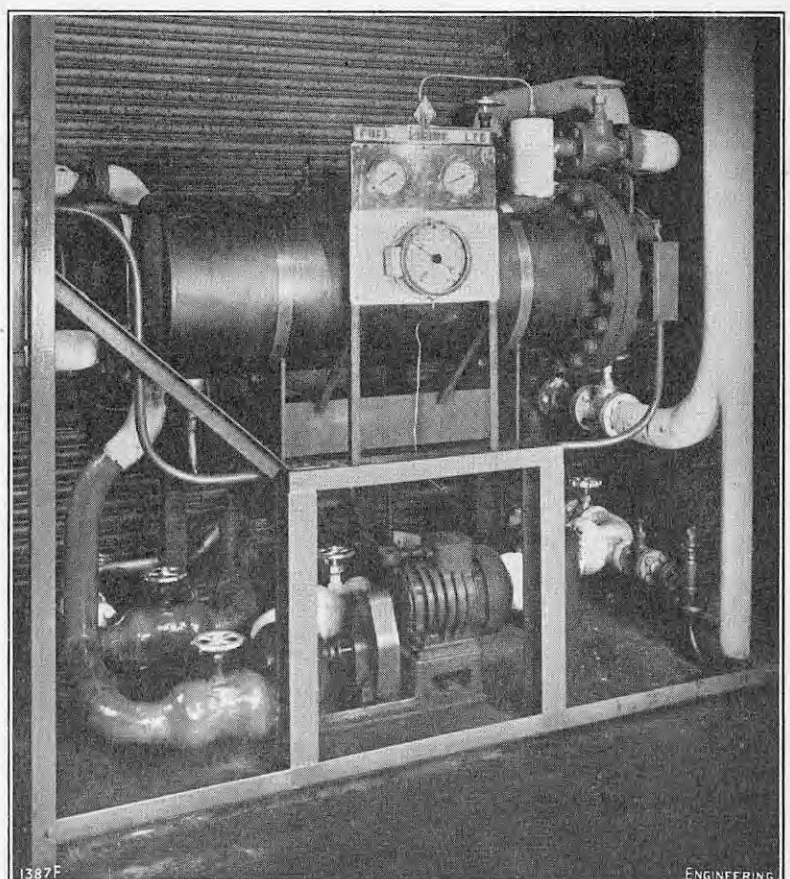


FIG. 6. OIL PUMPING AND HEATING PLANT.

ENGINEERING

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

Registered at the General Post Office as a Newspaper.

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

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SUBSCRIPTIONS.

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For Canada	£5 5 0

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ADVERTISEMENT RATES.

Terms for displayed advertisements can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2½ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

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

TIME FOR RECEIPT OF ADVERTISEMENTS

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

"Copy" instructions and alterations to standing advertisements for display announcements must be received 14 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

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

CONTENTS.

	PAGE
250-Ton and 125-Ton Ladle Cranes for John Summers's Steelworks (<i>Illus.</i>)	417
Literature.—History of the Second World War: Works and Buildings	419
Electric-Traction Braking.—III (<i>Illus.</i>)	419
Occupational Risks of Firemen	421
The Engineering Outlook.—X (<i>Illus.</i>)	421
Electrical Engineers' Exhibition	424
Instrument for Indicating Stresses in Ships Due to Cargo Distribution (<i>Illus.</i>)	425
Steam Turbine Research and Development	426
Combined Oil and Coal Firing at St. Pancras Power Station (<i>Illus.</i>)	427
Induction Stirrer for Electric Arc Furnaces (<i>Illus.</i>)	428
Notes from the Industrial Centres	430
Notices of Meetings	431
Personal	431
The Standard of Working	433
The Economical Survey, 1953	434
Notes	435
Letter to the Editor.—The Genesis of Design	436
Obituary.—Sir David Anderson, LL.D. (with Portrait)	436
Developments in Electrical Insulating Materials	436
The Institute of Metals	437
Non-Inflammable Hydraulic Fluid	438
Range of Bedford Commercial Vehicles (<i>Illus.</i>)	439
Noise from Supersonic Aircraft	439
Labour Notes	440
The National Institute of Agricultural Engineering (<i>Illus.</i>)	441
Scale in Sea-Water Distilling Plants (<i>Illus.</i>)	442
The Safety Factor in Construction.—II	445
Contracts	446
Diamond-Lapping and Polishing Compound (<i>Illus.</i>)	446
Launches and Trial Trips	446
The Design of British Power Stations	447
Books Received	448
Development of Rolls-Royce "Avon" Engines (<i>Illus.</i>)	448

PLATES.

Plates VIII and IX.—250-TON LADLE CRANE AT JOHN SUMMERS'S STEELWORKS.

ENGINEERING

FRIDAY, APRIL 3, 1953.

VOL. 175.

No. 4549.

THE STANDARD OF WORKING.

It would be asking too much of the most efficient librarian to expect him to produce a small book which is not only a guide to the causes of industrial accidents but also a source of information for managers, engineers, designers, welfare officers, safety officers, after-dinner speakers, historians, sociologists, politicians, trade unionists, playwrights, novelists, and any other writers, thinkers and talkers who are interested in social changes in industry in the past fifty years. Yet, such a book was published last week, and it was published for a Government department.* The 1951 annual report of the Chief Inspector of Factories (Sir George Barnett) contains, in addition to the customary review of the work of his staff, a survey of changes during the past half century in the conditions under which men and women work in industry. It is valuable material. It shows, more clearly perhaps than any other documented evidence, that however much the standard of living has risen during the period, the "standard of working" has undergone a far greater change. Such a survey, abridged, as it must be, in an annual report, deserves to be expanded into a full-length volume.

The changes have been wrought, in the first instance, by enlightened managers. Others have followed suit, sometimes tardily, and many years later, and in spreading the gospel the factory inspectors have done inestimable good. The differences that can exist between firms in this

respect may be gauged from the report of an inspector on a firm in his area: "... there has been little progress since 1901, simply because that firm had already reached then the standard that it has taken 50 years for most others to achieve." In 1907, a firm in Edmonton provided a three-course meal in a canteen for 6d., and in Glasgow it is remembered that, although there were no canteens, there was a system, much liked by many of the workers, by which housewives in the industrial areas provided good well-cooked meals for small parties of workmen. Free issues of beer to men—and women—in thirsty and unpleasant trades have passed away, like the old make-shift methods of preparing tea, or cooking a meal on a shovel over a fire. The "tea break" is firmly established and, as the report notes, "it is difficult to imagine any reversal of this policy having any success."

At the beginning of the century, the journey to and from work often entailed a walk that, by present standards, was long and dreary. For others it meant a journey by rail in primitive coaches with wooden seats, no heating and smoky oil lamps. One elderly man, telling an inspector of his boyhood memories, recalled how he used to sit between two fat men for warmth on the journey to the shipyard. Developments in road transport have altered not only travel between home and factory, but also the siting of factories. It is no longer regarded as essential for a works to be near a port or railway; the last war encouraged the dispersal of factories, and the growth of new towns is now altering the geography of industry. Trading estates have been developed (the first—Trafford Park—is still the largest in the world); many small firms have vanished or been absorbed, except in the craft trades, such as locksmithing and chain-making, where small firms with less than 20 employees abound; and the number of factories without power has declined every year.

The factory inspectors are concerned chiefly with accidents, industrial poisoning and diseases, health and welfare, and all the factors which affect employees as human beings. The great consolidating Factory and Workshop Act of 1901—the jubilee of which is marked by the Chief Inspector's survey—was the foundation of the changes which took place in the ensuing 50 years. It was followed by only one major revision and consolidation—the Factories Act of 1937—though Regulations and Welfare Orders have multiplied. In such a mundane matter as cleanliness in factories, the improvement has been pronounced. It has progressed simultaneously with improvements in lighting and interior decoration, and is typified by the remark of an elderly worker in an engineering works: "You don't get red feet nowadays." He was referring to the time when the workshop floor was earth, and iron swarf and chips were allowed to lie rusting on it, so that the men's feet became rust red. One man, aged 80, thought that it was in cleanliness that the greatest improvement had been made; in his early days rats used to collect scraps of food which had been dropped on the floor by the men. In lighting, too, the change has been significant: from the "gloom and pervading smell of gas" which linger vividly in the memories of those who started work early in the century, to the fluorescent lighting which is often, in an otherwise old-fashioned works, the only sign of progress.

In 1901, typhoid fever was endemic in some industrial areas. The sanitary accommodation was often so primitive that it is now difficult to imagine, as the Chief Inspector remarks, why it was considered necessary in some works to employ time-keepers to check men in and out of such places. The standards of sanitary accommodation are even now not universally high, but the average is certainly much better than at the beginning of the century; similarly with the amount of air space allowed per employee, and the temperature

* Annual Report of the Chief Inspector of Factories for the Year 1951. Cmd. 8772. H.M. Stationery Office. [Price 6s. 6d. net.]

and ventilation of shops and offices. The legal minimum air space per person was raised from the 250 cub. ft. laid down in 1901 to 400 cub. ft. in 1937. During the intervening years, the quality of the air itself has been improved: gas burners have been dispensed with, stoves now usually discharge to the outside air instead of polluting the workshop, and the humidity in textile establishments is controlled at a reasonable level.

It is in matters involving the safety of employees that the factory inspectors have encouraged the most noteworthy improvements. Gone are the days when, if an accident occurred on a machine, someone had to run to the main engine room to give warning that the engine should be stopped, although there is still a beam engine working in a Nottingham lace factory, and no doubt there are other examples of old steam engines at work. In 1901, inspectors complained that machinery left the makers with dangerous parts unfenced. The 1937 Act placed a definite obligation on the makers, in respect of certain parts, but the 1951 Report notes that users still complain that they are obliged to add to the fencing of many machines, and inspectors still spend considerable time advising manufacturers and encouraging better standards of fencing. Power presses are particularly difficult machines to deal with; there is now an appropriate standard of fencing for almost every press and operation, but full compliance with the standards has yet to be achieved.

It is not possible, unfortunately, to compare the accident rate in industry for the beginning and end of the 50-year period. The basis on which the statistics are compiled has been altered. The figures, for what they are worth, were 1,035 fatal and 82,725 non-fatal accidents in 1901, and 828 fatal and 182,616 non-fatal accidents in 1951. The figures for non-fatal accidents are obviously not comparable, but those for fatal accidents probably give, fairly accurately, an indication of the improvement which has taken place. The real improvement is almost certainly greater, when account is taken of the extensive mechanisation which has occurred since the beginning of the century.

Of all the other factors which the report briefly surveys, reference must be made to hours of work. "Nothing in the 50 years," it is stated, "has been more striking than the reduction in working hours, and probably nothing has been more welcome to the workpeople themselves." The usual working day was from 6 a.m. to 6 p.m., with half an hour for breakfast and one hour for the mid-day meal, and no authorised short breaks. Shift-working has been eased considerably, though it is interesting to note that there are still at least two men who each work from 6 a.m. to 11 p.m., with a long break of several hours in the middle of the day. No less an authority on working long hours than Mr. Churchill has recommended such an arrangement of the working day, but industry generally could not provide for such hours of employment, nor would employees welcome it. The whole structure of industry is now geared to the improved conditions which have rightly been developed. Almost all the shameful conditions which were not uncommon at the end of the Nineteenth Century have been eradicated, and "welfare" (a word unknown, the report states, to the 1901 Act) reigns supreme. It is difficult to imagine how any comparable rise in standards can be made in the next 50 years, but it is easy to see how much good could be done—for the nation, for families, and for individual men and women—if there were less personal concern for "welfare" in the factory and more for welfare in private life. In spite of the Factory Acts, men who work for themselves are to be found working hard and long, so that they may obtain the means to enjoy more fully the hours of leisure which they prize.

THE ECONOMIC SURVEY, 1953.

ABOUT 14 months ago the Chancellor of the Exchequer, the Rt. Hon. R. A. Butler, made a statement in the House of Commons during which he outlined in broad terms the steps the Government proposed to take to balance the national books. Dollar expenditure was to be reduced; allowances of currency for foreign travel were to be cut; less coal was to be bought from America; some restrictions were to be imposed on hire-purchase transactions; capital expenditure on buildings was to be pruned; economies were to be made in educational expenditure; and charges for the health services were to be introduced or increased. In these ways it was hoped to check the rate of national overspending and, providing costs did not continue to rise, to achieve a balance by the end of the year. It was not to be expected that this policy, even if it were applied with full vigour and completeness, would show immediate results, but the *Economic Survey for 1953*,* which was published this week, indicates that some advances in the right direction have been made. It must, however, be emphasised that these were not the only factors involved in bringing about an improvement and that other important influences have played their part.

Stated in general terms, world economic developments during 1952 both helped and harmed the United Kingdom. On the one hand, the fall in commodity prices greatly improved the terms of trade. On the other, it became much more difficult to sell goods overseas, especially during the second half of the period. The balance of payments crisis of the latter months of 1951, which contained all the seeds of disaster, was, however, checked with such success that by the end of 1952 the sterling area's position had much improved, in spite of heavy payments of interest and amortisation on the United States and Canadian loans. Unfortunately, though the balance with non-sterling countries during 1952 improved, that with the rest of the sterling area underwent a sharp change for the worse about the middle of the year; for exports fell heavily in face of the import restrictions which were imposed by countries trying to get themselves back into balance. In detail, the value of imports fell by 423*l.* million in value during 1952, compared with 1951, about three-quarters of this reduction being on account of volume and the remainder on account of price, owing to considerable falling off in the costs of raw materials.

Turning to the other side of the picture, the total value of exports shipped in 1952 was also lower than in 1951, in spite of the fact that as a whole prices rose by about 5 per cent. It is, however, satisfactory to note that the value of the machinery exported increased from 363*l.* million to 422*l.* million and of other engineering products from 160*l.* million to 173*l.* million, thus continuing the trend of previous years, although there was some slight falling off in the last quarter. During the earlier part of the year, too, exports were held back by the combined effects of the steel shortage and the heavy demands of defence and home investment. These conditions had the particularly harmful result that long delivery dates had to be quoted, which meant that orders were lost, even when the products were fully competitive on price and quality. It was to deal with this situation that the Government spread out the defence production programme and restrained the home civil demand for plant and machinery with results which seem at least to have been moderately satisfactory.

Home production and consumption are, however, factors of equal importance to exports in the national economy; and the changes which occurred in this

field during the year are fully analysed in the survey. As a whole, industrial production was about 3 per cent. less than in 1951, owing to falls in personal consumption and fixed investment (as well as exports), although these falls were more than offset by the rise in current expenditure of public authorities, which was almost wholly on account of defence. The value of consumers' expenditure was considerably higher in 1952 than in 1951, but this was more than accounted for by the higher prices; in fact, there actually appears to have been a drop of about 1 per cent. in personal consumption between the two years. This occurred in spite of the fact that the net effect of the Budget alterations was to leave consumers' real purchasing power unchanged, though expenditure must have been reduced by such factors as the fall in Stock Exchange prices, restraints on bank advances and restrictions on hire purchase. On the whole, however, it is considered that the changes in economy during 1952 were broadly in line with Government policy and were satisfactory to the extent that the state of the country at the end of the year was much healthier than it was twelve months previously and it was better able to respond to any increase in demand from overseas markets. In fact, the level of demand at home allowed a reasonable margin for flexibility, and, generally speaking, the prices of most consumer goods remained stable or decreased.

We may turn now from these generalities to those branches of the country's work with which engineers are likely to be most interested. Owing to the widespread slackening of activity, the coal consumption for general industrial purposes was about 2 million tons less in 1952 than in 1951, in spite of a 5 per cent. increase in consumption by the engineering industries. The consumption in both electric power stations and gasworks remained almost stationary. Actually, the production of coal in the calendar year was 226.4 million tons, which was 1.2 per cent. greater than in 1951, but the amount consumed in electric power stations only increased from 35.4 million to 35.5 million tons. This is partly ascribable to the fact that, while electrical output was 3 per cent. greater than in 1951, the 1,539 MW of new plant which was brought into operation had a beneficial effect on the efficiency of generation. The decline in industrial activity led to an improvement in the operation of the railway system, which is, however, cold comfort; and there was an easing in the steel shortage. Actually, production of this essential material reached 16.14 million ingot tons, or 500,000 tons more than in 1951, with the result that it was possible to some extent to build up stocks. The serious shortage of nickel and molybdenum, however, gave rise to difficulties. The net effect of all the changes in supply and demand described in the Survey is that the total industrial production fell slightly during 1952, although metal manufacture showed an increase. There was also a decline of about 145,000 in civil employment, although in this respect again there was little change for the worse in most branches of the engineering industry.

As regards the coming year, it is postulated that the main economic objective will continue to be the maintenance of an adequate and stable external balance, in order that the standard of living may not be undermined. There must continue to be concentration on the increase of exports, the responsibility for which is laid on industry, although it is admitted that the Government must create and maintain economic conditions favourable to such expansion. We hope that this statement indicates a certain change of heart, but it must also be accompanied by assistance in other directions. It is essential, for instance, to increase coal production and to ensure adequate supplies of steel, and, while current stocks of most raw materials are healthy, economy in their use is essential.

* *Economic Survey for 1953.* H.M. Stationery Office. [Price 1s. 6d. net.]

NOTES.

LORD WEIR'S GIFTS TO ENGINEERING INSTITUTIONS.

FIVE institutions have received from the Rt. Hon. Viscount Weir, P.C., G.C.B., LL.D., a gift of 10,000l. each. They are the Institution of Mechanical Engineers, the Institution of Naval Architects, the Institute of Marine Engineers, the Institution of Engineers and Shipbuilders in Scotland, and the North East Coast Institution of Engineers and Shipbuilders. The value of these most generous contributions to the funds of the principal professional bodies concerned with mechanical and marine engineering is enhanced by Lord Weir's intimation that he wishes the money to be used in benefitting the work of the institutions in any useful direction or form of activity according to the discretion of the respective Councils. At the annual general meeting of the Institution of Mechanical Engineers held on Friday, March 27, the President, Sir David Pye, F.R.S., said that he had personally called upon Lord Weir and had informed him, on behalf of the Institution, of the grateful thanks felt by the Council and members for his great generosity. The Council, he said, were now giving earnest consideration to the most beneficial use to which Lord Weir's gift might be applied, and would announce their decision in due course. Lord Weir is chairman of G. and J. Weir, Limited, Cathcart, Glasgow, and a director of a number of other engineering firms. He gave his services to the Government in various capacities during both World Wars. He was Director-General of Explosives and Chemical Supplies at the Ministry of Supply in 1939, and in 1942 he became chairman of the Tank Board. He is honorary President of the British Employers' Confederation. Lord Weir was elected a member of the Institution of Mechanical Engineers in 1906 and was admitted to honorary membership in 1918. He became a member of Council in 1919 and was appointed vice-president later that year, but retired from the Council in 1921. He has also been a member of the Institution of Engineers and Shipbuilders in Scotland for 57 years, and an honorary member since 1921. Members of the five institutions will undoubtedly be awaiting the decisions of the Councils with keen interest. The smaller institutions particularly will feel the benefit of Lord Weir's generosity.

JUBILEE OF THE METROPOLITAN WATER BOARD.

Thursday, April 2, 1953, marks the 50th anniversary of the first meeting of the Metropolitan Water Board. The proximity of the date to Good Friday (April 3) is presumably the reason why the Board advanced by a week, to March 27, the celebration of the event, which was marked by a luncheon in the head office at the New River Head, Rosebery-avenue, London, E.C.1, followed by a special meeting of the Board, to which a number of guests were also invited. The chair was taken, at both the luncheon and the meeting, by the veteran chairman of the Board, Mr. William H. Girling, O.B.E.—who, with the deputy chairman (Major F. W. Beech, C.B.E.) had received the guests. He was supported by a large attendance of the mayors or other principal officers of the urban areas or municipalities which either contribute to the Board's supplies or receive them. The luncheon was almost solely a social function, the speeches being brief, as the Board meeting was to follow immediately. At the meeting, the proceedings opened with the reading of a message from the Rt. Hon. Harold Macmillan, Minister of Housing and Local Government, who was unable to attend because of the death of Her Majesty Queen Mary. The Minister, after alluding to the work done by the Board in the past 50 years in developing the extent of their services and ensuring the purity of the supply, referred to the financial and administrative difficulties experienced by the Government in apportioning the limited amount of capital expenditure permissible, in present circumstances, among the many public services which had claims for consideration. His task, he said, had been made easier in the London area by "the co-operative and under-

standing attitude of the Metropolitan Water Board and the adaptability and hard work of their staff." Among the many speakers who added their tributes after the reading of Mr. Macmillan's letter were Lord Morrison, the Rt. Hon. Mr. Herbert Morrison, Captain Sir Jocelyn Bray, D.L., J.P. (chairman of the Thames Conservancy), and Sir Thomas Keens, D.L., J.P. (chairman of the Lee Conservancy Catchment Board). Lord Morrison recalled that the first meeting of the Board was held in the Privy Council's chambers in Downing-street, but, for the second, they were relegated to the premises of the Metropolitan Asylums Board. The principal formal item of business at the special meeting was the submission and adoption of a memorandum outlining the history of the undertaking (which combined the plant and services of the eight previously-existing water companies) and the changes that had taken place in 50 years in the work of supplying London with water. It will be recalled that a more extended history was given by Mr. H. F. Cronin, C.B.E., M.C., in his presidential address to the Institution of Civil Engineers, which was reprinted in *ENGINEERING*, vol. 174, pages 605, 622, 675 and 709 (1952). A small exhibition illustrating the work of the Board was arranged in a building adjacent to the offices, and the jubilee was further commemorated by the publication of a book in which the growth and operations of the organisation are described. We hope to review this volume in due course.

THE INSTITUTION OF STRUCTURAL ENGINEERS.

Professor A. G. Pugsley, O.B.E., D.Sc., F.R.S., a vice-president of the Institution, provoked a lively discussion when he introduced his "Simple Theory of Suspension Bridges" on Thursday, March 26, to an audience which included a number of engineers who had either designed suspension bridges or had been engaged on scientific research into the validity of different theories of design. The "old guard" was energetically led by Mr. H. H. Leys who referred to a number of suspension bridges in British Colonies, for which he had been responsible, and stated that he had always obtained very satisfactory results in practice by adhering to the methods advocated by a well-known American authority on this special branch of design. On the other hand, Mr. O. A. Kerensky and Mr. B. Wex, who had both been closely connected with design analysis for the Severn Bridge scheme, stated that they had already tested the author's new theory and found that, with the appropriate correlation factor, it led very rapidly to realistic estimates which were well in the right street, when compared with the results of more exact analysis. Professor Pugsley, however, had no difficulty in resolving the apparently conflicting views of his friends and critics, since the theory was intended for use in the design of spans of at least 1,000 ft. rather than spans of several hundred feet with which Mr. Leys had been professionally concerned. Explaining the theory in very simple terms, the author said that in long-span suspension bridges, with heavy tension cables, the applied loads were carried to a great extent by the increase in gravity potential of the cable as it deformed under load. This effect, the gravity stiffness he called it, had been neglected by Rankine in the well-known classical method of design, but the early designs based on Rankine's theory had been satisfactory in practice because for short-span bridges the gravity stiffness was usually no more than a subsidiary item of the problem; for spans like that of the Washington Bridge or the Severn scheme, however, it became a paramount consideration. The key to the new simple theory, he explained, was the assumption of an average value of the gravity stiffness of the cable, which enabled the problem of the stiffening girder to be treated by the analogy of a beam on elastic supports, or a railway track on its foundation. The solution of this problem was well known and could easily be applied to the suspension bridge; he did not expect to obtain accurate answers in view of the assumption of constant gravity stiffness which was a rather broad approximation, but he considered that a very rapid method of initial approximation with an accuracy of the order of 20 per cent. would lead almost immediately to preliminary designs which

could then be fairly quickly refined by one of the more exact methods of analysis. The paper is printed in *The Structural Engineer*, March, 1953.

THE WHITWORTH SOCIETY.

The annual dinner of the Whitworth Society was held at Simpson's Restaurant, Strand, London, on March 18. Although this is the main function of the year, the Society is not merely a social club. Graduates of a university, or past students of a technical college, in a sense constitute a corporate body with common interests or at least common recollections. Whitworth men, however, come from all parts of the country and have greatly varied educational backgrounds so that they have no corresponding centre of interest. The lacuna is filled by the Whitworth Society, which not only serves as a medium for social intercourse but occupies itself with the material interests of Whitworth men as a body. On more than one occasion it has made representations and suggestions to the Ministry of Education in connection with the regulations governing the Whitworth awards. Another activity in the educational field is the presentation of Whitworth Society Prizes to successful candidates for Ordinary National Certificates in both mechanical and electrical engineering. It is hoped that the encouragement afforded by these prizes may do something towards inducing the recipients to compete for Whitworth Scholarships. Two new Scholars were present as guests at the dinner on March 18, Mr. E. K. Armstrong, a Senior Scholar, and Mr. J. W. E. Ells, a Scholar. In replying to a toast, Mr. Armstrong said that he thought the Whitworth Scholarships were not sufficiently advertised: it was by chance that he ever heard of them. The Whitworth Society Prizes should do something towards assisting in this matter. The chair at the dinner was occupied by the President, Sir Henry Guy, who responded to the traditional toast to the Society proposed by Mr. P. P. Love. The toast to the new Whitworth Scholars was proposed by Professor S. J. Davies, who, it was announced, has been elected as the next President to follow Sir Henry Guy. Both Mr. Love and Sir Henry, in their speeches, referred to the important bearing of much of Sir Joseph Whitworth's work on modern conditions, Sir Henry quoting many passages from Whitworth's addresses illustrating his remarkable prescience. It was announced that the summer meeting would be held at Oxford and Harwell on June 18 and 19.

DUTY-FREE MACHINERY IMPORTS COMMITTEE.

After consultation with the Chancellor of the Exchequer, the President of the Board of Trade has decided to set up an independent committee to review the long-term problem of the duty-free entry of machinery into this country. The terms of reference of the committee are: "To consider and report whether it is in the national interest to provide for the duty-free admission into the United Kingdom of machinery, either by classes or in individual consignments; and, in this connection, to review the provisions of Section 10 of the Finance Act, 1932, and their administration, and to recommend what, if any, changes should be made." The chairman of the committee is Sir Henry Wilson Smith, K.C.B., K.B.E., and the other members are Mr. R. Bird, Mr. T. F. A. Board, C.B.E., Mr. M. A. Fiennes, M.I.Mech.E., Mr. C. H. Grist, Mr. R. Grove, Mr. S. J. Harley, B.Sc., M.I.Mech.E., M.I.P.E., Mr. A. V. Symons and Mr. Jack Tanner. The joint secretaries to the committee are Mr. D. P. Brearley, of the Board of Trade, and Mr. D. M. J. Gwinnell, of the Ministry of Supply. The present announcement by the President of the Board of Trade of the setting up of the committee, it is pointed out, follows the statement by the Chancellor of the Exchequer, in his Budget speech last year, on March 11, that the issue of licences under Section 10 of the Finance Act, 1932, for the duty-free import of machinery would be suspended for the time being, but that the long-term problem involved would be examined in consultation with industry. Communications for the committee should be addressed to the joint secretaries, Board of Trade, Horse Guards-avenue, London, S.W.1.

LETTER TO THE EDITOR.

THE GENESIS OF DESIGN.

TO THE EDITOR OF ENGINEERING.

SIR,—Your editorial comments under the title "The Genesis of Design," on page 370 of your issue of March 20, made very interesting reading. There is a fascination in occasionally escaping from the mundane activities of designing and making machines into that borderland where the engineer and the psychologist have for the moment a common interest. There are bound to be many competent engineers who doubt the value of such speculations. This, I contend, is rather the fault of the engineering curriculum than any inherent incompatibility in the two branches of knowledge. The chief merit of Mr. Wallace's book is that it carries the creative effort of the engineer a stage farther than the products of invention. The mind, too, has its laws, which are no less amenable to analysis than those in the material realm. It must be obvious to all who give thought to the subject that the more comprehensive our knowledge of all the factors in a given situation the greater will be the prospect of the successful achievement of our initial aims. Knowledge is still power.

It may be, as you have pointed out, that the enthusiasm of some writers leads them to dogmatise concerning the alleged laws of the mind, but this is a pardonable fault and need not detract from the real merit in making the attempt. For this reason, Mr. Wallace is to be congratulated for producing an eminently readable introduction to an aspect of engineering which is now attracting the attention of leading engineers and psychologists.

Yours faithfully,

S. C. MCKENZIE.

Allandale,
63, Sidney-road,
Rugby,
Warwickshire.
March 24, 1953.

OBITUARY.

SIR DAVID ANDERSON, LL.D.

WE regret to record the death of Sir David Anderson, which occurred at Dura, Cupar, Fifeshire, on Friday, March 27, at the age of 72. One of the leading British civil engineers, he was well known for his work in carrying out a number of important projects, as well as for designing many bridges and tunnels, frequently for construction under difficult conditions.

David Anderson was born on July 6, 1880, and was educated at Dundee High School and St. Andrew's University, where he obtained the degree of Bachelor of Science in Engineering. After a short period of practical training in the drawing office and works of Sir William Arrol and Company, Limited, Glasgow, he began his professional career as assistant to Sir Benjamin Baker in 1905, and was engaged on work connected with the widening of Blackfriars Bridge, London, and with the reconstruction of Rochester Bridge. He then joined Mr. (later Sir) Basil Mott and Mr. D. Hay and worked with them in a similar capacity and as chief assistant on the new Southwark Bridge and the extension of the Central London Railway to Wood Lane. During the 1914-18 war he served in the Royal Engineers, being demobilised with the rank of captain.

After the war he entered into partnership with Sir Basil Mott and Mr. David Hay as consulting engineers, and carried out a number of works the general object of which was the improvement of the road and rail communications of the country. Among these mention may be made of the single-span high-level road bridge at Newcastle-upon-Tyne, the construction of which did much to facilitate the passage of road traffic across the river without interfering with navigation. The single arch of this bridge has a span of 531 ft. between the centres of the abutment piers and at the time of its opening, was the largest in the country. A feature of the design of the bridge is the handsome abutment

towers which mark the ends of the bridge. To this period also belong the Wearmouth Bridge at Sunderland and the Tees vertical-lift bridge at Middlesbrough. As consulting engineer to the Corporation of London, Anderson's firm was concerned with the maintenance of four Thames bridges within the City boundaries.

Perhaps, however, the most important and difficult work for which the firm was responsible was the design and construction of the road tunnel under the River Mersey between Liverpool and Birkenhead. This tunnel, work on which was begun in 1925 and completed in 1934, comprised main and dockside traffic entrances at each end, from which short approaches led to the main tunnel. The total length of roadway constructed was 5,064 yards, the distance between the quay walls on the two sides of the river being 1,261 yards. At the deepest point the bottom of the under-river tunnel is 170 ft. below high-water level, while the



THE LATE SIR DAVID ANDERSON.

average cover of rock over the top of the tunnel is 20 ft. 6 in., the minimum being 3 ft. 6 in. As the tunnel was mainly to be used by road vehicles, it was provided with very complete ventilating plant, while equipment was also installed to deal with incoming water. Other work of this character with which the firm was associated was a project, prepared jointly with Messrs. Coode, Wilson, Vaughan-Lee and Gwyther, for building a road tunnel beneath the Thames between Purfleet in Essex and Dartford in Kent, and the construction of twin tunnels for pedestrians and cyclists beneath the Tyne between Howden and Jarrow. The firm were also responsible as joint consulting engineers for the London Passenger Transport Board for the realignment of the eastern portion of the Central Line to Newbury Park, Ilford.

Anderson received the honour of knighthood in 1951. He was elected an associate member of the Institution of Civil Engineers in 1906 and was transferred to the class of member in 1915. Having served on the Council and as vice-president, he was elected president for the 1943-44 session. During his connection with the Institution he contributed a number of papers to the *Proceedings* and was awarded the Telford Medal for a paper on the "Tyne Bridge, Newcastle." He also received a Telford Premium for a paper on "The Widening of Blackfriars Bridge." He was a member of the American Society of Civil Engineers and of the Association of Consulting Engineers, as well as an honorary LL.D. of St. Andrews.

DEVELOPMENTS IN ELECTRICAL INSULATING MATERIALS.

(Continued from page 376.)

DIELECTRIC LOSSES IN LIQUIDS.

AT the second session of the symposium on insulating materials, which was held at the Institution of Electrical Engineers on Tuesday afternoon, March 17, the subject of permittivity and dielectric losses in liquids was dealt with. The chair was taken by Mr. J. F. Coales and the rapporteur was Dr. L. Hartshorn, who said that the papers showed that in British electrical practice the one insulating liquid of supreme importance was mineral oil, which could be specified and reproduced within close limits. Its primary functions in practice were to support a voltage gradient and to protect the associated solid insulation, usually cellulose in the form of paper or press-board, against the absorption of water. It was possible to refine the oil to a point where it performed these functions perfectly. Nevertheless, in actual practice, the oil did not form a perfect barrier to the passage of water into the system it surrounded. This absorbed water nearly always caused an increase in the power losses in the insulation and a decrease in the breakdown voltage. It might be inferred that thermal instability set the limit to the performance of insulating material of this class under ordinary working conditions and it was satisfactory that a measurement of power loss at a voltage involving no risk should afford so reliable a guide to the chances of failure at the rated voltage.

It was not surprising to find that in actual practice oil did not remain serviceable for ever and it was desirable on large power systems to have some means of checking its condition after it had been long in service. Measurements of acidity and resistivity were useful for this purpose, but their interpretation was not always straightforward. In fact, the correlation between the conductivity and the acidity of an oil was not good, a major disturbing factor being the presence of iron compounds. An empirical formula had been given by which the conductivity could be calculated from the acidity and the iron content and the correlation between the results—those obtained by measurement—was reasonably good.

The papers presented at this session included one on "Some Aspects of the Deterioration of Insulating Fluids." In this, Messrs. D. G. Childs and A. W. Stannett described a survey of 66 selected transformer oils from all parts of the country, which was carried out to investigate the relationship of acidity and resistivity as guides to the quality of used oil and to examine the factors affecting resistivity with particular reference to iron compounds in the oil. As a result it was discovered that hydrocarbon oil, refined to comply with British Standard Specification 148 (1933), was behaving satisfactorily in the electricity supply industry at present. There was some indication, however, that a change in this situation might be produced by the tendency to take full advantage of plant capacity by loading to the maximum designed temperature. Evidence had also been collected to show that an oil having a better resistance to deterioration should result from the application of British Standard Specification 148 (1951), and this, together with the use of hydrocarbon oils containing antioxidants, might go far to meet the possibly exacting nature of future conditions.

Where low fire risk and higher operating temperatures were required synthetic transformer fillings might be used. These included the chlorinated diphenyls and the silicones, which were non-inflammable and resistant to oxidation. The present high cost of these substances, compared with that of hydrocarbon oil, however, prohibited their use except in special circumstances. Nevertheless, they were of considerable interest. Apart from their cost the main danger associated with the use of these substances was their tendency to form hydrochloric acid when a spark or arc occurred in them. Any acid dissolved was absorbed by tin tetraphenyl

and although the resulting compound was hydrolysed by alkalis it did not appear to be hydrolysed by water in the quantities which might be expected to be present in a transformer. It would therefore be necessary to absorb the hydrochloric-acid gas, which would probably be evolved at the same time.

A paper on the "Effect of Humid Air on Power Loss in Pure and Impure Paraffin Oil" was presented by Messrs. J. Dunkley and R. W. Sillars. A capacitor of the type described by Hartshorn and Ward, but having spherically curved electrodes to avoid trapping bubbles, was used for the measurements, which were made over the frequency range of 50 cycles to 30 megacycles on a very pure paraffinic oil and on the same oil containing a few parts per thousand of an ester of the type used in the plasticiser trade. Neither displayed a measurable power loss in the low-frequency region, but the oil containing the ester showed the usual dipole loss in the megacycle region. Treatment with humid air had no effect on the pure oil, but produced a serious low-frequency power loss in the oil containing the ester. This loss was proportional to the square root of the ester content and increased rapidly as the voltage was raised from 50 to 250 volts on a film 0.025 cm. thick. The conductivity corresponding to this power loss was roughly constant from 100 to 1,000 cycles and fell rapidly to a low value at about 3,000 cycles.

POWER FACTORS OF INSULATING OILS.

"The Measurement of the Power Factors of Insulating Oils at 50 Cycles" was dealt with by Messrs. R. G. Martin and E. A. Patterson, who described a modified Schering bridge which had been designed to measure the power factors of insulating oils from 0.00002 to 0.22 by the double ratio arm method. The total error in measurement of the 50-cycle power factor of an oil was about ± 3 per cent. ± 0.000015 . The range of capacitance measurable directly was from 58 to 1,290 picofarads, though this could be extended from 0 to 1,232 picofarads by the use of a substitution method. The accuracy of the capacitance measurements was within ± 0.1 picofarads. The accuracy of the bridge was checked by connecting a number of resistors in series with the standard capacitor and measuring the power factors of the various combinations at different settings. It was found that the measured power factor did not differ from the calculated power factor by more than ± 0.000005 for values from 0.00003 to 0.001, or by more than ± 2 per cent. for higher power factors.

The "Dielectric Properties of Oil-Soaked Press Board as Affected by Water" was the subject of a paper by Mr. R. T. Rushall. This dealt with the effect of water, in amounts capable of being absorbed from the normal atmosphere, upon the dielectric properties of oil-soaked pressboard within a temperature range of 20 to 90 deg. C. Experiments showed that the properties of moist oil-soaked pressboard were not appreciably impaired by the heating of the material to 90 deg. C. Moisture, however, added a component to the loss-tangent, which increased exponentially both with temperature and, above 4 per cent. moisture, with the moisture content. No appreciable reduction in the 20 deg. C. breakdown voltage was found with moisture contents of up to 40 per cent.; at 90 deg. C., the breakdown voltage was, however, noticeably reduced by 2 per cent. moisture and was reduced to one-half of the normal dry value by 4 per cent. moisture. There existed an approximate relationship between the dielectric loss factor measured at a relatively low voltage and the ultimate breakdown voltage for the material as determined in these tests. This was interpreted as evidence of the thermal character of the breakdowns.

In general, the relationships obtained showed the relative sensitivity to moisture of loss-tangent, permittivity and breakdown voltage and demonstrated the serious deterioration in the properties caused by the amount of water—roughly 8 per cent.—which could be absorbed by this type of insulation if exposed to an atmosphere of normal humidity for sufficient time. They also indicated how material containing moisture and subjected to a maintained electric stress could become thermally

unstable if the temperature of the material rose above some critical value. The normal loss-tangent temperature characteristic of moisture-contaminated oil-soaked pressboard could, however, be greatly modified by inequality in the distribution of moisture such as was likely to occur if moisture was absorbed by the material after oil impregnation. This factor must be taken into consideration when interpreting loss-tangent measurements as evidence of moisture in insulation of this class.

DIELECTRIC LOSS IN INSULATING OIL.

"Dielectric Loss in Insulating Oil" was dealt with in a paper by Mr. K. H. Stark. Considerable discrepancies, said the author, existed between the results of different laboratories when measuring the dielectric loss of the same insulating oils. These could arise either from contamination of the oil sample or from instability. Errors due to the first cause had been rendered negligible by evolving a suitable technique for cleaning and handling the commercially-available test cells. Instability of an oil during the course of a measurement was not so easily controlled, depending as it did on the composition of the oil. In fact, oxidation might cause the dielectric loss to fall to a small fraction of its initial value during the time required by some test cells to attain thermal equilibrium at 109 deg. C. This factor could render meaningless exact values of the dielectric loss of an oil at temperatures of about 100 deg. C. Not much reliance could therefore be placed on the exact high-temperature value of the loss angle of an oil, but only on its order of magnitude.

ELECTRIC STRENGTH AND BREAKDOWN MECHANISMS.

At the meeting on Tuesday evening, March 17, the subject considered was electric strength and breakdown mechanism. The chair was taken by Mr. M. Whitehead, and in introducing the papers, Dr. S. Whitehead, the rapporteur, said that they fell roughly into three groups: those dealing with intrinsic electric strength, those concerned with breakdown by discharges or initial partial breakdown in heterogeneous insulators and those about rather more individual breakdown processes. Although Fröhlich's theory of electronic breakdown gave good agreement with experiments on crystals, Messrs. J. H. Calderwood, R. Cooper and A. A. Wallace had made a number of experiments to eliminate the uncertainties which still existed and had shown that dispersion was considerably reduced, if care were taken to avoid residual strains in the crystal. Mr. H. G. Riddlestone had pointed out that the reduction of electric strength by changing from alternating to direct-current was small with polystyrene and with polythene was confined to the higher temperatures.

As the result of a series of studies on the electric strength of liquids, Mr. T. J. Lewis had discarded the cathode mechanism of liquid breakdown and had adopted a theory analogous to gaseous discharges. The paper by Messrs. J. B. Higham and P. K. Watson dealt with the ancillary factors which affected electric strength and although the results were not necessarily inconsistent with those of Lewis, it was uncertain whether the intrinsic electric strength of hydrocarbons was 1 to 2 megavolts per centimetre or 4 to 5 megavolts per centimetre, or even if there were a true intrinsic electric strength, though the present papers favoured that view. The papers by Messrs. J. H. Mason, E. Friedlander and J. R. Reed and W. L. Harris concerned discharges in a gas between one or two insulating surfaces and all adopted the hypothesis that when the breakdown field was reached in the gas an area of the insulating surface was discharged, the field collapsed momentarily and the redistribution of the charge persisted owing to high surface resistivity.

In his paper, Mr. B. Salvage showed the importance of impulse tests on high-voltage cables and gave results which indicated lack of dependence on insulation thickness, conductor size and gas pressure. He was of opinion that the impregnant broke down between adjacent turns of the first tape and estimated its electric strength as about 2 megavolts per centimetre, which was possible, but low.

(To be continued.)

THE INSTITUTE OF METALS.

(Continued from page 407.)

WE continue our report of the annual general meeting of the Institute of Metals, which took place in London from March 23 to 26, and now deal with the afternoon session of Tuesday, March 24, held at the Park Lane Hotel, Piccadilly. The President, Professor F. C. Thompson, occupied the chair.

RECRYSTALLISATION AND GRAIN GROWTH.

Four papers were presented during the session and the first two were considered jointly. The first was entitled "The Effect of Certain Solute Elements on the Recrystallisation of Copper," by Dr. V. A. Phillips and Professor Arthur Phillips, and the second, "Segregation of Iron and Phosphorus at the Grain Boundaries in 70:30 Brass During Grain Growth," by Professor H. M. Miekkoja. The first paper described work conducted at Yale University, New Haven, Connecticut, U.S.A., and the authors stated that the object of their investigation was to study the effect of a number of solutes on the low-temperature recrystallisation of high-purity copper after severe cold-rolling. By using 99.999+ per cent. purity copper as a basis material and making up oxygen-free alloys, it had been possible to study the effect of adding as little as 0.001 per cent. of another element. Phosphorus was outstanding in that a very small addition produced very large effects. Silver was exceptional in that the largest addition of 0.0271 atomic per cent. had an enormous retarding effect on recrystallisation, though, unlike phosphorus, cadmium and arsenic, it did not change the recrystallisation texture. In his paper on the segregation of iron and phosphorus in brass, Professor H. M. Miekkoja, of the Finland Institute of Technology, stated that during an investigation into the influence of impurities on grain growth in 70:30 brass, it had been found that if the iron content was 0.007 per cent. or more, small amounts of phosphorus, of the order of 0.002 to 0.019 per cent., strongly inhibited grain growth at temperatures up to 670 deg. C. It was suggested that, during grain growth, iron and phosphorus segregated, without forming any separate phase, at the grain boundaries, where they hindered the migration of parent atoms through the transition zone. At high temperatures the impurity atoms were dispersed throughout the lattice.

YOUNG'S MODULUS OF ALLOYS.

The third and fourth papers were also considered jointly. They both dealt with questions relating to Young's modulus, and were entitled "A Study of Some Factors Influencing the Young's Modulus of Solid Solutions," by Mr. A. D. N. Smith, and "The Young's Modulus, Poisson's Ratio, and Rigidity Modulus of Some Aluminium Alloys," by Mr. N. Dudzinski. Both authors are on the staff of the Royal Aircraft Establishment, Farnborough, Hampshire. In the course of his paper, Mr. Smith stated that the values of Young's modulus for a series of binary solid solutions of copper with zinc, gallium, germanium, silicon and arsenic, and of silver with cadmium, indium and tin, had been measured dynamically at room temperature. In agreement with earlier work, it had been found that, in any one system, the modulus decreased approximately linearly with the atomic percentage of the solute, although the rate of decrease differed for each system. This rate of decrease depended not only on the difference in atomic radii of the solute and solvent, but also on the difference in valency between the two constituents.

Mr. Dudzinski, in his paper, stated that he had examined the elastic properties of various binary and ternary aluminium-base alloys. With the exception of calcium, strontium and magnesium, all the alloying elements investigated had been found to enhance the value of Young's modulus of the binary alloys. Chromium had the greatest effect (about 0.47×10^6 lb. per square inch per weight per cent.) and titanium, vanadium, molybdenum, iron, tungsten, copper and silver having a diminishing influence in the order named. The specific Young's modulus, i.e., the ratio of E to density, of binary alloys was substantially increased

by the addition of manganese and chromium. In the ternary systems, aluminium-manganese-chromium alloys showed the highest increment in E (about 0.5×10^6 lb. per square inch per 1 weight per cent. of manganese + chromium); there was no improvement, however, in the presence of copper or silicon. A substantial gain in E had been observed in aluminium-copper-vanadium and aluminium-manganese-nickel alloys. The rigidity modulus had been found to increase linearly with concentration of the alloying element.

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 on the evening of Tuesday, March 24, at the Park Lane Hotel, Air Commodore F. R. Banks, C.B., O.B.E., Principal Director of Engine Research and Development, Ministry of Supply, paid tribute to the value of the work done by non-ferrous metallurgists in the aeroplane-engine field. He stated that if it had not been for developments in the light metals and in other non-ferrous metal alloys, the modern aero engine now in production would not have been possible. The response to this toast was made by the President, Professor F. C. Thompson, who also proposed the toast of the guests. In the course of his speech, he said that industry had been very generous in its help to the Institute. That assistance had not been given in money alone but many prominent men in the metal and engineering industries had devoted a good deal of their time to the affairs of the Institute.

On the following day, Wednesday, March 25, two concurrent technical sessions were held at the Park Lane Hotel. At session "A," the whole of the day was devoted to a general discussion based on a symposium of six papers concerned with "The Control of Quality in the Production of Wrought Non-Ferrous Metals and Alloys. Part I.—The Control of Quality in Melting and Casting." The symposium had been arranged by the Metallurgical Engineering Committee of the Institute. At session "B" papers relating to the "Corrosion of Alloys" and the "High-Temperature Oxidation of Alloys" were presented in the morning, while the theme of the afternoon session, at which 16 papers were presented, was "Creep and Plastic Deformation."

CONTROL OF QUALITY IN MELTING AND CASTING NON-FERROUS MATERIALS.

The first paper of the symposium on melting and casting was by Dr. A. R. E. Singer, lecturer in industrial metallurgy in the University of Birmingham; it dealt with "The Principles of Technical Control in Metallurgical Manufacture." As a result of his examination of the effects of economic and technical factors on the quality of manufactured products and of an analysis, in terms of basic principles, of the characteristics of controlled processes, the author concluded that physical measurements of quality characteristics should be made wherever possible in order to control production with certainty at economic tolerances and rejection rates. It was expected that an extension of automatic control to many metallurgical operations would occur in the near future. A better understanding of all industrial processes involving a human operator would result from applying the principles derived from the study of automatic control mechanisms. The use of continuous manufacturing processes would increase, together with the application of statistical quality control for achieving high and consistent quality at low cost. A greater use of statistical methods in industrial problems involving small numbers of products might be forecast. From a sample survey it was concluded that advances in the control of quality would be made by extending technical control to cover more of the primary variables in manufacture.

The second paper, entitled "The Control of Quality in the Melting and Casting of Aluminium Alloys for Working," was by Mr. R. T. Staples and Mr. H. J. Hurst, of T.I. Aluminium, Limited, Birmingham. These authors stated that in reviewing the factors significant in the melting and casting of nine standard groups of aluminium alloys intended for use in wrought forms, the conclusion must be reached that quality could be maintained

only by the simultaneous operation of a multiplicity of indirect controls. In their works, in addition to the direct supervision exercised by the production staff, an inspection staff operated during the whole of the 24 hours. Members of this staff reported major defects as soon as they were found and summarised their findings at the end of each working shift. Every morning the findings on the material inspected during the preceding 24 hours were summarised and placed before the foundry superintendent. Similarly, summaries were prepared covering each week's work on one furnace for any one product, and, in this case, a sub-analysis against shifts was shown.

In order to arrange suitable and co-ordinated action, a weekly meeting was held, attended by representatives of the production, inspection, and metallurgical staffs. At these meetings, the inspection department tabled their findings, summarised for the week, and the metallurgical department presented any complaints regarding material which had arisen in the main or sub-plants. "Standard Practice Sheets" on which were entered detailed particulars relating to melting and casting techniques, were based on the information given at these weekly meetings and it was decided when a standard practice had been established. The yield values obtained in producing any particular run of material provided a means of assessing both its quality and the efficiency of the controls applied, thus providing target values for action. The success of the control measures adopted was considered to be proved by the fact that 90 per cent., or more, of the gross production weight cast was forwarded to the rolling mills and extrusion plant.

"The Control of Quality in Melting and Casting Copper and High-Conductivity Copper-Base Alloys" was the title of the third paper of the symposium. It was by Mr. J. Sykes, of the Enfield Copper Refining Company, Limited, Brimsdown, Middlesex, who stated that the materials available to fire-refiners and melters of copper included blister copper, process scrap and virgin and secondary electrolytic copper. The character and chemical composition of such metal varied very considerably. Control in the selection of raw material was dependent on the accurate analysis of representative samples. Such analyses could be made chemically or spectrographically. The bulk of the high-conductivity shapes cast in the United Kingdom was produced from blister copper and high-grade copper scrap. Melting, followed by fire-refining, was carried out in reverberatory furnaces fired either by pulverised fuel or by fuel oil. Furnace capacities might vary from 50 to 180 tons, but the charging, melting, refining, and casting sequence always covered a 24-hour cycle. Recently, a 6-ton oil-fired furnace of the reverberatory-tilting type had been installed in the works of the Enfield Copper Refining Company. Melting in this furnace was rapid and from 45 to 50 tons a day were being poured into 1,000-lb. vertically-cast cakes.

In electric-arc furnace melting the risk of serious contamination of the charge was slight. In the case of oil-fired reverberatory furnaces two types of oil fuel were often employed. During melting down, when a high heat input was required, and during part of the oxidation period in the refining process, heavy fuel oil was used. This could contain as much as 2.75 per cent. of sulphur, but, provided that oxidising conditions and efficient combustion were maintained, no serious sulphur "pick-up" occurred. When the oxidation process had reached the stage at which about 0.6 per cent. of oxygen was present in the molten copper, the heavy-oil burners were replaced by others using a light gas oil. This should have a sulphur content of less than 0.2 per cent. Contamination of the metal from the magnesite-brick lining of the furnace hearth was negligible, as the impurity content of the refractories was very low. For casting refined copper, the bone ash used as a mould dressing must possess certain properties. It should adhere to the mould and form a smooth surface which would not react with molten copper. High magnesium content should be avoided, or adherence would be poor. Moreover, no volatile substances should be present.

(To be continued.)

NON-INFLAMMABLE HYDRAULIC FLUID.

A FLUID developed for use in hydraulic presses and other plant in cases where resistance to fire is of importance was demonstrated recently at the central research laboratories of Monsanto Chemicals Limited, Fulmer Hall, Fulmer, Buckinghamshire. The liquid is one of a family of chlorinated diphenyls and polyphenyls termed the Aroclors, and the hydraulic fluid demonstrated, Aroclor 1248, is a chlorinated diphenyl containing 48 per cent. by weight of chlorine. It is a non-inflammable, clear, stable, non-corrosive and mobile liquid which shows no tendency to foam or entrain air and is particularly free from sludging troubles; its specific gravity is 1.45. The product is therefore recommended as a safe fluid for use in operating the hydraulic rams of die-casting machines and presses, in the place of inflammable mineral oils.

Three simple tests to demonstrate the non-inflammability of Aroclor 1248 were conducted at Fulmer Hall. In the first test, drops of the new fluid and of a typical mineral hydraulic oil were allowed to fall on to the surface of a 2-in. diameter steel pipe heated to a dull-red heat. The oil immediately burst into flames, but the Aroclor evaporated off as a dense white mist, without igniting. In the second test, two 6-in. wicks of asbestos cord were soaked, one in the new fluid and the other in a mineral hydraulic oil. Both were then suspended about 6 in. above two lighted Bunsen burners. The Aroclor showed little or no tendency to take fire and when ignition did take place, the flame was extinguished on the removal of the burner from beneath it. The wick soaked in mineral oil, on the other hand, immediately caught fire and burned itself out. In the third test, an electrically-heated muffle furnace was raised to a temperature of 650 deg. C. A quantity of Aroclor 1248 thrown into the hottest part of the muffle failed to ignite and evaporated off as dense white fumes. Hydraulic oil when thrown into the muffle immediately ignited.

The new fluid, it is pointed out, is very searching when hot and tends to show up slight leaks that would not be apparent with mineral oils. Hence, pipe joints should preferably be screwed and welded and this construction should be used wherever possible in place of flanged joints. Another characteristic of the fluid is that it will loosen any rust that may be present in the reservoirs or pipelines of a hydraulic system, but once these surfaces are clean, the fluid will maintain them free from rust. It is highly recommended, therefore, that filters should be fitted to a system when Aroclor is employed. The normal recommendations for the mineral-oil type hydraulic fluids regarding contamination with water apply with equal rigour to Aroclor 1248. Moreover, the new fluid will plasticise, soften and swell rubber and some synthetic materials and, in consequence, silicones, asbestos, polythene, lead, aluminium or chrome leather must be employed for making gaskets. Similarly, packings for rotating and reciprocating shafts must be carefully selected so as to obtain adequate sealing without swelling and resultant binding. Neoprene-bonded cork rings have been tested and have been found satisfactory for this purpose. From the point of view of toxicity, Aroclor 1248 is stated to be neither a skin irritant nor a skin "sensitiser." Should the fluid come into contact with very hot surfaces, however, the vapours arising therefrom should not be allowed to accumulate in the air, and some exhaust system of ventilation is recommended.

Two test runs using the new fluid in a Vickers-Detroit vane-type pump coupled to a Vickers hydraulic relief valve are of interest. The tests, conducted at Fulmer Hall, each ran continuously for 1,000 hours. In one case, the 1,000 hours period was followed by a further 300 hours on a daily "start-stop" basis. These tests showed that Aroclor 1248 has high stability and "lubricity" and is a satisfactory non-inflammable and non-corrosive fluid for operation with vane-type pumps. The pump and relief valve used in the tests were lent to the Fulmer Hall laboratories by Stein and Atkinson, Limited.

MEDIUM-WEIGHT LORRY.

VAUXHALL MOTORS, LTD., LUTON, BEDFORDSHIRE.



FIG. 1. 5-TON DROP-SIDE LORRY.

RANGE OF BEDFORD COMMERCIAL VEHICLES.

A RANGE of new Bedford commercial vehicles designed for loads from 20/25 cwt. to 5 tons and termed "middle-weight trucks" is now in production at Vauxhall Motors, Limited, Luton, Bedfordshire. These vehicles supersede the K, M and O range. They include five different sizes of chassis with the cab behind the engine. The 3-, 4- and 5-ton models are made with either a long or short wheelbase and various bodies are made to fit each size. The 4- and 5-ton vehicles and a tractor for articulated lorries can be fitted with either a Perkins P6V Diesel engine or a standard Bedford extra-duty petrol engine. The same cab is used throughout the range. Fig. 1, on this page, shows the 5-ton drop-side lorry. A feature of these lorries is the all-steel cab, which is made as a single assembly, comprising front wings, bonnet and grille, and is mounted, together with the radiator, on a sub-frame which is supported on three rubber mountings, one at the front beneath the radiator and one each side at the rear of the cab. This method of mounting permits the maximum amount of chassis-frame movement without causing any distortion of the cab, as can be seen in Fig. 2, and at the same time reduces the movement of the cab and improves the riding comfort. The engine is placed well forward of the cab to give room for a passenger in the centre. The driving seat is a single unit and has 5 in. of movement fore and aft; the double passenger seat is of the bench type.

The chassis frame used on the 4-ton and 5-ton models has been increased above the size used on the previous models to 8.88 in. deep and 0.25 in. thick. The semi-elliptic leaf springs are 45 in. long by 2.25 in. wide at the front and 45 in. by 2.5 in. at the rear; on the 4-ton and 5-ton models the rear springs are 60 in. by 2.5 in. and short "helper" springs are fitted above the rear springs of the 5-ton model. The shock absorbers are of the double-acting end-to-end discharge type. The front axle is an "I"-section drop forging with inclined pivots. Oil-bath lubrication is used for the pivot pins on the 4-ton and 5-ton models. The steering knuckles are of the yoke type, with steel-backed lead-bronze bushings and plain thrust bearings. The steering box has a ratio of 21 to 1 and is of the semi-irreversible worm-and-sector type with angular-contact ball bearings for the worm and lead-bronze steel-backed bushes for the drop-arm shaft. Adjustment is provided for backlash in the worm and sector. The turning circle is 43 ft. for the smallest model of the range and 56 ft. for the 5-ton model. The rear axle of the vehicle illustrated is of the fully-floating type, forged integral with the outer flanges, and the shafts are interchangeable. Heavier axle shafts are used when a Diesel engine is installed. Provision is also made for fitting an Eaton two-speed axle, which has high ratio of 5.83 to 1 and a low ratio of 8.11 to 1.

The Bedford extra-duty petrol engine is a six-cylinder in-line unit with push-rod operated overhead valves, carried in a detachable cylinder head.

The bore is 3.375 in. and the stroke 4 in., giving a capacity of 214.7 cub. in. (3,519 c.c.) and the compression ratio is 6.22 to 1. Two versions of this engine are made: that installed in the 20/25-cwt. and 3-ton vehicles develops 76 brake horse-power at 3,200 r.p.m. and gives a maximum torque of 168.5 lb.-ft. at 1,000 r.p.m., and the other, which develops 84 brake horse-power at 3,100 r.p.m. and a torque of 170 lb.-ft. at 1,000 r.p.m., is installed in the 4-ton and 5-ton models. The gearbox is built as a unit with the engine and the whole is carried at three points on rubber mountings. The lubrication system is of the high-pressure forced-feed type and the oil is circulated through a strainer in the crankcase and a by-pass filter with a replaceable element; the crankcase is ventilated by suction from the inlet manifold, and the air intake is through an oil-bath air cleaner mounted on the rocker cover. The fuel is delivered by a mechanical pump and a double-acting vacuum booster pump (for windscreen-wiper operation) driven from the engine camshaft, to a six-phase down-draught carburettor with an automatic part-throttle economy device and accelerating pump. The cooling water is circulated by a centrifugal pump, and the radiator, which is carried on the sub-frame of the cab, has a frontal area of 400 sq. in. and a core thickness of 2.75 in. The cooling system capacity is 30 pints. A 12-volt electrical system is used and both the generator and the 7-in. sealed front lamps used are a result of the standardisation talks between the "Big Six" vehicle manufacturers, and accessory manufacturers. The clutch used with this engine is a single dry-plate type of 10 in. nominal diameter.

The alternative engine, a Perkins P6V Diesel, is a six-cylinder in-line unit running on a four-stroke cycle. It has a bore of 3.5 in., a stroke of 5.0 in. and a compression ratio of 16 to 1, giving a cubic capacity of 288.6 cub. in. (4,728 c.c.). The maximum horse-power developed is 83 at 2,400 r.p.m. and the maximum torque is 204 lb.-ft. at 1,300 r.p.m. A 12-in. diameter clutch plate is employed with this engine. The advantage gained by using this alternative engine can be quite considerable as a 5-ton lorry operating under heavy conditions will give about 10 miles a gallon with the petrol engine, whereas 15 miles a gallon is possible with the Diesel engine—a gain of 50 per cent. To an operator running 50,000 miles in a year this would mean a saving of a little over 400%, resulting from the lower fuel consumption and the prevailing cheaper cost of the fuel in this country.

The 14-ft. drop-side body shown in the illustrations has pressed-steel cross-bearers. The hardwood floor boards are clamped to them with longitudinal wearing strips, the edges of which lap over the floorboards. The side sills are of metal and the pressed-steel centre posts and rear corner posts are detachable, as are the tail-board and sides, so that it can be easily converted into a flat-platform vehicle. The cross-bearers are bolted to aluminium die-cast supports, which, in turn, are bolted to the chassis side-members, and the rear supports extend beyond the end of the chassis frame to the rear of the body. Two rear lights are fitted at the full width of the vehicle.



FIG. 2. SHOWING CHASSIS-FRAME MOVEMENT RELATIVE TO CAB.

NOISE FROM SUPERSONIC AIRCRAFT.

DURING recent years the noise from jet aircraft has become a considerable nuisance to those who live in the neighbourhood of Service aerodromes. With the advent of aircraft capable of exceeding the speed of sound in a dive from high altitude, the somewhat alarming phenomenon that has become known as the "sonic boom" has caused many people to wonder whether the nuisance is likely to develop into a destructive agent. Recently, a report* has been issued by the College of Aeronautics, Cranfield, compiled by four members of the Department of Aerodynamics, that suggests that, in fact, some limitations may have to be imposed on supersonic flight in order to avoid serious effects on ground observers and on other aircraft in the vicinity.

When an aircraft passes through the speed of sound, and back to subsonic speed, in a dive from high altitude, observers on the ground may hear one, two or more sharp "bangs" which, the authors of the report consider, are in fact the shock waves formed as a result of the aircraft speed being greater than the speed of propagation of the pressure disturbances created by the aircraft during its flight. The sensation of noise created by shock waves, even weak ones, is stated to be much greater than the jet noise, which is the principal component in the noise of subsonic aircraft. If the height, speed and size of the aeroplane and the shock-wave pattern are known, it should be possible to assess the intensity of the noise.

The shock-wave pattern of an aerofoil in steady flight has been established by a number of researches. At subsonic speeds above the critical Mach number it is known that a small shock-wave of finite length, nearly normal to the surface, is formed downstream of the point on the aerofoil at which the local Mach number is above 1. At higher speeds, the wave spreads and moves back towards the trailing edge, and may become bifurcated forming front and rear tailwaves, joined at their outer extremity. The rear tailwave is generally weak. At steady supersonic speed, a bow wave is formed ahead of the body; above a certain Mach number determined by the nose angle, the bow wave becomes attached to the nose of the body. Little work has, however, been done on the effect of acceleration and retardation on the shock-wave

* "On Some Aspects of the Noise Propagation from Supersonic Aircraft," G. M. Lilley, R. Westley, A. H. Yates, and J. R. Busing. Report No. 71. The Librarian, The College of Aeronautics, Cranfield, Bletchley, Buckinghamshire. [Price 5s.]

pattern, and the main part of the report, therefore, is devoted to a qualitative analysis of such effects. The analysis has been confirmed by experiments in a hydraulic analogy channel.

The authors of the report conclude that the complex shock pattern around an aircraft will generally resolve, at distances from the aircraft that are large compared with its dimensions, into a bow wave, a front tail wave and a rear tail wave trailing far behind the aircraft. When an aircraft is retarded, in a dive, from low supersonic speed to subsonic speed, they contend that, as the aircraft passes through sonic speed, the bow wave separates from the nose and continues travelling towards the ground. At the same time, the front tail wave moves towards the nose and separates from the aircraft when the Mach number has fallen below the critical. The rear tail wave also moves forward and tends to coalesce with the front tail wave before or after the latter leaves the aircraft, depending, among other things, on the time of the supersonic flight. The bow wave and its reflections from the ground, it is estimated, will pass an observer directly below the path of the aircraft in a period of time so short that only one "boom" is heard. This is followed by the tail waves. One, two or three "bangs" will be heard by ground observers, depending on their position relative to the aircraft. After the tail wave has passed, the observer will hear the jet noise, modified by Doppler effect to appear as a high-pitched shriek followed by a low-pitched roar. At high supersonic speeds, it is stated, the pattern is more complex and more than three shock waves may be experienced on the ground.

A supersonic dive, however, may not always produce the characteristic booms at ground level on account of the effect of variations of wind velocity and temperature with altitude which may cause upward refraction of the shock waves. If, at a certain altitude h_2 , the speed of sound is equal to the aircraft speed at some higher altitude, h_1 , then shock waves originating from the higher altitude h_1 will be refracted back at the height h_2 . In steady supersonic flight at constant altitude, however, refraction would only occur at low supersonic Mach numbers, and in general the shock waves would be expected to reach the ground.

The authors of the report discuss several problems that require consideration before frequent supersonic flight could be tolerated over populated areas. The intensity of the shock waves increases greatly if they originate at low altitudes, and although the time interval during their passage may be small, the noise level might be sufficient to cause pain or mechanical damage to the ear. They suggest tentatively, however, that provided aircraft in straight and level supersonic flight operate at altitudes above 5,000 ft., a pressure rise of 4 lb. per square foot (corresponding to a noise level of 140 decibels, at which physical pain is experienced) is unlikely to be exceeded. To limit the pressure rise to 0.4 lb. per square foot (120 decibels), they suggest that aircraft flying at Mach 2 must operate above 20,000 ft., and at Mach 3 above 22,000 ft. The same limiting altitudes should apply during supersonic dives. (These figures are based on the assumption that, for estimating the strength of the shock waves at a large distance from the aircraft, the latter can be replaced by an equivalent body of revolution, which is assumed to be 30 ft. long with a fineness ratio of 10 per cent.) To guard against unpleasant or dangerous effects from shock waves overtaking slower-flying aircraft, it might be necessary to restrict supersonic flight to a radius of at least four miles from either the nearest aircraft or ground level.

The authors also consider whether or not the crew of a supersonic aircraft will hear the booms it creates. Although, during retardation through the critical Mach number, the tail shock waves travel forward over the body towards the nose, the shock wave is greatly diffused in the subsonic viscous boundary layer adjacent to the body surface, and it is considered that the intensity of the noise experienced would be much less than that at ground level. The report suggests, in conclusion, that problems of stability and control may arise as a result of shock waves passing across the wings or body of an aircraft.

LABOUR NOTES.

PLEAS for action by Mr. R. A. Butler, the Chancellor of the Exchequer, to rectify the high level of purchase tax on semi-luxuries, as an encouragement to ordinary workpeople to exert themselves to increase production, were contained in a letter recently sent to Mr. Butler by the British Steel Founders' Association. Mr. Butler was reminded of the visit of the productivity team from the steel-foundry industry to the United States in 1949, and of the active and continuous campaign which the Association had since conducted, in co-operation with its member-firms, to put into practice throughout the industry in the United Kingdom the lessons which were then learnt. At the third productivity conference, organised by the Association in November last year, it was stated, exhaustive notes of progress, experience, and cause and effect were compared. These brought into focus the outstanding importance of the workman's attitude of mind which enabled him to look beyond the pounds, shillings and pence in his pay packet and to visualise the outcome of his endeavours in terms of the actual things which his money could buy.

In other words, the letter continued, if a man could be brought to realise that he was working for additional comforts for himself, his wife, and his family, such as a motor car, a television set, a refrigerator, or some other piece of domestic equipment, he would work harder and more keenly than if his outlook were circumscribed by the more conventional notion of wages in terms of money symbols only. Members of the industry's productivity team who toured American steel foundries in 1949 were convinced that employees there consciously exerted themselves to earn more money in order that they might acquire semi-luxuries of the type mentioned. The Association considered that this attitude accounted to quite a substantial extent for the fact that productivity in its industry was higher in the United States than it was in Great Britain by something between 50 and 90 per cent.

There could be no doubt, it was stated, that the high level of purchase tax was largely responsible for putting beyond the reach of ordinary people so many semi-luxuries of the type mentioned, and that it constituted, therefore, one of the major impediments to maximum productivity. As a body of employers, the Association believed that, so far as British workpeople were concerned, the purely monetary incentive to the attainment of maximum efficiency and output had relatively little force under the conditions obtaining at the present time. The Association considered that the value of the "transpecuniary incentive" referred to was being dissipated because so many articles which a man and his family might naturally desire to possess, in order to improve their standard of life, were removed from their reach, formerly, by the shortage of supplies and, at the present time, by excessive costs. In reply, Mr. Butler promised to "bear in mind" the suggestions which the Association had put forward.

Trade unions catering for the various branches of the Civil Service attained a new high level of membership last year, according to figures contained in the current issue of the *Whitley Bulletin*, the monthly journal of the staff side of the Civil Service National Whitley Council. An increase of no fewer than 17,000 members was recorded by the Council's constituent unions during 1952. The total membership at the end of that year was 563,000, compared with 546,000 at the end of 1951, and with 327,000 at the end of 1939.

Urgent efforts to spread the strike of vehicle builders at the Longbridge works of the Austin Motor Company, Limited, were reported as a mass meeting in Birmingham on Monday of the men concerned in the dispute. They were informed that demands would be made that all vehicle builders in the employ of the British Motor Corporation, of which the Austin Company forms part, at works in the Midlands and at Oxford should cease work.

In all, some 43,000 persons are employed at these plants. Shop stewards belonging to the men's union, the National Union of Vehicle Builders, employed at the Corporation's other factories met in Birmingham on Tuesday to discuss the whole position. A meeting of officials of other unions having members in the employment of the Austin Company at the Longbridge works was due to take place on Wednesday, and it was stated that they would be asked to make sure that no action likely to prejudice the vehicle builders was taken at the works.

The union's request for the appointment of a court of inquiry to investigate the dispute reached the Ministry of Labour on Monday. Conciliation officers of the Ministry immediately approached the Austin Company and the Trades Union General Council for their views. The consent of employers as well as of the union concerned, to the appointment of a court of inquiry is necessary if the decisions of such a body are to become binding on both sides. Sir Walter Monckton, the Minister of Labour, announced in the House of Commons on Tuesday that the discussions with the Ministry were continuing and that he would make another statement before the Easter recess.

In accordance with the ultimatum, issued by the Austin Company at the beginning of last week, notices of dismissal were sent last Saturday to 1,583 employees at Longbridge. As it was reported that there were 2,377 vehicle builders who originally went on strike, it may be presumed that the remaining 794 have returned to work during the six weeks that the dispute had been in progress. The men received a full week's pay and all outstanding sums due to them from the company. This action was followed by an announcement by the union that the allowances to be paid by it to the dismissed men would be raised by 10s. to 2l. 10s. a week, for each man, and by 1s. to 6s. a week, for each child.

When sending out the dismissal notices, the Austin Company issued a statement saying that employees discharged would presumably report to their labour exchanges and that, when the company had any vacancies to fill, the exchanges would be notified in the usual way. As the strikers had all been discharged, a dispute no longer existed. Therefore, those employees, numbering between three and four thousand, who were still suspended in consequence of the strike, would be paid by the company for the guaranteed week of 34 hours as from last Monday.

Changes in the full-time rates of wages, which came into force in the United Kingdom during February, benefited about 1,635,000 workpeople, and the total cost of these increases is estimated by the *Ministry of Labour Gazette* for March amount to approximately 543,000l. a week net. In the main, the increases principally affected persons employed in building, civil-engineering construction and coal mining. In the first two of these occupations, the increase amounted to 2d. an hour for both men and women operatives.

Industrial disputes in progress in the United Kingdom during February last were more numerous and more severe in their effects than those which occurred during the preceding month. There were, in all, 176 stoppages in progress during February, and, in them, 36,300 workpeople were involved and 152,000 working days lost; compared with 140 disputes in January, in which only 24,900 persons took part and only 60,000 working days were lost.

Of the total of 152,000 working days lost in February, 134,000 were lost by 31,100 workpeople involved in stoppages which began in that month. Of this number of employees, 21,100 were directly involved in the stoppages, and the remaining 10,000 thrown out of work at the establishments where the stoppages occurred without themselves being parties to the disputes. The number of days lost in February also included 18,000 days lost by 5,200 workpeople through stoppages which had continued from the previous month.

AGRICULTURAL ENGINEERING INVESTIGATIONS.

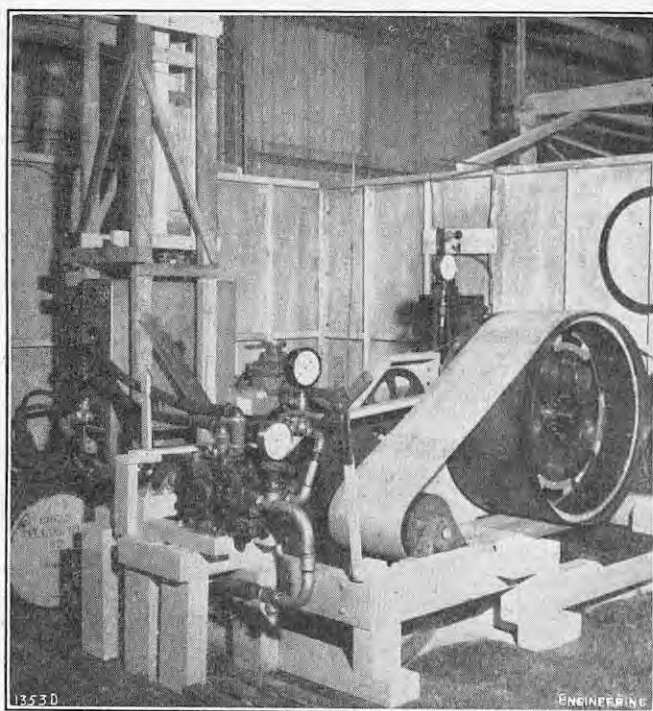


FIG. 3. TESTING HYDRAULIC TRANSMISSION SYSTEM.

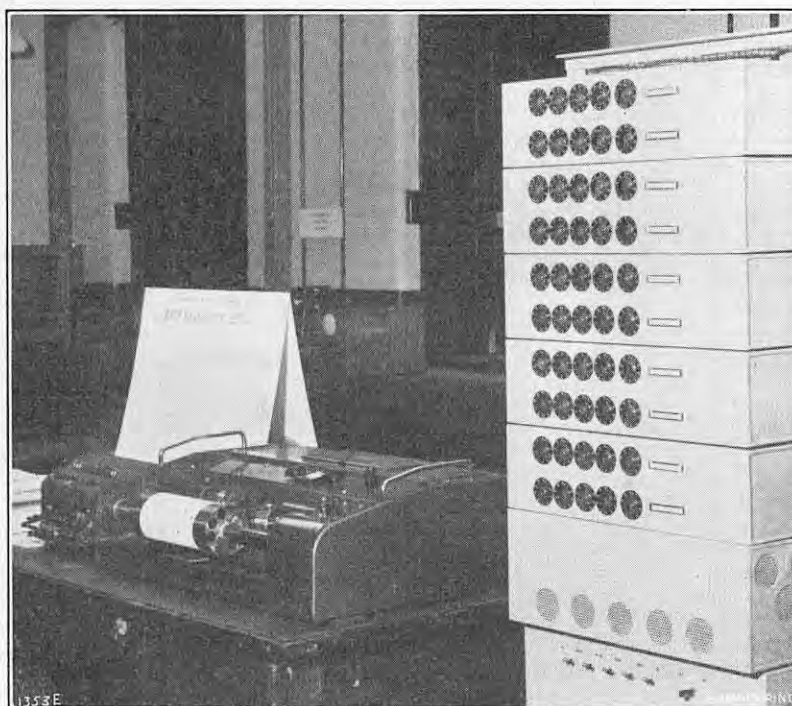


FIG. 4. G.P.O. AND N.I.A.E. DROPLET. COUNTER.

THE NATIONAL INSTITUTE OF AGRICULTURAL ENGINEERING.*

By W. H. CASHMORE, B.A., M.I.B.A.E.

(Concluded from page 415.)

RESEARCH AND DEVELOPMENT.

WORK on plough design and the effect of tractor wheels on soil structure are examples of N.I.A.E. research. A three-furrow plough has been modified so that the middle body is suspended by a series of wire resistance strain gauge components, which enable the forces acting on the plough body to be recorded, the vertical and horizontal forces being measured. It is thought that deviation of the forces from the mean value will be important, because the fluctuations in loading are often considerable and allowance has to be made for them in designing a plough. The main types of plough body—general purpose, semi-digger and digger—have been compared at working speeds ranging from $\frac{3}{4}$ to 5 m.p.h. Preliminary experiments indicate that the semi-digger body has a slightly higher draught than the other two, and that increasing the speed increases the draught of all three types, which rises more sharply at the higher speeds by about 25 per cent. This work will provide useful information to plough designers, particularly in connection with mounted ploughs, but is obviously long-term.

In the Soil Physics Section, attempts are being made to measure the mechanical properties of the soil. Apparatus which has been developed includes a torsion shear box to measure shear strength of top soils, and an adhesion meter for determining the value of the strength with which soil clings to other materials. Until some of the fundamental principles are understood, sound progress cannot be made in developing machines closely related to the soil. Some of the measurements have a bearing on other N.I.A.E. investigations; for instance, if a relationship can be established between the dirt tare of sugar beet and the adhesion of the soil, it should be possible to compare the performance of a beet harvester on one soil with that of another working on a different type of soil.

In connection with the effect of tractor wheels on soil structure, experiments have been made on the change in volume weight of the soil, and penetrometer readings have been made; results indicated that compaction did not occur deeper than 4 in.,

but that, quite often, the tractor wheel running in the furrow bottom reduced soil drainage, showing that water permeability was an important factor. The work on the latter has been done in collaboration with the soil department of Cambridge University; plots of land surrounded by impervious channels have been irrigated and the run-off collected in the ditches surrounding the plots, the permeability being indicated by the proportion of the applied water which can be collected.

A recent instance of development in which the N.I.A.E. was asked to assist has been that of a machine to harvest groundnuts. Three different types of machine, which are being developed for harvesting potatoes, were sent out to Tanganyika in 1952, and operated under a wide range of conditions. As a result of these trials and experimental runs with stationary rigs on the site, a new design has been evolved for lifting, removing soil, stripping off and bagging the nuts in one operation. This machine has been built in the N.I.A.E. workshop and was given a trial during November, 1952, on an out-of-season crop of groundnuts grown on irrigated land.

Another development, which might make an important contribution to agricultural engineering, is the hydraulic propulsion of a tractor.* The principle is that of an engine-driven pump of variable output, supplying oil to hydraulic motors built into tractor wheels. The hydraulic motor is designed so that the wheel is made to revolve round the stationary stub shaft. A single control-lever on the pump can give stepless variable speeds, forward or reverse, and the changes can be made without stopping. If the system proves successful, it would simplify the design of farm tractors and make it possible to change from two-wheel to four-wheel drive at a relatively small increase in cost. The most important advantage would be that the designer would be free to use the space taken up by the orthodox transmissions. It would revolutionise the design of self-propelled implements, because the engine and pump could be mounted in an easily accessible position and transferred from one machine to another. Preliminary work with an experimental testing rig, shown in Fig. 3, herewith, has given encouraging results.

Work on grain drying serves as an example of how improvements in design are brought about. Earlier research work had established two systems for dealing with amounts of grain which do not justify the purchase of a standard grain drier—

the platform drier and the ventilated drying silo. In each case, the main lines of plant layout have been accepted after extensive trials on farms and the N.I.A.E. work on this subject is now mainly concerned with details of equipment, aiming at improved performance.

In 1949, three platform driers were placed on farms, and by the 1952 harvest there were some 750 plants in various parts of Britain. As a result of consultations with the N.I.A.E., a platform drier has been installed at the Empire Cotton Research Station at Kampala, Tanganyika, for drying cotton seed and maize; another has been used by the Sudan Government at Juba for drying sorghum; and an experimental unit will be operated in Tanganyika in connection with the development of a groundnut harvester. Development work is proceeding on lightweight combustion equipment, which will cover the possible future requirements and be suitable for platform or silo driers. The idea is to produce a unit integral with the main ventilating fan so that it can be delivered to the farm as a single piece of equipment, easy to install.

The principle of the ventilated silo plant is to pass warm air up through a porous or perforated floor. To improve the performance by reducing the pressure loss across the floor, a number of alternative materials have been tested, including slotted blocks and perforated tiles. For all work on grain, special equipment has been investigated and developed, including electric hydrometers, moisture meters, and airflow meters for measuring air velocities below 25 ft. per minute.

HORTICULTURE.

Horticulture, like agriculture, is making increasing demands for new machinery and equipment to enable growers to raise the efficiency of their production. Until the Horticultural Department was set up as part of the N.I.A.E., in 1948, there had been little official investigational work into horticultural engineering problems in Britain. The Horticultural Department carries out investigations and research to determine basic principles and data, and also develops machines and equipment, but the testing of horticultural machinery is dealt with by the agricultural testing department. For glasshouse work, a standard glasshouse, 150 ft. by 30 ft., has been installed. It is heated by a low-pressure steam system having a vacuum arrangement at the condensate main so that condensation can occur below 212 deg. F. Temperature-measuring apparatus has been designed, with mechanical and electronic integrating devices. Relative humidity is

* Paper read before the Institution of British Agricultural Engineers in London on February 24, 1953. Abridged.

* See ENGINEERING, vol. 173, pages 605 and 637 (1952).

measured throughout the house in a similar way. The ventilation rate must be known, in order to calculate the heat losses and the rate of cooling in summer, and is determined by measuring the decrease in carbon dioxide which is introduced into the house, the CO_2 concentration being measured by an infra-red type of apparatus. The instrumentation evolved at Wrest Park will become the standard for five similar experimental houses in Lancashire.

The problem of spraying is another example; earlier investigations into the physics of drift spraying had resulted in the development of a low-volume sprayer which was investigated in co-operation with East Malling Research Station. It was found that the droplet size would need to be smaller and more uniform. Further development on this subject will be greatly assisted by the use of a drop counting and sizing machine, which has been developed in conjunction with the G.P.O. Research Station; it is illustrated in Fig. 4, on page 441. Although no standard method of testing a spraying machine has yet been drawn up, the N.I.A.E. is already in a position to give some assessment of performance, and various spraying machines have been sent for trial to enable manufacturers to make improvements.

Of the many other problems being tackled, another is mentioned because it illustrates the link-up of the programme internally. In an investigation into the steering of horticultural tractors, a deviation meter was designed and constructed to measure the extent to which the tracking of a set of tools deviates from a given straight line. The deviation is recorded at the same time as the torque exerted on the steering wheel, and the angular deflection of the steering wheel. These three factors should eventually relate the position of the driver to the accuracy of the operation, such as hoeing. As already mentioned, experimental work has been started on a hydraulic-transmission tractor which, if successful, would be of particular interest to horticulture, and the results of these steering experiments would be incorporated in any experimental tractor built for horticulture. Apart from this possibility, the information, when obtained, will be available for manufacturers of small horticultural tractors.

SCOTTISH MACHINERY TESTING STATION.

The Scottish Station operates the same testing scheme as that at Wrest Park. Machines manufactured in Scotland are usually tested at Howden, but there is an interchange with Wrest Park, when the requirements of the test make it desirable. Generally, the Scottish Station can more easily provide wet conditions, hilly land and rough marginal land. The season in Scotland is also later and sometimes machines are moved up from the South to obtain an extended season. In addition to testing, investigations and experiments form an important part of the programme; there is a link-up with the main N.I.A.E. programme, and research work on root harvesters, potato harvesters and grass driers, for example, is undertaken under Scottish conditions.

The Scottish Station has a number of problems of its own, such as the affect of sloping ground on the performance of machines; the investigation into land reclamation and improvement is an example. In addition to working specialised reclamation machines and stump-jump equipment designed for stony ground, bracken control and eradication is being tried out in two areas representing different types of land, one the rolling hills and the other steep slopes with numerous outcrops of rock. The special machines being compared are a bruiser, a crusher, a breaker and a slasher; a standard mounted mower has been included for comparison.

CONCLUSIONS.

The N.I.A.E. policy is not only to improve the standard of farm machinery and equipment, but also its status by co-ordinating the work of research stations, the experience of farmers and the development and experimental side of implement manufacture. The Institute is neither equipped nor expected to show farmers or implement manufacturers how to carry out their own work. Much of the

benefit of the Institute's work reaches the farmer indirectly.

The manufacturers have direct contact with the N.I.A.E. in connection with tests and can co-operate on general development or components. They can also avail themselves of basic information to assist and guide their design staff. The Institute is now making contact with many overseas countries, including the Dominions and Colonies. Visits are exchanged and it is hoped that, as a result, it will be possible to provide general information and special testing facilities to assist manufacturers to increase exports.

It is absolutely essential that the N.I.A.E. should be in very close touch with the practical side of agricultural engineering. The response from manufacturers and farmers could, with advantage, be greater; it is disturbing to find a greater interest in a piece of research from overseas countries than at home. New and improved machines are necessary for British farming and the export trade. In some cases, our level is such that we have little to gain from examination of overseas models, and design must proceed on results from experimental work and research. On the other hand, there are cases where improved machines have been made for new methods, but these methods are not properly understood by the farmers, and results are unsatisfactory.

SCALE IN SEA-WATER DISTILLING PLANTS.*

By H. HILLIER, O.B.E., M.I.Mech.E.

(Concluded from page 380.)

CALCIUM SULPHATE SCALE FORMATION.

THROUGHOUT the tests, no appreciable amount of CaSO_4 was found in the scale on the evaporator shell or on the heating surface, except where mentioned. Further, no appreciable CaSO_4 in suspension was recorded. A large blow-down to prevent CaSO_4 scale incurs an appreciable thermal loss, larger pumping plant, and additional power, so it is desirable to operate at the minimum blow-down with which CaSO_4 scale will be avoided. Tests were therefore carried out at various evaporation temperatures and brine concentrations to determine the conditions under which CaSO_4 precipitates.

The evaporator was run at a given vapour temperature, with sufficient heating steam to maintain vigorous boiling conditions. No blow-down was used and sea water was fed in to maintain the water level. Brine samples were taken and filtered, and the total calcium and sulphate concentrations were estimated. The measured ionic product, $\text{Ca}^{++} \times \text{SO}_4^{--}$ (in mg. per litre), plotted against the brine concentration, followed a smooth curve so long as no measurable CaSO_4 was precipitated. When the precipitation point was reached, the ionic product showed a clear departure from the curve.

Analyses of brine from evaporation in operation show little trace of calcium sulphate as a precipitate in suspension; so it is probable that precipitation occurs mainly as scale on the heating surface. If this is so, the controlling factors may be, not the evaporator-vapour temperature and the general brine density, but the local temperature and brine density at the heating surface. Accurate measurement of the local conditions obviously presents considerable difficulties. The temperature of the surface of the metal of the coils is probably close to the saturation temperature of the steam inside the coils.

Consideration of the test results suggests that the concentration of the brine at the heating surface must be appreciably greater than the concentration in the main body of the brine in the shell. When a bubble of steam forms on the heating surface, the concentration of the solids at the perimeter of the bubble must be appreciably greater than the general concentration of the brine; and this concentration is probably a controlling factor. Some deposition of CaSO_4 may occur when each bubble is formed; but the flow of brine over the surface as the bubble

is released probably re-dissolves part or all of the deposit. The rate of deposition will increase with temperature difference across the heating surface; the lower the temperature and concentration of the brine, the greater is its capacity to take the deposits back into solution.

It is difficult to assess accurately the maximum brine concentration at which the formation of a CaSO_4 scale for any given operation conditions will be avoided. For most plants, operating at the usual evaporator-vapour temperatures and with moderate temperature-differences, CaSO_4 scale will be avoided with a blow-down of 100 per cent. of the made water. For low-temperature operation with small temperature differences, a 50 per cent. blow-down, with a brine concentration of 3, would be satisfactory. The use of a brine concentration of 1.5, with 200 per cent. blow-down, does not seem justified.

TREATMENT WITH HYDROCHLORIC OR SULPHURIC ACID.

It was known that CaCO_3 scale could be removed by the use of hydrochloric acid and a test was carried out with a continuous addition of 0.32 lb. of commercial inhibited hydrochloric acid (sp. gr. 1.14), per ton of sea water. The test was run for 203 hours at 180 deg. F., with a brine concentration of 2 and a brine pH varying between 7 and 8. The output was maintained substantially constant and heat-transfer coefficients were as shown in Table III.

At the end of the test a loose powder, which could be rubbed off with a cloth, had formed on coils 2, 3, and 4. On coil 1, there was a mixture

TABLE III.—Test Results, Hydrochloric Acid Treatment.

Coil No.	Evaporator-Vapour Temperature, Deg. F.	Coil Steam Pressure, Lb. per Sq. In. Abs.	Nominal Temperature-Difference, Deg. F.	Heat-Transfer Coefficient, B.Th.U. per Sq. Ft. per Deg. F. Difference in Temperature.
1	180	33	75.8	1,394
2	180	17	39.5	754
3	180	12.27	23.0	553
4	180	—	—	—

of an adherent scale, with a maximum thickness of 0.003 in., and a powdery deposit. The analysis of the scale on coil 1 was: calcium carbonate (CaCO_3), nil; calcium sulphate (CaSO_4), 80.7 per cent.; magnesium hydroxide ($\text{Mg}(\text{OH})_2$), 8.3 per cent.; copper oxide (CuO) + iron oxide (Fe_2O_3), 2.5 per cent. The amount of deposit on coils 2, 3, and 4 was insufficient for an analysis. The treatment was sufficient to prevent any appreciable scale formation and the heat-transfer rates given were maintained throughout the test.

Similar results can be obtained by the use of sodium bisulphate (NaHSO_4), which ionises in water almost completely to $\text{Na}^+ + \text{HSO}_4^-$ followed by the further partial ionisation of the bisulphate ion, HSO_4^- into $\text{H}^+ + \text{SO}_4^{--}$.

The hydrogen ions react with the carbonate ions in the brine and form gaseous carbon dioxide and water. The addition of sodium bisulphate thus destroys carbonate ions with the formation of carbon dioxide as a gas and water. An 800-hour run was made with an Admiralty evaporating plant at another site, using an injection into the evaporator of 0.53 lb. of NaHSO_4 per ton of sea water. The evaporator-vapour temperature was 174 deg. F., with a nominal temperature-difference of 23 deg. F. The evaporator output was 2,400 lb. per hour and the brine concentration 2.3. No material change in operating conditions occurred during the run and there was practically no scale formation in the evaporator when opened up.

TREATMENT WITH ORGANIC DISPERSIVES AND PHOSPHATE COMPOUNDS.

Organic dispersives and phosphate compounds are sometimes put forward as preventives of scale formation in sea-water evaporators. Tests were therefore carried out with various mixtures of organic and phosphate compounds, injected into the test evaporator. In one test, a mixture of tannins was injected into the evaporator. There

* Paper presented to the Institution of Mechanical Engineers at a meeting held in London on January 30, 1953. Abridged.

SCALE IN SEA-WATER DISTILLING PLANTS.

Fig. 13. VARIATION OF HEAT-TRANSFER COEFFICIENT WITH OPERATING TIME: TREATMENT WITH TANNIN.

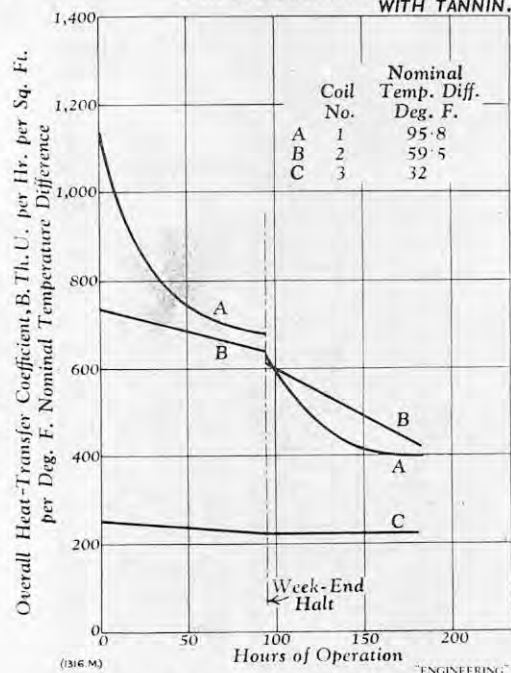


Fig. 14. VARIATION OF HEAT-TRANSFER COEFFICIENT WITH OPERATING TIME: TREATMENT WITH ORGANIC-PHOSPHATE MIXTURE.

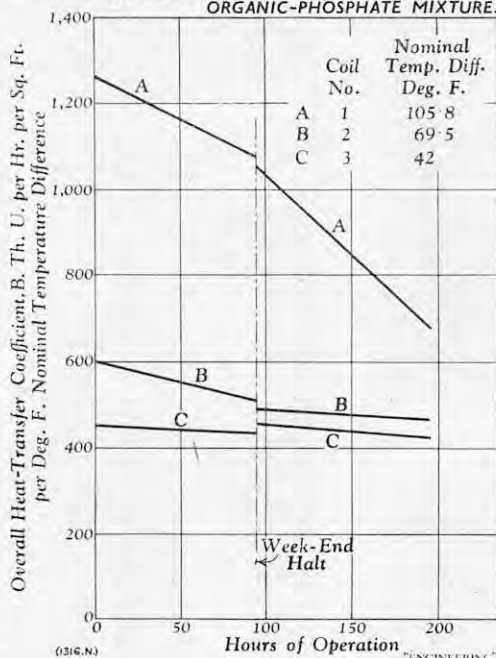
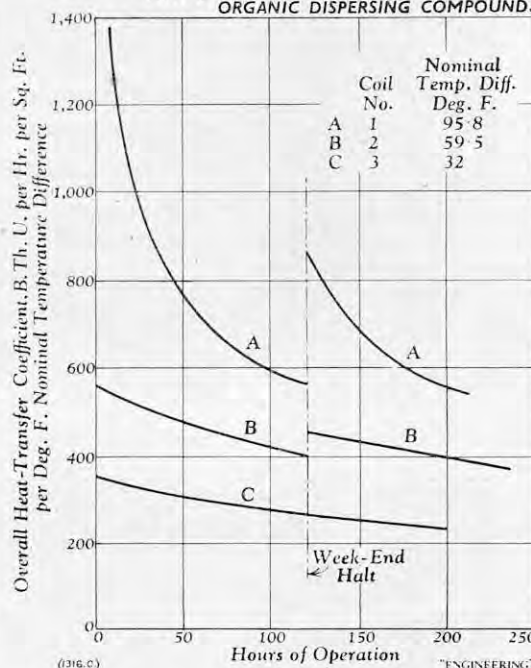


Fig. 15. VARIATION OF HEAT-TRANSFER COEFFICIENT WITH OPERATING TIME: TREATMENT WITH ORGANIC DISPERSING COMPOUND.



was a drop in the heat-transfer coefficients during the test. Variations in the rate of injection were subsequently tested without obtaining any material difference in performance. As compared with the test without treatment under similar conditions, the use of tannin effected a marked reduction in the deposition of CaCO_3 but gave rise to an appreciable amount of $\text{Mg}(\text{OH})_2$ in the scale, which was accompanied by a considerable amount of organic matter. A test was made with a very much smaller rate of tannin injection. Fig. 13, on this page, shows that, during a run of 171 hours, with a tannin injection of 0.014 lb. per ton of sea water, there was a serious fall in the heat-transfer coefficients at the higher temperature-differences.

In these tests, tannin reduced the deposition of CaCO_3 to a small amount and maintained $\text{Ca}^{++} + \text{CO}_3^{--}$ in solution to a much greater extent than in the tests without treatment. This is probably due to the tannin providing a colloidal suspension of negatively-charged particles, capable of flocculating the positively-charged calcium ions. The treatment, however, gave rise to an appreciable amount of $\text{Mg}(\text{OH})_2$ in the deposits, in conditions where it did not appear when no treatment was used. The deposits on the tubes were of a sludgy nature, containing a considerable amount of organic matter in a loose bulky sludge, which offered a considerable resistance to heat flow. When dry, the scale was powdery and could be scraped away. The addition of tannin alone does not appear advantageous.

Another test was made to judge the effect of the use of trisodium phosphate. For this test, the sea water was heated close to evaporation temperature in a direct-contact heater, from where it passed into a settling tank. The trisodium phosphate was introduced into the pipeline between the direct-contact heater and the settling tank. The reactions and precipitation in the settling tank were by no means complete. The treatment eliminated the deposit of CaCO_3 as a scale and reduced the rate of scale formation. The scale was composed mainly of $\text{Mg}(\text{OH})_2$ and $\text{Mg}_3(\text{PO}_4)_2$, with a little MgCO_3 . When wet, the scale was of a soft sludgy nature and could be removed by hard rubbing with a cloth or by soaking in a solution of hydrochloric acid. The treatment resulted in a large amount of precipitated solids, suspended in the brine. The phosphate appears to combine preferentially with the magnesium; the CaCO_3 is maintained in solution or suspension; but the formation of $\text{Mg}(\text{OH})_2$ is promoted, as shown by the appearance of $\text{Mg}(\text{OH})_2$ in the scale and the large amount in suspension in the brine.

The use of trisodium phosphate leads to the formation of hydroxyl ions in addition to those

resulting from the disintegration of the bicarbonate and carbonate ions and is likely, therefore, to promote a $\text{Mg}(\text{OH})_2$ scale formation if magnesium phosphate does not form preferentially. In the tests made, both magnesium hydroxide and magnesium phosphate were formed in appreciable quantities; deposits resulting therefrom set up an appreciable resistance to heat flow.

A test of 196 hours was made, in which an organic-phosphate mixture was injected direct into the evaporator at the rate of 0.016 lb. per ton of sea water; the evaporator-vapour temperature was 150 deg. F., the shell pressure was 3.71 lb. per square inch absolute, and the brine concentration factor was 2. The mixture contained phosphate equivalent to 35 per cent. trisodium phosphate; 12 per cent. starch; and the balance of tannin, sodium alginate, and other organic matter. Fig. 14, herewith, shows the variation in the heat-transfer coefficients. The treatment prevented the deposition of CaCO_3 in the scale, but led to a scale formation containing $\text{Mg}(\text{OH})_2$, MgCO_3 , and $\text{Mg}_3(\text{PO}_4)_2$, with an appreciable amount of organic matter. Apart from the organic matter, the scale formation was very similar to that formed in the previous trisodium-phosphate test; although the amount of trisodium phosphate used was very much smaller.

A test in this series was made with an injection, per ton of sea water used, of 0.06 lb. of an organic dispersive mixture of the sodium salts of dinaphthyl methane disulphonic acid and ethylene bisimino diacetic acid. Fig. 15, herewith, shows the variations in the heat-transfer coefficients during a test of 215 hours. In this test, the scale was hard and smooth, but the inclusion of organic matter reduced the strength of the scale so that portions of the scale broke away from the coils. This is probably responsible for the improvement in the heat-transfer coefficients of coils 1 and 2 over the week-end halt. No flaking occurred on coil No. 3 with the low temperature-difference. Fig. 16, on page 444, shows the coils at the conclusion of the test and demonstrates the partial shedding of the scale from coils 1 and 2. The use of this treatment did not affect the chemical reactions appreciably; but the organic inclusions in the scale matter appear to weaken the scale structure, thereby facilitating the shedding of the scale in a cracking operation.

In the test on the Admiralty evaporating plant, in connection with the use of sodium bisulphate, during a run of 1,050 hours with the organic treatment mentioned above, the evaporator-vapour temperature-difference across the heating surface of the evaporator rose steadily from 23 to 43 deg. F., the heat-transfer coefficient varying from 450

B.Th.U. per hour per square foot per degree F. temperature-difference, at the commencement of the run, to 180 B.Th.U. per hour at the finish. The scale formation produced was predominantly CaCO_3 , with considerable quantities of $\text{Mg}(\text{OH})_2$, and varied in thickness from 0.016 to 0.108 in. Fig. 17, on page 444, shows the scale formation on a ship's evaporator coils after 2,700 hours' steaming.

The use of organic dispersive and phosphate compounds does not prevent scale formation, but may alter the character of the scale appreciably, to a degree varying with the compound used. Where a loose soft sludge is formed, it appears to offer an appreciable resistance to heat flow and may be more objectionable than the scale that would be formed without treatment. The use of an organic compound to weaken the scale structure and facilitate shedding of the scale in operation, and during cracking operations, is beneficial in reducing the effects of scale formation and is also advantageous in that the scale cracked off breaks up more readily and so helps to maintain the brining system in operation for longer periods without cleaning. In general, evaporators operating with such treatment require to be designed for an average heat-transfer coefficient of the order of 250-300 B.Th.U. per hour per square foot per deg. F. temperature-difference, with temperature-differences ranging between 50 deg. and 100 deg. F. The shedding of the scale is only partial and there is always a considerable residual scale formation on the coils, which offers a considerable resistance to heat flow.

TREATMENT WITH FERRIC CHLORIDE.

In view of the large amounts of calcium and magnesium in sea water, it is doubtful if there is any reasonable treatment that could be applied to precipitate harmlessly these two solids to the extent that would prevent their deposition on the heating surfaces as scale. The treatments used for boiler feed-water do not offer any hopeful line of attack on the problem. It has been shown that heating and boiling results in the formation of hydroxyl ions, due to the progressive disintegration of the bicarbonate and carbonate ions; test results show that the hydroxyl ions can be prevented from forming scale by supplying hydrogen ions, with which they combine preferentially to form water.

When it was realised that the scale formation was due to the carbonate alkalinity in the brine, short-term tests were made with various additives to study their effect on the alkalinity, and it was found that ferric chloride was quite effective in reducing the brine alkalinity. The plant was therefore run for a period of 150 hours with ferric chloride added at the rate of 0.31 lb. per ton of sea water supplied

SCALE IN SEA-WATER DISTILLING PLANTS.

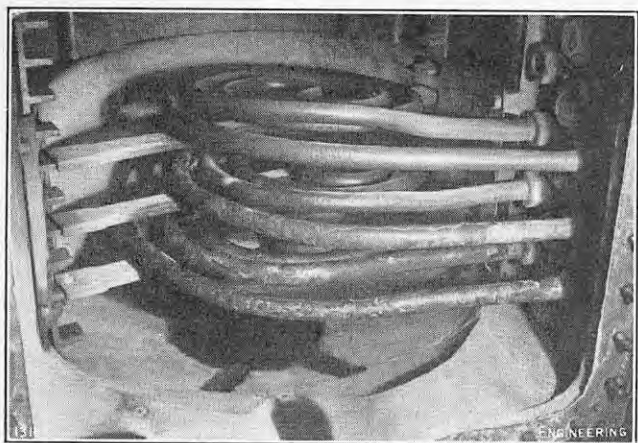


FIG. 16. SCALE AFTER TREATMENT WITH DISPERSIVE COMPOUND.

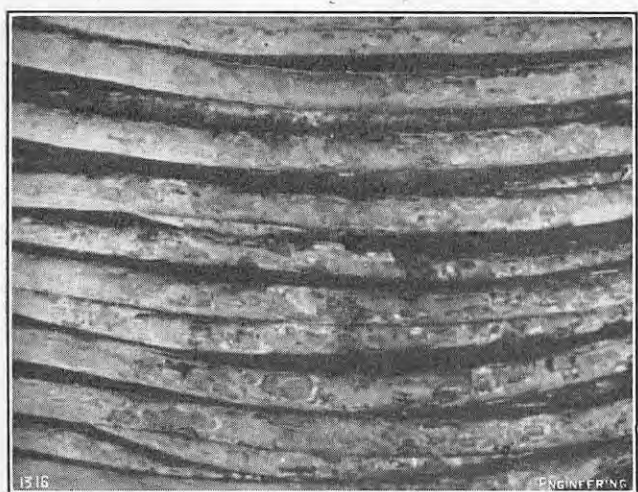


FIG. 17. SCALE ON SHIP'S EVAPORATOR COILS.

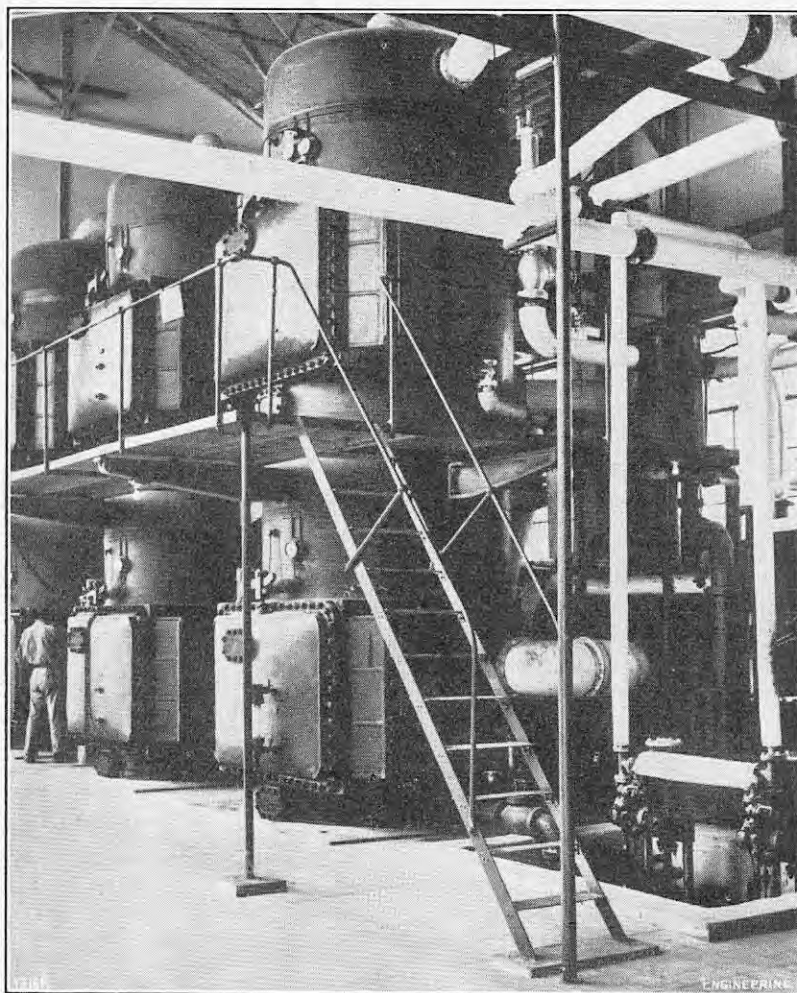


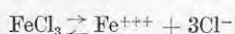
FIG. 18. SEXTUPLE-EFFECT EVAPORATING PLANT.

to the evaporator, which was operated at a vapour temperature of 160 deg. F. with 100 per cent. blow-down. There was no appreciable change in the operating conditions throughout the run; and, when the evaporator was opened, there was no scale on any of the coils. The plant was therefore run for another 150 hours with the addition of ferric chloride reduced to a rate of 0.225 lb. per ton of sea water; again without any appreciable change in the operating conditions.

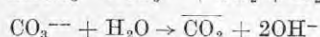
The total test occupied 300 hours of running time, and the heat-transfer coefficients are shown in Fig. 19. The coefficients were substantially constant, and the evaporator heating-surfaces and shell were completely free from scale.

To check the other end of the temperature range, tests were run for periods of 90 and 220 hours, with an addition of 0.40 and 0.51 lb., respectively, of ferric chloride per ton of sea water. The heat-transfer coefficients were again substantially constant and no scale formation was experienced, with the exception of a little on coil No. 1 during one test and a little scale on the shell after the other.

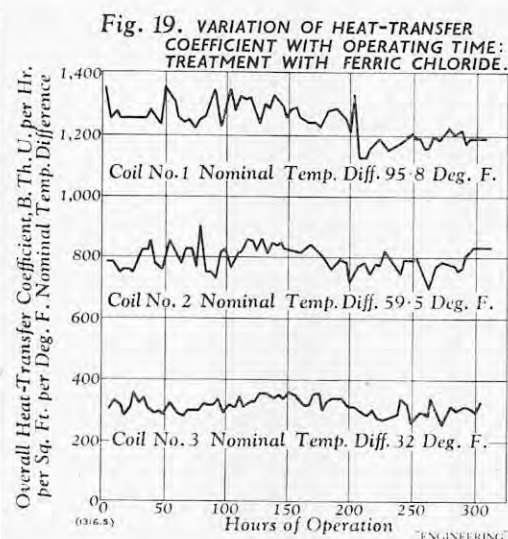
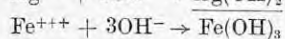
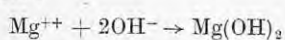
The reactions that take place with the injection of ferric chloride are: the ferric chloride is ionised in the brine,



the bicarbonates and carbonates are decomposed, thus:



and, in the presence of magnesium ions, the hydroxyl ions combine to form $\text{Mg}(\text{OH})_2$. In the presence of ferric ions, Fe^{+++} , some of the hydroxyl ions form ferric hydroxide and the two reactions proceed together, thus:



The latter appears to be the predominant reaction and the former does not persist to a sufficient extent to form a $\text{Mg}(\text{OH})_2$ scale. If sufficient ferric chloride is supplied, the mopping up of the hydroxyl ions by the ferric ions allows the disintegration of the carbonate ions to proceed so far that the formation of both the CaCO_3 and $\text{Mg}(\text{OH})_2$ scales is avoided. Ferric hydroxide does not form a scale, because of its low solubility. Table IV, shows the comparative insolubility of ferric hydroxide.

The effect of ferric chloride has been confirmed on other plants. With the Admiralty evaporator mentioned, a run of 1,200 hours was made, using ferric chloride, and all operating conditions were maintained substantially constant. The evaporator-vapour temperature was 174 deg. F., with a nominal temperature-difference of 23 deg. F. and a blow-down of 50 per cent. When the evaporator

was opened up, the greater part of the coil surface was free from scale. In another test, a triple-effect evaporating plant, supplied with low-grade steam at a pressure of 6 lb. per square inch gauge with the vapour from the third-effect evaporator at 24 in. vacuum, was operated for a period of 2,172 hours at sea without any change in operating conditions, the output being maintained substantially constant. All three evaporators were practically free of scale.

Another commercial plant in which this treatment has been tested is a sextuple-effect sea-water evaporating plant operating on shore in the West Indies, shown in Fig. 18, on this page. This plant is supplied with steam at 25 lb. per square inch gauge, the vapour from the sixth-effect evaporator

TABLE IV.—Solubility Product Values.

Substance.	Solubility Product at Temperature Noted.
Calcium sulphate, $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$	6.1×10^{-5} (10 deg. C.)
Magnesium carbonate, MgCO_3	2.6×10^{-5} (12 deg. C.)
Calcium carbonate, CaCO_3	0.99×10^{-5} (15 deg. C.)
Magnesium hydroxide, $\text{Mg}(\text{OH})_2$	1.2×10^{-11} (18 deg. C.)
Ferrous hydroxide, $\text{Fe}(\text{OH})_2$	1.6×10^{-14} (18 deg. C.)
Ferric hydroxide, $\text{Fe}(\text{OH})_3$	1.1×10^{-36} (18 deg. C.)

passing into a distilling condenser at 24 in. of mercury. This plant completed a run of 1,000 hours with the output constant within 7.5 per cent. The steam pressure was practically constant throughout the run and the slight variation in output was due to fouling of the distilling-condenser tubes and a very thin scale on the first-effect evaporator coils. When opened up, there was a slight scale formation of the order of 0.002 in. thickness on the first-effect coils, with no scale formation of consequence on any of the other evaporator surfaces.

These operating results confirmed that scale formation in a sea-water evaporating plant can be completely prevented by the addition of ferric chloride at the rate to suit the conditions.

THE SAFETY FACTOR IN CONSTRUCTION.—II.*

By PROFESSOR F. C. THOMPSON, D.Met., M.Sc.

THE factor of safety to be employed in any proposed structure is a matter for the engineer to decide. The metallurgist can be helpful, however, by indicating possible sources of increased strength in engineering materials, and, therefore, without any modification of such factor of safety as the engineer may deem necessary, to obtain the given strength in the structure with smaller sections and, therefore, with economy in material. All attempts to estimate the theoretical strength of metals have suggested figures enormously higher than those, in fact, found. An explanation of this has been sought by invoking internal defects in the crystals, which may act as cracks or points of stress concentration. The insuperable difficulty of accepting this suggestion, however, seems to lie in the fact that, whenever special care is taken to produce a metallic crystal in its most perfect form, the strength of the crystal, so far from increasing as the theory would seem to demand, is lowered considerably. It appears, therefore, that it is the theoretical treatment which is subject to defects, and that there is, at the moment, little or no possibility that the very high strength which has been suggested theoretically can, in fact, be hoped for.

CAUSES OF FAILURE.

So far as static stresses are concerned, it is usually found that failures of engineering parts can rarely be ascribed to any single cause, but are the result of a combination of additive factors. Direct overstressing is, in fact, uncommon, except in those cases where it is known to occur and has been allowed for in the design. The most dangerous single stresses are almost invariably tensional, which is, perhaps, not unexpected, since such stresses will tend to open out cracks once they have been originated. This is in agreement with, for instance, the work of Bridgman,[†] where samples which have been stressed under high hydrostatic pressure show increased strength, and often a most spectacular increase in ductility. Stress concentration must result from all structural discontinuities within the material, from inclusions or from inhomogeneity of composition or structure, and leads to highly localised internal stresses, called by Lazlo[‡] "tessellated." The exact effect of such structural stresses still appears to be somewhat uncertain, though they may be high. There can be no doubt, however, that inclusions can, and not infrequently do, have a most pernicious effect by acting as stress raisers and the starting points of cracks.

At the free surfaces, the three-dimensional stress system which pertains to the interior gives place to a simpler two-dimensional one, and there is good evidence for the belief that such free surfaces can be locations of considerably reduced strength. No better evidence of the influence of these free surfaces can be desired than that provided by Edwards and Pfeil[§] during their investigations which led ultimately to the production of single crystals of iron by the stress-anneal technique. The effect just considered is the immediate result of the absence of normal stresses at the surfaces, and is independent of other reasons for superficial weakness, such, for instance, as decarburisation, the harmful effect of which on the fatigue strength of a part has been more than adequately demonstrated.

Bad design, in many cases due to too rapid a change of section, by setting up stress concentrations may lead to unexpected failure, but such cases

should have been foreseen. Brearley* has pointed out that the engineer himself, by insisting on the stamping of parts for the purpose of identification, is responsible for the deliberate production of notches from which failure can, and does, commence. Rough machining, by tearing the surface, is another possible source of failure,[†] as are all surface irregularities. Although the engineer's factor of safety is designed to allow for these and similar conditions, the simultaneous occurrence of two or more may not be adequately covered, and it is then that failure will take place.

Apart from the actual loss of metal, the rusting of steel is highly detrimental in the formation of pits which act as points of stress concentration, in the embrittlement of the material, due possibly to the occlusion of hydrogen, and, under conditions leading to fatigue, in the rapid acceleration of this process. Moreover, since the volume of the rust formed is roughly four times that of the steel from which it was produced, the corrosion leads to a considerable expansion, thus setting up stresses which may be sufficient to shatter rivets or crack concrete cladding.

Whether the full effect of the rate of loading has been completely elucidated may be a matter of opinion. There is good evidence, however, that the total energy absorbed in, for instance, the Izod test is actually higher in impact than during slow bending. This fact gives rise to the obvious question whether shock stresses are, in fact, so particularly dangerous, and there would appear to be a still incompletely explored field of research to provide a clear answer to this most important question. Service stresses may be highly complex, and another question to which, in my opinion, no completely satisfying answer has yet been given, is the extent to which the mathematical treatment of complex stresses, particularly in the plastic range, is to be relied on in practice. It is agreed that a simple tensile stress may be resolved into a shear stress and a second tension normal to the shear plane. On the basis of the atomic structure of metallic crystals, I am by no means convinced that the normal tension across the surface can be neglected, as is often assumed, despite the evidence which appears to support that belief.

At elevated temperatures, the microstructures of alloys may show marked signs of instability; the breakdown of laminated pearlite to the globular form is an example. Such changes may cause serious weakening or, particularly in the lower temperature range, definite embrittlement. In iron, at temperatures not much above that of the room, abnormalities in mechanical properties, such, for instance, as the modulus of rigidity or the limit of proportionality in torsion, have been observed by many workers.[‡] How far such abnormalities may be responsible for failures at temperatures between that of the room and, say, 250 deg. C., is uncertain, but the possibility does arise. There are a number of corresponding examples in which even a single phase may show marked variation in properties over a certain temperature range. The low notched-bar values found in the α -phase of the brasses between about 350 and 650 deg. C., for instance (see Table I), afford an example, regarding the explanation of which there is, so far as I am aware, nothing even to suggest where the cause is to be sought.

TABLE I.—Effect of Temperature on the Toughness of 70:30 Brass.

Temperature, deg. C.	Impact Value, ft.-lb.
15	44
300	32
350	6
500	6
600	6
700	11

* *The Treatment of Tool Steel*, by H. Brearley, page 136. Longmans, London, 1916.

† H. Brearley, *loc. cit.*, page 63.

‡ "The Effect of Temperature on Some of the Properties of Metals," by Professor F. C. Lea, *Proc. I. Mech. E.*, 1922, page 885; and *ENGINEERING*, vol. 113, page 829 (June 30, 1922). Also *Jl. I. and S. Inst.*, vol. 107, page 465 (1923).

IMPROVEMENT BY CHEMICAL MEANS.

An unhardened steel consisting of ferrite and carbide may be modified by the addition of alloying elements which are held in solid solution in the ferrite or which, alternatively, pass into the carbide. There is little evidence to suggest that variations in the composition of the carbide, of themselves, exert any measurable effect on the ordinary mechanical properties, and it is, therefore, to the composition of the ferrite that attention must be directed. A solid solution in iron, as in any other metal, may take place either by substitution of iron atoms for others of manganese, nickel, cobalt, etc., where the atoms are similar in size, or by interstitial solid solution in the "holes" between the iron atoms where the alloying element is one of which the atomic size is relatively small, e.g., carbon, hydrogen, nitrogen or boron. In the steels, both forms of solution may occur simultaneously. The time will come, possibly in the near future, when the internal stresses due to the degree of lattice distortion, and therefore the hardening which results from such substitution or replacement, may be calculated, and alloying of steel will then be placed on a truly scientific basis.

It is a curious fact, which seems to be a general phenomenon in metallurgy, that a greater hardening effect is obtained when small proportions of a large number of different elements are dissolved than when the same total amount, even of the most efficient of these, passes into solution. The high-tensile gold alloys and the complex steels used for tools or for high-temperature service illustrate this fact equally. So far as ordinary steels are concerned, it would appear that a very large field of investigation, at present inadequately explored, is that of the simultaneous addition of many elements, nickel, chromium vanadium, copper, molybdenum, aluminium, etc., all in small amounts, of the order of a fraction of 1 per cent. The simultaneous effects of hydrogen, nitrogen and boron in even smaller amounts could well go side by side. As time goes on, the tendency for the average steel to contain greater and greater percentages of "residual" elements increases, and the time has already come when it would repay much work and trouble to inquire how far these, instead of being regarded merely as nuisances, can be turned to good account in raising the strength of steels.

As the carbon content of an unhardened steel increases, so do the elastic limit and the tensile strength. Simultaneously the ductility tends to fall. Where the material is to be subjected to service under stresses which are essentially static, the question inevitably arises whether the steels employed at the present time are not of unnecessarily low carbon content; in other words, whether it is necessary for the engineer to insist on such high values of the elongation per cent. and reduction of area as he does at the moment. This is for the engineer himself to decide, but if he could satisfy himself that existing specifications demand a higher ductility than is necessary, higher carbon steels, of increased strength, could be employed and a corresponding saving in the tonnage used could be effected.

Even with a carbon content as high as 0.45 per cent., with a manganese content of 0.78 per cent., 1½-in. diameter bars, normalised at 870 deg. C., give the following test figures: yield point, 27 tons per square inch; maximum stress, 44 tons per square inch; elongation on 2 in., 27 per cent.; and reduction of area, 54 per cent.; with an Izod value of 31 ft.-lb. It is difficult to believe that such a steel does not possess both sufficient ductility and adequate toughness for most normal constructional requirements.

The time, too, has surely come when the question of the reliability of the higher-manganese steels should be settled. There is sometimes a feeling that such steels, with a manganese content between perhaps 1½ and 2 per cent. are "uncertain," but the evidence for this is by no means conclusive. May I quote here at length from Bullens's well-known book*: "It has been difficult for the carbon-manganese structural steels to live down their previous

* *Steel and Its Heat Treatment*, by D. K. Bullens. Third edition, page 350. Chapman and Hall, Limited, London (1927).

* The second of two Cantor Lectures, delivered to the Royal Society of Arts, London, on March 2, 1953. Abridged. The first lecture, delivered on February 3, 1953, was reprinted on page 343, ante.

† *Studies in Large Plastic Flow and Fracture*, by P. W. Bridgman. McGraw-Hill Publishing Company, 1952.

‡ *Jl. I. and S. Inst.*, vol. 147, page 173 (1943); vol. 148, page 137 (1943); vol. 150, page 183 (1944); and vol. 152, page 207 (1950).

§ *Jl. I. and S. Inst.*, vol. 109, page 129 (1924).

DIAMOND-LAPPING COMPOUND.

ENGIS, LIMITED, LONDON.

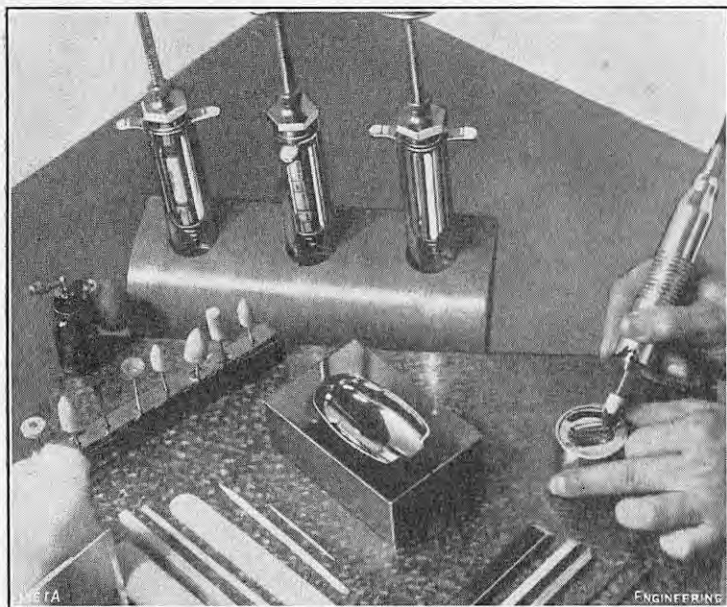


FIG. 1. APPLICATOR GUNS AND OTHER EQUIPMENT.

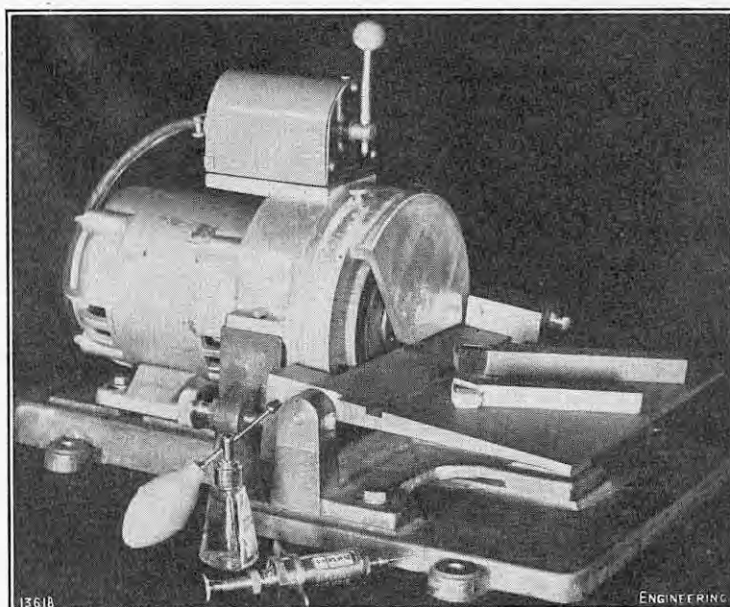


FIG. 2. LAPPING TUNGSTEN-CARBIDE TIPPED TOOLS.

bad name for being 'brittle.' The author has not changed his opinion . . . that the carbon-manganese steels are not brittle. With proper control of heating, forging, and finishing temperatures, and saturation on heating for hardening, followed by a rate of cooling denoted by carbon-manganese content in relation to the mass-surface factors, these steels are no more sensitive than the other alloy structural steels, and, in fact, less sensitive than some. . . . It is not to be inferred that the carbon-manganese steel is the 'one, all-purpose' steel, for such is not the case; but it is a low-price steel suitable for many purposes and its value is not generally recognised." Typical figures for steel containing 0.3 per cent. carbon and about 1.6 per cent. manganese, normalised at 900 deg. C. and tempered at 400 deg. C., even in the as-cast condition, are: yield point, 29 tons per square inch; maximum stress, 45 tons per square inch; elongation on 2 in., 20 per cent.; and reduction of area, 39 per cent.; with an Izod value of 39 ft.-lb. There is nothing here to suggest anything dangerous. Such a test, in fact, suggests a material of thoroughly good properties.

(To be continued.)

CONTRACTS.

ASHMORE, BENSON PEASE & CO., LTD., Stockton-on-Tees, have received an order from the Steel Company of Wales, Ltd., for the construction of a blast furnace to produce between 1,300 and 1,500 tons of iron a day. The new furnace will have a hearth diameter of 29 ft., and it is expected to be in production by the end of 1955. The firm have already built three blast furnaces for the Steel Company of Wales, at Margam. The new order is worth between 1,500,000l. and 2,000,000l.

SULZER BROS (LONDON) LTD., 31, Bedford-square, London, W.C.1, announce that the French National Railways have ordered 20 double six-wheel bogie Diesel-electric locomotives, each with a Sulzer twin-bank engine of 2,050 b.h.p. maximum output, for handling all the heavy passenger and freight transfer traffic over the Grande Ceinture lines. These connect the various main-line terminal stations in Paris.

THE REDHEUGH IRON AND STEEL CO. (1936) LTD., Gateshead, have received an order valued at 40,000 dols. for the supply of welded steel pipes for Toronto, Canada, where they will be used for a new sewerage system.

GUY MOTORS LTD., Park Lane, Fallings Park, Wolverhampton, have received an order valued at 16,976l., from the Darlington Corporation for the supply of eight motor-omnibus chassis. The single-deck bodies, which are to be furnished with central entrance doors and can accommodate 41 passengers, are to be supplied by Charles H. Roe, Ltd., Crossgates, Leeds. This order is worth 12,960l.

DIAMOND-LAPPING AND POLISHING COMPOUND.

A DIAMOND-PARTICLE compound for lapping and polishing has been recently marketed, under the trade name "Hyprez," by Engis, Limited, 25, Victoria-street, London, S.W.1. To avoid contamination, the compound is packed in sealed cartridges and, for application to the workpiece, a cartridge is loaded into a calibrated "gun" fitted with a reducing needle which ensures that the compound is applied in the small quantity required. In the case of tungsten-carbide tools, the life has been found to be considerably lengthened when the cutting faces have been polished with the compound, and moulds for press-work, particularly for plastics, have given improved pressings after similar treatment.

The compound, which is made in 18 different grades, consists of a matrix in which are suspended the diamond particles, ranging in size from $\frac{1}{4}$ to 90 microns, and in concentration according to the grade. The matrix is coloured to enable the grade to be distinguished and the tint of the colour further indicates the strength or concentration of the diamond particles in the grade. Thus, there are available three strengths of the 1-micron grade compound, each coloured blue; the light blue tint denotes a thin compound for final finishing, the medium blue the standard quality of this grade, and the deep blue, with a high diamond content, for use where rather more material has to be removed from the workpiece.

Although it is also available in 1-gramme containers, the compound is normally sold in 5-gramme cartridges, the cartridge case being of glass so that the distinguishing grade-colour of the matrix can be recognised. In order to load the compound into the gun for use, the end seals of the cartridge are broken away and the cartridge is inserted into the body of the gun, which is a veterinary-size hypodermic syringe. A number of these guns, each of which is kept for use with one grade only, and other ancillary apparatus, are shown in Fig. 1. A graduated plunger with a stop-nut permits the compound to be dispensed in known quantities. Fig. 2 illustrates the operation of lapping tungsten-carbide tipped tools. Hyprez is best used with standard laps or polishing tools but a felt bob mounted on the spindle of a light flexible-drive drill (of the type used by dentists) is particularly convenient method of treating intricate surfaces. With variable atmospheric conditions, the compound may become too stiff to work; in this case, a suitable fluid that will thin the matrix is available from the makers.

LAUNCHES AND TRIAL TRIPS.

S.S. "SILVERBURN."—Single-screw cargo vessel, with accommodation for a small number of passengers, built and engined by William Gray & Co., Ltd., West Hartlepool, for the Silver Line, Ltd., London, E.C.2. Main dimensions: 406 ft. between perpendiculars by 56 ft. by 36 ft. 4½ in. to shelter deck; deadweight capacity, 8,865 tons on a draught of 24 ft. 11½ in.; gross tonnage, 5,023. Triple-expansion steam engine working in conjunction with a Bauer-Wach exhaust turbine, and two oil-fired boilers. Service speed, 10½ knots. Trial trip, March 4.

M.S. "POLARTANK."—Single-screw oil tanker, built and engined by Barclay, Curle & Co., Ltd., Whiteinch, Glasgow, for Melsom and Melsom, Larvik, Norway. Second vessel of an order for three. Main dimensions: 566 ft. by 72 ft. 6 in. by 40 ft. 6 in.; deadweight capacity, about 19,000 tons. Barclay Curle-Doxford six-cylinder airless-injection oil engine, developing 8,000 b.h.p. Speed, 15½ knots. Trial trip, March 11.

M.S. "CORBURN."—Single-screw cargo vessel, built by the Goole Shipbuilding and Repairing Co., Ltd., Goole, for Wm. Cory and Son, Ltd., London, E.C.3. Main dimensions: 258 ft. by 39 ft. 3 in. by 19 ft.; deadweight capacity, 2,790 tons. Eight-cylinder Diesel engine, developing 1,040 b.h.p. at 205 r.p.m., constructed by British Polar Engines, Ltd., Glasgow. Speed, 11 knots. Trial trip, March 12.

M.S. "ROYAL CROWN."—Single-screw oil tanker, built by Joseph L. Thompson and Sons, Ltd., Sunderland, for Hall Brothers Steamship Co., Ltd., Newcastle-upon-Tyne. Main dimensions: 495 ft. between perpendiculars by 69 ft. 6 in. by 40 ft. 4 in.; deadweight capacity, 16,400 tons on a draught of 30 ft. Six-cylinder opposed-piston oil engine, developing 6,800 b.h.p. at 118 r.p.m. in service, constructed by William Doxford and Sons, Ltd., Sunderland. Service speed, 14 knots. Launch, March 16.

M.S. "QUEENSBURY."—Single-screw cargo vessel, with accommodation for a small number of passengers, built by the Burntisland Shipbuilding Co., Ltd., Burntisland, Fife, for the Alexander Shipping Co., Ltd. (Managers: Houlder Brothers & Co., Ltd.), London, E.C.3. Main dimensions: 430 ft. between perpendiculars by 59 ft. 9 in. by 39 ft. 3 in.; deadweight capacity, about 10,500 tons on a draught of 26 ft. 9 in. Two Gray-Polar six-cylinder Diesel engines, geared to one propeller shaft through hydraulic couplings and single-helical reduction gearing, and developing 4,315 s.h.p. at 110 r.p.m., constructed by the Central Marine Engine Works of William Gray & Co., Ltd., West Hartlepool. Launch, March 16.

M.S. "BARON KILMARNOCK."—Single-screw oil tanker, built by the Caledon Shipbuilding and Engineering Co., Ltd., Dundee, for H. Hogarth and Sons, Ltd., Glasgow. Main dimensions: 515 ft. between perpendiculars by 71 ft. by 38 ft. 9 in.; gross tonnage, 12,500; deadweight capacity, 16,500 tons on a draught of about 30 ft. Six-cylinder Diesel engine, developing 6,950 b.h.p., constructed by John G. Kincaid & Co., Ltd., Greenock. Speed, 15 knots. Launch, March 17.

THE DESIGN OF BRITISH POWER STATIONS.*

By S. D. WHETMAN, B.Sc., and
A. E. POWELL, B.Sc. (Eng.).

(Continued from page 350.)

CONDENSATE AND FEED HEATING SYSTEMS.

PARTICULARS of the condensate and feed-heating systems at the stations reviewed are given in Table III. The closed-feed system adopted at all the stations is not complicated by a balance control valve. During normal operation the system is

* Paper read before a joint meeting of the Institutions of Mechanical and Electrical Engineers on Thursday, March 5, 1953. Abridged.

TABLE III.—CONDENSATE AND FEED-HEATING SYSTEMS.

Description.	Blackwall Point.	Earley	Cliff Quay.	Poole.	Littlebrook "B."
Final feed temperature, deg. F., at economical load	340	340	340	Nos. 1, 2 370 Nos. 3, 4 388	404
Feed-heating stages: low pressure	1	1	2	2	2
Feed-heating stages: high pressure	3	3	3	3	4
Extraction pumps per machine, and capacity, gallons per minute	Two 390	Two 700	Two 750	Two 600 Two 575	Two 575
Boiler feed pumps: motor-driven, lb. per hour	Four 335,000	Four 450,000	Seven 500,000	Five 525,000	Four 570,000
Boiler feed pumps: steam-driven, lb. per hour	Two 350,000	Two 465,000*	Two 520,000	Two 545,000	—
Hot-well capacity, cub. ft.	Two 1,700	Three 1,440	Three 2,600	Three 2,300	Two 2,000
Evaporators: Central, lb. per hour	Two 16,000	—	One 10,000	Two 25,000	Two 25,000
Evaporators: Unit, lb. per hour	—	Two 8,000	Two 8,000	—	—
Water-treatment plant:					
Type	Lime soda	Lime soda	Lime soda	Demineralising and lime soda	Lime soda
Output, gallons per hour	4,200	3,000	6,000	8,500 6,000	10,000 ("A" Station)
Boiler feed pump discharge pressure, lb. per square inch	870	850	865	1,285	1,700
Type of leak-off	Mechanical	Hand-operated	Mechanical	Thermal	Thermal and mechanical

* Auto-starting.

TABLE IV.—BOILER PLANT.

Description.	Blackwall Point.	Earley.	Cliff Quay.	Poole.	Littlebrook "B."
Type of economisers	Multi-loop	Multi-loop	Multi-loop	Multi-loop	Multi-loop
Type of air heaters	Tubular	Plate	Tubular	Plate	Plate
Type of superheaters	Multi-loop (horizontal)	Multi-loop (vertical)	Multi-loop (horizontal)	Multi-loop (horizontal)	Multi-loop (horizontal)
Furnace walls:					
Front and rear	Bailey block	Spaced bare tubes	Bailey block	Fin tube	Fin tube
Side	Tangent bare tubes	Spaced bare tubes	Bailey block	Fin tube	Fin tube
Superheat control	Gas by-pass	Desuperheater	Desuperheater	Desuperheater	Desuperheater
Volume of combustion chamber, cub. ft.	24,100	10,000	26,800	24,000	13,000
Boiler heating surfaces, in sq. ft.:					
Boiler	15,000	7,465	7,359	3,820	6,360†
Furnace	4,250	2,507	4,520	5,758	3,940
Primary superheater	4,770	5,530	9,160	11,250	5,700
Secondary superheater	2,550	3,770	5,090	3,190	1,300
Economiser (low temperature)	23,900	8,640	18,100	9,660	15,400
Economiser (high temperature)	—	—	5,700	5,796	—
Air heater (low temperature)	78,000	35,640	68,600	57,456	51,840
Air heater (high temperature)	4,350	10,710	16,300	14,630	12,960
Maximum air temperature, deg. F.	450	504	450	496	514
Exit gas temperature, deg. F.	300	270 deg. F. at precipitator outlet	300	300	285
Mills:					
Number per boiler and type	Three—ball	Two—roller and table	Three—ball	Three—roller and table	Three—roller and table
Output, lb. per hour, 8 per cent. mixture	18,300	13,200*	18,300	21,000	Two—18,400 One—6,400
Number of burners and position	Six—front wall	Four—corners	Twelve—front wall	Twelve—corners	Eight—corners
Fans:					
Induced draught	Two 2-speed	Two 2-speed	Two 2-speed	Two 2-speed	Two 2-speed
Forced draught	Two 2-speed	Two 2-speed	Two 2-speed	Two 2-speed	Two 2-speed
Draught control	Damper	Damper	Damper	Damper	Damper
Automatic combustion control	Yes	Induced draught and superheat only	Yes	Induced draught and superheat only	Yes
Steam soot blowers:					
Pressure	Boiler pressure	Boiler pressure	Boiler pressure	Boiler pressure	Boiler pressure
Type of control	Hydraulic	Electric	Electric	Electric	Electric
Dust-extraction equipment	Electrostatic precipitator	Electrostatic precipitator	Electrostatic precipitator	Electrostatic precipitator	Electrostatic precipitator
Type of ash handling	H.P. sluicing	H.P. sluicing	H.P. sluicing	H.P. sluicing	H.P. sluicing
Type of dust handling	Dry aspiration	Dry aspiration	Aspiration and sluicing	Dry aspiration	Aspiration and sluicing
Ash and dust disposal	Bunkers (lorry or barge)	Bunkers (lorry)	Sluicing	Bunkers (lorry or barge)	Sluicing

* At 6 per cent.

† Plus reheater 24,400 sq. ft.

kept free from air by ensuring an upward flow through the balance connection to the hot wells, where the aerated layers of water are taken by the overflow connection to low-level reserve feed-water tanks. The make-up from the evaporators is admitted to the system at the condenser through the feed heater drain. When the evaporators are not operating, or when extra make-up is required, the water is passed from the reserve tanks to the make-up tank associated with each condenser. At all stations the feed pumps are installed at operating floor level to meet the desires of the staff. From the constructional point of view it is, however, important to mount the pumps at basement level, especially when they are very large. All the pumps are of single-speed design and are specified to give their rated output against full boiler blow-off pressure. They are provided with automatic leak-off

arrangements to ensure an adequate flow of water through them at reduced loads and thus to avoid overheating. At Littlebrook and Poole these leak-offs are controlled by the temperature and a pressure-reducing orifice, which at Littlebrook is provided with several holes to reduce the noise caused by the high velocity. Unit evaporators have been replaced at Littlebrook, Blackwall Point and Poole by high-efficiency central evaporators of the triple-effect vapour-compression type, as these give a steady high grade output. There is little to choose between the two systems in overall economy and in base load stations the advantage of dispensing with the auxiliary high-pressure steam range to the central evaporator may justify the unit arrangement.

HIGH-PRESSURE PIPEWORK.

Alloy steel with 1 per cent. chromium and $\frac{1}{2}$ per cent. molybdenum was used for the steam-piping systems at Poole and Blackwall Point, as it was felt that a temperature of 865 deg. F. was approaching the limit for plain carbon steel. At Littlebrook, $\frac{1}{2}$ per cent. molybdenum steel and at Cliff Quay and Earley carbon steel are employed. Carbon steel was also used for the feed piping at all the stations. At all the stations, too, both the high-pressure steam and feed systems have butt-welded intermediate pipe joints with flanged seal-welded joints at the valves. Bolted joints are provided at those terminal points where periodic dismantling is necessary during routine plant overhauls.

The authors suggest that the standard allowances for pressure drop between the superheater outlet and the turbine stop valve of 25 lb. per square inch for the 600 lb. and 850 deg. F. cycle, and of 50 lb. per square inch for the 900 lb. and 900 deg. F. cycle are below the economic figure; and that the allowance for temperature drop along the pipe line of 15 deg. F. in both cycles is on the liberal side. The adoption of the economic drop in the pressure ranges under discussion would have resulted in higher steam velocities with a consequent reduction in the size of the pipes. On all pipes of 4-in. bore and above, butt welds were made by the arc-welding process and were subjected to non-destructive examination by either the magnetic method or single-wall γ -ray radiography, the radiating source being inserted into the tube through prepared bosses. The reheater pipework system at Littlebrook is carbon steel, both the inlet and outlet pipes being of 15-in. bore. All the joints are of the flanged and bolted seal-weld type.

BOILER DESIGN.

General particulars of the boilers are given in Table IV.

The boilers at Cliff Quay and Blackwall Point are of the same rating, but the furnaces of the former are completely lined with refractory blocks. The three-drum bent-tube type at the latter is more representative of present-day practice, as the Bailey wall surface has been considerably reduced. Cliff Quay embodies long-flame burners fired from near the top of the combustion chamber, whereas the Blackwall Point boilers have short-flame burners in the front furnace wall. The Blackwall Point boilers are supported entirely from the top of the structure and the superheaters are entirely controlled by gas by-pass. At Cliff Quay, however, control is by attemperator, with a gas by-pass, which is adjusted in the initial stages of operation. Comparing the boilers at Earley and Poole, the former is of the three-drum design, while the latter has two drums, both being corner fired. Poole was designed and Earley modified to burn low-volatility coal. The Earley furnace has plain tubed walls with a $2\frac{1}{2}$ -in. spacing between the tubes, which are backed with refractory. To assist the maintenance of operation these tubes were entirely covered with a belt of refractory about 7 ft. deep about the centre lines of the burners. The Poole furnaces have fin-tubed walls with the fins removed and the tubes filled with a refractory at burner level. Both have primary and secondary superheaters with attemperator control, but whereas Earley has pendant superheaters, those at Poole are of the horizontal self-draining type.

The Littlebrook reheater boilers were designed to give their maximum efficiency in the region of the

turbine economic rating. The primary steam temperature is controlled by desuperheaters and the reheaters by a non-automatic gas by-pass, which is partly open at maximum load. The forced-draught fans are at basement level with the low-temperature air heater on the suction side. At all the stations the air heater is divided into low and high temperature sections, the latter being in front of the economiser. This was done to provide high-temperature air for dealing with very wet coals, but has seldom proved to be necessary.

GENERATORS AND SWITCHGEAR.

All the main alternators operate at 3,000 r.p.m. The specifications stated the essential requirements as to output voltage and reactance and left the manufacturer free to offer his preferred design. When generator transformers were required, the choice of alternator voltage was influenced by the trend towards the standardisation of voltage ratios. The exciters are direct driven on the 30-MW and 40-MW machines at Blackwall Point and Earley. Cliff Quay and Littlebrook have a single 1,000 r.p.m. motor-driven exciter per alternator with a flywheel incorporated to maintain the excitation during system disturbance. These motor-driven exciters were adopted at a time when the position was indeterminate because difficulties with the commutation on exciters coupled to large 3,000 r.p.m. alternators had led to the decision to abandon the direct drive temporarily and no alternative had been accepted as standard. They have proved quite reliable, but are subject to the disadvantage that severe electrical disturbances may interrupt the excitation. At Poole, and on later larger machines, the exciters are geared at 1,000 r.p.m. Rheostats operate in conjunction with normally inactive automatic regulators for high-speed excitation control. The Littlebrook alternators were the first hydrogen-cooled machines to be commissioned in this country.* The hydrogen-cooled and seal-oil treatment system are more comprehensive than those now being installed, since manufacturers have taken advantage of first-hand operating experience to reduce and simplify this ancillary equipment. Operation has been wholly satisfactory.

In general, the output of all stations was intended to be exported at high voltage and the alternator and its step-up transformer were, therefore, treated as a single unit and switched at that voltage. Blackwall Point supplies a 33-kV and 22-kV cable system in addition to a local 11-kV sub-station, and would appear to be a case for 33-kV generation. The provision of direct connection with Barking, however, introduced serious switchgear fault-rating difficulties and it was found more economical to use 11/33-kV generator transformers and switch at 33 kV with metalclad oil-circuit breakers rated at 1,000 MVA. At Earley the first two alternators were wound for 33-kV and connected to the 'bus-bars at the adjacent substation. The third alternator, which generated at the same voltage, was provided with a transformer and switched at 132 kV to avoid increasing the fault power at the 33-kV 'bus-bars. At Cliff Quay there is considerable local load at 33 kV, in addition to the major export at 132 kV. The preponderance of the latter and short-circuit considerations, however, led to the decision to switch all the machines at 132 kV and to provide inter-'bus-bar transformers to the subsidiary 33-kV switchgear supplying the local network and the 33/3-kV station transformers. The 132-kV switchgear incorporates 2,500-MVA outdoor double-break air-blast circuit-breakers with non-linear voltage dividing resistors across each break. It was the first power station installation of this type.

At Poole the whole output is fed to the 132-kV grid and the local demand is taken from the grid substation at Bourne Valley, eight miles to the east, whence a 33-kV system has been superimposed on the 11-kV network. As the growth of the local load was mainly to the east of Bourne Valley, this was preferable to the establishment of a subsidiary 11-kV or 33-kV switchboard at the former station. At Littlebrook 66-kV and 132-kV 'bus-bars with inter-'bus-bar transformers were provided when the "A" station was built, the intention being to switch at one or other voltage

DEVELOPMENT OF "AVON" AERO ENGINES.

ROLLS-ROYCE, LTD., DERBY.

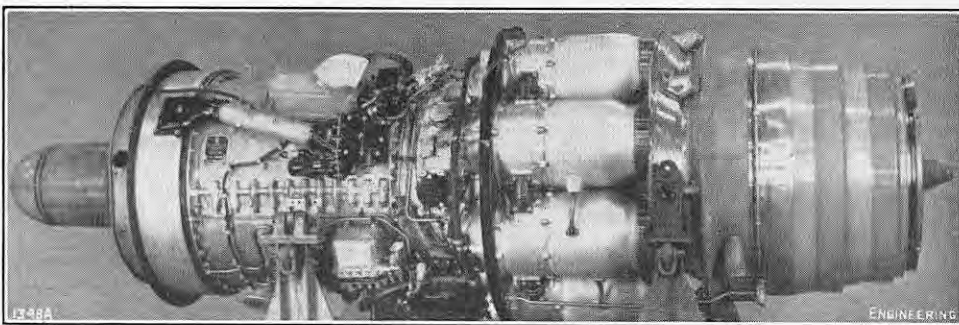
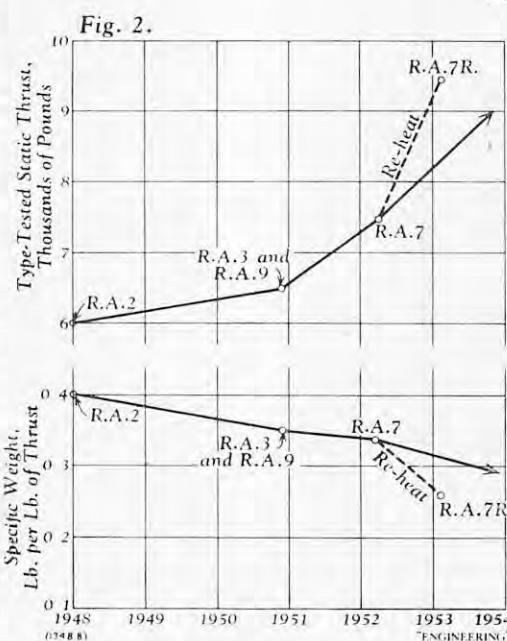


FIG. 1.



according to requirements. Both the Littlebrook "B" machines are, in fact, switched at 132 kV and the one station transformer is also connected to the 132-kV 'bus-bars. The 66-kV switchgear is metalclad and pneumo-oil operated, while the 132-kV outdoor circuit-breakers are of the single-break horizontal oil-impulse type and are each rated at 2,000 MVA.

(To be continued.)

BOOKS RECEIVED.

- Elements of Propeller and Helicopter Aerodynamics.* By PROFESSOR DANIEL O. DOMMASCH. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 35s. net.]
- The Induction Motor.* By DR. HERBERT VICKERS. Second edition. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 70s. net.]
- Timber and Fire Protection.* Timber Development Association, Limited, 21, College-hill, London, E.C.4. [Gratis.]
- Royal Photographic Society of Great Britain. Library Catalogue.* Supplement to Author Catalogue, 1939. Offices of the Society, 16, Princes-gate, London, S.W.7.
- Handbook of Applied Hydraulics.* Edited by CALVIN VICTOR DAVIS. Second edition. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 36, U.S.A. [Price 15 dols.]; and McGraw-Hill Publishing Company, Limited, 95, Farringdon-street, London, E.C.4. [Price 107s. 6d.]
- Canada. Department of Mines and Technical Surveys. Memorandum Series No. 123. Electronic Concentration of Ores with the Lapointe Pichen Bell.* By C. M. LAPOINTE and R. D. WILMOT. [Price 50 cents.]
- No. 125. Tin in Canada: Occurrences and Uses.* By W. R. MCCLELLAND. [Price 25 cents.] The Director, Department of Mines and Technical Surveys, Mines Branch, Ottawa, Canada.
- Locomotive and Train Working in the Latter Part of the Nineteenth Century.* By E. L. AHRONS. Vol. IV. W. Heffer and Sons, Limited, Cambridge. [Price 15s. net.]

DEVELOPMENT OF ROLLS-ROYCE "AVON" ENGINES.

ROLLS-ROYCE LIMITED, Derby, have announced that the Avon RA.7R axial-flow jet engine, equipped with reheat, has successfully completed a 150-hour type-test at a gross rating of 9,500 lb. static thrust. The Avon RA.7 engine, without reheat, illustrated in Fig. 1, was type-tested in March, 1952, at a static thrust rating of 7,500 lb., and production of the engine has recently commenced in the Rolls-Royce factories. It will be installed in the latest types of Royal Air Force operational aircraft, and in Australian-built bomber and fighter aircraft. It will also be manufactured under licence overseas. Engines of this rating were flown at the flying display of the Society of British Aircraft Constructors in 1950, 1951 and 1952. Fig. 2 illustrates the way in which the static thrust of the Avon engine has been developed. In 1948, the design thrust of the experimental RA.2 engine was rated at 6,000 lb. By 1951, the thrust had been increased to 6,500 lb. on the RA.3 and RA.9 engines (a type-test rating) and, as already noted, in 1952 the thrust rating of the RA.7 version without reheat had increased to 7,500 lb. It is known that a civil Avon engine, to give a thrust of 9,000 lb., is under development. Also under development is the Avon RA.14 engine, no details of which have been released. The corresponding improvement in specific weight of the engine is shown in Fig. 2. Although the total weight of the RA.7 engine has been increased to withstand the loads imposed at high speeds on fighter aircraft, the thrust-to-weight ratio has continued to rise.

In the Rolls-Royce group of factories, nine different marks of Avon engine, for fighter, bomber, naval, and civil aircraft, are being constructed. Seven of these are of RA.7 rating, and the remaining two are of RA.3 or RA.9 rating. Development work has also been in progress on anti-icing measures, and the bench and flight-testing of the anti-icing system has now been completed. As from March, an anti-icing system is being included in the specification for production RA.7 engines.

Referring to re-heat, Rolls-Royce, Limited, state that, although the overall fuel consumption when reheat is in use is greatly increased, it is in fact the most economical means of thrust augmentation, particularly at high speeds. Thus, a reheat system which can provide 25 per cent. thrust increase at take-off will produce nearly 50 per cent. increase at 700 m.p.h. and over 65 per cent. increase at 1,000 m.p.h. They claim that, for the same expenditure of fuel, reheat will almost halve the time to climb to the service ceiling of the aircraft. The maximum altitude at which a fighter can operate, and its manoeuvrability at altitude, can be greatly raised by reheat.

PETROLEUM INFORMATION BUREAU.—The Petroleum Information Bureau, 29, New Bond-street, London, W.1, have issued a list of the literature they publish free of charge. Their publications explain, in non-technical language, the work involved in the search for crude oil, its production, transport, refining and its diverse applications. The list also enumerates the visual aids (films, models, photographs and samples) that are available on loan, free of charge, from the Bureau.

* See ENGINEERING, vol. 165, page 559 (1948).