

TANK LORRY FOR FUELLING "COMET" AIR LINERS.

SIXTY tank lorries of a new type, known as the Dorset fueller, are to be introduced by the Shell Petroleum Company, Limited, St. Helen's Court, Great St. Helen's, London, E.C.3, on international airfields to serve the needs of advanced aircraft, such as the British Overseas Airways Corporation's fleet of de Havilland Comet air liners, which are expected to go into service next year. Initially, the vehicles will be stationed in pairs at each main fuelling stop on the routes to Johannesburg and Sydney; it is intended to use the two vehicles simultaneously to refuel the aircraft at a rate of about 400 gallons a minute. They have been designed by the operations engineering department of the Shell Company. The tanks and pumping equipment are constructed by Thompson Brothers (Bilston), Limited, Bilston,

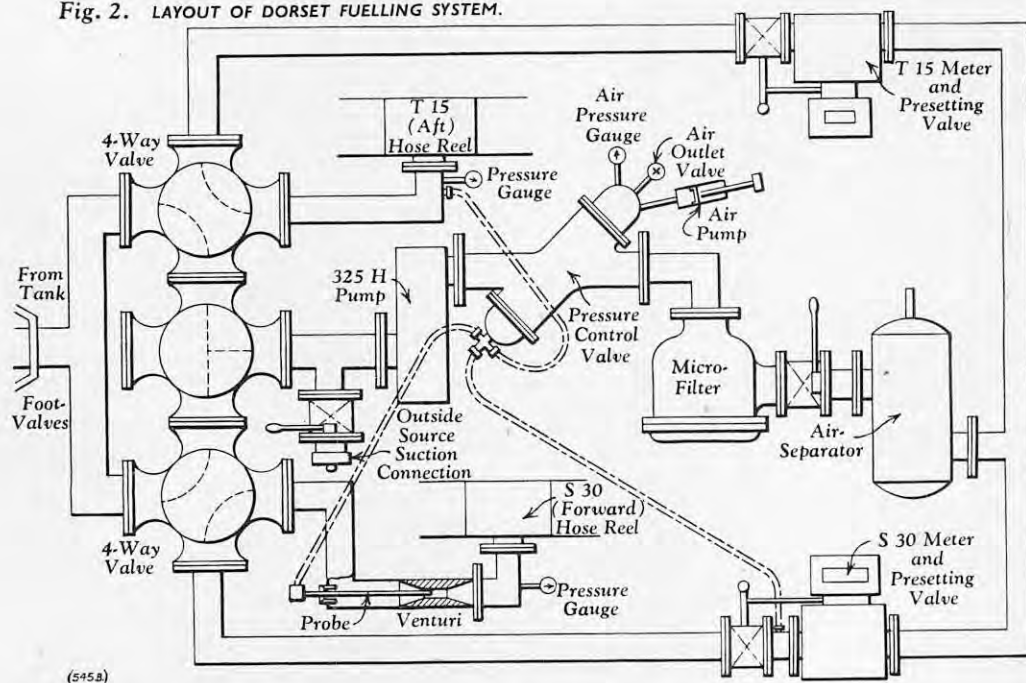
200 gallons per minute. It is also required to defuel the aircraft either by way of the over-wing tank fuelling orifices or through pressure connections; to transfer fuel from one aircraft tank to another for aircraft load adjustment—i.e., to defuel one tank while refuelling another; and to deliver fuel to an aircraft and simultaneously to take on fuel from an outside source to supplement the capacity of the fueller. The specification also called for the use of microfilters on all fuelling operations; and required that the vehicle should be self-loading by means of its own pumps, and also to be capable of being refilled by the pumps of an outside installation, should operate in all climates ranging from the Arctic to the tropics, and should conform with official Road Transport Regulations, in order to transport fuel supplies from the main depot to the airport. It was also laid down that the vehicle should be simple and reliable to operate, and should require the minimum of maintenance. A

four-position three-way valve (actually a four-way valve with one port blocked), one of two hose lines, and one of two pre-setting Wayne-Smith fuel-flow meters. The latter can be set to shut off the flow after a pre-selected quantity has passed. One of these meters, an S.30, is used with the forward hose for under-wing pressure fuelling. The other meter, a T.15, of smaller capacity, is used with the rear hose-line, which is brought into action when two hoses are used for over-wing fuelling. The third outlet of the three-way valve is connected through the fuel pump, a pressure-control valve, a 10-micron filter, a gate valve and an air separator to a T-junction, the other branches of which are connected to the other side of the two pre-setting fuel-flow meters. Between the pump and the three-way valve is a branch suction connection for an outside source; this connection is closed by a gate valve except when outside fuel is being delivered either to the tank or through the hose lines to the aircraft.



FIG. 1. THE "DORSET" TANK FUELLING LORRY.

Fig. 2. LAYOUT OF DORSET FUELLING SYSTEM.



From the diagram, Fig. 2, it may be seen that, by combining various positions of the valves, any one of the specified fuel-transfer operations can be carried out. The simplicity of the controls may be appreciated by referring to Fig. 3, which shows the layout of the control panel, fuel-flow and pressure-indicating instruments. Below the instrument panel are the two four-way valves with the three-way valve between them; the S.30 pre-setting meter can be seen on the right, and the T.15 on the left. Since the Dorset will be operated by men of many different nationalities, whose knowledge of the English language may be small, the operation of the controls is made clear by providing fuel-flow diagrams, related to the control-lever settings for each of the various operations.

The successful development of a valve for controlling the pump-delivery pressure has made it possible to adopt a single centrifugal pump, giving a high output with a compact layout; the centrifugal pump also has the advantage that no bearing surfaces liable to wear are in contact with the fuel. A Pegson type 325H self-priming 3-in. pump, which can be seen on the left of Fig. 4, which shows the pumping compartment, has been selected; at a pump speed of 3,250 r.p.m., it is capable of delivering 225 gallons a minute against a pressure of 75 lb. per square inch. The pump has a step-up gearbox giving a speed increase of 61 to 15, the drive being by belt from a power take-off on the gearbox of the vehicle.

Thompson-Viberti automatically self-centring and locking four-way valves are employed in the Dorset fuel system. Cross-sectional views through one of these valves are reproduced in Fig. 5, on page 579; it consists of a cast-aluminium body with a tapered bore, housing a four-way plug provided with bonded-in metal-to-rubber seals. Normally, a strong spring forces the plug up into the taper, the rubber seals being thereby compressed. The plug stem carries a

Staffordshire, and are mounted on Leyland Hippo 19 H/7 chassis supplied by Leyland Motors, Limited, Leyland, Lancashire.

The Dorset, which is illustrated in Fig. 1, and has a fuel capacity of 3,000 Imperial gallons, has been designed to carry out "over-wing" fuelling of individual tanks, using two hoses, at a rate of not less than 100 gallons per minute per hose, or "under-wing" or pressure-fuelling, by which several aircraft tanks are fuelled simultaneously, at

working life of at least ten years is expected.

The problem of providing high pumping speeds and carrying out the diverse operations required, without adding to the cost and complexity of the vehicle, has been solved by adopting the layout diagrammatically represented in Fig. 2. The five compartments of the tank are connected, through foot-valves, to a common suction manifold leading to two four-way valves; the other three outlets of the four-way valves are connected, respectively, to a

"DORSET" TANK LORRY FOR FUELLING AIRCRAFT.

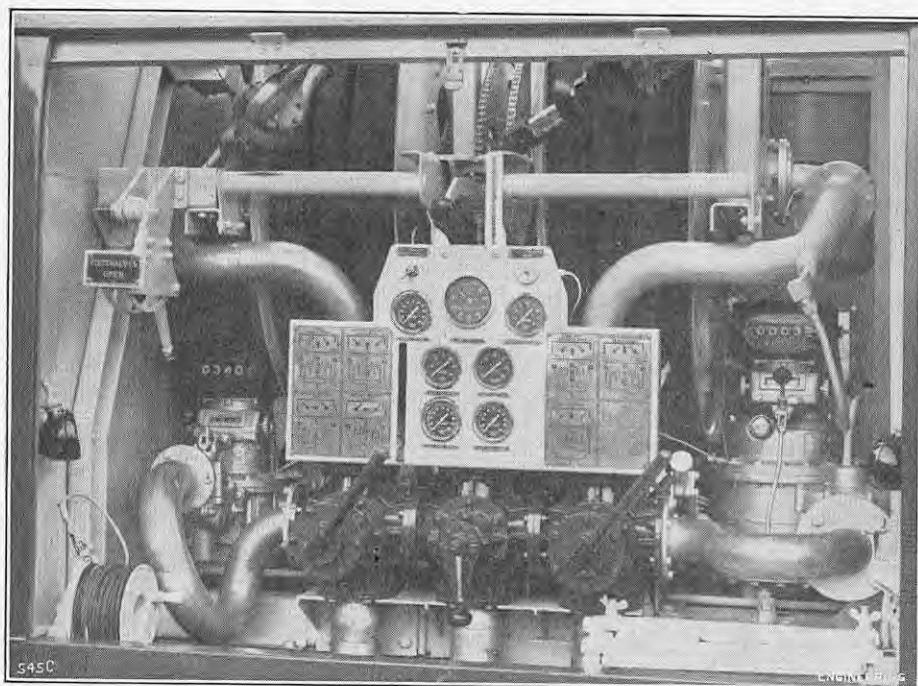


FIG. 3. OPERATING STATION.

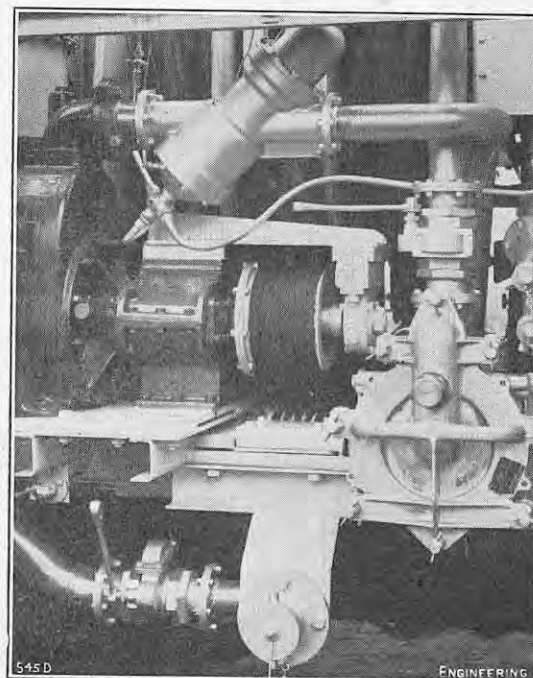


FIG. 4. PUMP COMPARTMENT.

ball housing which is keyed to an operating collar so that it can slide up and down, but cannot rotate relatively to the collar, which runs in a thrust bearing. The operating collar is actuated by a pivoted lever. Below the operating collar is a fixed collar, attached to the body of the valve, on which are cut four V-shaped notches forming a cam track. Two small hardened-steel wheels attached on opposite sides of the plug stem engage with the cam tracks in such a way that when the valve is seated, the wheels are held by the spring in two opposite "valleys" on the cam track. To rotate the valve plug, the operating lever, which carries a cam engaging with the ball at the end of the plug stem, must be depressed to overcome the spring and force the plug off the taper, decompressing the seats and at the same time disengaging the wheels from the cam track; the lever can then be turned to rotate the valve shaft as required. If the operator releases the lever before, or after, it is properly located, the wheels will make contact with the sloping sides of the cam track and, under the action of the spring, will travel up the track into the appropriate valley, thus centring and locking the valve.

It has been necessary to provide automatic control of the fuel delivery pressure for several reasons. Firstly, in aircraft provided with pressure-fuelling systems, such as the Comet, as soon as the aircraft fuel tanks are filled, the tank valves shut off automatically. Without an automatic pressure-regulating valve this would cause an immediate rise of pressure in the aircraft fuel gallery, which could not be tolerated. Secondly, the truck is expected to serve a number of different aircraft with differing requirements of fuel flow and pressure; and thirdly, it was desired to compensate for the frictional losses in the pumping system. The pressure-control valve, which has been developed by the Shell Company, is shown in cross-section in Fig. 6, opposite, and can also be seen in Fig. 4, above. In addition to its use on the Dorset fueller, the intention is to use it on airfield static fuelling installations, where fuel from main storage is pumped direct to the aircraft by way of underground pipelines and small dispensing trolleys carrying hoses, filters and meters.

The Shell pressure-control valve (Fig. 7) comprises a poppet valve carrying a tapered cone seating in a tapered stainless-steel insert, arranged diagonally across the direction of fuel flow; to each end of the valve stem, which is extended on both sides of the valve, are attached pistons working in cylinders formed in the end caps of the valve body. The space above the top piston forms an air chamber, to which is connected a hand-operated air pump,

a pressure gauge and an air-release valve so that the pressure may be adjusted to any desired value. The space below the lower piston forms a fluid-monitoring chamber which can be connected through a bleed line to any point in the system at which it is necessary to control the pressure; in the Dorset, there are three such bleed lines connected to the monitoring chamber through a four-way junction piece. The effective areas of the two pistons and the poppet valve are equal, so that the valve is in static pressure balance; the angular arrangement of the valve, however, provides a degree of dynamic unbalance so that, as the flow velocity increases, the valve tends to close.

In operation, the pressure in the air cylinder is raised to the required flow shut-down pressure. So long as the air pressure is greater than the fuel pressure at the controlled station, the valve is held off its seat; as the fuel pressure rises in the monitoring chamber and equals the air pressure, the valve is progressively closed. The valve is fully automatic in that it permits full flow until the maximum fuel delivery pressure is reached, and it then meters the flow until the shut-off pressure is reached and the valve closes completely. When used with the Comet, the full delivery pressure is 25 lb. per square inch and the shut-off pressure is 30 lb. per square inch. The conical valve seat prevents undesirable pressure fluctuations as the valve closes.

In detecting the sudden rise of pressure at the hose nozzle when the aircraft tank-valves close during pressure-fuelling, it is clearly inconvenient to take the pressure tapping actually at the nozzle; it is, in fact, taken in the fixed piping leading to the forward hose reel. To compensate for the frictional loss in the hose line, a Venturi nozzle is fitted in the pipe and a hollow probe is inserted into the nozzle through a gland in the elbow of the pipe. This can be seen in Fig. 2. By suitably adjusting the position of the probe during installation, it is possible to reproduce the hose-nozzle pressure at the probe. The probe is connected through the junction piece in the fluid-monitoring chamber.

When fuelling with both hoses, it is necessary also to have a connection from the rear hose reel to the fluid-monitoring chamber, since the two hose lines can be operated independently and one could be closed before the other. To protect the pumping system from carrying the entire pump pressure when both meter set-stop valves close, a third connection to the fluid-monitoring chamber is taken from between the S.30 flow meter and its set-stop valve. By this means it has been possible to allow much higher flow rates than would otherwise be possible. These fuel-pressure bleed lines

are indicated in broken lines on the diagram reproduced in Fig. 2.

Fig. 8, opposite, shows the four-way junction piece, in which are three spring-loaded non-return ball valves. One of these, connected to the tapping between the S.30 meter and its set-stop valve, is loaded so that it will not lift until the fuel pressure in the pipelines reaches 70 lb. per square inch, which occurs when both the flow-meter set-stop valves are closed simultaneously. The other two ball valves, which are connected to the bleed lines leading to the two hose reels, are lightly loaded and are deliberately made "leaky" so that, when they are closed, a small quantity of fuel is allowed to leak through a passage past the ball; this allows for the displacement of the fuel in the monitoring chamber when the pressure-control valve opens, and also serves to restrict the speed at which the poppet valve opens.

For economy in manufacture, easy accessibility, and maximum capacity, the 3,000-gallon fuel tank is of almost square section, and is electrically welded, the ends being die-pressed in a single operation. The tank is divided into five compartments to conform to road transport regulations. The tank is lined with aluminium, to ensure a high standard of fuel cleanliness, and all the internal fittings are of aluminium or aluminium alloy, welded by the argon-arc process. To reduce the condensation of water vapour on the walls of the tank, a vent line, fitted with a vacuum and pressure relief valve, provides a connection to atmosphere. Seven drain valves are provided on the tank, pipework and fittings. All pipework is internally and externally hot-tinned. The accessibility of the components for servicing may be judged from Figs. 3 and 4. The three-way and four-way control valves and fuel-flow meters are reached from the right-hand side of the vehicle, and access to the pump, the pressure-control valve, and the micro-filter, the outside-source suction connection, and the vapour return hose connections, is from the left. For major overhauls, the complete pumping, metering and delivery equipment can be removed from the chassis as a unit.

The power take-off system provides for driving the centrifugal pump and the two hose reels. A Thompson split-transmission gearbox is installed in the drive behind the Leyland Hippo gearbox, allowing the drive to be taken through any of the main gearbox ratios, either to the rear axles or to the power take-off shaft. The forward end of the take-off shaft is connected, through a Layrub coupling, to a pulley shaft from which the pump is driven at about four times the main-shaft speed by multiple

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Fig. 5.
FOUR-WAY VALVE.

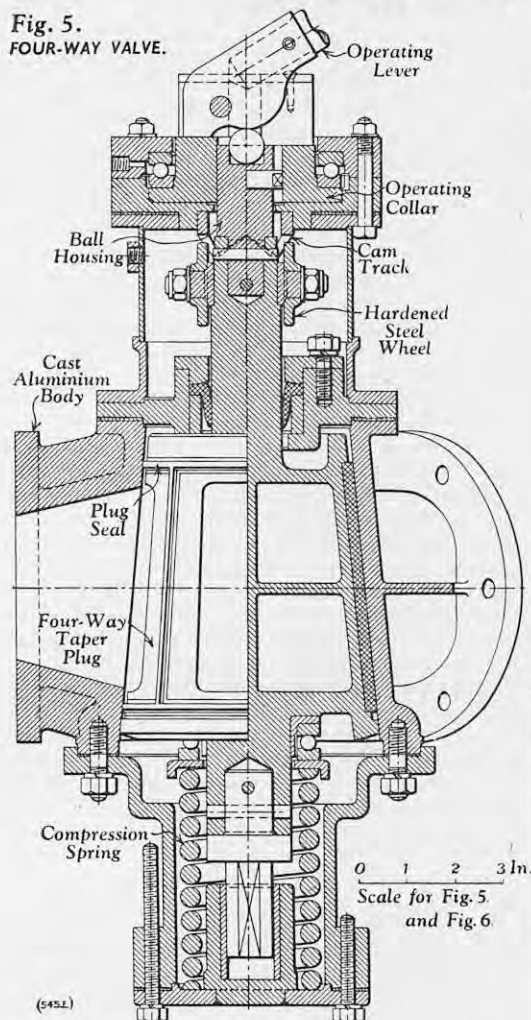
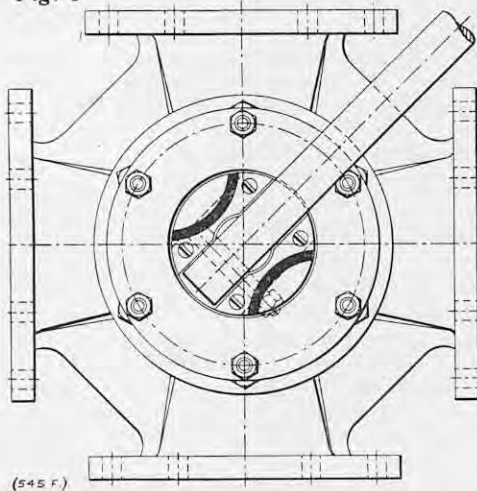


Fig. 6



belts; thus the pump is running whenever the power take-off is engaged. From the other end of the take-off shaft, chains and sprockets transmit the drive through a manually-operated double cone-clutch unit to the hose reels, which can each carry 90 ft. of 1½-in. hose, 75 ft. of 2-in. hose, or 45 ft. of 2½-in. hose.

It may be of interest to record briefly some of the principal features of the well-established Leyland Hippo chassis, which was described in detail on page 272 of our 162nd volume (1946). It has a Leyland six-cylinder direct-injection Diesel engine, with a bore of 4.8 in. and a stroke of 5.5 in., developing 125 to 130 brake horse-power at 1,800 r.p.m., and a maximum torque of 410 lb.-ft. at 900 r.p.m. It has a single dry-plate clutch and remotely-controlled five-speed gearbox, the fifth, fourth and third speeds being in constant mesh. Twin fully-floating rear driving axles are employed, with overhead worm drive. The wheelbase is 17 ft. 9 in., and the turning circle 68 ft. With the

Fig. 7. HIGH-PRESSURE CONTROL VALVE.

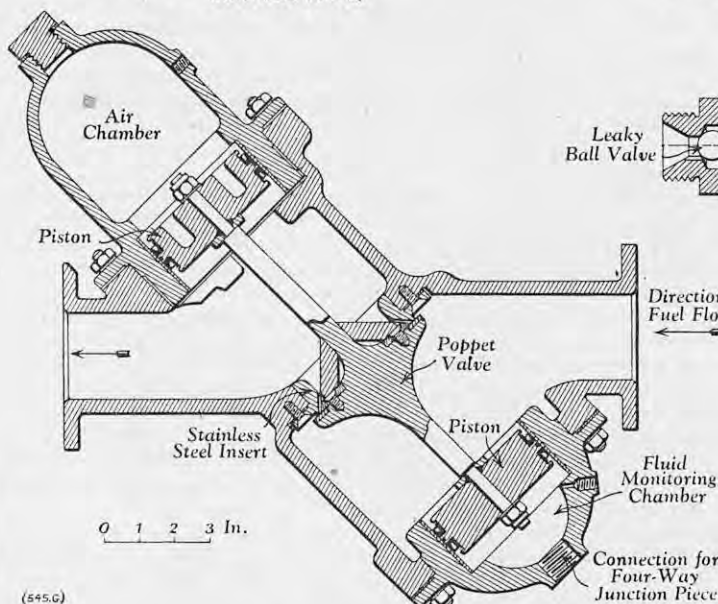
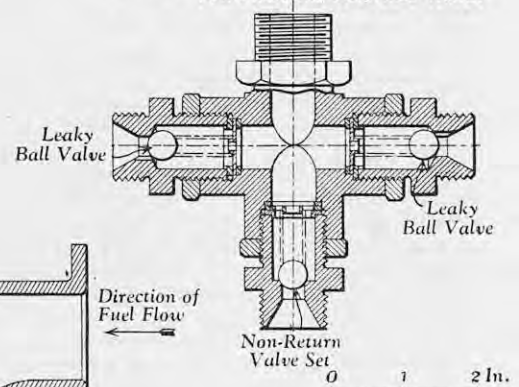


Fig. 8. FOUR-WAY JUNCTION PIECE FOR PRESSURE-CONTROL VALVE.



Dorset cab, tank and fuel system installed, the complete vehicle has an overall length of 29 ft. 10 in., width 7 ft. 5 in., height 8 ft. 9 in., and weighs, fully loaded, 20 tons 19 cwt.

The performance of the Dorset surpasses the specification appreciably. It can, in fact, deliver over 350 gallons of fuel a minute through two 2-in. hoses. At London Airport, recently, the prototype gave a demonstration, fuelling a Comet air liner. A single 2½-in. hose was connected to one of the Comet's two pressure-fuelling points, and fuel was delivered simultaneously into three tanks at a rate of 208 gallons per minute. Using two Dorset fuellers, one to each pressure-fuelling connection, it will be possible to pump 6,000 gallons of fuel into the tanks of the Comet within 15 to 20 minutes.

LITERATURE.

Hydraulic Transients.

By GEORGE R. RICH, B.S., D.Eng. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 6 dols.]; and McGraw-Hill Publishing Company, Limited, Aldwych House, London, W.C.2. [Price 51s.]

THE monographs sponsored by the American engineering societies deal with specialised subjects, and this book should be welcomed because it explores the borderland between the civil, mechanical and electrical phases of hydro-electric projects where overall operation is concerned. The author, who was formerly chief design engineer to the Tennessee Valley Authority and is now in practice as a consultant, makes no claim to originality, but his work is valuable because it co-ordinates, in one comprehensive volume, data which have been available hitherto only in the journals of technical societies and in foreign publications. The practical examples and tabulated calculations relating to important projects form an excellent guide to engineers approaching hydraulic transients for the first time. The analytical treatment of the interdependent variables which such phenomena involve produce differential equations incapable of formal solution, and may discourage those attempting to follow them with only limited time and mathematical equipment at their disposal. Nevertheless, they form the basis of two systems for studying waterhammer problems. The concluding chapter outlines the graphical methods, but Continental treatises deal more effectively with specific problems. While basic mathematics forms the foundation of arithmetical integration methods, it is within the scope of those accustomed to hydraulic calculations.

The first chapter introduces conventional waterhammer theory with Allievi pressure-variation charts in terms of pipeline and turbine gate characteristics. The examples utilise arithmetical integra-

tion to calculate the conditions prevailing in a pressure-tunnel system, with and without a surge chamber, when a by-pass valve is opened or closed. The Calame-Gaden equations are applied to define the sub-division of the waterhammer wave at the junction between the surge chamber and the tunnel. Turbine speed-regulation formulae, including runaway and waterhammer effects, are developed for load demand and rejection. These merely determine maximum values, and the transient state must be ascertained step by step. The examples concern turbine speed rise and pipeline waterhammer with normal closure and jammed-gate conditions, and the time required for a machine to pick up load. These are interesting, because they employ model tests for predicting turbine performance under normal and abnormal conditions.

A useful chapter on stability of turbine governing is based on Gaden's *Considérations sur le Problème de la Stabilité*, using speed-responsive instead of accelerometer-type elements. Charts of dimensionless coefficients relating the governing and waterhammer oscillations to amplitude and phase displacement between gate and head oscillations are based on a mathematical analysis which includes the influence of governor compensation and damping. These are of general application, and are subsequently correlated with turbine type, efficiency, rapidity of damping and load characteristics to give the initial approximations for two stability studies, including the overall effect of parallel operation.

Transients may occur in pumping installations during starting up and after a power failure. The latter condition is investigated in Chapter 4, which includes typical centrifugal-pump characteristics for reversed rotation and flow. These are applied to the case where there is no discharge valve and the pump runs backwards until the head gates are closed. Additional calculations specify the closure time for a rotary valve which will prevent waterhammer and reversed impeller rotation. This is followed by text, diagrams and test results describing quick-opening slow-closing surge suppressors, their limitations, and their dimensioning in terms of flywheel effect and pipeline parameters. Air valves for critical points in the pipeline are illustrated by an arrangement drawing. No information is given about the dimensioning of these protective devices.

Surge-chamber investigations follow the original work of R. D. Johnson, who invented the differential type to which one chapter is devoted. This collects into one theme data required for establishing trial dimensions of the tank, riser, ports and surging limits in relation to friction losses, turbine performance, stability and critical velocity as a preliminary to computing load demand and rejection curves by arithmetic integration. One unusual example describes a special port design, based on model tests, for instantaneous full-load demand and rejection.

tion conditions. The tabulated calculations provide curves on a time base for conduit velocities and water levels in the tank and riser. Comparison with operating tests provides a check on the computations. Restricted-orifice surge chambers are similarly treated, but advantage is claimed for differential tanks because, with the former type, waterhammer may make governing critical, even with modern rapid-response equipment. This, coupled with a statement relating conduit length and area to orifice dimensions for waterhammer relief, provides a criterion for the application of both types which warrants investigation. Additional studies on differential tanks dealing with the decelerating head on load rejection, suppression of synchronous load changes, and the stability of one tank serving two turbines, with one on a blocked governor, will be appreciated. The curves showing amplification of surge levels and tunnel velocities based on arithmetical integration illustrate the limitations of a practice which is sometimes used to ensure stability.

It may be questioned whether turbine speed regulation and surge-chamber and governor stability should disregard the influence of system interconnection and restricted orifices, both of which permit, in theory and practice, reduction of the free surface area demanded by the Thoma criterion. The author has tacitly recognised in the preface that design on the basis of isolated station operation may incur unnecessary expenditure, but unfortunately he considers the electric analogy too specialised for inclusion. Research is being done at the Massachusetts Institute of Technology and elsewhere on this method, because it is realised that interrelated changes in the hydraulic and electrical systems cannot be studied independently.

Multiple-purpose projects bring navigation locks into the hydro-electric field, but the treatment of the problems mentioned in Chapter 7 has been confined to German publications, with which the author supplements his own work to provide an admirable summary of the conditions demanded by quiet lock filling if hawser breakages and wrecked gates are to be avoided. The main forms of filling systems are described. An analysis, with numerical examples, incorporating port-entrance contraction allowances establishes that the longitudinal header type, with uniform port spacing, produces non-uniform flow distribution, and that laterals near the lower gates may function before those adjacent to the upper gates. These effects may disturb vessels in the lock. The limitations of mathematical analysis are stressed. For lifts of 15 to 30 ft., Venturi loops in the terminal structures are preferred. These utilise a trapezoidal section at the valves to give small initial openings, and flaring conduits to reduce chamber inflow impulse forces. Analysis of this system includes acceleration head, friction and related losses, but neglects waterhammer and the effect of transitory motion in the chamber on the filling conduits. This leads to a differential equation suitable for arithmetical integration, and an example with calculated and model test results is given.

Transients in open channels serving hydro-electric plant result from sudden output variations, and navigation channels are subject to gradual changes in tidal elevation. Both questions are treated in Chapter 8. The former is based on R. D. Johnson's method, with the introduction of channel slope and friction as finite steps; and Airy's differential equations are developed with an infinite series solution and extended to navigation channels with a lock at one end, and other conditions. Numerical examples are included. Apart from minor typographical errors, the book is adequately printed, indexed and referenced. The calculations and descriptive matter make for easy and interesting reading for those hydro-electric engineers who have occasion to investigate interrelated hydraulic and plant problems.

Applied Mechanics for Engineers.

By Professor SIR CHARLES INGLIS, F.R.S., Past Pres.Inst.C.E., Hon.M.I.Mech.E. Cambridge University Press, Bentley House, 200, Euston-road, London, N.W.1. (Price 42s. net.)

THE writer of a book on mechanics for engineers is faced with the need for compromise, since a course in theoretical mechanics often lacks the attraction

resulting from practical applications, while a course in applied mechanics may be so technical and limited in its scope as to obscure the meaning and utility of the basic principles. It should be possible to explain the fundamental ideas in such a way as to emphasise their practical value and make them a matter of intelligent interest to students of engineering in universities and technical colleges. Sir Charles Inglis easily meets these requirements by basing his book on lectures given by him over a number of years to students working for an honours degree in Cambridge University.

In restricting the 20 chapters of the book to the knowledge of applied mechanics that a student may be expected to acquire in his second and third years, the author assumes some preliminary knowledge of the fundamental principles of statics, the theory of structures, and dynamics, together with some aptitude in the solution of straightforward differential equations. The treatment falls into three main parts. In the first of these, consisting of six chapters, the reader gradually acquires a working knowledge of statics, starting with the basic principles of rigid bodies. Thence his attention is drawn progressively to graphical methods of solution, and to the theory of taut wires, catenary problems, stresses in frameworks, and the deformation of frameworks. Here, as in the other chapters, the scope of the study owes much to numerous illustrative examples, which serve the dual purpose of giving meaning to the abstractions of formal theory and of exciting interest by novelty in the case of several problems. The numerous and useful diagrams serve further to increase the reader's understanding. This applies also to the exercises at the end of each chapter, which together occupy about 20 per cent. of the pages, though many students, no doubt, would welcome the inclusion of the answers to these questions.

Following a chapter on friction between dry surfaces, the second of the main parts introduces the dynamical aspect of the subject, under the chapter-headings of particle dynamics, kinematics, and simple harmonic motion, in which has been incorporated the technique of harmonic analysis. Thus, the student should grasp without much difficulty the subsequent discussion of circular motion and motion along a curve. By easy steps, these topics lead to the further consideration of moments of inertia, two-dimensional rigid dynamics, the principle of energy, and moment of momentum.

The treatment lacks little in the matter of detail, as may be indicated by reference to the third part of the work, where about one-third of the book has been devoted to the study of vibration and allied phenomena. Consistent with the aim of the author, mathematics is skilfully employed for the purpose of expounding mechanical vibrations and practical examples of periodic motion, after which due attention is paid to the underlying theory of coupled systems, aperiodic springs, pressure waves and self-excited oscillations. Chapter XX, on gyroscopic principles and their applications, merits special notice, since Sir Charles Inglis there returns to the subject of the Thomas Hawksley Lecture which he delivered in 1943 before the Institution of Mechanical Engineers, when a general problem of some difficulty to many students was explained and exemplified in masterly style. It is a matter for regret, however, that Lagrange's equations find no place in the book, since they provide means of generalisation important in the work of a practising engineer, as indicated in standard treatises which have been published during the past 25 years in this country and others. The point throws up the difference between subjects which may be avoided by a student as unnecessary for passing an examination, and studies which he will be wise to make if he wishes to take up engineering as distinct from teaching.

INSTITUTION OF ELECTRICAL ENGINEERS.—The annual dinner of the North Midland Centre of the Institution of Electrical Engineers will be held at the Queen's Hotel, Leeds, on Friday, November 16, when Sir Hubert S. Houldsworth, K.C., D.Sc., chairman of the National Coal Board and Pro-Chancellor of the University of Leeds, will be the guest of honour. Applications for tickets should be sent to Mr. T. G. Bridgwood, honorary secretary of the Centre, Department of Electrical Engineering, The University, Leeds, 2.

PRELIMINARY INVESTIGATION OF HYDRAULIC LOCK.

By D. C. SWEENEY, Ph.D., G.I.Mech.E.

(Concluded from page 516.)

THAT the force opposing relative motion of the locked parts must arise from a lateral reaction between them is evident, as also is the fact that this reaction can be produced only by an out-of-balance pressure distribution in the fluid in the working clearances. In attempting to account for such a distribution, the conditions arising in the case of components having geometrically perfect surfaces will be considered first. With the piston parallel to the cylinder bore, though not necessarily concentric, the clearance space will be uniform in the axial direction. The axial pressure drop will be linear and there will be a symmetrical distribution of pressure around the piston. Hence no out-of-balance transverse force can arise. If the piston be supposed tilted across the bore, either partly or fully, the distribution will be modified. In each region where the clearance decreases towards the outer end, the restriction will cause a general increase in the fluid pressure, the reverse taking place on the opposite side of the piston. Thus, there will be a resultant couple tending to restore the piston parallel to the bore. The experimentally-observed movement of the piston confirms this conclusion.

An assumption that the materials are capable of elastic deformation goes no farther in accounting for the out-of-balance force, but if the effect of macroscopic surface irregularities is considered, it can be shown that the symmetry of the pressure distribution in the clearance space may be disturbed so as to result in a transverse force on the piston. In particular, the effect of taper will now be illustrated by considering viscous flow between plane surfaces of unlimited width.

In the general case of viscous motion between closely-spaced fixed surfaces the rate of flow per unit width at any point (x, y) is,

$$U = -\frac{h^3}{12\mu} \frac{\partial p}{\partial x}, \text{ in the } x \text{ direction, } \quad (2)$$

and

$$V = -\frac{h^3}{12\mu} \frac{\partial p}{\partial y}, \text{ in the } y \text{ direction, } \quad (3)$$

where h is the distance between the boundaries at the point (x, y) measured in the z direction, i.e., normal to the surface containing the x and y axes, p is the pressure and μ the viscosity.

The equation of continuity is

$$\frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} = 0, \quad (4)$$

which, if μ is constant, gives

$$\frac{\partial}{\partial x} \left(h^3 \frac{\partial p}{\partial x} \right) + \frac{\partial}{\partial y} \left(h^3 \frac{\partial p}{\partial y} \right) = 0. \quad (5)$$

The solution of this equation for p depends on the functional form of h and the boundary conditions.

Consider the case, illustrated in Fig. 11, opposite, of steady flow between two closely-spaced plane surfaces inclined at a small angle. The co-ordinate axes are chosen so that the lower surface is in the plane $z = 0$, with the x axis parallel to the direction of greatest inclination. The surfaces, which are assumed unlimited in the y direction, extend from $x = 0$ to $x = l$. The equation of the upper surface is $z = h = h_1 + mx$, where $m = \frac{(h_2 - h_1)}{l}$.

Equation (5) reduces to

$$\frac{\partial}{\partial x} \left(h^3 \frac{\partial p}{\partial x} \right) = 0, \quad (6)$$

which, on integration, gives

$$p = p_2 + (p_1 - p_2) \frac{\left[\frac{1}{h^2} - \frac{1}{h_2^2} \right]}{\left[\frac{1}{h_1^2} - \frac{1}{h_2^2} \right]}, \quad (7)$$

where p_1 and p_2 are the pressures at $x = 0$ and $x = l$, respectively.

The total thrust R on each surface per unit width in the y direction is found by integrating over the length l , and is

$$R = p_2 l + (p_1 - p_2) \frac{l}{1 + \frac{h_2}{h_1}}. \quad (8)$$

With parallel surfaces, $R = \frac{1}{2}l(p_1 + p_2)$. Therefore, for the same pressure difference, the thrust on parallel surfaces exceeds that on inclined surfaces by the amount

$$R = \frac{(p_1 - p_2)l}{2} \frac{h_2 - h_1}{h_2 + h_1} \quad (9)$$

With the same inclination of the surfaces in the reverse direction, i.e., $h_1 > h_2$, the value of R , as given by equation (9), would be of the same magnitude but opposite in sign.

As an illustration of the magnitude of the force when the clearance is small, put $h_1 = 0.0001$ in., $h_2 = 0.0002$ in., $l = 1$ in. and $p_1 - p_2 = 100$ lb. per square inch. The value of R is 16.7 lb.

Tapering oil films in the clearance between a piston and cylinder may be caused by departures from geometric truth of the components in a number of ways. The most obvious is that the piston or cylinder may taper in the axial direction. Curvature of the centre line of either component, or surface undulations which produce tapers over limited areas of the surfaces, are other possibilities. In the case of a clearance which has a resultant taper diverging towards the low-pressure end, the average pressure will be lowest on the side of the piston where the separation of the surfaces is least. Hence, the position is unstable, and the out-of-balance force on the piston will tend further to reduce the separation until, in the equilibrium position, the piston is pressed against the cylinder bore. With a clearance converging towards the low-pressure end, however, excess pressure will build up in the region of minimum separation of the surfaces and tend to push them apart, thus exerting a centralising effect on the piston. Of the two possibilities, the diverging film seems the more likely to occur in practice in units such as piston valves or reciprocating pumps. It would occur, for instance, with bell-mouthing of the bore, such as might arise in machining or from wear.

The reason for the marked influence of the lack of uniformity in the components on the magnitude of the locking force observed in the experiments is now evident. The complete absence of a locking force, particularly in the case of the hard cylinder, can be attributed to a taper giving an oil film converging towards the outer end over the appropriate section of the piston. The measured dimensions of the brass and No. 1 mild-steel pistons tend to confirm this. That lock occurred more frequently in the soft cylinder would appear to be attributable to the slight bell-mouthing of the lower end of the bore of this cylinder. The influence of small dimensional deviations elsewhere, however, may not be negligible, and would account for the observed variation of force with relative angular position of the components. A comparison of the results given in Figs. 4 and 5, page 514, *ante*, shows that the greatest locking forces, and therefore the greatest reactions were obtained with the case-hardened piston. This might be expected, since the diametral clearances were least in these cases and the surface irregularities on which the reactions depended would therefore be proportionately greater.

The efficacy of circumferential grooving as a means of reducing the locking force is easily explained. It gives a more nearly uniform pressure distribution around the piston by limiting the magnitude of the deviations from the theoretically perfect linear pressure drop. Grooving the components has the disadvantage that the total leakage path is reduced, and the rate of leakage, therefore, probably increased. It would appear, however, that the width of the grooves need not be large, it being necessary to ensure only that their cross-sectional area is great compared with that of the clearance. With a given length of piston or cylinder land available for this purpose, the optimum condition should be that with as large a number of closely spaced grooves as is practicable.

The theoretical analysis indicates a linear relationship between the transverse force on the piston and the pressure difference between the inner and outer ends of the clearance. Provided the coefficient of friction is independent of load, this agrees with the observed relationship between locking force and oil pressure. The agreement provides evidence that the phenomenon is purely hydrodynamical. Since modern hydraulic systems operate at pres-

ures as high as 5,000 to 10,000 lb. per square inch, the possibility that additional effects may occur at pressures considerably in excess of those employed in the investigation cannot be ignored. The increase in fluid viscosity which occurs at high pressures would result in a modified pressure distribution, and the fluid pressure and reaction between the piston and cylinder might cause sufficient distortion of the parts to modify the form of the clearances. In either case, a linear relationship between locking force and pressure could no longer be expected.

The piston movement and the build-up of the locking force can be supposed to occur in three stages. Firstly, there is the interval occupied by the movement of the piston which brings it into contact with the cylinder bore. This has been termed the "contact interval." It will vary according to the initial position of the piston, being governed by the out-of-balance force on the piston and the pressure required to squeeze fluid from between the approaching surfaces. Secondly, there is the period during which compression of the protruberances forming the actual areas of contact takes

Fig. 11.

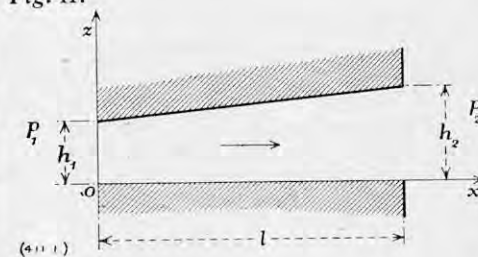
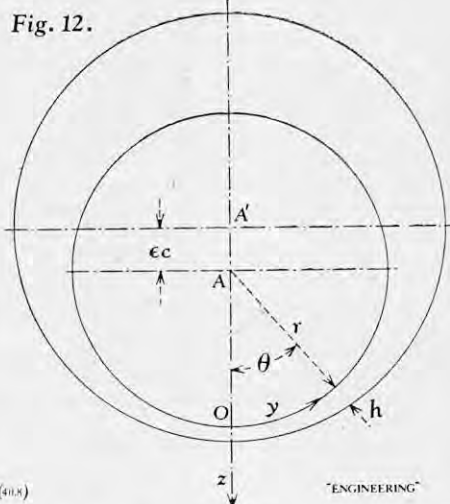


Fig. 12.



place and fluid trapped between the surfaces is squeezed out still farther. An increasing locking force must be a concomitant of this compression, and the period is referred to as the "build-up interval." Thirdly, there is the time required for the piston to roll around the cylinder bore to a stable position. The surface compression, referred to above, may take place simultaneously with this rolling movement. Support for this picture of the manner in which the locking force builds up is provided by G. I. Chinn* who states that observation of leakage past a valve spindle showed that the initially annular sheet of oil broke and receded until leakage was concentrated in a small sector, hydraulic lock commencing with the recession and increasing in intensity as it continued.

Since, as was shown by the observations of piston movement, no circumferential displacement occurred on releasing the piston by reciprocation in the bore, the third phase, under the conditions obtaining in Figs. 6 and 7, pages 514 and 515, *ante*, was absent. The intervals indicated by these curves, therefore, amount to a contact interval and a build-up interval. Further analysis of the contact interval indicates a possible basis for comparison of these curves.

Consider the movement, under the influence of a

steady radial force, of a piston in a cylinder bore for the case in which the clearance is filled with a viscous fluid. The piston and cylinder are of uniform circular cross-section with their centre lines parallel, and the difference c in their radii is assumed small compared with the piston radius r . Fig. 12, on this page, represents a transverse section at any axial position in the bore, which is of sufficient length for end effects to be neglected. A system of rectangular co-ordinates is employed in which the axes of x and y lie in the surface of the piston, the former being axial and the latter circumferential. The z -axis is normal to this surface, the origin O being at the point of minimum separation of the surfaces. The piston is assumed to be moving in the direction AO , and at any instant the displacement of the centre lines is ϵc .

Equating the rate of increase of quantity of fluid in a small element $h dx dy$, where h is the separation of the surfaces at the point (x, y) , to the rate of increase in volume of the element,

$$-\frac{\partial U}{\partial x} - \frac{\partial V}{\partial y} = \frac{dh}{dt} \quad (10)$$

where U and V are given by equations (2) and (3) on page 580. Hence

$$\frac{\partial}{\partial x} \left[\frac{h^3}{12\mu} \frac{\partial p}{\partial x} \right] + \frac{\partial}{\partial y} \left[\frac{h^3}{12\mu} \frac{\partial p}{\partial y} \right] = \frac{dh}{dt} \quad (11)$$

The first term in this equation can be eliminated since end effects are ignored and any superimposed axial pressure gradient will be uniform in the axial direction. The circumferential pressure distribution is therefore determined by the equation

$$\frac{\partial}{\partial y} \left[\frac{h^3}{12\mu} \frac{\partial p}{\partial y} \right] = \frac{dh}{dt} \quad (12)$$

The surface separation, h , is approximately $h = c(1 - \epsilon \cos \theta)$. Hence

$$\frac{dh}{dt} = -c \cos \theta \frac{d\epsilon}{dt}$$

On writing $r\theta$ for y , and integrating, equation (12) gives

$$p = p_0 + \frac{6\mu r^2}{\epsilon} \frac{d\epsilon}{dt} \left[\frac{1}{h^2} - \frac{1}{h_0^2} \right] \quad (13)$$

where p_0 and h_0 are, respectively, the pressure and surface separation at $\theta = \pi$.

The total thrust per unit length on the piston, neglecting the component of viscous traction on its surface, is

$$\begin{aligned} R &= 2 \int_0^\pi p r \cos \theta d\theta \\ &= \frac{12\mu r^3}{\epsilon^2} \frac{d\epsilon}{dt} \int_0^\pi \frac{\cos \theta d\theta}{(1 - \epsilon \cos \theta)^2} \\ &= \frac{12\pi \mu r^3}{c^2} \frac{1}{(1 - \epsilon^2)^{3/2}} \frac{d\epsilon}{dt} \quad (14) \end{aligned}$$

thus

$$\frac{dt}{d\epsilon} = \frac{12\pi \mu r^3}{c^2 R} \frac{1}{(1 - \epsilon^2)^{3/2}}$$

and, by integration, the time required for movement between positions ϵ_1 and ϵ_2 with a steady force R acting on the piston is

$$t = \frac{12\pi \mu r^3}{c^2 R} \left[\frac{\epsilon_2}{\sqrt{1 - \epsilon_2^2}} - \frac{\epsilon_1}{\sqrt{1 - \epsilon_1^2}} \right] \quad (15)$$

The equation shows that an infinite time would be required to bring perfectly smooth surfaces into contact (i.e., putting $\epsilon_2 = 1$). However, J. J. Bikerman,* commenting on work by E. Heidebroek† in which the times required for separation of two flat plates immersed in a liquid were measured, suggests that the times can be used to give a measure of the surface roughness of the plates by determining the effective separation of the surfaces when in "contact." Similarly, it can be argued that, in the present case, surface roughness will limit the maximum effective value of ϵ_2 , so giving finite values of t .

With highly finished surfaces, the value of ϵ_2 would be nearly unity and the term in ϵ_2 large

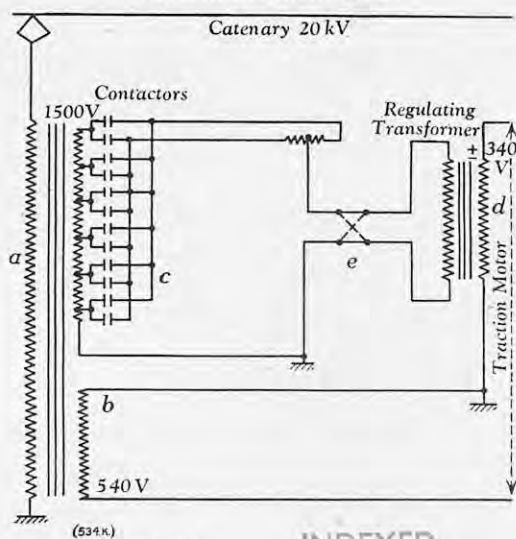
* "A Note on Oiliness and Surface Roughness," *Jl. Soc. Chem. Ind.*, vol. 62, page 41 (1943)

† "Untersuchungen über den Schmierzustand in der Grenzreibung," *Angewandte Chemie*, vol. 54, page 85 (1941).

* Communication on "Hydraulic Seals," by T. E. Beecham and F. H. Towler. *Proc. I. Mech. E.*, vol. 160, No. 4, page 554 (1949).

SINGLE-PHASE ELECTRIC TRACTION AT 50 CYCLES.

Fig. 16. VOLTAGE REGULATION SYSTEM ON ALSTHOM LOCOMOTIVE.



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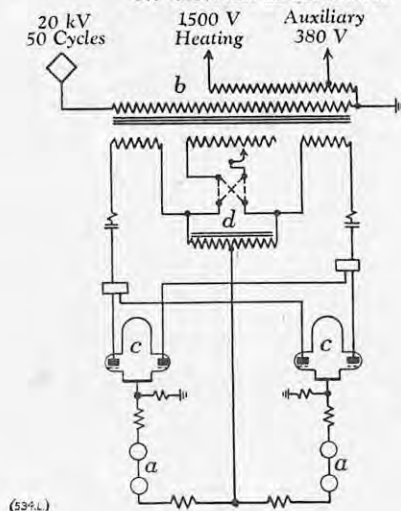
SINGLE-PHASE ELECTRIC TRACTION AT 50 CYCLES.

(Concluded from page 548.)

In addition to the Oerlikon-Winterthur locomotive, which was described in last week's issue, the experimental rolling stock on the Aix-les-Bains-La Roche-sur-Foron line includes a 4,050-h.p. C-C unit, the mechanical and electrical parts of which were both constructed by La Société Alsthom, Paris. This locomotive has been designed for hauling mixed traffic at a speed of 100 km. per hour when supplied with 50-cycle single-phase current at 20 kV. Its overall length is nearly 62 ft. and its total height with the pantographs down is 14 ft. The total weight is 118 metric tons, of which the electrical equipment accounts for 62.2 tons. The bogies are built up of welded tubular elements, and the axleboxes are connected to the side frames through Silentbloc articulated links. The body, which is also a tubular structure, is supported on each bogie by two oscillating pivots, which are restrained laterally by the Alsthom system of spring links and by helical springs, which provide transverse stability. The top and bottom of each pivot consists of a conical rubber pad, while the intermediate part is of steel and supports the articulated links. The provision of two pivots on each bogie ensures that the frame is always parallel to the body, while as the motors are wholly suspended any transfer of weight between the axles is avoided.

The electrical equipment consists of six forced-ventilated motors, which are arranged in pairs, each pair having an output of 610 h.p. at the continuous rating and of 675 h.p. at the one-hour rating. They are connected to the axles through gearing, quills and elastic couplings and exert tractive efforts of 2,330 kg. and 2,920 kg. respectively, under the two rating conditions, giving a maximum service speed of 62.5 m.p.h. As will be seen from Fig. 16, when the locomotive is operating on single-phase current at 22 kV these motors are supplied from the transformer *a* which has two secondary windings *b* and *c*. One of these windings, *b*, gives a voltage of 540 volts and is connected to the secondary of the regulating transformer *d*, the voltage of which is ± 340 volts. The primary of the latter transformer is supplied through the reversing switch *e* from the secondary *c* of the main transformer, the voltage being variable up to 1,500 volts by means of a series of tapings. In this way a voltage varying from 880 (540 + 340) to 200 (540 - 340) can be supplied to the motors in 22 steps. When regenerative braking is employed the armatures of four of the motors are connected through resistances, while their fields are supplied at a variable voltage from the transformer *d*, thus giving 10 braking notches. The locomotive can also be operated from the 1,500-volt direct-current system,

Fig. 17. DIAGRAM OF ELECTRIC CIRCUIT ON RECTIFIER LOCOMOTIVE.



in which case a 500-h.p. motor is used to drive a constant-output generator, the latter in turn supplying the pairs of motors in parallel. Under this condition of supply, eight running notches are obtained by varying the excitation. The main control apparatus consists of electro-pneumatic contactors, which are supplied from a 48-cell battery with a capacity of 80 ampere-hours. Interlocks are provided to prevent any power being supplied from the 20-kV line when the equipment is arranged for direct-current operation, and vice-versa.

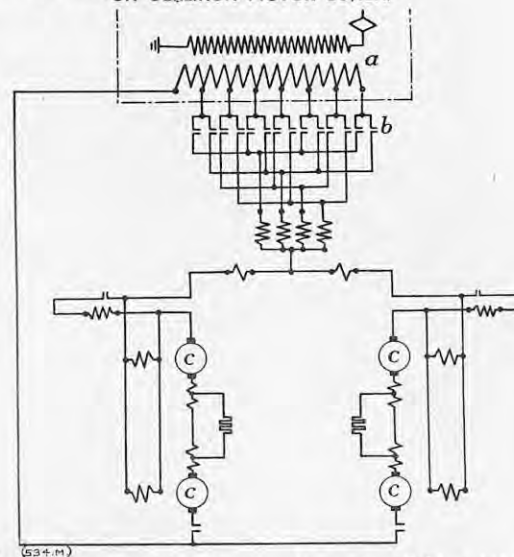
The auxiliary equipment on this locomotive consists of three fans, for cooling the traction motors and the interpole shunt resistances, and an oil circulating pump. These auxiliaries are all driven by 380-volt 50-cycle squirrel-cage motors, which are supplied from an Arno converter, the latter being in its turn connected to a single-phase auto-transformer. This converter also drives a shunt-wound dynamo, which supplies current to a motor driving an air compressor and power for charging the battery. When the locomotive is operating on direct-current this motor is connected to a generator, which obtains its supply from the main converter and can also be used for charging the battery. When using single-phase power, current for heating is obtained at 1,500 volts from a tapping on the main transformer and when the locomotive is running on direct-current it is taken from auxiliary connections on the main circuit breaker.

Each pair of motors is provided with two small transformers, the primaries of which are connected to the armatures and the secondaries are arranged in opposition. The resulting voltage of the three motor circuits is then supplied to a relay through rectifiers. Any large difference due to wheel slip will trip the relay and light a lamp in the driver's cabin.

A third locomotive, for the construction of which Alsthom were also responsible, is of the B-B type and is equipped with pumpless air-cooled rectifiers. It is designed for mixed-traffic service at a maximum speed of 62.5 m.p.h., the output being 2,840 h.p. at the one hour rating and 2,700 h.p. continuously. Its total length is 42 ft. 8 in., and its height with the pantographs down 14 ft. 6 in. Its total weight is 79 metric tons, of which the electrical equipment accounts for 33.5 tons. Generally speaking, the mechanical construction is similar to that of the C-C locomotive just described.

The locomotive is fitted with four nose-suspended motors, each of which has an output of 675 h.p. on continuous rating, giving a tractive effort of 3,000 kg. These motors are connected in pairs, as shown at *a* in Fig. 17, and, when single-phase operation is in use, are supplied from the line through the main transformer *b* and the rectifiers *c*, the latter being connected in parallel. Speed regulation is obtained by varying the voltage at the rectifier terminals between 0 and 1,350 volts by means of the regulating transformer *d*. Further regulation

Fig. 18. DIAGRAM OF MAIN CIRCUIT ON OERLIKON MOTOR COACH.



can be effected by shunting the motor field, a total of 29 running notches being obtained by a combination of the two methods. The various controls are operated electro-pneumatically by contactors, which are supplied from a battery.

The rectifiers, which are of the air-cooled type, have a continuous output of 830 amperes at 1,350 volts and can carry an overload of 1,200 amperes at the same voltage for 10 minutes. They are equipped with six main, two auxiliary and two excitation anodes, as well as with arc starting equipment. The main anodes are provided with grids as a protection against reversal and back-firing. The two auxiliary anodes are used to supply the compressor motor and deliver a unidirectional current of 100 amperes at 175 volts. They are also capable of dealing with the starting peaks. The excitation anodes are supplied from a direct-current generator and take about 8 amperes at 80 volts.

The auxiliary plant comprises four fans for supplying cooling air to the motors, rectifiers and oil coolers, as well as an oil pump and two motor-generator sets for the rectifier auxiliaries. These are all driven by 380-volt single-phase motors, which are supplied from a tapping on the main transformer. The heating circuits are supplied at 1,500 volts from another tapping.

In addition to the locomotives, which have been described, experiments are also being made with three motor coaches. One of these had been in service since 1925 in the Paris suburban area and its electrical equipment consisted of four nose-suspended motors, each having an output of 247 h.p. when supplied with direct current at 1,500 volts. The coach was adapted for single-phase working in the Oullins shops of the French National Railways, the changes consisting mainly of replacing the direct-current motors by single-phase motors and installing ventilating ducts. The layout of the new electrical equipment was determined by the coach dimensions, to comply with which the transformer was placed near the centre of the body under the floor with the contactors close to it and the fans under the platforms. Current is collected at 20 kV from a single pantograph and is led through two switch-fuses on the roof to the transformer, indicated at *a* in Fig. 18. This transformer is of the forced-ventilated oil-cooled type and has an output of 1,035 kVA. The secondary voltage is adjustable in 13 stages by means of the electro-pneumatically-operated contactors *b*. The four traction motors *c*, each of which has an output of 313 h.p. on continuous rating, are of the compensated series-wound type and, as will be seen, are connected in pairs. They are rigidly mounted on the bogie frame and are fitted with flexible couplings to facilitate increasing the maximum speed from 50 to 75 m.p.h. The contactors are controlled automatically from the driver's cab by a master switch with five notches, the arrangement being conventional, except that at starting the main

motor fields are short-circuited until the coach has reached a speed of about 7 m.p.h.

The auxiliary equipment, which consists of fans for cooling the traction motors and field shunts, a compressor, a pump for the transformer oil and a converter for charging the battery, is driven by 380-volt single-phase motors. The car lighting is supplied from a 380/72-volt transformer, or from a battery which is brought automatically into action should the normal system fail. Current for the lighting in the driver's cab and for the headlights is always supplied from the battery. Heating is obtained from a 1,500-volt tapping on the transformer.

A rake of three vehicles, consisting of two motor coaches with a trailer between, is also being tested. This rake was formerly employed on the German railways and has been converted to its present use by the Société Nationale des Chemins de Fer Français. Each motor coach has a power-driven bogie at one end and a trailing bogie at the other, while the trailer is a four-wheel vehicle. The main transformer is mounted above the power-driven bogie and the motors, which are nose-suspended, drive the axles through main and intermediate pinions and gearing.

The single-phase current is collected at 20 kV by a single pantograph and is led through a fuse to the main transformer, which is shown at *a* in Fig. 19. This transformer was originally wound for a frequency of 16 $\frac{2}{3}$ and its secondary voltage is 800 volts, which is too high for the traction motors. Regulation is therefore effected by the cam-operated contactors shown at *b*, one set of which supplies the voltage divider *c*. The centre of this divider is connected through the circuit breaker *d* to one end of an intermediate transformer *e* and thence through the reversing switch *f* to the motors *g*. Another set of contactors *h* is connected through the circuit breaker *d*₁ to the coil *e*₁ of the intermediate transformer and thence to the reversing switch.

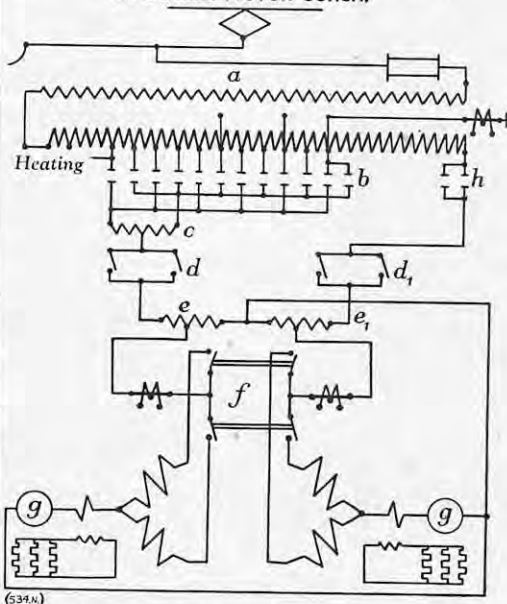
The traction motors are equipped with 14 sets of brushes, each of which has a current-carrying area of 24 sq. cm. This area is, for experimental reasons, divided between either three or five brushes per set. Three of the motors weigh 2,160 kg. but in the case of the fourth the weight has been reduced to 1,850 kg. by making the housing of aluminium alloy. Some of the motors have also been fitted experimentally with self-contained fans. In this way, it is possible to obtain an output of about 330 h.p., which is sufficient for the requirements on the Aix-les-Bains—La Roche-sur-Foron line. An interesting point about the auxiliary equipment is that the compressors are mounted on the traction motors and are driven by direct-current motors supplied from a small battery. It is therefore possible to obtain compressed air without using the pantograph.

A third rake, consisting of a motor coach and trailer, comprises a unit which has been withdrawn from the 600-volt direct-current Paris suburban system and has been equipped with Westinghouse ignitrons. This equipment, which provides a constant motor voltage instead of the variable voltage employed on the other stock, is installed in a compartment on the motor coach at the opposite end to the driver's cab. As will be seen from Fig. 20, single-phase current is drawn from the overhead line through the fuses *a* and is supplied through the transformer *b* and the anode reactors *c* to the four ignitrons *d*. It then passes through the smoothing reactor *e* to the control system *f* and the motors *g*. Virtually, therefore, alternating-current apparatus has been superimposed on the existing direct-current equipment, the accelerating resistors and series-parallel change-over arrangements only being maintained to simplify the transformation, because the characteristics of the motor are not altogether suitable for the Aix-les-Bains—La Roche-sur-Foron line. Normally, however, speed regulation will be effected by varying the voltage, as has been done on the other stock. It may be noted, moreover, that the use of accelerating resistors necessitates the ignitrons operating continuously at constant voltage, a more difficult condition than would exist if tap regulation were employed. Each pair of ignitrons is capable of supplying a rectified current of 650 amperes at 600 volts, the 30 per cent. ripple in which is reduced by

the smoothing reactor. The ripple is further reduced to 10 per cent. by diverting the 100-cycle harmonic through the resonant circuit *h*.

In this article an attempt has been made to summarise the reasons which led the Société Nationale des Chemins de Fer Français to employ single-phase electric traction at 50 cycles on the Aix-les-Bains—La Roche-sur-Foron line, and to describe the equipment which is now being used to investigate the advantages and disadvantages of this system. It may be repeated that the advantages are that it is only necessary to install primary substations at intervals of from 30 to 55 miles, and that these

Fig. 19. DIAGRAM OF PRINCIPAL CONNECTIONS ON DOUBLE MOTOR COACH.

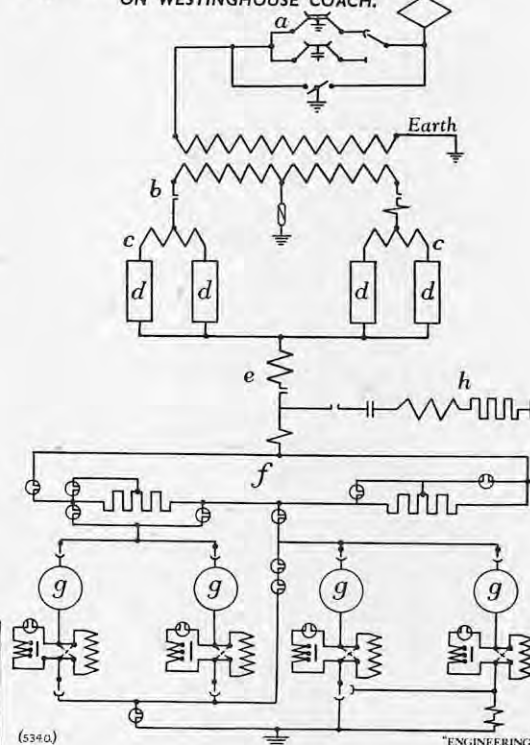


need only contain simple transformers and their associated equipment. Added to the saving under this heading is that obtainable from the employment of a lighter overhead system, owing to the high voltage used. Against these advantages must be placed the risk of unbalance on the three-phase power system, although this is not considered to be great and will become of less importance as the demand for other purposes increases. The voltage drop on the overhead system is considerable, but this can, it is thought, be adequately compensated by the installation of series capacitors at intervals. The principal drawbacks would seem to be the lower efficiency of the motors, which is principally due to the losses in the shunts of the auxiliary poles, and the poor commutation. Considerable optimism was, however, expressed on both these points at the Annecy conference. Indeed, it was stated that it was more difficult to build 1,500-volt and 3,000-volt direct-current motors than single-phase motors of similar power and lower voltage, while the maintenance was about the same in the two cases. When rectifiers or other converting plant is used, the advantage is felt to be with 50 cycles, since the machines and equipment are smaller than at lower frequencies. Problems in the detailed design of the motors, which have been encountered and solved, have already been dealt with.

Whether these arguments can be justified or not depends, however, on the results of the trials. These are not yet available, but we hope that when they are full publicity will be given to them. In the meantime, the attitude of the British Railways authorities, who were represented at the conference, is not without interest. It will be recalled that in the Report of the Committee which was appointed by the Railway Executive and the London Transport Executive to consider the question of railway electrification, and which was published in the spring of this year,* the conclusions reached were generally unfavourable to the use of the 50-cycle system. It was pointed out, for instance, that the engineers of the Deutsche Bundesbahn did not think that sufficient experience had been obtained on the Hölentalbahn to justify its adoption, although this system had been in use on that line since 1933. After calling attention to the drawbacks of the

single-phase 50-cycle motor, it was pointed out that inter-running between a 750-volt direct-current system and a single-phase 50-cycle system would be difficult and could only be effected by installing extra equipment, as single-phase 50-cycle motors are not suitable for operating two in series on the former voltage. It was admitted, however, that this difficulty might be overcome by the use of ignitrons. As a result, it was felt that the single-phase 50-cycle alternating-current system could not be recommended as a standard on British Railways, although it might be used with advantage on secondary lines. At the time this recommendation was

Fig. 20. DIAGRAM OF POWER CIRCUITS ON WESTINGHOUSE COACH.



made, it is clear that the Committee were aware of the Aix-les-Bains—La Roche-sur-Foron experiments. Nevertheless, it would be well if the matter were not considered to be settled. It would also be highly desirable for British manufacturers to investigate fully the possibilities of the 50-cycle system in view of the fact that, if it proves successful, it may have considerable influence on the progress of railway electrification in other countries.

RADIO CAPACITORS.—The Radio Industry Council, 59, Russell-square, London, W.C.1, have issued Sections 1 and 2 of two specifications covering variable preset capacitors with air (RIC/142) and mica (RIC/143) dielectrics, respectively. They have also issued Section 3 of Specification RIC/131, which deals with fixed paper dielectric tubular foil capacitors.

MEMORIAL TO JOHN LOGIE BAIRD.—A memorial plaque to John Logie Baird, a pioneer in the development of television, was unveiled by Sir Robert Renwick, president of the Television Society, outside 22, Frith-street, Soho, London, W.C.2, on Wednesday, October 24. It may be recalled that it was on these premises that Baird gave his first demonstration of television in 1926. Mr. W. C. Keay, a founder member of the Television Society and a fellow student of Baird at Glasgow, introduced Sir Robert and a vote of thanks was proposed by Mrs. Runge, deputy chairman of the London County Council, who were responsible for the erection of the plaque.

GAS-TURBINE POWER STATION.—The National Gas Turbine Establishment of the Ministry of Supply are building a 10,000-kW gas-turbine power station, which is expected to be operating by the end of 1952. It will be mainly an experimental plant for studying operating techniques, but it will also generate power for the Establishment and the waste heat will be used to heat the buildings. The station may also supply electricity to the national grid. The plant will consist of a high-pressure turbine running at 3,000 r.p.m. and driving an alternator, and a low-pressure turbine running at 2,800 r.p.m. and driving a compressor. Kerosene or gas oil will be used as fuel.

* ENGINEERING, vol. 171, page 386 (1951).

THE ELECTRICAL RESEARCH ASSOCIATION.

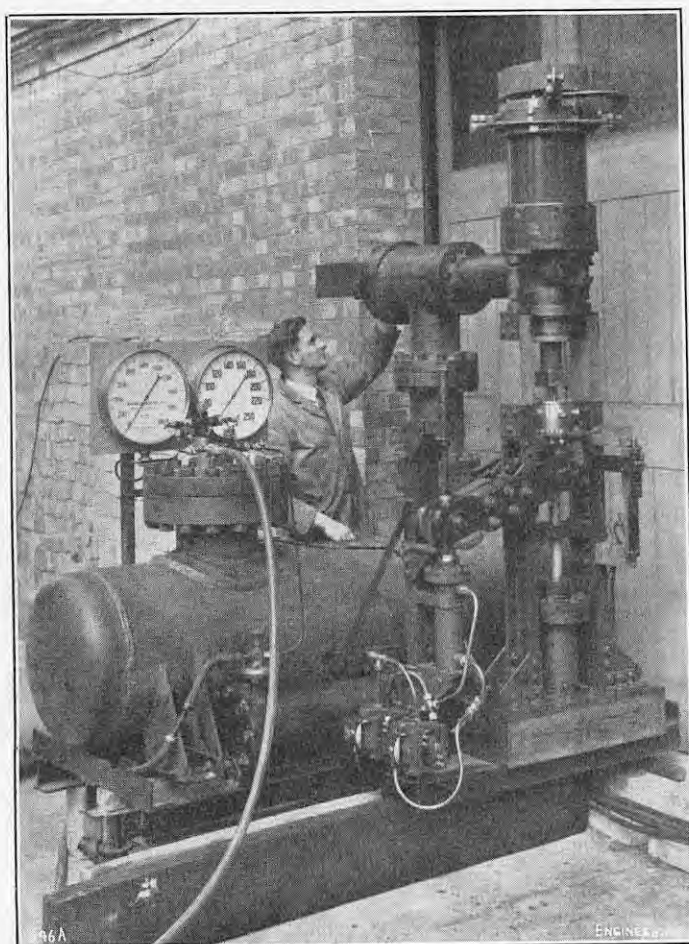


FIG. 1. EXPERIMENTAL AIR-BLAST CIRCUIT BREAKER.

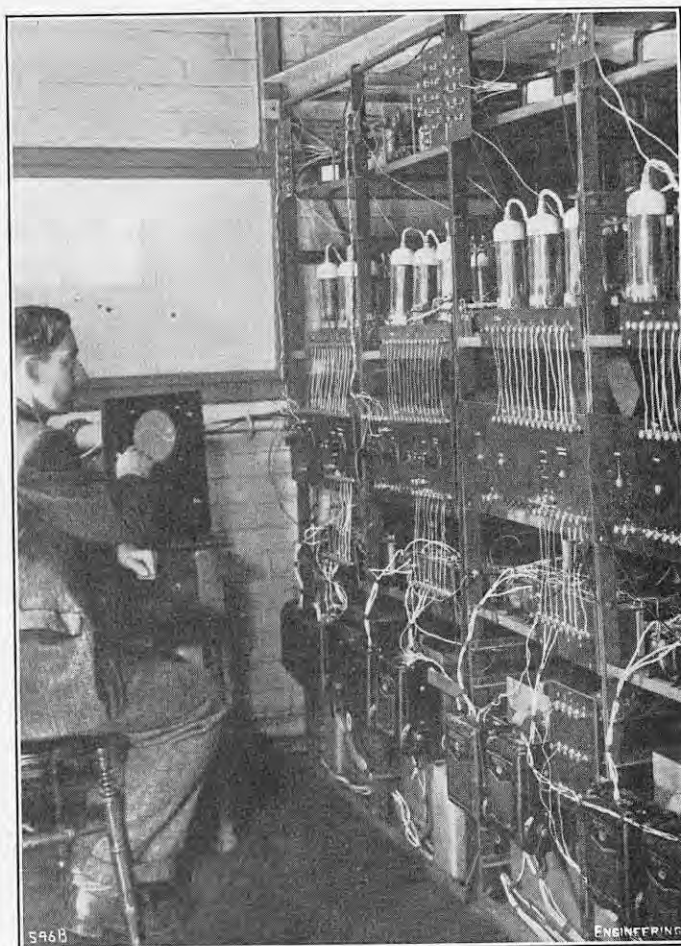


FIG. 2. MODEL OF DIRECT-CURRENT TRANSMISSION SYSTEM.

THE ELECTRICAL RESEARCH ASSOCIATION.

As recorded in our columns at the time, the research laboratories of the British Electrical and Allied Industries Research Association, in Wadsworth-road, Greenford, Middlesex, were opened by H.R.H. the late Duke of Kent on October 22, 1935. By 1938, a scheme to double the working space available, by the construction of a three-storey building on the same site, had been promulgated, but little progress had been made when war broke out in 1939. About half the three-storey building was completed in the first year of the war, but since that time no permanent building construction has been permissible. As would be expected, the work of the Association developed extensively during the war and has continued to do so since the termination of hostilities. To accommodate the staff and equipment required, standard prefabricated buildings were erected, so that, at the present time, some 90 per cent. of the site of 1½ acres has been covered. Any really useful extension of the buildings at Greenford is thus impracticable.

In order to enable members of the Association and others concerned with the electrical industry to see something of the work that has been, and is being, done for the advancement of that industry, "open days" were held at the Greenford laboratories on October 10, 11 and 12 for the first time since the laboratories were opened in 1935. The previous day, October 9, was reserved mainly for visits by members of the Council of the Association, of which the Rt. Hon. Lord Citrine, P.C., K.B.E., is President. Dr. S. Whitehead, M.A., M.I.E.E., F.Inst.P., is director of research and the total staff numbers about 300. The exhibits arranged for the visitors were intended only to show a representative cross-section of the Association's work, some of which is carried out extra-murally. Even so, a large marquee had to be erected to stage some of the exhibits, a circumstance which made apparent both the magnitude of the work and the limitations of the present accommodation. We understand

that it is intended, as soon as possible, to construct further buildings for research work at Leatherhead, Surrey, where the Association's secretarial and administrative offices are now located. It must have been evident to the visitors on the "open days" that there is a genuine need for further accommodation, and they could have been left in little doubt that the new buildings, when available, will be put to good use in furthering the interests of the members of the Association, of the electrical and allied industries in general, and consequently of the whole community.

In general, the exhibits to be shown on the "open days" were selected on account of their industrial importance and related more to the researches now in progress than to those which have been completed and passed into current practice. The work in progress could be seen in the course of a tour round the laboratories, but, as previously mentioned, a great deal of work is carried out extra-murally in the universities, in Government and other laboratories, and at the Association's separate establishments, of which the field station at Shinfield, near Reading, Berkshire, where investigations relating to the uses of electricity in agriculture are carried out, is an example. Such work, of course, could only be represented by drawings, photographs and models which were displayed in the marquee.

Since 1935, the Association has expended a total of nearly 2½ million on research work for its members and its annual income has increased from 66,000*l.* in 1935 to 216,000*l.* in 1950. It will be evident, therefore, that to give a representative cross-section of the work done and in progress by a collection of exhibits was a task of considerable magnitude. To study all the exhibits in a single day was obviously impossible, but, as they had been carefully grouped to cover various more or less distinct branches of the work, the visitors were able to devote their attention to those subjects in which they were particularly interested. The research work of the Association may be divided broadly into the following sections, covering magnetic materials, insulating materials, electrical

discharge in gases, switchgear and control gear, transmission and utilisation, surges and transformers, rural electrification and wind power, power-plant materials, meter bearings, space and water heating, ignition, and the welding arc. The divisions, however, are by no means absolute, the work in one section frequently affecting that in one or more other sections. Fortunately, however, an excellent booklet describing the work of the Association and the exhibits was prepared in advance, and this proved to be a valuable guide for the guests at the "open days" as well as a concise permanent record of what has been done and what is still in progress. As much of the completed work has been published already, the following notes refer mainly to work in progress and to the permanent equipment of the laboratory, although they are very far from being exhaustive.

The work on magnetic materials covers sheet steel for transformers and materials for permanent magnets, much of the former being concerned with the behaviour of single crystals of silicon iron and having been carried out in the Cavendish Laboratory and in the universities of Nottingham, Bristol and Sheffield. An intensive study of silicon-iron sheet, for the purpose of improving its magnetic properties, has been carried out at the Cavendish Laboratory in co-operation with the research departments of several of the sheet-steel manufacturing firms. In addition to work of a fundamental character on materials for permanent magnets, the Association has co-operated with the research department of William Jessop and Sons, Limited, in the development of commercial permanent-magnet alloys, and several reports on the subject have been issued. Equipment for testing the stability of permanent magnets has been developed and installed at the National Physical Laboratory; one of the exhibits shown was a balance, made at Teddington, for measuring stability.

As an example of the work done by the Association in connection with insulating materials, mention may be made of the fact that the mechanism of the electro-chemical breakdown of these materials in-

direct-current fields was first discovered in the Greenford laboratories and means for delaying the breakdown were investigated. As a result of this work, the life of paper capacitors in direct-current work can be increased several times. The equipment for investigating insulating materials of all kinds includes a crystallographic X-ray set, and the exhibits included a range of mechanical-testing apparatus designed for studying the relations between electrical and mechanical properties, a high-voltage Schering bridge for the detection and measurement of discharges in insulation, and apparatus for long-time corona breakdown tests at temperatures as low as -80 deg. C. Another interesting item of equipment exhibited was a micro-balance for weighing *in vacuo* at controlled temperatures up to 60 deg. C. and capable of reading to 10^{-7} gramme. Special photographic emulsions are used for detecting sub-microscopic cracks in conducting glazes and conducting faults in aluminium-oxide films, and one of the exhibits showed the results obtained. Apparatus is also available for investigating structural changes in dielectrics at pressures up to 1000 atmospheres.

Research work on switchgear has always been, and still is, a very important branch of the Association's activities and has resulted in some significant developments, notably the air-blast circuit breaker with a short fully-scoured air gap and the oil-filled side-blast baffle pot. The aggregate rupturing capacity of the circuit breakers fitted with arc-control arrangements licensed under the Association's patents and now in commercial use exceeds 1,500 million kVA. Fig. 1, on page 585, shows a heavy-duty axial air-blast circuit breaker on which much experimental work has been carried out.

Some interesting work which has been completed recently and will shortly be published is a photographic study of the form and movement of the arc during the whole period of arcing. Photographs displayed showed the rapid changes in arc form which occur as the pressure in the reservoir exceeds that necessary to give a velocity equal to that of sound in air in the throat of the circuit breaker. A notable piece of apparatus exhibited, known as a "recollectograph," has been developed to store recordings of current and voltage waves made during faults on a power system before they are detected by the protective relays installed. The instrument is provided with 72 recording tracks in the form of steel wire on a cylinder and can record 12 different current and voltage disturbances simultaneously. After a fault has been recorded, the cylinder moves along its axis, bringing another set of 12 recording tracks into use and this can be repeated six times. The instrument can "play back" the recordings on the screen of a cathode-ray oscillograph.

One of the exhibits in the transmission and utilisation section was a model direct-current transmission system used for the solution of problems relating to the control, stability and protection of high-voltage direct-current transmission systems. Up to 600 miles of cable and 1,050 miles of overhead line can be represented, with all the terminal equipment, control and protective circuits. Fig. 2, on page 585, shows the appearance of the apparatus. The work in this section covers the transmission of power at high voltages, insulated cables, interference between power and communications systems, overhead lines and earthing, safety and circuit problems. For convenience, the experimental work is carried on in two laboratories, one of which is mainly concerned with heavy current and supply-frequency work, while the other deals with light-current techniques. Fig. 3, on this page, shows the equipment installed in a street manhole for tests on lead-sheathed cables in ducts.

(To be continued.)

ELECTRICITY SUPPLY IN FRANCE.—According to the annual report of Electricité de France, the electricity consumption in France during 1950 amounted to 33,390 million kWh, a figure which constitutes a record. Of this total, 16,250 million kWh was derived from hydro-electric plant and 16,953 million kWh from thermal stations. The installed capacity of the hydro-electric plant was 6,100 MVA and of the steam plant 4,245 MW. The electricity generated by water power increased by no less than 47 per cent. over 1949 owing to the better conditions.

THE ELECTRICAL RESEARCH ASSOCIATION.

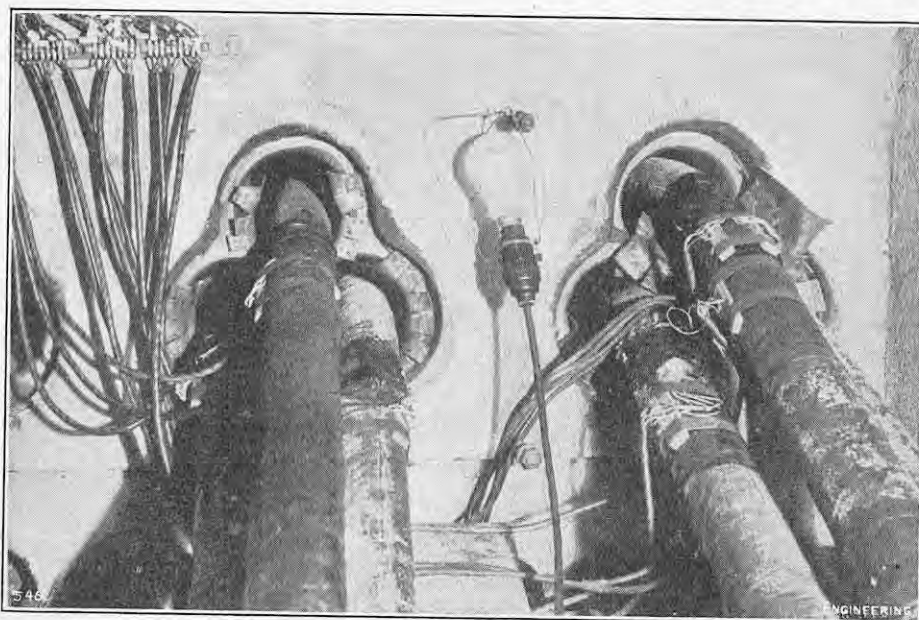


FIG. 3. TESTS ON LEAD-SHEATHED CABLES IN DUCTS.

SAFETY IN AIRCRAFT.

PRESENT-DAY trends in the airworthiness requirements for civil aircraft and possible methods for reducing the damage to passengers in crashes were discussed in a lecture entitled "Modern Trends in Civil Airworthiness Requirements," given by Mr. Walter Tye, O.B.E., F.R.Ae.S., to the Royal Aeronautical Society on Thursday, October 18. Considering the general relation between safety and airworthiness, Mr. Tye said that although no normal person expected 100 per cent. safety, and possibly the advantage of speed offered by the aeroplane was sufficiently attractive to allow aircraft to run at a higher risk rate, he thought that the safety level of air travel should be comparable with that of surface travel. That was still far from the case, although American and British statistics showed that the accident rates, in terms of aircraft miles flown, had steadily diminished over the past 15 years.

Accidents were usually caused by a combination or sequence of events involving both material failures and human errors. In some cases, more rapid response of the engines to opening the throttles in a baulked landing, and better stalling qualities, might have helped. In America, full studies were being carried out on "human engineering"—the practical application of psychology, physiology and anthropology to the relationship of man and machines; the engineer had much to gain from such studies.

Out of 41 British accidents examined, on 15 occasions the aircraft struck the ground, either on approach or during cruising, while flying in bad visibility. Approach and navigational aids should be developed which presented information accurately, reliably and simply to the pilot. Systems which demanded an acquired skill to be interpreted were potentially dangerous. Air collisions and accidents resulting from ditching—frequently due to getting lost—could also be reduced by improved equipment.

Mr. Tye then turned to consider trends in airworthiness regulations, which had to satisfy the demands of safety without sacrificing economic efficiency. By relating the structural requirements to the fundamental factors affecting safety, it had been possible to reduce strength margins without detriment to safety. For example, the strength requirements for landing gear recognised the relationship of landing loads to the velocity of descent at impact; gust conditions were generally superseding arbitrary manoeuvring-load conditions for wing design, and the definition of the gust was becoming more realistic. Greater knowledge of flight loads might allow further reduction of strength margins, with resulting improvements in payload.

About 10 years ago the United States had adopted a scheme of matching the aeroplane to the route, in laying down performance requirements. This had been developed farther in the United Kingdom. The average rates of climb, take-off and landing distance for the type of aeroplane were determined; these values were then reduced by a margin to allow for aeroplane variability, and to allow for the failure of one engine. They were then scheduled for a number of parameters, such as temperature, altitude, runway gradient, and wind-speed, which the operator could determine; the weight of the aeroplane was adjusted

for each flight to give a certain safety margin under the conditions of that flight. The pilot could reduce the weight below the calculated value if he thought it safer to do so. The variability of performance between two apparently identical aircraft was largely due to variation in engine power. If the reason for this was fully understood, it might be possible to reduce the variation by altering overhaul methods or periods; the gain in payload would more than compensate for increased ground-servicing costs. Accidents caused by lack of performance did not exceed (and in British operation were considerably less than) 8 per cent. of the total. To reduce this rate, it would probably be necessary to take account of two-engines-inoperative conditions, with catastrophic economic consequences.

Accidents due to airworthiness failure were usually associated with some detail which had gone wrong in some unforeseen manner. For this reason, considerably more flying was now required before an airworthiness certificate was granted; the aeroplane had to be tested over its operating routes with typical crews and maintenance procedure. A number of defects had been revealed and corrected by these means.

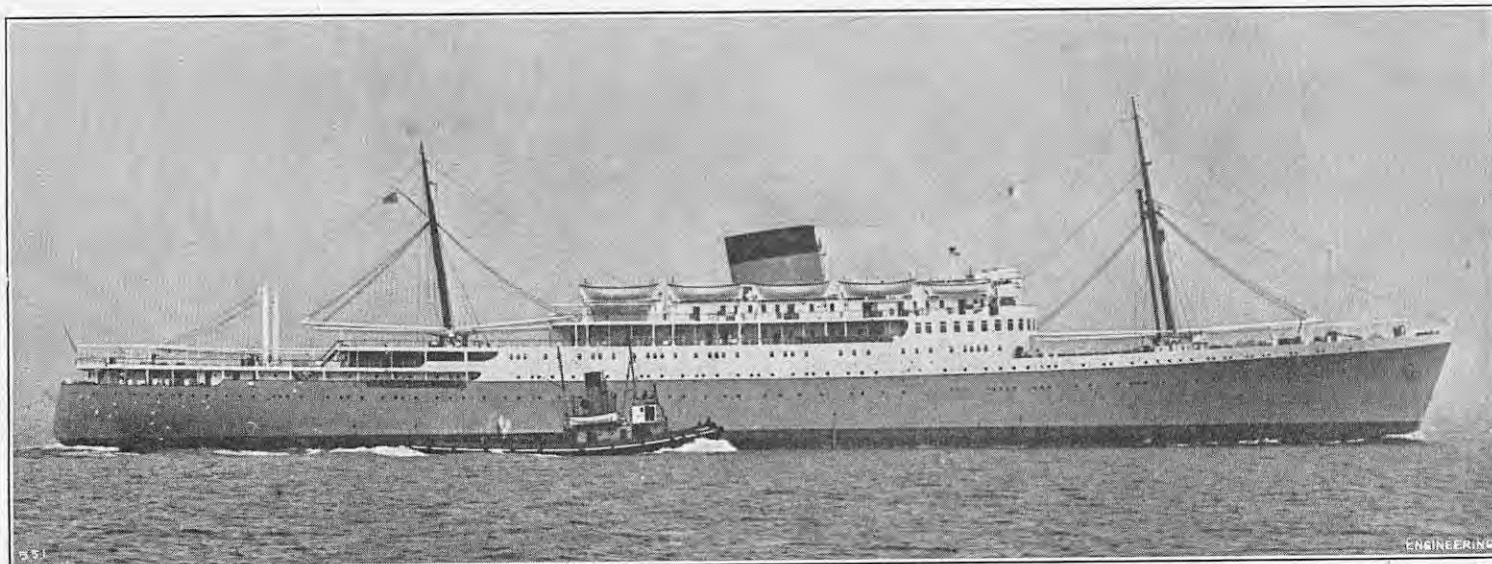
For a given expenditure of weight, it was likely that better protection for the passengers in a crash would save more lives than would improved airworthiness. From an analysis of accidents during 1946 to 1949 to transport aeroplanes, in which the aircraft struck the ground, 36 per cent. were not fatal; in 45 per cent. some occupants were killed; and in 19 per cent. all the occupants were killed. In those cases where some persons were not killed, the accident was potentially "survivable" and it should be possible to save more people. If the impact speed was high, as when an aircraft flew into a hill-side, the fatality ratio (i.e., persons killed to persons involved) appeared to be high, 65 to 90 per cent., whether or not fire occurred; in accidents at low speeds, such as during approach, the outbreak of fire increased the fatality ratio from about 20 to about 50 per cent. There were, therefore, two possible courses: to investigate whether impact speeds could be reduced, and to lessen the consequences of the impact, whether direct injury or fire.

About half the aircraft considered in the analysis which crashed at low speed had stalling speeds ranging from 70 to 80 m.p.h., and showed a fatality ratio of 25 per cent. The other half had considerably higher stalling speeds and a fatality ratio of 50 per cent. Records of accidents to small aeroplanes with stalling speeds of 50-60 m.p.h. showed that they were rarely fatal. Reversion to slower and simpler aircraft, if practicable, would solve many problems.

An aircraft usually hit the ground with the nose first, and the energy was absorbed by crushing the nose structure, the aft part of the fuselage being protected by the wing. The accelerations in such a crash appeared to range from 5g to 20g. American tests had shown that the normal safety belt offered adequate protection for crash accelerations up to 20g, provided that the passenger's head did not strike the seat ahead or a window frame as he was thrown forward. With shoulder harness, accelerations up to 40g could be withstood by the human body, and with backward-facing seats it was probable that still higher accelerations could be survived. If passengers were to be seated forward of

THE UNION-CASTLE LINER "RHODESIA CASTLE."

HARLAND AND WOLFF, LIMITED, BELFAST.



the wing, however, there was nothing to be gained by providing seats and harness stronger than the aircraft structure; in that case Mr. Tye considered that seats stressed to 10g should be provided forward, and to 20g aft of the wing. The requirement at present was that seats should withstand 6g; the required increase in strength resulted in a weight penalty of about 5 lb. for 10g seats and 15 lb. for 20g seats.

To protect the passenger from head damage there were three possibilities—backward-facing seats, widely-spaced forward-facing seats, or seats facing each other. The backward-facing seat supporting the head was ideal; it was said, however, without much evidence, that passengers did not like them. Forward-facing seats widely spaced, i.e., pitched at 45 in. to 50 in. apart, were reasonably satisfactory, but were not likely to be acceptable for high-capacity short-range aircraft; the conventional 40-in. spacing was ideal for causing head injuries. Facing seats showed no advantage in space over forward-facing seats. While closely-spaced forward-facing seats were still employed, the seat back should be designed to yield under impact; large-diameter thin-gauge tube should be used, and adequate padding, such as 2-in. thick plastic foam, should be provided; rubber and other elastic materials were not suitable as they caused a rebound.

The principle for eliminating crash fires was to prevent ignitable materials from coming into contact with ignition sources. The tanks should be able to stand high impact loads, and should be placed so that falling structures, etc., were not likely to puncture them. They should be remote from sources of ignition and from the aircraft occupants. The hot engine surfaces and exhaust gases should be rendered inert and cooled. Pumping of fuel and oils after the crash should be prevented, and sparks should not be generated in broken electrical circuits. An investigation of a large number of crashes of multi-engined military aircraft with severe structural damage showed that, in 30 per cent. of the cases, the fuel tanks did not burst. With better types of elastic-bag fuel tanks, therefore, it should be possible to reduce the frequency of bursting fuel tanks, which were found to be present in 67 per cent. of the crashes where major fires occurred. It was not safe to instal tanks in wing leading edges, in the fuselage, in the centre-section or close to the engines. If wing-tip tanks were used, they could be dropped before a premeditated crash, or might be torn away safely in an unexpected crash.

It was doubtful whether the present system for spraying fire-extinguisher fluid into the air intake and over hot parts of the engine was adequate in regard to the quantity of fluid and the rate at which it was supplied. With jet engines, the quantity of fluid required was so large as to be impracticable, and the only course was to stop combustion by turning off the high-pressure cocks; it was believed that this caused rapid cooling. Since electrical leads were almost certain to be severed, a master switch was required to cut off the electric supply at impact. Most British aircraft used an inertia-operated switch to carry out these operations at the moment of impact, but they were not fitted in American-built aircraft. The United States were carrying out large-scale research, crashing aircraft under controlled conditions, and, said Mr. Tye, he believed that the results of these tests would justify the crash switch and promote the development of more effective equipment.

THE PASSENGER AND CARGO LINER "RHODESIA CASTLE."

THE twin-screw passenger and cargo liner Rhodesia Castle, which is illustrated above, of 17,300 tons, left London on her maiden voyage on October 18. Built for the Union-Castle Mail Steamship Company by Harland and Wolff, Limited, at their Belfast shipyard, and launched there in April, 1951, she is the first of three similar vessels to be used by the Union-Castle Line on their round-Africa service. A sister ship, the Kenya Castle, is expected to go into service early in 1952, and the third ship will probably sail later in the same year. In general appearance, the Rhodesia Castle resembles the company's 18,400-ton Bloemfontein Castle, described in *ENGINEERING*, vol. 169, page 381 (1950), except that she has two masts instead of one. In both ships, the passenger accommodation is all of one class.

The vessel has an overall length of 576 ft., a length between perpendiculars of 540 ft., a moulded breadth of 74 ft., and a moulded depth of 35 ft. 6 in. There are four complete steel decks, a lower deck forward and aft of the machinery space, a promenade deck and a boat deck. The hull is divided into ten watertight compartments by nine bulkheads, all extending to the upper deck. Fresh water, water ballast, and fuel oil are carried in the double bottom. The forward and after peaks, also, may be used for fresh water or water ballast, and there are deep fresh-water tanks at the sides of the shaft tunnel and deep fuel-oil tanks forward of the boiler room. The cargo space consists of two holds forward, and three aft of the machinery space, with additional space in the 'tween decks. Some of the cargo spaces are equipped for the carriage of refrigerated produce. The cargo hatches are served by eleven tubular steel derricks, six of 10-ton, four of 5-ton and one of 30-ton capacity. All are worked by electric winches.

Accommodation is provided for 530 passengers in one, two, three and four-berth cabins, some of which have private bathrooms or shower baths and lavatories attached. All cabins are fitted with hot and cold running water and have controllable ventilation. The public rooms include a spacious dining saloon on the upper deck with seating for 280 passengers, a lounge, smokeroom and library on the promenade deck, a verandah on the boat deck, and a club room, nursery, and children's play rooms on the bridge deck. Additional recreational facilities are provided by way of an open-air swimming pool and space for deck games. The fire-protection equipment includes a fire-detecting and extinguishing system in the cargo spaces and a sprinkler system throughout the passenger accommodation. There are nine lifeboats fitted with hand-propelling gear and one lifeboat driven by a Diesel engine.

The vessel is propelled by twin screws, driven by Parsons-type triple-expansion steam turbines through double-reduction gearing. The propelling machinery was constructed by the shipbuilders. The ahead turbines are of the all-reaction type, but the high-pressure and low-pressure astern turbines, which are incorporated in the intermediate-pressure and low-pressure ahead turbine casings, respectively, are of impulse type. Each set of turbines is disposed round its main gear-wheel in a manner which makes for ease of access and simplicity of overhaul. The low-

pressure turbines exhaust into underslung condensers of Messrs. G. and J. Weir's regenerative type, constructed under licence by Messrs. Harland and Wolff. The condenser circulating water is supplied by four vertical-spindle centrifugal pumps, two for each unit, and the condensate passes through a three-stage regenerative feed-heating system before re-entering the boilers. Two evaporators, working in conjunction with a distiller, provide fresh water for the main boilers and for ship's use generally.

Three oil-fired Babcock and Wilcox watertube boilers supply steam for the turbines at a working pressure of 450 lb. per square inch at the superheater outlet, the total temperature being 750 deg. F. A motor-driven regenerative air pre-heater is incorporated in each boiler and the boilers have the Howden system of forced and induced draught. Two oil-fired Cochran boilers provide saturated steam for the various hotel services in the ship.

The propellers are three-bladed and made of manganese bronze. Thrust blocks of Michell type are installed aft of the main gearcases. The steering gear is operated electro-hydraulically and the rudder is of stream-lined design. With the exception of the stand-by main turbo-driven feed pump, the steam-driven auxiliary feed pumps and the air ejectors, all the auxiliary machinery is driven electrically. For power supply, there are two turbo-driven generators and three Diesel-driven generators in the engine room. The turbo-generator sets have single-reduction gearing and each has a normal output at full load of 750 kW. Each turbine also has its own surface condenser and auxiliaries. The Diesel sets are of Messrs. Harland and Wolff's design and manufacture, and each is capable of generating 450 kW. They are complete in themselves with pumps, coolers, filters, silencers, air compressors and air reservoirs for starting purposes.

Electricity is supplied for lighting and power at 220 volts, direct current. In addition to the main supply, already described, there is an emergency supply obtained from a single Diesel-driven generator of 75 kW capacity in conjunction with a 200-volt emergency storage battery which is switched in automatically to provide power for steering and for emergency lighting, etc., should the main supply fail. There is also a low-voltage supply, from a 24-volt nickel-iron battery, charged by means of two motor generators, which is used for telephones, call systems, etc. The electrically-operated watertight doors are of Messrs. Harland and Wolff's manufacture and can be controlled either from the bridge or locally. Sound reproduction equipment is provided for relaying broadcast and other programmes to the public rooms.

BRITISH RAILWAYS' DIESEL-ELECTRIC LOCOMOTIVE No. 10202.—The British Railways Diesel-electric locomotive No. 10202 began a full schedule of main-line working on Monday, October 29, between Waterloo and Exeter. At 1.25 a.m. it leaves London with a newspaper train, returning from Exeter at 7.30 a.m. The next departure from Waterloo is at 1.0 p.m., and the engine returns from Exeter for the second time each day at 5.55 p.m. This represents a total revenue-earning mileage of 687 daily and is maintained from Monday to Saturday inclusive; Sunday is the only day on which the engine goes to a depot. The daily fuel consumption is about 760 gallons of oil.

GARAGE WITH CONCRETE SHELL ROOF.



FIG. 1. GENERAL VIEW OF GARAGE.

GARAGE WITH CONCRETE SHELL ROOF.

A 'BUS garage building with a reinforced-concrete shell roof supported by prestressed-concrete edge beams has been completed recently for the Bournemouth Corporation. It provides a column-free covered area of about 45,000 sq. ft., being 300 ft. long by 150 ft. wide; the span of 150 ft. is the largest yet constructed in this country with prestressed edge beams and a shell roof. The building, which will ultimately be duplicated, is part of a new depot in the Castle-lane district of Bournemouth which will occupy a 24-acre site. Eventually there will be two garages each large enough for 99 buses, with a long narrow office block running between. Fig. 1 shows the building already finished, and the office block can be seen in the background in Fig. 2. The scheme will also include a wash building, a maintenance-workshop block, a canteen and recreation room, an assembly hall and general administrative offices. Provision is also made for sports grounds, etc. The narrow office section was arranged centrally between the two garages to provide direct access from both and at the same time make an effective fire-break between them. Although planning is complete, only one of the garages and the office block alongside, together with the wash building, part of the maintenance workshops, the canteen and recreation room, are included in the present construction programme. The main contractors are Messrs. James Drewitt and Son, Limited, Boscombe; the contractors for the prestressed work are the Vibrated Concrete Construction Company, Limited, 2 Caxton-street, London, S.W.1; the consulting engineers are Messrs. R. Travers Morgan and Partners, 11, Victoria-street, London, S.W.1; and the architects are Messrs. Jackson and Greenen.

The layout of the whole garage is planned for a working circulation as follows. Vehicles entering the depot are taken over by the garage staff. They then proceed to the wash building and, after being cleaned inside and out, pass on to the fuelling station. From there they are driven to the garage, where they are parked, facing the exit in readiness to leave for the next duty.

The roof of the new building is a reinforced-concrete thin shell structure made up of nine cylindrical-shaped vaults with prestressing in the edge beams. The span, which is transversal, bridges the 150 ft. width of the building without intermediate support. All nine vaults have a radius of curvature of 22 ft. 10½ in., a rise from springing to crown of 6 ft. 9½ in., and, except at the ends and springing where there is a slight increase, a shell thickness of 2½ in. The chord width all through is 33 ft. Intermediate edge beams are alike, 10 in. wide and 5 ft. 6 in. deep. The external edge beams are slightly larger and have an up-stand. The beams were cast *in situ* and post-tensioned by the Magnel-Blaton system. An extractable rubber core was used to form the cable ducts and the complete cable threaded in after the withdrawal of the core. The wire used was 0.276-in. (7-mm.) diameter hard-drawn steel of 95 to 110 tons per square inch ultimate strength. With an extension of 7¼ in. on the 150-ft. span, the stress induced in the 152 wires used in each intermediate edge beam was 125,000 lb. per square inch, which in turn induced a total compressive force in the concrete of 1,136,250 lb. (507.4 tons). Under the constructional loads this compressive force was sufficient to "hog" the beams ⅜ in. A 15 per cent. allowance was made for losses due to concrete shrinkage and to creep in the steel and the concrete, which occur

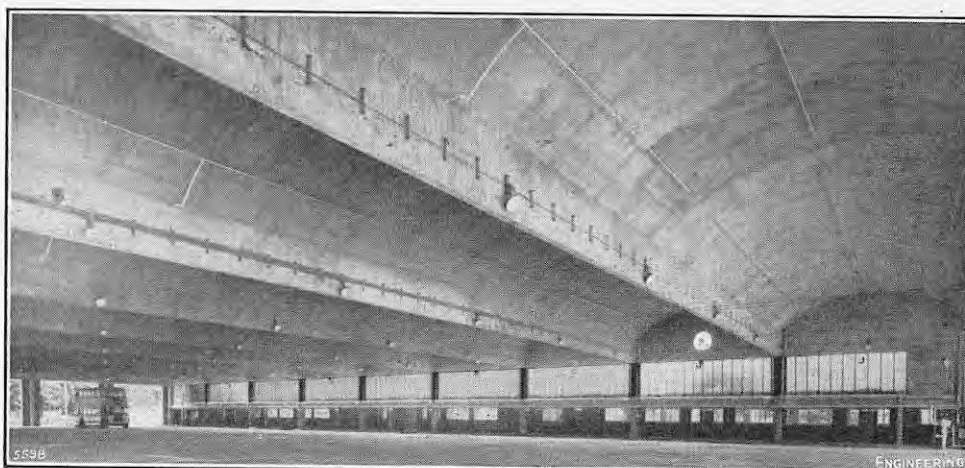


FIG. 2. INTERIOR, SHOWING SHELL ROOF AND PRESTRESSED EDGE BEAMS.

with time. The final prestress is not less than 430 tons.

In order to minimise the effects of shrinkage, each edge beam was cast in three separate stages. Concrete used for them had a specified 28-day strength of 6,000 lb. per square inch. The mix used was 1:1½:3 and compaction was obtained by vibration. The casting of the beams and of the end tie frames preceded the construction of the shell vaults, but it was not until the concrete of the vaults had been cured to a specified strength that prestressing was carried out. For the vaults proper, the pressure-sprayed method of concreting was adopted, and for this work, where finely graded materials only are used, the mix was 1:3. Here the reinforcement is of mild steel, most of it in the form of mesh fabric, but partly in the form of bars. The total design load on each roof bay is 195 tons, and of this there is a live-load component of 60 tons. Strain-hardened square twisted steel reinforcement gives continuity between the edge beams and vaults, and although they were separately constructed and formed by different methods, the two act together and function as a monolithic whole. There are no expansion/contraction joints anywhere in the structure; stresses resulting from temperature change have all been allowed for in the design.

Columns supporting the roof carry all the vertical loading and the moments induced by wind on the building as a whole. For these the concrete used was a nominal 1:2:4 mix, which was vibrated. The reinforcement was of ordinary round mild-steel rods. In general, the foundations, for which a safe ground pressure of 2½ tons was taken, are 3 ft. 6 in. down. Inside the building the clear height from floor to underside of edge beam is 19 ft., a dimension which has been adopted to suit trolley buses. There is no roof lighting. The calculated value of natural illumination from the side lighting provided is 15.00 lumens per square foot with the doors open, and 9.50 lumens with the doors closed, whereas the recommended value in the Illuminating Engineering Society's Code for garages of this kind, where only general maintenance is undertaken, is 7.00 lumens per square foot. Artificial light comes from parabolic dispersive reflectors fitted to the beams, which direct light along the lanes between the parked vehicles. There is no heating, except to the office

block, but the garage and offices are fitted with a sprinkler system. The wall infillings of the structure are generally of brick.

The vehicles are washed and cleaned in a small separate building, a reinforced-concrete column-and-beam framed structure with a flat roof. It is designed to take two buses, one behind the other. Each vehicle, as it passes through, stands first at the position where the inside is cleaned and vacuumed, and then moves forward to a second position, where it is sprayed over with water from sparge pipes attached to side gantries. Refuelling operations are carried out below a corrugated canopy constructed of thin concrete and cantilevered out from the side wall of the garage. Four 20-gallon per minute electrically-operated meter pumps—two for petrol and two for Diesel oil—are installed.

The maintenance-workshop building, like others in the scheme, is a reinforced framed concrete structure, roofed principally with thin shell vaults. However, whereas the vaulting of the garage block is of straightforward cylindrical form, that of the workshops is of north-light construction. With the exception of the spans, of which there are two (55 ft. and 52 ft.), the dimensions have been standardised all through. The bay width is 13 ft., but to free the floor of unnecessary interruption, alternate columns have been omitted almost everywhere, except where they occur in the outside and inner division walls and make no obstruction. Prestressing is applied to this roof too; the cables here being incorporated in the thickened top edge of the vault. When the whole project is complete the maintenance workshops will be able to deal with a fleet of 550 buses. The first section, forming part of the present programme, is designed to handle 250 and is planned and equipped to carry out repair work of every kind, including complete overhaul. It includes a machine shop, electrical shop, smithy, timber mill, paint and body shops, tyre-repair shop, and stores of all kinds, including one for clothing. The inspection pits are of various types: three, although intended for the removal of under-floor engines in anticipation of probable changes in bus design, will for the present be used for buses of normal design. Two, with hydraulic jacking equipment, will deal with four-wheeled buses, and a further one, which also has hydraulic jacking, is for six-wheeled buses.

AUTOMATIC TRACK-PLOTTING INSTRUMENT FOR AIRCRAFT.

DECCA NAVIGATOR COMPANY, LIMITED, NEW MALDEN, SURREY.

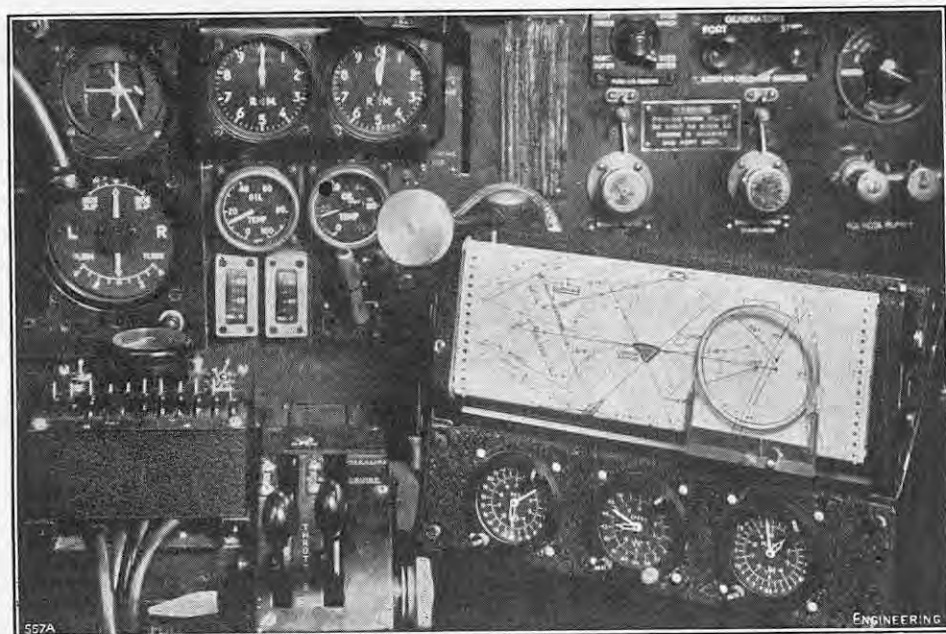


FIG. 1. FLIGHT LOG IN "ANSON" AIRCRAFT.

AUTOMATIC TRACK-PLOTTING INSTRUMENT FOR AIRCRAFT.

FOR rather more than a year the Ministry of Civil Aviation have been carrying out flight trials with an instrument known as the Flight Log, which automatically draws on a chart the track followed by the aircraft. Fig. 1 shows the equipment installed in one of the Ministry's Anson aircraft. Designed and constructed by the Decca Navigator Company, Limited, 247, Burlington-road, New Malden, Surrey, the Flight Log is a development of the Decca Navigator aircraft-receiving equipment. It is interesting to record that the Decca Navigator system has been used by the Central Photographic Establishment of the Royal Air Force in conjunction with aerial-survey work for the Directorate of Ordnance Survey, for which precise navigation is required. Owing to its simplicity, accuracy, and wide range of applications as a navigational aid, the Flight Log has aroused considerable interest among civil-aviation authorities. At the meeting of the International Civil Aviation Organisation in June it was recommended that the Flight Log should be tested in service; and representatives of European air lines and civil-aviation bodies have been invited by the Ministry of Civil Aviation to take part in flights during the next few weeks over the airways of southern England in a Handley Page Marathon aircraft equipped with a Flight Log.

A detailed description of the basic Decca Navigator system, in its marine application, was given on page 439 of our 167th volume (1949). The same principle is applied to air navigation, and in fact the existing ground transmitting stations for marine navigation also serve for aerial navigation. The receiving equipment, however, is not identical; the latest aircraft receiver, the Mark VII, is designed for the higher cruising speeds of aircraft, and gives a much improved service when atmospheric noise is high, as may be the case in the equatorial thunderstorm belt. Briefly, it may be recalled, the Decca Navigator system is a low-frequency continuous-wave system, and comprises "chains" of four ground stations—three slave stations, known as Red, Green and Purple, at the corners of a triangle, near the centre of which is a master station. The transmission frequencies of the four stations bear a fixed harmonic relationship to one another, and the slave transmissions are "phase-locked" to the signals transmitted by the master station. Receiving circuits in the aircraft detect the four transmitted signals; and according to the position of the aircraft relative to the ground stations, there will be phase differences between the received slave and master signals. These phase differences are indicated, respectively, on three integrating rotating-pointer indicators known as the Red, Green and Purple Decimeters.

The Decimeter markings correspond with a series of red, green and purple hyperbolic position lines marked on the maps and charts supplied to the navigator (when the Flight Log is not fitted). Each position line represents a constant phase-difference between

the signals received from the master station and the slave station of the corresponding colour. The interval between two position lines is known as a "lane." On entering the area covered by a Decca chain, the navigator sets each Decimeter by means of "lane-identification" signals transmitted by the ground stations at every minute for each colour. On marine installations and the earlier Mark VI aircraft receiver, which is installed in the Anson aircraft shown in Fig. 1, the lane-identification signals were indicated on a fourth non-integrating instrument, but on the Mark VII aircraft receiver, non-counting lane-identification pointers actuated by a separate movement are incorporated in the Decimeters; during lane-identification transmissions, the two pointers are coincident. Thereafter, the Decimeters count the number of lanes traversed by the aircraft. To obtain a fix, it is necessary to read off two Decimeters only and to find on the chart the point of intersection of the indicated position lines; the two Decimeters selected are those which give the widest angle of intersection on the chart.

It will be realised that interpreting the Decimeters and fixing the position of the aircraft on the chart, although completely satisfactory for marine craft, is not a procedure which the pilot of a high-speed aircraft can undertake readily. For this reason the Flight Log, which conveys directly to the pilot his position and his ground track, has been developed. It also allows the ground speed to be determined, by switching in time signals which produce small deflections of the recorded track at regular time intervals. The Flight Log, which consists of a display head, shown on the right of Fig. 1, a torque amplifier, and a control panel, on the left of Fig. 1, weighs about 120 lb. and occupies just over 3 cub. ft. of space. The outputs of the receiving circuits which drive the two operating Decimeters in a basic Decca Navigator system are fed to the torque amplifier and are used to drive two electric motors, one of which traverses a strip chart past a 10-in. by 4-in. viewing aperture in the display head, in response to one system of Decca co-ordinates; at right angles to the movement of the chart, corresponding to the other co-ordinate, an ink stylus is driven, through a screw mechanism, by the other motor. The receiver output is also taken to three Decimeters, which are used solely for setting up and for checking. The Flight Log charts, which are stored in the display head, are made up before the flight into a continuous roll, the scales being chosen to suit various requirements. Push-button controls are provided for setting-up the instrument and selecting the appropriate chart so that as soon as the boundary of one chart is reached, a new chart can be brought into operation.

It will be appreciated that since the Decca position lines are hyperbolas, and that in the Flight Log they are transformed to rectangular co-ordinates, the charts prepared for use in the Flight Log would show considerable distortion; for instance, a circular track might appear as an elongated oval. The amount of distortion depends upon the angle of intersection of the Decca position lines and varies over the coverage area. It



has been found in practice that, provided the charts are well-marked with suitable data, such as constant-range "circles," track distances, etc., the distortion is acceptable to the pilot over large areas of the coverage. In the Mark VI Flight Log installed in the aircraft illustrated, there is, however, a mechanism for overcoming the distortion; instead of using the primary position-line patterns to drive the chart and the stylus, it is possible to use sum and difference patterns—for example, the difference between the Red and Green rotations can be transmitted, through a differential gear train, to actuate one axis of the display head, and their sum can be used to drive the other axis. Such secondary patterns have larger angles of intersection than the primary patterns, and, therefore, show less distortion when converted to rectangular co-ordinates. Selector switches are provided on the control panel for different combinations of sum and difference patterns, by means of which the whole coverage area can be shown effectively; the use of suitable sum and difference patterns also makes it possible, in general, to present the chart to the pilot in the conventional "north upwards" manner. Each chart prepared for use in the Flight Log is clearly marked to indicate to the pilot which patterns are to be fed to the instrument.

One of the principal advantages of the use of the low-frequency Decca system for aircraft navigation, in comparison with very-high-frequency navigational aids, is that the range of the system is independent of the height of the aircraft. Low- and medium-frequency receivers are, however, susceptible to interruptions in the reception of normal transmissions by static discharges. The Decca lane-identification system provides a means for correcting such interruptions, but in order to avoid the necessity for re-setting, wick dischargers are fitted and insulated wire is used for the aerials. To reduce the static interference arising from the impact of charged droplets on the aerial, the Decca anti-static aerial has been developed; it is housed in a vertical mast of aerofoil section, a shield being provided along the leading edge to screen the receiving element. The efficiency of the aerial is comparable with that of a long-wire system. The vertical shield can be used as a very-high-frequency communication aerial. An anti-static aerial fitted flush with the skin of the aircraft has also been developed.

The Decca Flight Log, in addition to its obvious use for navigation from point to point, provides a complete record of the track and ground speed during the flight. It enables the pilot to hold any desired traffic pattern, and as an approach aid it indicates simultaneously the displacement of the aircraft from the desired track and the rate of approach to that track. There are at present three Decca chains in operation—the English chain, the Danish chain, and the North British chain. French, German and South-West British chains are under construction, and it is hoped to establish other chains to cover the greater part of western Europe. Fig. 2 shows the coverage contour within which the accuracy is greater than one nautical mile by day and five nautical miles by night for 95 per cent. of the time. As the master station is approached the accuracy is considerably greater. The Ministry of Civil Aviation consider that the Decca system and the Flight Log may provide Europe "with a better air-navigational service than any at present in use or contemplated, and at a much lower cost than for any comparable system."

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

ELECTRIC POWER SUPPLIES.—Officials of the British Electricity Authority express optimism that power cuts may not be so severe this winter as last. Compared with a year ago, the new generators in use this winter will increase the capacity by 100,000 kW at Braehead and 60,000 kW at Clyde's Mill. Arrangements have also been made to obtain a supply, during certain periods of the winter, of 185,000 kW instead of 100,000 kW from the North of Scotland Hydro-Electric Board. Supplies will also be augmented by a 60,000-kW generator which is expected to come into use soon at Portobello. A different opinion, however, was expressed by Mr. G. Mathers, chairman of the Scottish Electricity Peak Economy Committee, at a Press conference held in Edinburgh on October 30. He stated that Scotland's power-supply position was likely to be most acute in the period just before the New Year. It might be necessary to cut supplies during the present month by at least 38,000 kW in South-West and South-East Scotland.

COMPETITION FOR DESIGNS FOR SHIPS' CABINS.—A prize of 250*l.* for the best design for the decoration, furnishing, and fitting of a suite of ship's cabins, submitted in a competition organised by the Scottish Committee of the Council of Industrial Design, has been provided anonymously. The suite should be suitable for a ship intended to serve on any of the world's trade routes. Competing designers are asked to plan the arrangement of a double cabin, sitting-room, and private bathroom suite, in which the sitting-room would be convertible into a subsidiary double cabin. Entries close on January 16, 1952, and will be judged by a panel of three, representing the Institution of Naval Architects, the Chamber of Shipping, and the architectural profession.

PORT REORGANISATION AT DUNDEE AND PERTH.—Members of the Docks and Inland Waterways Executive are visiting Dundee and Perth on November 15 and 16 as a further preliminary step in the preparation of a scheme for the reorganisation of port administration. They will meet Dundee Harbour Trustees and shipbuilders, a Dundee group of port employers and Dundee Chamber of Commerce, and Perth Town Council, Perthshire Chamber of Commerce, and other trading interests, also wharfingers at Newburgh, and representatives of shipowners and of the Transport and General Workers' Union.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—The prize presented by the Institution of Engineers and Shipbuilders in Scotland to the best pupil in National Certificate courses in naval architecture in Scotland has been awarded to Mr. Stanley Milne, 98, Queen-street, Peterhead, who will receive it at a ceremony in Robert Gordon's College, Aberdeen. He is employed by John Lewis and Sons, Ltd., shipbuilders, Aberdeen.

CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH IRON AND STEEL INDUSTRY.—Increasing scarcity of iron and steel occasions grave anxiety concerning the extent of tonnage allocations when the system of sharing distributable quantities becomes operative again next month. Makers' stocks have been heavily depleted this year and the shrinkage in imports of raw materials has been serious; in the nine months ended September 30 the intake was less than a third of the unloadings for the corresponding period a year ago. With iron production on a reduced scale and the requirements of consumers considerably swollen by rearmament plans, the fear of a steel famine is growing. Severe cuts in steel exports have been made. It was announced on October 29 that the shortage of steel ingots might entail a further reduction in the weekly number of shifts worked during the next two months at the West Hartlepool Works of the South Durham Steel & Iron Co., Ltd. The shifts have already been reduced from the normal 17 to 15 a week.

PRODUCTION OF IMPLEMENTS FOR THE FERGUSON TRACTOR.—To mark the completion of their 100,000th agricultural implement for Harry Ferguson, Ltd., the directors of Steels Engineering Products, Ltd., held a luncheon at the firm's Crown Works, Sunderland, on Thursday, November 1, during which Mr. J. Eric Steel, managing director of the company, made a presentation to the directors of Harry Ferguson, Ltd. Steels Engineering Products, Ltd., is a wholly-owned subsidiary of Steel & Co., Ltd., and the contracts for Harry Ferguson, Ltd., represent the greatest part of their agricultural-

machinery programme, this work having commenced in December, 1946. The 100,000th implement to be produced was a tiller, the other implements making this total being fixed-time and spring-time cultivators, three-row ridgers, potato spinners, post-hole diggers, steerage hoes and manure loaders. Actually, the plant in which these instruments are produced is capable of achieving an output closely approaching 100,000 implements per annum, but, owing to the shortage of steel, the present rate of production is approximately 50,000 per annum.

LANCASHIRE AND SOUTH YORKSHIRE.

FUEL RESERVES.—Industry and power stations in Yorkshire began the official coal winter on November 1 with 300,000 tons more coal in reserve than at the corresponding date last year. The level of gasworks stocks, however, causes anxiety; they amount to 129,000 tons only, representing 3.6 weeks' average winter supply. Electricity generating stations have 5.6 weeks' supply. Industrial stocks at the beginning of the coal winter were 573,000 tons, or 4.6 weeks' supply, representing an increase of 112,000 tons over last year. On the other hand, house-coal stocks are so low that, in the North-Eastern Region of the Coal Board, which includes Sheffield, Rotherham, Doncaster, Barnsley and places in the Don and Dearne valleys, deliveries until next April are to be 6 cwt. less than the permitted maximum.

STAGGERED HOURS OF WORKING.—Under the electricity load-spreading plan, over 1,000 firms in Sheffield and Rotherham started staggered-hours working on November 5. The object is to remove one-fifth of the electricity load from peak periods. There is one late shift a week from noon to 8 p.m., on a rota basis until the end of the staggered-hours scheme on March 31, 1952. Some firms are making the necessary saving by transferring load to the night shift, while some others switch off a proportion of plant during peak-load times.

NEW COKING PLANT.—A battery of 25 new coke ovens is to be installed at Beighton Brookhouse, near Sheffield, to replace 25 ovens which have been operating since 1930. It is expected that the new ovens and by-product plant will be ready for use within 18 months. The estimated cost is 330,000*l.* The present plant supplies 2,000 tons of coke a week to steelworks and provides piped gas to Sheffield industry. The large capital expenditure is part of a replacement scheme by the United Coke and Chemical Co.

COAL GASIFICATION.—The results of experiments in the underground gasification of coal at Newman Spinney, Eckington, near Sheffield, have encouraged attempts to burn coal much deeper underground and over greater distances. Mr. C. A. Masterman, technical director of underground gasification to the Ministry of Fuel and Power, states that boreholes are now being sunk to reach a seam 200 ft. deep and, if the new project is successful, it might grow into an underground system extending between 200 to 300 yards from which gas would be tapped. In three months about 100 tons of coal have been burned underground and some millions of cubic feet of gas obtained.

THE MIDLANDS.

NICKEL CONCESSION.—As a result of representations by the Walsall Metal Trades Association, the Board of Trade has granted certain concessions for the use of nickel by local manufacturers. For the manufacture of saddlery and harness fittings, including spurs, stirrups, and bits, nickel silver containing a maximum of 15 per cent. of nickel may now be used. The arrangement will be subject to licence, valid for six months. At the end of that period the position will be reviewed.

ALLEGED BLACK MARKET IN METALS.—The Midland Branch of the National Union of Manufacturers is seeking evidence from its members about illegal deals in metals. There have been many allegations in recent months that an extensive black market in metals of all kinds exists in the Midlands, and the N.U.M. is hoping to find evidence of specific cases so that the matter can be reported for legal action by the appropriate Ministry.

PLANS FOR RE-BUILDING BIRMINGHAM.—A second report on the development plan for the city of Birmingham is now before the City Council. Considerable re-location of industry is planned. A site at Adderley Park, at present used as a corporation refuse tip, is scheduled for housing displaced firms in new factories which will be built for the purpose, and it is proposed to build flatted factories on a site near the Gun Barrel Proof House in Banbury-street. These flats are to accommodate firms from the Snow Hill and Whittall-street area, near the centre of the city. Another development proposed is the dispersal of certain industries, particularly those such as chemical, textile and clothing manufacture, which do not conform to the general pattern of industry in the city. These industries, together

with a proportion of the population, would go to neighbouring towns, such as Droitwich, Redditch, Cannock, Lichfield and Tamworth.

BLAST-FURNACE RE-LINING.—No. 5 blast furnace at the Bilston Steelworks of Stewarts and Lloyds, Ltd., has been blown out and is being re-lined.

BROOKHIRST JUBILEE.—The jubilee of Brookhirst Switchgear, Ltd., Chester, a firm that was established rather more than 50 years ago by the late Mr. John A. Hirst for the manufacture of motor control apparatus, was celebrated on Monday, October 22, by the opening of an extension to the works. This extension, which covers an area of some 45,000 sq. ft., includes assembly, test and inspection departments, as well as a packing bay and warehouse and a social hall. After the opening ceremony, long-service presentations were made to 136 employees, each of whom had not less than 25 years' service.

SOUTH-WEST ENGLAND AND SOUTH WALES.

COAL EXPORTS AND PIT PROP IMPORTS.—A barter plan between Portugal and Britain will mean an immediate increase in coal shipments to that market. The arrangement provides for Britain to supply 50,000 tons of coal, about half of which will be Welsh, in exchange for wolfram, sulphur and peeled pitprops. Supplies of French pitwood for the Welsh mines, however, are causing concern. Current contracts have run out and no new agreement has been reached. This year the French authorities reduced the export quota to 50,000 tons, and, so far, have refused to grant any additional quota. Last year South Wales imported 200,000 tons of French pitwood. In the pre-war years, about 400,000 tons per annum were received.

CARDIFF TO WESTON-SUPER-MARE FERRY BOATS.—A proposal for a ferry service across the Bristol Channel from Penarth to Uphill, near Weston-super-Mare, has been outlined to the Cardiff Development Committee. The distance across the Channel is about 12 miles. Representatives of Western Marine Co., the firm contemplating the project, said it was intended to use two boats, to cost about 10,000*l.* each. Each would carry about 40 motor vehicles and there would be an all-the-year-round service.

BLASTING FOR LIMESTONE.—Following several weeks of preparation, 50,000 tons of limestone rock were blasted in one operation from the face of a quarry on the Black Mountains, Carmarthenshire, owned by Brynamman Limestone Products, Ltd. Five tons of explosives were used. It was the first time that a heading blast had been used in a South Wales quarry.

MAN-POWER REDUNDANCY IN ABERDARE VALLEY.—The question of redundancy in some of the new light industries in the Aberdare area is causing concern. On November 2 the Aberdare Council convened a public meeting at which trade organisations and political parties were represented. They discussed the position at the factory of Murphy Radio, Ltd., Hirwaun Trading Estate, where there was a possibility of some 400 employees becoming redundant by Christmas. It was decided to ask the firm to meet a deputation on the question, and to request the Board of Trade Regional Controller to receive a deputation on the general question of redundancy in the Aberdare Valley.

BOYS IN HEAVY INDUSTRIES.—The youth employment officer for Swansea, Mr. K. J. Cutler, in his report to the local youth employment committee on November 1 last, referred to the fact that fewer boys were entering the heavy industries, and, in particular, the tin-plate shops. He reported that only five boys had gone into the industry in a little over two months and that there were about 30 vacancies.

ITALIANS IN SOUTH WALES.—Several hundred more Italians are to be introduced into South Wales industries in the near future, according to Sir Percy Thomas, chairman of the Welsh Board for Industry. He told a Press conference at Port Talbot that already 380 Italians were employed in South Wales and it was proposed to have a further 250, some of whom, it was stated, were already on their way.

LEVEL CROSSING AT PORT TALBOT.—Details have been published of a 250,000*l.* scheme to eliminate a level crossing responsible for a serious traffic bottleneck at Port Talbot. The level crossing is on the main Cardiff-Swansea road and a scheme prepared by the Port Talbot borough engineer, Mr. G. V. Griffiths, has been approved by the Town Council, the Steel Company of Wales and the Welsh Board for Industry. It has been drawn up for rapid implementation as it is not expected that the Ministry of Transport scheme for a by-pass road will be proceeded with for some years.

NOTICES OF MEETINGS.

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

INSTITUTION OF ELECTRICAL ENGINEERS.—Education Discussion Circle: Monday, November 12, 6 p.m., Victoria-embankment, W.C.2. Discussion on "The Equipment of an Electrical Engineering Laboratory," opened by Mr. A. Draper and Dipl.-Ing. T. Siklos. **Western Centre:** Monday, November 12, 6 p.m., South Western Electricity Board's Offices, Colston-avenue, Bristol. "Development of the Electrical System on the Bristol Brabazon Mark I Aircraft," by Mr. M. J. J. Cronin. **North-Eastern Centre:** Monday, November 12, 6.15 p.m., Neville Hall, Westgate-road, Newcastle-upon-Tyne. "Protection of Electrical Power Systems," by Mr. H. Leyburn and Mr. C. H. W. Lackey. **North Midland Centre:** Tuesday, November 13, 6.30 p.m., 1, Whitehall-road, Leeds. "The Nervous System as a Communication Network," by Dr. J. A. V. Bates. **Radio Section:** Wednesday, November 14, 5.30 p.m., Victoria-embankment, W.C.2. "Life of Oxide Cathodes in Modern Receiving Valves," by Dr. G. H. Metson, Dr. S. Wagener, Mr. M. F. Holmes, and Mr. M. R. Child. **District Meeting:** Wednesday, November 14, 7 p.m., Southern Electricity Board's Offices, 37, George-street, Oxford. "Electricity Supply Distribution," by Mr. W. F. Sands and Mr. J. L. Taylor. **Southern Centre:** Wednesday, November 14, 7.30 p.m., The R.A.E. College, Farnborough. "Electricity in this Century," by Mr. E. A. Logan.

INSTITUTION OF PRODUCTION ENGINEERS.—Sheffield Section: Monday, November 12, 6.30 p.m., Royal Victoria Station Hotel, Sheffield. "Induction Heating in Industry," by Mr. E. May. **Yorkshire Section:** Monday, November 12, 7 p.m., Hotel Metropole, Leeds. "Productivity and the Machine Tool," by Mr. N. Stubbs. **Birmingham Graduate Section:** Tuesday, November 13, 7 p.m., James Watt Memorial Institute, Birmingham. "Design and Manufacture of a Tractor," by Mr. H. E. Ashfield. **Dundee Section:** Tuesday, November 13, 7.45 p.m., Mathers Hotel, Dundee. "Modern Cutting Tools and Machine-Tool Design," by Mr. C. H. A. Welsh. **Preston Section:** Wednesday, November 14, 7.15 p.m., The Bull and Royal Hotel, Church-street, Preston. "Television," by Mr. T. Worswick. **Institution:** Thursday, November 15, 7 p.m., The Royal Empire Society, Northumberland-avenue, W.C.2. "Drop Forging," by Mr. K. Fidler. **Leicester Section:** Thursday, November 15, 7 p.m., College of Art and Technology, The Newark, Leicester. "We Must Do Better," by Mr. E. C. Gordon England. **South Essex Section:** Thursday, November 15, 7.30 p.m., Mid-Essex Technical College, Chelmsford. "Standardisation in Engineering," by Mr. E. L. Diamond. **Glasgow Section:** Thursday, November 15, 7.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. "Some Interesting Set-ups on Modern Machine Tools," by Mr. R. C. Fenton.

INSTITUTION OF THE RUBBER INDUSTRY.—Midland Section: Monday, November 12, 7 p.m., The Pavilion, Goodyear Park, Wolverhampton. "Material Handling in the Rubber Industry," by Mr. A. J. Bullivant.

WOMEN'S ENGINEERING SOCIETY.—London Branch: Monday, November 12, 7 p.m., 35, Grosvenor-place, Westminster, S.W.1. "Opportunity and Progress," II.—"Training To-Day," by Mr. J. W. Bispham and Mr. S. L. Whitby.

INSTITUTION OF CIVIL ENGINEERS.—Railway Engineering Division: Tuesday, November 13, 5.30 p.m., Great George-street, S.W.1. Discussion on "Economy in Railway Civil Engineering." Introductory Notes: "Economy Through Labour Productivity and Incentive Schemes," by Mr. G. C. Stevens; "Economy Through Organisation," by Mr. J. T. Thompson; "Economy by Supervision," by Mr. A. K. Terris; and "Economy Through Design," by Mr. P. S. A. Berridge.

INSTITUTE OF MARINE ENGINEERS.—Tuesday, November 13, 5.30 p.m., 85, The Minories, E.C.3. Lecture on "Ships That Serve Ships," by Mr. T. Clark. **Tuesday, November 13, 7.30 p.m., Paddington Technical College, Saltram-crescent, W.9.** "The Construction of Marine Boilers," by Lieut.-Comdr. (E) A. P. Monk.

ILLUMINATING ENGINEERING SOCIETY.—Tuesday, November 13, 6 p.m., Lighting Service Bureau, 2, Savoy-hill, W.C.2. "The Equipment and Functions of an Illumination Laboratory," by Mr. H. F. Stephenson. **Liverpool Centre:** Tuesday, November 13, 6 p.m., Merseyside and North Wales Electricity Board's Offices, White-chapel, Liverpool. "Lighting of Architecture," by Mr. G. Grenfell Baines.

INSTITUTION OF WORKS MANAGERS.—Merseyside Branch: Tuesday, November 13, 6.30 p.m., The Adelphi Hotel, Liverpool. Brains Trust Meeting.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—South Western Branch: Tuesday, November 13, 6.30 p.m., The R.W.A. School of Architecture, Bristol.

"The Heating and Ventilating Systems of the House of Commons," by Mr. J. R. Kell.

SHEFFIELD METALLURGICAL ASSOCIATION.—Tuesday, November 13, 7 p.m., The Grand Hotel, Sheffield. "Some Simple Theoretical Aspects of Ferrous Metallurgy," by Dr. K. W. Andrews.

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—Western Group: Tuesday, November 13, 7.30 p.m., at the Works of the British Oxygen Co., Ltd., Bristol. "Welding in Vehicle Repair," by Mr. W. Goodchild. **East Midlands Centre:** Wednesday, November 14, 7.30 p.m., The Mechanics Institute, Nottingham. "The Organisation and Maintenance of Motor Vehicle Fleets," by Mr. R. C. Hunt. **North-East Centre:** Thursday, November 15, 7.30 p.m., The Hotel Metropole, Leeds. "Vacuum and Air Brakes," by Mr. S. H. Edge.

INSTITUTION OF WATER ENGINEERS.—South-Eastern Section: Wednesday, November 14, 2.30 p.m., Institution of Civil Engineers, Great George-street, S.W.1. "Submersible Pumps and Motors," by Mr. W. L. Gardiner.

INSTITUTE OF PETROLEUM.—Wednesday, November 14, 5.30 p.m., 26, Portland-place, W.1. "Detergents from Petroleum," by Dr. S. F. Birch.

REINFORCED CONCRETE ASSOCIATION.—Wednesday, November 14, 6 p.m., Institution of Structural Engineers, 11, Upper Belgrave-street, S.W.1. "Design and Construction of Concrete Pavements," by Mr. F. N. Sparks.

LIVERPOOL ENGINEERING SOCIETY.—Wednesday, November 14, 6 p.m., 9, The Temple, 24, Dale-street, Liverpool. "Water Treatment for High-Pressure Boilers," by Mr. E. L. Streatfield.

BRITISH INSTITUTION OF RADIO ENGINEERS.—North-Eastern Section: Wednesday, November 14, 6 p.m., Neville Hall, Westgate-road, Newcastle-upon-Tyne. "Television Aerial Design," by Mr. G. L. Stephens.

INSTITUTE OF FUEL.—North-Western Section: Wednesday, November 14, 7.30 p.m., Grosvenor Hotel, Chester. "Modern Steam Generators," by Mr. W. C. Carter. **East Midland Section:** Thursday, November 15, 6.15 p.m., East Midland Gas Board's Showrooms, Nottingham. "Generation Development in the East Midland Division of the British Electricity Authority," by Mr. E. R. Knight.

DIESEL ENGINE USERS ASSOCIATION.—Thursday, November 15, 2.30 p.m., Caxton Hall, Westminster, S.W.1. "Instrumentation for Diesel Engines in Service," by Mr. J. D. Thorn.

ROYAL SOCIETY.—Thursday, November 15, 4.30 p.m., Burlington House, Piccadilly, W.1. "The Mechanical Behaviour of Single Crystals of Certain Metals," by Dr. E. N. da C. Andrade, F.R.S., and Mr. C. Henderson.

INSTITUTION OF MINING AND METALLURGY.—Thursday, November 15, 5 p.m., Geological Society's Apartments, Burlington House, Piccadilly, W.1. "Major Changes in Mining Practice of Rhokana Corporation, Ltd., 1940-50," by Mr. E. K. McDermott.

SOCIETY OF CHEMICAL INDUSTRY.—Road and Building Materials Group: Thursday, November 15, 6 p.m., Institution of Structural Engineers, 11, Upper Belgrave-street, S.W.1. "Roads of the Past: Their Makers, Users, Traffic and Mode of Construction," by Professor R. J. Forbes.

INSTITUTION OF MECHANICAL ENGINEERS.—Midland Branch: Thursday, November 15, 6 p.m., James Watt Memorial Institute, Great Charles-street, Birmingham. "Live Load Tests on Wire Ropes and Fittings," by Mr. T. E. Dumbleby. **Institution:** Friday, November 16, 5.30 p.m., Storey's gate, St. James's Park, S.W.1. Thomas Hawksley Lecture on "Some Fuel and Power Projects," by Dr. H. Roxbee Cox. **AUTOMOBILE DIVISION.—Luton Centre:** Monday, November 12, 7.15 p.m., Town Hall, Luton; and **London:** Tuesday, November 13, 5.30 p.m., Storey's gate, St. James's Park, S.W.1. "Independent Rear Suspension," by Mr. D. Bastow.

CHEMICAL SOCIETY. Thursday, November 15, 7.30 p.m., Burlington House, Piccadilly, W.1. Various original papers.

JUNIOR INSTITUTION OF ENGINEERS.—Friday, November 16, 6.30 p.m., 39, Victoria-street, S.W.1. Chairman's Address on "Cranes and Lifting Machinery," by Mr. P. B. Hebbert. **North-Western Section:** Saturday, November 17, 2.30 p.m., 16, St. Mary's Parsonage, Manchester. Film Evening.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE.—Friday, November 16, 6.45 p.m., 39, Elmbank-crescent, Glasgow, C.2. "Basic Refractories," by Drs. J. R. Rait and W. F. Ford.

INSTITUTION OF ENGINEERING DRAUGHTSMEN AND DESIGNERS.—Friday, November 16, 7 p.m., London School of Hygiene and Tropical Medicine, W.C.1. "The American Approach to Productivity," by Mr. R. D. Chapman.

INSTITUTE OF BRITISH FOUNDRYMEN.—Bristol and West of England Branch: Saturday, November 17, 3 p.m., The Grand Hotel, Bristol. "Production of Heavy Castings for Electrical Equipment," by Mr. N. Charlton.

PERSONAL.

Mr. S. S. C. MITCHELL, C.B., O.B.E., M.I.Mech.E., has been appointed Controller of Guided Weapons and Electronics in the Ministry of Supply, in succession to AIR CHIEF MARSHAL SIR ALEC CORYTON, K.C.B., K.B.E., M.V.O., D.F.C., who, as stated on page 559, *ante*, has been made managing director of the engine division of the Bristol Aeroplane Co., Ltd.

Mr. C. H. GIBSON, A.M.I.Mech.E., A.M.I.N.A., has been appointed chief mechanical engineer to the Manchester Ship Canal Co., Ship Canal House, King-street, Manchester, as from November 1, in succession to Mr. T. A. GUEST, O.B.E., A.M.I.Mech.E., who retired owing to ill health on October 31, after 30 years of service with the company.

Dr. J. WARD, B.Sc., M.I.Mech.E., M.I.Mar.E., has retired from his post as head of the Department of Civil and Mechanical Engineering at the Technical College, Huddersfield, and has been appointed technical consultant to the Norwood Engineering Co., Huddersfield. Mr. J. D. WALKER, B.Sc., A.M.I.Mech.E., lecturer in the Civil and Mechanical Engineering Department, has been appointed to succeed Dr. Ward.

Mr. N. E. ROWE, C.B.E., B.Sc., F.R.Ae.S., M.I.Mech.E. Wh.Ex., is to be technical director of Blackburn & General Aircraft Ltd., Brough, East Yorkshire, as from January 1, 1952. AIR VICE-MARSHAL H. N. THORNTON, C.B.E., is also joining the board and will be responsible for sales. His office will be at 43, Berkeley-square, London, W.1. CAPTAIN C. E. WARD has been appointed London manager. The firm have also been appointed agents for the TURBOMECA range of gas turbines, and have formed a BLACKBURN-TURBOMECA DIVISION at their London office, 43, Berkeley-square, London, W.1, to handle sales.

Mr. R. R. MADDOCK, B.Eng., A.M.I.E.E., A.M.I.Mech.E., generation engineer (construction), Eastern Division, British Electricity Authority, has been appointed chief generation engineer (construction), Midlands Division, in succession to Mr. L. F. JEFFREY, B.Sc., M.I.C.E., M.I.Mech.E., M.I.E.E., who has recently been appointed controller of the East Midlands Division.

Mr. W. H. PURDIE, director of William Doxford & Sons, Ltd., Sunderland, has been elected chairman of the National Association of Marine Enginebuilders for 1951-52. Mr. EWEN H. SMITH, director of David Rowan & Co., Ltd., Glasgow, has been elected vice-chairman.

Mr. W. E. MITCHELL, the chief engineer, and Mr. J. W. WHIMPENNY, the production manager of W. H. Dorman & Co., Ltd., Stafford, have been appointed to the board of the company as special directors.

Mr. G. R. FISHER is relinquishing the appointments of general manager of operations for, and director of, the Zinc Corporation, Ltd., and of director of New Broken Hill Consolidated, Ltd., to take up the position of vice-chairman of Mount Isa Mines, Ltd., as from January 1, 1952.

Mr. D. E. JEWITT, M.I.Mar.E., who has been associated with the marine work of the British Thomson-Houston Co., Ltd., Rugby, since 1910, and was appointed engineer, marine department, in 1943, retired on October 31 after 45 years of service.

Mr. E. H. DISCOMBE, M.I.W., a delegate director and commercial manager of Murex Welding Processes Ltd., Waltham Cross, Hertfordshire, has retired after upwards of 35 years of service with the company.

Mr. P. J. C. BOVILL, B.Sc., local director and general manager of the Chemicals branch of Newton Chambers & Co., Ltd., has been appointed vice-chairman of the local board.

Mr. H. E. CLARKSON, Mr. R. D. KIRK and Mr. R. UPWARD, have gone to Australia to join Perkins Diesel Overseas Pty. Ltd., after completing their training in the maintenance and servicing of Diesel engines with the parent company, F. Perkins Ltd., Queen-street, Peterborough.

Mr. L. A. JARVIS and Mr. G. A. HUNT have been appointed to the board of High Duty Alloys Ltd., Slough, Buckinghamshire.

Mr. D. K. G. SLOAN has been appointed secretary and chief accountant of the Aluminium Castings Co., Ltd., in succession to Mr. R. B. McMILLAN.

Mr. D. HANCOCK has joined E. Boydell & Co., Ltd., as technical representative in South West England. He will operate from 134, St. Katherine's-road, Exeter.

Sales representation for LANCASHIRE DYNAMO & CRYPTO (MFG.) LTD., in Northern Ireland, is now in the hands of Burke & Son, Ltd., 18, Strangford-avenue, Belfast. Mr. J. MCCANDLESS, M.Sc., M.I.E.E., until recently deputy electrical engineer for Belfast, and now a director of Burke & Son, Ltd., will act as manager for Northern Ireland.

J. H. FENNER & Co., LTD., Marfleet, Hull, have opened a new branch at 73-77, Manchester-road, Burnley. The manager is Mr. E. HARDY.

LIGHT-ALLOY SLUICE GATES.

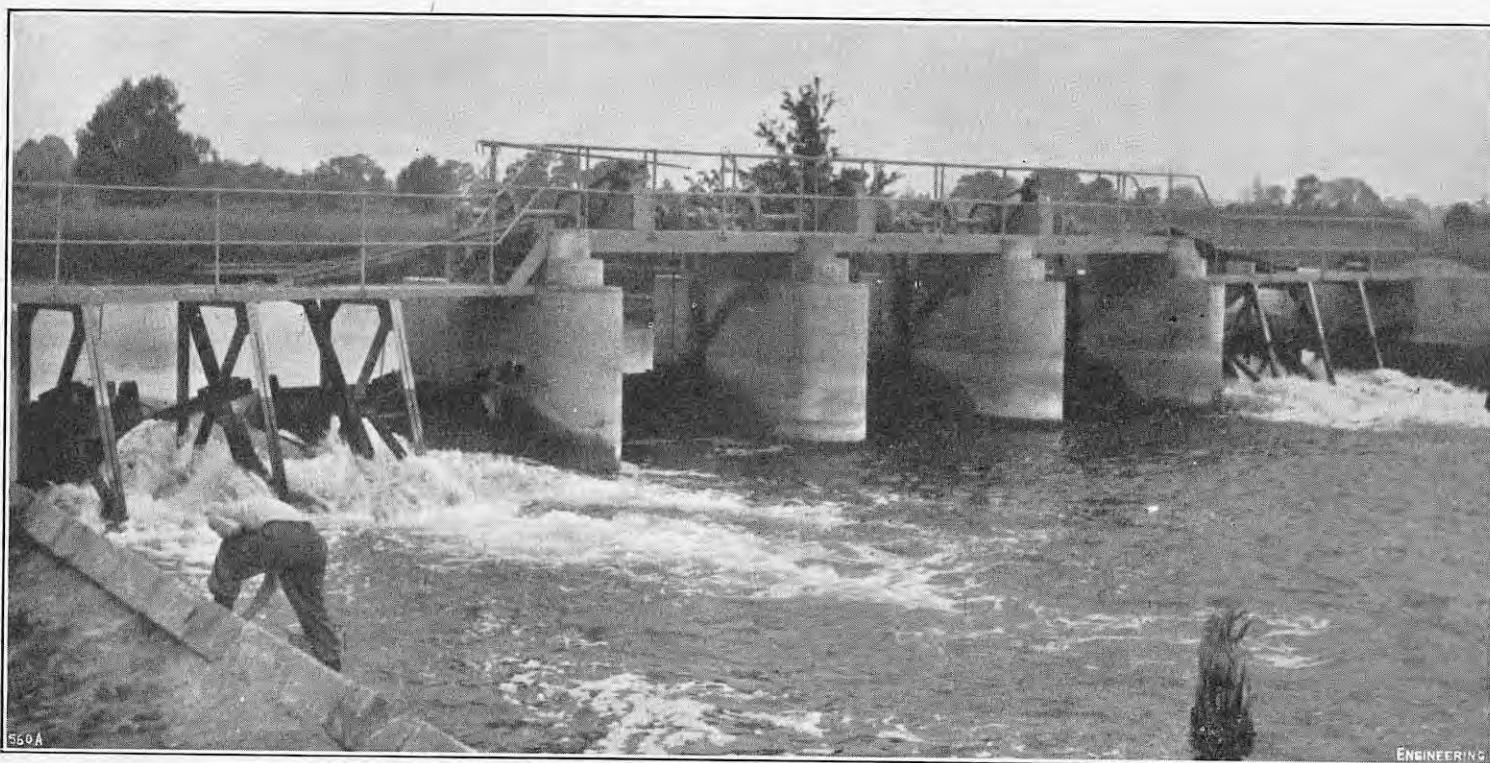


FIG. 1. EYNSHAM WEIR, DOWNSTREAM SIDE.

SLUICE GATES OF
"BIRMABRIGHT" LIGHT ALLOY.

THIRTY-ONE sluice gates constructed of Birmabright light alloy are being installed on four Thames weirs. The weight of the gates is thus considerably reduced, and although the gates are not geared and there is therefore no advantage from that point of view, the size of the counterweights is much less than it was with steel gates. The design of the gates has been carried out under the direction of the chief engineer of the Thames Conservancy, Mr. R. V. W. Stock, M.C., B.Sc., M.I.C.E., M.I.Mech.E., with the co-operation of Messrs. Birmabright, Limited, Woodgate Works, Quinton, Birmingham, 32.

All the gates are of the radial or sector type and are counterbalanced for hand operation without gearing. The advantage of this type of gate is that the resultant thrust from the water pressure and almost all the friction (apart from the slight friction of the sealing strips) are concentrated at the pivot pins; thus the torque due to friction is small and the gates are readily operated by hand. The gates are fabricated from standard extruded sections of Birmabright BB 019 alloy, and have skin-plates of Birmabright BB 3 alloy. The rivets are also a Birmabright alloy. The sealing or staunching of the gates is provided by half-round rubbing strips of BB 5 alloy, the strips being attached to thin bent plates and mounted on the front of the gates. When the gates are lowered the strips are pressed firmly against the staunching guides by the water pressure. The strips are visible on the open gates shown in Fig. 3. The light alloy was supplied "Alochromed," and a coat of zinc-chromate primer was applied before painting with the final colour.

For the Eynsham weir, shown in Figs. 1 and 3, eight gates, each 5 ft. 6 in. by 2 ft. 6 in., have been fabricated by Messrs. Westwood Dawes and Company, Stourbridge. These gates are only half the weight of similar sized gates in steel which were put in at Marlow weir. Messrs. Westwood Dawes have also provided 13 gates, 7 ft. 6 in. by 1 ft. 7 in., at Hurley main weir, and four gates, 7 ft. by 3 ft. 6 in., at Bray weir. At Grafton weir, the Head, Wrightson Aluminium Company, Limited, 20 Buckingham Gate, London, S.W.1, have built six gates, 5 ft. 6 in. by 3 ft. 1 in. If all these gates prove to be as durable as steel gates, the use of Birmabright alloys should be even more advantageous for larger, geared radial gates and for automatic tipping gates.

ROYAL AERONAUTICAL SOCIETY.—The 5th Louis Blériot Lecture organised jointly by the Association Française des Ingénieurs et Techniciens de l'Aéronautique and the Royal Aeronautical Society, will be given in February, 1952, by Mr. H. Knowler, A.M.I.C.E., F.R.Ae.S., in Paris. The 40th Wilbur Wright Memorial Lecture will be given by Sir Harry M. Garner, C.B., M.A., F.R.Ae.S.

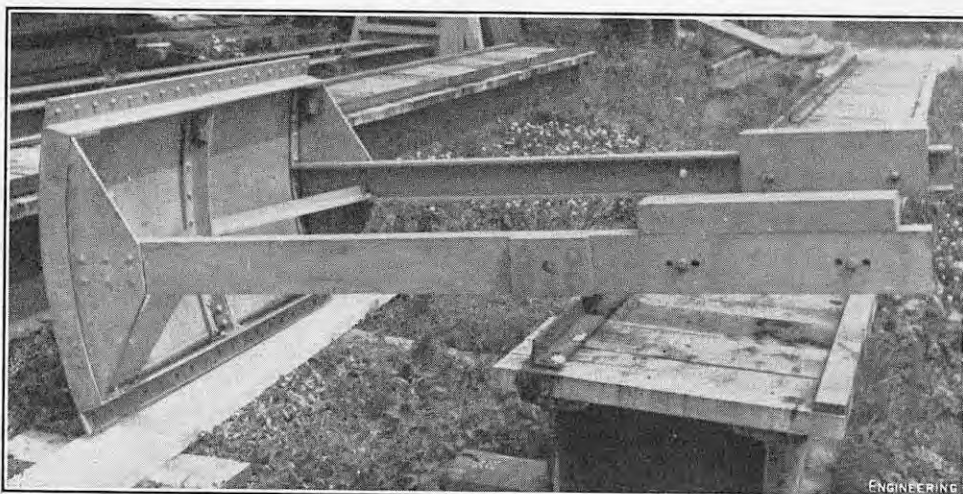


FIG. 2. GATE FOR GRAFTON WEIR.

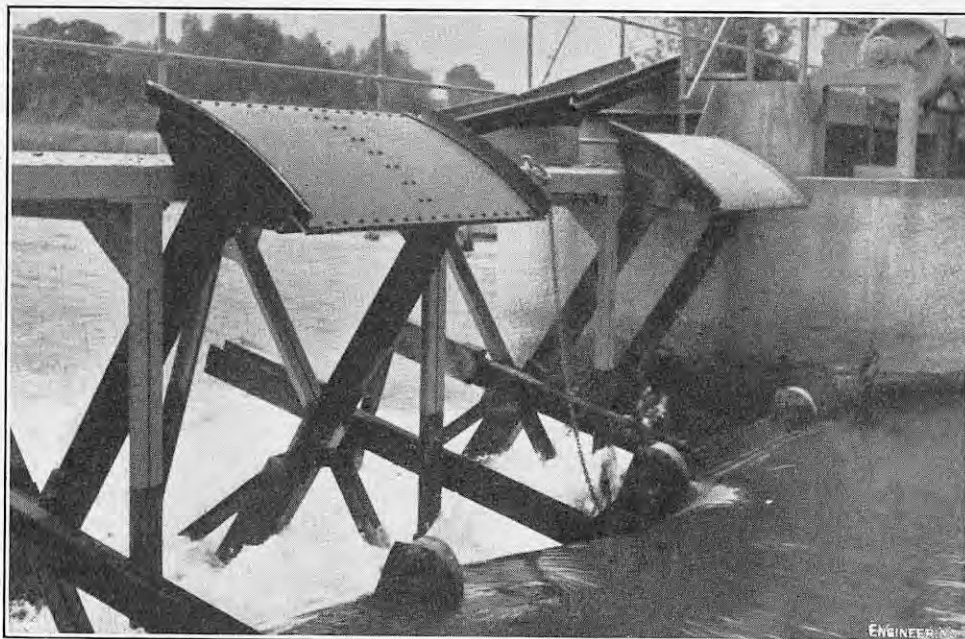


FIG. 3. GATES AT EYNSHAM, TWO LIFTED.

ENGINEERING,

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

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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ADVERTISEMENT RATES.

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

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

TIME FOR RECEIPT OF ADVERTISEMENTS.

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

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

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

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ENGINEERING

FRIDAY, NOVEMBER 9, 1951.

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No. 4476.

THE STANDARD OF LIVING.

THE phrase "standard of living" is current in the pronouncements of sociologists and politicians, but precisely what it means is not usually explained. Some may measure it by the size of pay packets, some by public services described as "free" but actually paid for, some may think its most important item would, or should, be the absence of regulations controlling their individual activities and there may be others who think their standard of living is higher than it used to be because they now work on only five days a week. On this reckoning, it would presumably be higher still if they worked only on four. None of these supposititious definitions can fairly be said to cover the whole of the items which make up the material welfare of a community, and it is with material things that the standard of living appears to be concerned. Possibly a definition which would be widely accepted is that the standard is determined by the goods and services generally available, with a rider to the effect that wages and salaries shall be adequate to pay for them.

This broad definition involves the assumption that the requirements and wishes of all individuals are similar, which is clearly not correct. There are many who now look upon the television service as an important contribution to their standard of living and probably some, in areas not yet covered,

who think their standard is unfairly reduced by its absence. On the other hand, there are considerable numbers of people to whom the service is of no interest and some, who have been waiting months or years for a telephone connection, who are hostile to it. An examination of the value set by different classes of people on the various things which constitute the present standard of living would lead to ramifications which cannot be pursued here. What is to be noted, however, is that the constituents of the standard are continually changing. Most of those who now look upon television almost as one of the necessities of life had never heard of it ten years ago and managed quite nicely without it.

The nation has been assured many times that its standard of living is to be preserved and it is to be hoped that those who give the assurances realise on what that standard is based. The physical, chemical, engineering and medical discoveries and inventions on which the material prosperity of Western Europe and North America is founded were made by physicists, chemists, engineers and biologists and not by the mass of the people, but the full and proper utilisation of those discoveries and inventions depends on the people themselves. Sir John Anderson, the chairman of the Port of London Authority, has stated that in the London docks there is a floating grain elevator which cost 150,000l. It works so quickly that the employees concerned contend that it is taking the bread out of their mouths and refuse to use it. Accordingly, it is standing idle. The engineers who designed this elevator made a contribution towards raising the standard of living; the men who refuse to use it are debasing that standard and increasing the cost of food, which is an important item in the standard. This is but a single example illustrating a point of view and a practice which is widespread.

It has just been said that food is an important item in the standard of living; it would be more accurate to say that it is the most important item and that if food supplies are to be maintained even at the present level more effective use must be made of the work of the relatively small band of scientific workers. It is not necessary to point out that there is a world shortage of food; there has been one for many years. As we pointed out last week, Malthus's prophecy that the world would starve because of population overtaking production proved false owing to the greatly increased yields made possible by engineering and biological progress. As far as this country is concerned, the situation was saved by the opening up of the great food-producing areas in North America, as a result of the same progress. In 1951, however, conditions appear to be getting a little nearer to those envisaged by Malthus. North America has not ceased to export food, but its population is rising and it is consuming more of its own production. It is doubtful whether that production can be materially increased. Europe obtains food from countries other than those in North America, but there is no certainty that this can make up for a reduction in American supplies. A report published by the Food and Agricultural Organisation of Washington stated that in 1934-8 Europe, excluding Russia, obtained 33 per cent. of the world production of food; in 1947-48, it obtained 25 per cent.

There is an important factor in this matter, the implications of which are probably not always realised. Eastern countries, industrially undeveloped, are demanding the right to emerge from tutelage and to manage their own affairs. Lack of experience and lack of administrative tradition will result in those affairs being managed inefficiently for very many years; outputs will fall and prices rise. Furthermore, these countries, with rapidly rising populations, are attempting to raise their own standards of living. They are eating more of their own food and, as far as they are able, will

compete for outside supplies; this will raise world prices. India, with a rapidly increasing population, has already become an importer of food. The general situation will be made worse if undeveloped countries make a habit of repudiating contracts and agreements. This will check the investment of foreign capital and further retard development.

These remarks about food apply also to most of the imported raw materials on which the prosperity, and the standard of living, of this country depends. It may be that the United Kingdom, as a member of the British Commonwealth, will be able to obtain sufficient supplies of food and most raw materials from the Dominions and Colonies, but we must expect to have to pay for them. Favourable consideration of the needs of these islands will no doubt continue to be given by the great Dominions, but they will expect something in return for their food and raw materials; and that something, in sufficient volume, and at competitive prices, will only be provided if the workpeople of this country take proper advantage of the methods, tools and materials which scientific and technical progress has made available. Much credit has been claimed by some politicians for the percentage rise in output which has been attained since the war. How far that rise falls short of the possible has been made clear by the Anglo-American productivity reports.

There is another matter which is of importance in connection with the maintenance and improvement of the standard of living. The complicated technical processes on which that standard is based, which owe their existence to the small band of scientific workers, require an important contribution from that band for their continued operation. The mass of the people not only did not devise the processes and machines on which modern material prosperity is based; they cannot even keep them running without trained scientific assistance. As is generally known, there is a shortage of scientific workers in this country. Almost as much has been said about it as about the standard of living. The questions of scientific education and increase in the number of scientific workers have been discussed many times in these columns and no doubt will be discussed again in the future. To do so now would be beside the point, but there are two minor aspects of the matter which may be mentioned. There are very many trained physicists, chemists, and engineers working in Government departments of one kind or another. We do not suggest that they are wasting their time, but it may be suggested that some of their work is not so important as increased output. Some of these people might usefully be transferred to industry. The second matter will probably not be regarded as "minor" by those directly concerned. There are many women who would make able chemists, physicists and biologists, and it may be wondered if it is sound policy to discourage them from studying for such professions by paying smaller salaries than men receive who are engaged on the same work. This matter is usually discussed from the point of view of simple justice, but it might be considered that these women should be encouraged because the nation cannot afford to do without their services.

The country, however, is not suffering only from a shortage of trained scientific workers; there is an equal shortage of labour generally. The number of the former cannot be increased rapidly; the number of the latter cannot be substantially increased at all. Nevertheless, the output from industry could be increased almost at once. It is merely a matter of dropping rigid demarcation and taking proper advantage of the methods and machines which the work of the scientific minority has made available. There is reason to believe that some labour leaders understand this, but they do not appear to be able to persuade their followers to act as though they also did. At the inquiry by the Railway Staff Tribunal into the railway unions'

claim for a 10 per cent. increase in wages, Mr. W. P. Allen, speaking for the Railway Executive, said, "we are not satisfied with the degree of assistance we have received from certain sections of the staff . . . in our efforts to improve efficiency and reduce general operating costs." Wages, which in 1938 totalled 103,750,000 £ , had increased in 1951 to 241,250,000 £ . A rise of this kind, for the same, or possibly less, effective work done, merely increases the cost of living and reduces its standard for everybody. How long it will be before organised labour realises that its own greatest advantage lies in frankly accepting the possibilities and implications of modern industrial methods, and in the abandonment of practices which waste man-power, none can predict; but there is no question that the present standard of living cannot be maintained, much less increased, in any other way.

SAFE MEANS OF ACCESS.

AMONG the many obligations placed upon employers by the Factory Acts and regulations there is one of which the meaning has often to be interpreted by the Courts. It is required by s.26 of the Act of 1937 that an employer must provide safe means of access to the places where a workman has to work. In a recent case (*Farquhar v. Chance Bros., Ltd.* (1951) 2 T.L.R. 666), the facts were as follows. A man was employed at a factory where there was a glass furnace. Without going into details, it is enough to say that, in the course of his work, he had to reach a platform which was 13 ft. 6 in. above the ground. The proper way to reach this platform was by a ladder, but the man tried to get to the platform by stepping across a gap of 4 ft. 6 in. between the platform and a girder a little higher up. He slipped and fell, sustaining injuries which resulted in his death. To his knowledge, suitable ladders were kept, some in a store 50 ft. away and others in a store 100 ft. away, and he had used a ladder on a previous occasion. In these circumstances, the employers were prosecuted for not providing safe means of access. The justices at Smethwick dismissed the application, but the factory inspector appealed to the Divisional Court.

The appeal was dismissed. The Lord Chief Justice said: "The employers had provided ladders, and if he (the deceased man) did not choose to use a ladder which he could have fetched himself, I do not think it can be said that the respondents have failed to provide a safe means of access." One of the judges (Mr. Justice Hilbery) said, however, "I should have thought, if I had been free to so find, that it would be right to say that you do not provide an article as a safe means of access to a place of work where work has to be done at a particular time, if you merely provide an article which can be made into a safe means of access. An article which can be made into a safe means of access is not the same thing as a safe means of access. A ladder in a store, however well maintained it may be, is merely a ladder, and, perhaps one of many which would be suitable for use as a means of access to a place of work. In my view, it does not become a means of access to a particular place of work until it is placed in such a position as is appropriate for its use as a way of getting to that place of work; and that is a question of degree." His Lordship went on to intimate that, if he had been deciding the case in a common law action, where the issue was whether the widow could maintain her claim under the Fatal Accidents Act on the basis that there had been a breach of the Factories Act, 1937, he would have decided in her favour.

In support of this opinion, he adduced a decision of Mr. Justice Devlin in the case of *Pinch v. Telegraph, etc., Co.* (1949) 65 T.L.R. 153. In that case, the plaintiff had suffered an injury to his eye by a flying particle of metal. The Factories Act, 1937,

and regulations made thereunder, required that the employers should provide an effective screen or goggles to protect persons engaged in the work on which the plaintiff was employed. In the factory, it had been the practice to hang suitable goggles near the plaintiff's machine, but, at the relative date, as a consequence of their having been mishandled, they were hanging in the foreman's office about 300 ft. away. It was proved that the plaintiff had not been given special instructions as to where to find the goggles. It was held that, in these circumstances, the employers had not fulfilled their obligation to "provide" goggles. With all respect to Mr. Justice Hilbery, the case of the goggles is widely different from those in the case of the ladder, if only because, in the latter case, it was in evidence that the man who suffered knew where a ladder was normally kept.

As, however, Mr. Justice Hilbery did not dissent from the view of the other two judges, and admitted that it was a question of the degree of care which an employer must take to provide "safe means of access," his opinion is academic. At the same time, many people will find it difficult to follow his reasoning. In every factory, a ladder has to be used on occasions. Must an employer see to it that there is a ladder available and ready to hand at every place where it may be required? To this question the answer is plain enough. What more can be expected of an employer than that he should have a ladder available at any time in a place known to all his workmen? It may be doubted whether another judge would have found that, in this case, the employers had failed to discharge their duty under the Statute. But though, in our view, the widow could not have made a successful claim at common law, it is obvious that she would have been entitled to an award of compensation under the Workmen's Compensation Act, her husband having been the victim of an accident arising out of and in the course of his employment. That being so, she would be entitled to prefer a claim under the National Health Insurance Act which would give to her all that she could have been awarded under a series of statutes which have now been repealed.

NOTES.

THE INSTITUTION OF MECHANICAL ENGINEERS.

A THEORY to account for the "cratering" of cemented-carbide cutting tools was advanced by Dr. E. M. Trent, M.Met., in a paper, "Some Factors Affecting Wear on Cemented Carbide Tools," which he presented at a meeting of the Institution of Mechanical Engineers on Friday, November 2. He suggested that the temperature of the rubbing surface of the chip, on leaving the body of the work-piece, increased rapidly from the time when it first made contact with the tool until it broke contact or until the melting point of the chip material (or of some alloy between the tool and the chip) was reached. The cratering type of wear in alloys containing free tungsten carbide was due to the formation of a fused alloy between the chip and the tool. The author had obtained evidence that, during friction at high speeds, this fused alloy could be formed between the tungsten carbide and the steel, the melting point of the alloy being not higher than 1,300 deg. C., which was much lower than that of tungsten carbide and nearly 200 deg. C. lower than that of many steels. Experiments showed that at 1,325 deg. C. there was a very rapid reaction between steel and a tungsten-carbide cobalt material; similarly with a material of tungsten carbide, titanium-tungsten carbide, and cobalt. A cemented carbide of titanium-tungsten carbide and cobalt, however, was attacked only slightly even at 1,350 deg. C. It was therefore reasonable to conclude that the rapid cratering of tools of the tungsten-carbide-cobalt type, when used on steels at high speeds, was caused by the formation of a very thin fused layer between the chip and tool surfaces, this layer consisting of an alloy of tungsten carbide with steel, which melts at

about 1,300 deg. C. This theory explained several phenomena, observed in practice, which the author enumerated. The discussion was opened by Mr. C. Eatough, who remarked that although, as the author had said, oxidation was probably not significant as a cause of wear during high-speed continuous cutting, as on a lathe, it was probably operative in the case of milling with carbide tools, since the cutting blades were continually entering and leaving the work. Dr. F. T. Bowden, in a contribution read by Dr. A. J. W. Moore, said he saw no difficulty in accepting the author's conclusion that a temperature rise of about 1,300 deg. C. would be reached, and Dr. Moore himself, speaking of the remarkable speed at which the chip's temperature was raised, said that there was plenty of evidence to show that when friction took place under such clean sliding conditions the meaning of the coefficient of friction began to disappear, and there might be values of 6 or 7, or even 20. In other words, the substances welded together. Mr. H. Burden disputed the author's theory of a fused layer, citing as evidence against it the observed appearance of the backs of chips. He suggested that if any alloy were formed its formation was intermittent. The chairman, Mr. J. M. Newton, B.Sc., closed the discussion with a plea to the makers of cemented-carbide tools not to identify such tools merely by symbols; the type of carbide should also be stated.

THE KELVIN MEDAL.

The Kelvin Medal for 1950, which was awarded to Dr. Theodore von Kármán, F.R.S., by the Awards Committee, consisting of the Presidents of eight leading institutions, which selects a recipient every three years, was presented to Dr. von Kármán on Tuesday, November 6, at a special meeting held in the Institution of Civil Engineers, Great George-street, London, S.W.1. Dr. W. H. Glanville, F.R.S., President of the Institution of Civil Engineers took the chair at the special meeting and invited Lord Runciman, President of the Institution of Naval Architects, to make the presentation. Lord Runciman, in doing so, explained that the Kelvin Medal was an international award, nominations for which were made to the Awards Committee by engineering and scientific societies in all parts of the world. Dr. von Kármán was chosen to receive the Medal because of his outstanding work on the flight of supersonic aircraft, rockets and guided missiles in his capacity as Professor of Aeronautics and Director of the Guggenheim Aeronautical Laboratory at the California Institute of Technology. A vote of thanks to Lord Runciman was proposed by Sir Andrew Bryan, President of the Institution of Mining Engineers, and seconded by Sir John Hacking, President of the Institution of Electrical Engineers. At the ordinary meeting of the Institution of Civil Engineers, which followed, Mr. A. S. Quartermaine was inducted as President by the retiring President, Dr. Glanville, and delivered his address, which we commence to reprint on page 599 of this issue.

HADFIELD'S HEAVY FORGE SHOP.

On Thursday, November 8, H.R.H. The Duke of Gloucester, K.G., performed the opening ceremony for a new heavy forge shop at the East Hecla Works, Tinsley, Sheffield, of Hadfields, Limited. The main purpose of the shop is to improve the firm's heavy special-steel forging facilities, and the equipment provided includes two air-hydraulic forging presses, one of 2,700 tons and the other of 1,500 tons capacity, and the necessary ingot re-heating and forged-product heat-treatment furnaces. The installation has been designed to handle ingots up to 45 tons in weight and to produce forgings up to 40 in. in diameter or 40 ft. long, rings having a maximum diameter of 12 ft., and sleeves measuring up to 6 ft. in diameter and 10 ft. in length. The new building occupies an area of 122,000 sq. ft., and is divided into four bays, namely a stock bay, a forge bay, a furnace bay and a heat-treatment bay. The last three bays have a crane span of 80 ft., a height of 52 ft. from floor level to crane-rail level and a total length of 386 ft. The stock bay has the same length as the other three but has a crane span of 57 ft. 9 in., and a height from floor level to crane rail of 39 ft. 6 in. The two

forging presses are served by 11 gas-fired re-heating furnaces ranging in size from 15 ft. by 7 ft. 3 in. by 7 ft. to 12 ft. by 6 ft. by 6 ft., while, in the heat-treatment section, there are nine furnaces which are also gas-fired, the largest measuring 40 ft. by 14 ft. by 9 ft., and the smallest 15 ft. by 9 ft. by 6 ft. 7 in.

MEASURING SMALL PARTICLES.

At King's College, University of London, on Tuesday evening, November 6, Dr. H. E. Rose, Reader in Mechanical Engineering in the college, delivered the first of four public lectures on the Measurement of Particle Size in Very Fine Powders. Stressing that the accurate determination of the geometrical relationships of a small particle was seldom of interest in itself, the lecturer emphasised the importance, nevertheless, of being able to estimate and control the sizes and size-distributions of particles forming powders used in industrial and chemical processes. Examples where such control was important were provided by vacuum-tube manufacture, in which fine powders were employed to absorb residual gases, pigment manufacture, where the particle size influenced the life of the paint, and cement manufacture, in which the setting-time and ultimate strength of the product depended on the size of the constituent particles. In the case of very fine particles, less than 60 microns in diameter, which would pass readily through the finest sieve, size-determination depended on an ability to measure the particle sizes by some other means. The three important quantities were the size-frequency, the specific surface, and the shape. Size-frequency and specific surface could be determined by photo-extinction methods. Surface area could also be determined by nitrogen-absorption, but the area so found might be many times greater than the superficial area determined by the photo-extinction method since the nitrogen molecules would frequently penetrate interstices in the particles. A number of size parameters were in common use including, for non-spherical particles, four definitions of an equivalent diameter. The relations between these were illustrated and some analysis was made of a typical size-distribution curve. Illustrative lantern slides were also shown. In his subsequent lectures, which will be given in Kings College on November 13, 20 and 27, respectively, all at 5.30 p.m., Dr. Rose will elaborate his subject and discuss in detail various methods of size-estimation.

THE ROYAL INSTITUTION.

The series of Friday Evening Discourses at the Royal Institution, 21, Albemarle-street, London, W.1, was resumed on Friday last, November 2, when the speaker was Sir John Cockcroft, C.B.E., F.R.S. Choosing as his subject "Experiments with High-Energy Nucleons and Quanta," Sir John said that the central problem of present-day nuclear physics was to discover the nature of the forces which held together the protons and neutrons in an atomic nucleus against the enormous electrical repulsion between the protons. For example, in an atom of uranium which had 92 protons in its nucleus, the electrostatic repulsion between the protons was approximately 10^{26} atmospheres. Reviewing the history of atomic physics, the lecturer suggested that it could be divided into four periods. The first was that of the Curies, the discovery of radioactivity and the associated degeneration of the heavy unstable elements into lead. The second phase was distinguished by the early work of Rutherford and Moseley, the development of the nuclear theory of the atom, the experiments of Marsden and Geiger, and the enunciation by Niels Bohr of his theory of stable electron orbits. The third era had been called the Golden Age of atomic physics. It had witnessed Rutherford's transmutation of light atoms by means of high-speed α -particles, the identification of the neutron by Chadwick, the discovery of the positron by Anderson, the development of particle accelerators, such as the Cyclotron, and, in its closing stages, nuclear fission on a grand scale. The fourth and latest phase, that since the war, had been marked by the discovery of still more nuclear particles, of which there were now some 20, either identified or due for discovery in the near future. This number included the various

mesons, transient particles the creation of which was believed to be associated intimately with the intranuclear bonding forces. Experiments had been carried out with the aid of the Harwell Cyclotron to determine the nature of these forces, which could be neither electrostatic nor magnetic. One set of experiments had consisted in bombarding a thin sheet of polythene with neutrons released from a beryllium target within the Cyclotron. The polythene, in its turn, emitted a stream of protons, the scatter pattern and energy distribution of which could be determined by the aid of an atomic "telescope." Discussing the role of mesons, Sir John recalled that their existence had first been predicted on theoretical grounds by Yukawa, in Japan, in 1934. He had calculated that their mass would be intermediate between those of an electron and a proton and that their life would be of the order of one millionth of a second. According to current theory, the nucleons were surrounded by meson fields, and Fermi had suggested that the interaction between a proton and a neutron consisted in the transfer of a positive meson from the former to the latter, which thereupon became a proton. Other interactions could be explained by the exchange of neutral, or negative, mesons. The study of mesons was now being actively pursued in several countries and new facilities for the work were continually being provided. The powerful Cyclotron at Chicago university was capable of producing streams of mesons. Particle accelerators, such as the Cyclotron, and high-energy X-rays, also found an important application in the production of new isotopes. After referring to the importance of cosmic-ray research in nuclear physics, and showing a number of lantern slides illustrating atomic disintegrations, the lecturer concluded by expressing the view that in the next decade important discoveries would be made in the atomic field which would greatly advance knowledge of fundamental physics.

FARADAY HOUSE OLD STUDENTS' ASSOCIATION.

The annual dinner of the Faraday House Old Students' Association was held at the Savoy Hotel, London, on Friday, November 2, the President (Mr. J. C. Thompson) being in the chair. In proposing the toast of "Faraday House" the President of the Institution of Electrical Engineers (Sir John Hacking) said that the functions of the Institution and of Faraday House were complementary. The first laid down standards of training both in theory and practice and the second provided the basic instruction necessary to attain those standards. Faraday House was unique in that it arranged for both types of training to take place during a four years' course, compared with five years by other bodies, a policy which necessitated great concentration on the part of both staff and students. The electricity supply industry was passing through a difficult period and had not escaped political criticism. He hoped, however, that no drastic changes would be made, as these might be harmful both to the industry and to the public. Technical co-ordination had led to economies, but these might be frittered away if discontent were caused among the workers or energy expended in replying to unjustified criticism. The Principal (Dr. W. R. C. Coode-Adams), in reply, said it was difficult to make the sandwich system comply with the requirements of industry. If civilisation were to continue it was necessary to have engineers, but whether this was a good thing, however, was another matter. The toast of "The Guests" was proposed by Mr. A. W. Berry. In reply, Vice-Admiral Sir Michael Denny said that the creation of the new L Branch in the Navy had added both to its strength and its effectiveness, for present day equipment could not be operated without the assistance of specialists. Faraday House had provided a large number of recruits for this branch and the records showed that a high standard had been reached. There was still, however, a shortage of personnel.

INQUIRY INTO LOSS OF S.S. "ELETH."—The formal investigation into the total loss of the s.s. Eleth while on a voyage from Birkenhead to Dundalk, Co. Louth, on February 2, 1951, has been fixed for hearing at the County Sessions House, Islington, Liverpool, on Tuesday, November 27, 1951, at 10.30 a.m.

LETTERS TO THE EDITOR.

TRAINING IN TWO CRAFTS.

TO THE EDITOR OF ENGINEERING.

SIR,—I was pleased to see in your Labour Notes (issue of November 2), that Sir Godfrey Ince, in his recent address to the British Association for Commercial and Industrial Education, had proposed the introduction of intensive training methods, which would provide in our apprentices and trainees resultant craftsmen skilled in two skilled crafts, in place of one in the same amount of time. This is a proposition which I have put before the Institution of Production Engineers at all the Centres in my recent lectures on "The Fundamentals of Production Management" and "Production Management Problems"; it has met with a response from production managers, and obviously needs further study with the Trades Union Congress.

The advantages, for the community as a whole, of double training in the same period of apprenticeship, traineeship, or extended periods on the American basis, are that each skilled craftsman has two crafts within his competence, doubling his security in jobs which he can tackle, and all manufacturing concerns have a very much improved flexibility of skilled labour, which, in the varying demands of their product, can be intensively utilised to suit high efficiency in the pursuit of higher productivity.

I trust this work will attract the attention of the various institutions concerned, now that it has been so admirably initiated in its general national context by Sir Godfrey Ince.

Yours faithfully,

M. SEAMAN,

General Manager.

The British Oxygen Company, Limited,
Engineering Works,
Angel-road,

London, N.18.

November 5, 1951.

TESTS ON CONCRETE WITH ELECTRICAL-RESISTANCE STRAIN GAUGES.

TO THE EDITOR OF ENGINEERING.

SIR,—I was interested to read, on page 531 of your issue of October 26, the reply of Dr. Grassam and Dr. Fisher to my letter which was published on page 468 of the October 12 issue. The main point of discussion appears to be the nature of the distribution of strain along a longitudinal strip of a cylinder undergoing axial compression, and this is dependent on the nature of the deformed shape of the cylinder.

The statement that the effect of complete lateral restraint at the ends of the cylinder is, theoretically, to raise the value of the effective modulus of direct elasticity at the ends by 2 per cent. over the value existing at the mid-height of the cylinder, which might be assumed to be laterally unrestrained, appears to be based on the assumption that the lateral constraint is produced by forces acting normal to the surface of the cylinder. This type of constraint would keep generators of the cylinder normal to the face of the loading platens at the ends while allowing curvature towards the mid-height. The generators, however, do not deform in this manner.

The lateral constraint is produced by the frictional force developed between the loading platens and the ends of the cylinder. This force acts tangentially in such a manner as to oppose the lateral expansion which would otherwise accompany the longitudinal contraction. This tangential force will therefore induce shear stresses at the ends of the specimen which will cause curvature of the generators. This curvature will be a maximum at the ends and will decrease towards the mid-height so that tensile strains which are caused by the curvature will be greatest at the ends. These tensile strains are superimposed on the compressive strain, and the gauges which record the overall longitudinal strains will therefore show maximum strain at the mid-

height and decreasing compressive strains towards the ends. This curvature effect, and hence the variation in axial strain, can be reduced by lubrication between the ends of the cylinder and the loading platens, but I do not know how the magnitude of the relief can be predicted in any particular case.

The lack of symmetry in my strain distribution curves is probably caused by unequal distribution of aggregate. The asymmetrical form of strain distribution became inverted if the cylinder was loaded in an inverted position, and on breaking up the cylinder there was found to have been a tendency for the coarser aggregate to settle towards the bottom of the cylinder.

I am not clear about the explanation of the fact, quoted by the authors, that they obtained a hoop strain at the mid-height which was about five times that measured at the ends, while at the same time they found a uniform longitudinal strain in the specimen. I agree with Dr. Grassam and Dr. Fisher that the sensitivity factor of an electrical-resistance strain gauge depends to a small extent on the value of Poisson's ratio for the material under test, and also to a small extent on the nature of the adhesive used, and it was for those reasons that I originally stated that the factor was "virtually" a function of the gauge.

Yours faithfully,

K. R. PEATTIE,

Lecturer in Civil Engineering.

The University of Nottingham.

November 3, 1951.

METAL ECONOMICS.

(Concluded from page 555.)

WE conclude below our report of the general discussion on "Metal Economics" held in London under the auspices of the Institute of Metals on Wednesday, October 17. Mr. D. A. Oliver was the second speaker in the afternoon discussion on "Scrap Reclamation, Secondary Metals and Substitute Metals."

Mr. D. A. Oliver stated that what had been said that morning was reassuring, as showing that there was no need to panic so far as Mother Earth was concerned. At the same time, the need for caution in economic arguments had been reinforced. In the first paper of the afternoon session, that by Mr. Bristow, Mr. Sidery and Dr. Sutton, the remark was made that the designer had great scope for influencing the metal economy side of the project. "Economic production calls for the closest collaboration between designer, production engineer and metallurgist," the authors had said. He would like to underline that statement, because there was an idea abroad that metal shortages were a figment of someone's imagination in some Ministry, and that if only existing designs were adhered to long enough, things would right themselves and business be as usual. If we were going to make appreciable economies in the national industrial field it did involve the most "dreadful" amount of re-design, hard work, fresh development and testing. In this connection, the only case that he could quote which had at all an atmosphere of completeness was one that had happened in the United States about a year ago. The radio and television industry there were told that their industry was rather a luxury one, and that they could have only about two-thirds of the metal they had had previously to meet a rapidly rising market. They had faced the situation, and sets which previously had weighed 28 lb. were re-designed to weigh only 17½ lb. It was a brilliant piece of research from beginning to end. Transformers were reduced in weight; they ran a little hotter, so that some more holes were made in the box and little flues put in, and they cooled themselves. The watt loss on the transformer was greater, but the consumer, rather than not have a television set, did not mind paying fractionally more on his electricity bill for the running of his set. In some cases one metal was sacrificed to save another, and magnesium, which fortunately came from sea-water, was very effective in protecting other metals. In some cases, therefore, the loss of the metal was not to be deplored if it saved corrosion losses in other directions.

Standardisation had naturally great possibilities for savings, and it was very interesting to find, in Mr. Dinsdale's paper, what was almost a closed-circuit economy, with a large measure of self-help inside that economy. It looked as though there was a move in the right direction for returning scrap to the makers, and it seemed to be becoming more customary for merchants to give more favourable consideration in supplying a particular user if he returned his scrap direct to them. Whatever might be thought of this, it was undoubtedly resulting in greater overall efficiency. Two interesting points were mentioned in the paper by Mr. Bristow, Mr. Sidery and Dr. Sutton. One was the possibility of replacing copper-bearing condenser tubes by aluminium. In the recent visit to the United States of the special team on scarce materials, under the aegis of the Anglo-American Productivity Council, an experiment in which aluminium or aluminium-alloy tubes were actually in a condenser had been referred to, and the information given had been that the performance to date was very satisfactory. With regard to the use of aluminium for 'bus-bars, Dr. Smithells had told him that it had been standard practice in the aluminium industry to use these made of aluminium, and recently, in Austria, in a large works he had seen a magnificent example of very massive aluminium 'bus-bars. The jointing difficulties had apparently been overcome; they were well scraped and mated and bolted with steel bolts, and one point which was made about them was that, owing to their lightness, they did not need such heavy supports along the length of the wall against which they were running. Another factor which was helping the economy drive, particularly in the sphere of ferrous metals and highly-complex alloys, was the use of the oxygen lance. This was an extra facility which had come into the picture in the last few years, and was very important in connection with limiting the carbon in stainless steels. Mr. Bucknall that morning had referred to the enormous importance of returning scrap to the makers of the particular product. The value of this needed emphasis, because, very often, provided due care was taken in segregation, the maker could recover the metals contained in the scrap immediately, with minimum losses and resulting in a maximum rate of circulation.

Dr. U. R. Evans said that Mr. Bristow, Mr. Sidery and Dr. Sutton, in their paper, had made the statement that "corrosion control can contribute substantially to metal conservation." He fully agreed. Conversely, prohibition of adequate corrosion control could contribute substantially to metal shortages. This was a very real danger at the present juncture and was not fully realised, at a time when, with a view to economy, the non-ferrous metals for the protective coating of steel were being cut down. Relatively large and valuable masses of manufactured steel were jeopardised in that way. In this situation, it was surely logical to consider the principles which governed the way in which protection varied with the thickness of a protective coat. It should be noted that the principles were utterly different according to whether one considered a metal which was anodic to the steel basis, such as zinc, or a metal like nickel, which was cathodic to the basis. In the case of zinc, it was frequently stated that the useful life of a zinc coat was proportional to its thickness. That was an over-simplification, but, in certain situations, it might serve, and, where it did, it should be relatively easy to decide what thickness of zinc could be used at the present time, having regard to the shortage of zinc and the value of the steel article which it was to protect. It was very important to notice, however, that this rule failed entirely if the zinc coating was not uniform. Some years ago an authority on galvanising had stated that, below a certain mean thickness of zinc coat, it was impossible to get uniformity. Consequently, it would always be uneconomic to go below that limiting thickness where one could no longer obtain substantial uniformity of thickness.

The case of nickel was mathematically quite different, as had been shown to some extent in some recent work at Cambridge—work which would be published in three papers in the journal of the Electrodepositors' Society. A very small reduction

in thickness of, say, nickel plating compared with what was customary could seriously cut down the effective protection. One of the things which worried him, at the present time, was the possibility that our reputation for high quality in export goods would disappear because someone would be tempted to send abroad plated articles which looked very like what had been sent in the past, and looked very much the same in the showroom, but which would look very different after a short time in service. That did not apply only to metal plating, and it did not always result from a desire for economy; sometimes it was due to carelessness. In a letter received by him recently, Mr. H. H. Burton had written: "I have been observing carefully the behaviour of the body protection on modern cars made since the war, and it is a fact that most of these are already in a much worse condition than those of cars made pre-war which are still in use. Some of the examples one sees are so shocking that one is forced to the conclusion that the steel sheeting could never have been properly cleaned before the protective coatings were applied." Speaking quite generally, Dr. Evans concluded, there was little doubt that greater care in the choice and application of protective coatings, whether metallic or non-metallic, would contribute to metal conservation quite as much as the organisation of the return of the uncorroded residues to the metallurgical industry in the form of scrap.

A communication from Mr. H. J. Miller, of British Copper Refiners, Limited, who was unable to be present, was read by Mr. N. B. Vaughan, and constituted the last contribution to the discussion. Mr. Miller wrote that secondary copper and copper-base materials arose from three different sources, namely, in the first place, "process scrap," recovered in engineering and other works from the fabrication of various products (this was sometimes termed "new scrap"). Secondly, there was "salvage or demolition scrap," which was obtained from recovery operations consequent upon the obsolescence of equipment, apparatus, vehicles, buildings, etc. (this was often described as "old scrap"). Thirdly, there were residues which comprised the slags, skimmings, and other by-products arising from the metallurgical industry which could not be utilised directly. It must be emphasised that the circulating or "run-around" scrap in the metallurgical industry, comprising rejected castings and wrought products, together with croppings, shearings, and other waste, did not enter into the picture of metal scrap supplies. This circulating scrap, while being a very high percentage of the total throughput of the works, should not give rise to any difficulties in use providing there was adequate segregation.

As regards the supplies of scrap from the three sources mentioned above, the available statistical data revealed the predominant importance of the first two groups; the residue type of material, which needed special processing, arose in much lower quantities than the other two. Another point which might be deduced from the available data was that, while over extended periods there was a fairly constant arising, or flow, of scrap, there might be enormous variations within short periods in the supplies of these materials, depending entirely on the relative rates of activity of different branches of the industry, and on the market "sentiment." Process scrap or new scrap became available after an interval of a few weeks or months from the time the semi-fabricated strip, sheet, rod or other products had been manufactured. The amount of such scrap varied widely, say from 10 per cent. to 50 per cent. for individual products, though it was probable that it averaged about 20 per cent. of the total quantity of semi-fabricated material. Clearly, in conditions of expanding trade, the time-lag which occurred before such scrap was returned to the metallurgical works resulted in a temporary scrap shortage; while, on the other hand, in conditions of contracting trade, it resulted in a glut. Thus, short-term trade cycles had important effects. By themselves both the expansion and contraction of trade affected the demands for scrap as well as virgin metals, because of the necessity of filling up, or alternatively of reducing, the "pipeline" in the works organisation.

The amount of scrap from demolition or salvage

operations was subject to an altogether different series of variations. While it was generally recognised that the non-ferrous metals were largely indestructible, and therefore that they might ultimately be recovered, there was nevertheless a fairly large loss due to inevitable waste and the imperfections of salvaging and recovery. It was not possible to state accurately any probable average recovery factor, but he would place it at 65 per cent.; this, incidentally, was a figure which had previously been established for the recovery factor for iron and steel products. This recovery factor might be expected to apply to copper and copper-alloy products after they had reached an average life of 25 years; this latter figure was, in itself, merely an estimate, as products had a life ranging from a few months to upwards of 100 years. Thus the quantity of old scrap which came forward at any given time bore a relationship to the metal put into service in the previous generation.

To some extent the decision to scrap plant, structures, buildings, etc., depended on the availability of replacements or improvements, whether this was in electrical equipment, ships, motor-cars, or other products; thus, decisions about obsolescence programmes were entirely dependent on the availability of new products. In addition, market prices had an influence on the rate at which scrap was recovered or sold by demolition firms, there being a tendency for supplies to be withheld with rising prices and to come forward with falling prices. It was therefore fairly clear that the supplies of salvage or old scrap were subject to a peculiar set of laws, and it was for these reasons that the metallurgical industries could not rely on stability except over long periods. It followed from these arguments that, with conditions of stable industry over a period of 25 years—which conditions had never existed and indeed were unlikely ever to exist—new scrap would amount to 20 per cent. of the metallurgical industries' turnover for copper and copper alloys, and the raw-material feed would be 65 per cent. old scrap. As, in general, there had been a gradual expansion in the consumption of copper, subject, of course, to many sudden increases and setbacks, old scrap had never reached this absolute importance. It was of interest to note that, in the years immediately before 1939 in the United States, old scrap amounted to 28 per cent. and new scrap to 14 per cent., thus giving a total of 42 per cent. of the copper consumption, the remaining 58 per cent. being virgin metal. This was an unusual state of affairs, to a large extent brought about by the more or less static industrial activity experienced in the decade 1930-39, and the performance had not been repeated since. In any event, the figure of 14 per cent. for new scrap seemed to be on the low side, because of the incompleteness of the statistics.

Fears had been expressed by primary-metal producers that scrap-metal supplies could exert a predominating effect on the livelihood of primary-metal producers. This was especially the case under conditions of contracting trade, because the flow of scrap metals was uncontrollable, such materials being thrown on to the market regardless of price conditions. Eventually, old copper-scrap supplies could exceed the supplies of virgin copper, and, although it could not be visualised that this could happen for a long time, there was evidence of the validity of this contention by the experience with lead, where old scrap supplies were now so abundant. As regards the uses to which copper and copper-alloy scrap could be applied in the metallurgical industry, it was his view that the combined efforts of scrap-metal merchants and consumers had resulted in a satisfactory utilisation of material. Under conditions of complete freedom of activity, there was an incentive to up-grade scrap, namely, to use it for the highest-grade purposes possible. In general, it was only in the case of excessive up-grading that difficulties occurred. Under conditions of primary-metal shortage, such as existed at the present time, many unnatural forms of incentive to employ scrap were experienced. The conditions which now existed were most certainly not typical of previous years, and, therefore, too much emphasis should not be placed on the present conditions, and on some of the difficulties encountered.

For convenience, he regarded the copper industry

as consisting of eight sections, each of which was characterised by totally different requirements; these sections of the industry were: (1) copper for electrical products; (2) other fabricated copper products; (3) brass strip, tubes, etc. (i.e. alpha-brass products); (4) brass rod and sections (i.e. alpha-beta brass products); (5) brass castings; (6) gunmetal and bronze castings; (7) miscellaneous (including special alloys); and (8) copper sulphate. Each of these groups differed in its capacity for absorbing scrap, because of the fact that the inevitable impurities associated with scrap had different effects, a matter which was recognised by British Standard and other specifications applying to the various products. On account of the varying effects of impurities, the scrap consumption in the eight groups of the copper industry varied from nil up to 100 per cent., the latter figure applying to those compositions and types of castings made from alloy ingots, and also to certain grades of brass-rod products, as well, of course, as copper-sulphate manufacture. The relative tonnages involved in the eight groups were clearly of importance, and when brass castings and brass rod were required in large quantities the scrap-metal absorption was naturally appreciable. On the average, all the eight groups of the copper industry could utilise up to 40 per cent. of the total scrap, so that the virgin copper requirement was 60 per cent. The figures published by the British Bureau of Non-Ferrous Metals Statistics for recent months confirmed these percentages. Actually, in pre-war years in England, the percentages were probably nearer 30 per cent scrap and 70 per cent. virgin metal.

The overall conclusion was that it would not always be possible to absorb all the "arising" of new and old scrap directly; the excess amounts would of necessity have to be treated for recovery of the constituent metals. Indeed in the United States such recovery had been undertaken for a very long time and large quantities of electrolytic copper had been produced from secondary materials. Owing to the cost of the methods of extraction and purification, the prices which the scrap commanded were lower than if it were used for direct production. Hence this recovery had only been made on marginal amounts and, from the arguments which had been advanced, these marginal amounts would tend to become greater. Efforts must always be made to ensure a greater direct use of scrap, as this was more economic. To facilitate this, it was most important that process or new scrap should be kept clean and well segregated, and that, in the case of old scrap, there should be the most judicious classification. In all instances there should be a maximum "up-grading." Finally, while much could be written in regard to the classification and preliminary treatments undertaken to render scrap more amenable in physical form, and sometimes in composition also, for direct use, the commonest methods were magnetising processes to remove iron, burning to remove volatile matter, centrifuging to remove water (as from swarf), and baking, shearing or masticating to reduce the volume of the scrap, as was the case with slittings and turnings.

The President, in a brief final speech, stated that in the debate between what might be called roughly the pessimists and the optimists on the prospects for the future supplies of metals, it might be said that, on the whole, the optimists had put their views with the greater force. Industry would hope that this reassurance would prove to be well founded. It was not certain, at the moment, how fully the Institute would be able to report that day's proceedings. The Publications Committee would have to look very carefully at existing commitments for paper, and see what could be squeezed out to use, in some form, a report on the discussion on "Metal Economics." He was glad to say, however, that the proceedings would be reported in the technical journals. He hoped that that day's meeting would encourage the Institute to return to this subject by way of another discussion during next year. It would then be most interesting to see how far that day's opinions and prognoses would stand and how far they would require modification.

A vote of thanks to the authors, moved from the chair, was carried by acclamation and the meeting terminated.

P. W. WILLANS: A CENTENARY MEMOIR.

By K. W. WILLANS, M.I.Mech.E.

ON November 8, 1851, the year of the Great Exhibition, Peter William Willans, inventor of the Willans central-valve steam engine, was born in the city of Leeds. He was the third child and the second son of Obadiah Willans, and his mother was Elizabeth Tetley, daughter of Henry Tetley of Azenby Lodge, Topcliffe, near Thirsk. From old records it seems that the Willans family were of Scottish extraction, emigrating to England with James I and settling in Yorkshire, where, for generations, they had been woollen manufacturers. Another branch of the family settled in Ireland. The Tetleys were farmers. His mother died at the early age of 43; but his father, who died in 1896, was then 87, his elder sister died in 1940 at the age of 92, and his brother, John Russell Willans, in the same year at the age of 85. It is probable, therefore, that my father would have lived to a great age and preserved his mental powers to the end, had it not been for a bolting horse. On May 23, 1892, when he was driving to Brookwood station on the then London and South Western Railway, his horse took fright at a passing train and bolted. My father was thrown out on to his head, fracturing his skull, and died without recovering consciousness.

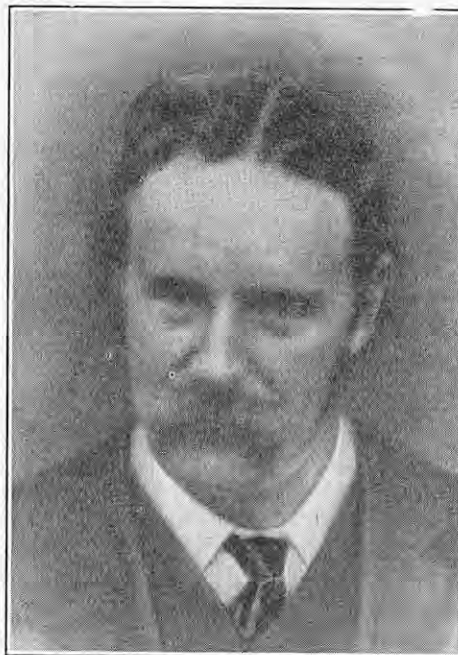
Looking back on the obituary notices, which appeared in every technical journal at the time, it is easy to see how myths come into being. My father, after a period at a "dame's school," went at the age of 10 to the Leeds Grammar School; that was in January, 1862. He left the school in 1867 to start his apprenticeship. He was undoubtedly idle, in the sense that he did not work at his lessons, but at the same time his memoirs state that, when he reached the Fifth and Lower Sixth forms, his verse-making in both Greek and Latin gave promise of a brilliant university career, had he not transferred to the scientific department of the school. The fact is that my father (like his son) worked hard at what he wanted to learn and at that alone. Again, I doubt very much the statement made in another memoir that he was a firm believer in a classical education. In the late eighties and early nineties, educationists were already at loggerheads on that debatable issue and I suspect that it was convenient to ascribe views on the subject to anyone whose opinion was sought on other matters.

In 1867, my father began an apprenticeship with the firm of Carrett and Marshall, in Hunslet. Shortly before he came out of his time, in 1872, the firm changed hands and also their name, eventually to become much better known as Hathorn, Davey and Company. My father was asked to continue as an improver, but, as his great friend W. H. Massey* had left Leeds for London, and as a vacancy for a draughtsman existed at John Penn's works at Greenwich, he went South and started there. It was while he was working at Penn's that he studied the theory of steam engineering, as far as it was then known; and it was from that time onwards that he learned mathematics, not by attending evening classes, but by seeking out the knowledge required for the solution of immediate problems. In later years, he paid generous tribute to the help given to him by his close friend, John Macfarlane Gray, to whom he owed much of his knowledge of the higher mathematics.

While still at Penn's, my father took out his first engine patent, No. 974 of 1874. This patent covered steam engines with three lines of reciprocating parts, the steam distribution to each line being controlled by valves driven by the adjacent line. Reverse rotation was obtained by changing the sequence. The first engine of this type was built at Penn's and drove the pattern-shop machinery for many years; but the firm were not prepared to undertake its manufacture, so my father left them and, in company with W. H. Massey and a Mr. Ward, started the firm of Willans and Ward to develop the invention for both stationary and marine purposes. Tangye Brothers took the licence for manufacturing the engine for land use, while Hunter and English, of Bow, built it for

marine purposes. This engine suffered from certain basic defects, the main one being that the exhaust from the cylinders passed into the crank chamber and thence to the condenser or atmosphere, but it was, without doubt, the first commercially successful enclosed-type engine. In 1880, my father married, and, together with Mark Heaton Robinson, founded the firm of Willans and Robinson at Thames Ditton, to build engines under patents Nos. 974 of 1874 and 1572 of 1880, the latter patent remedying certain detail defects of the earlier one. The firm also built yachts and launches.

In 1884, pressed by Colonel R. E. B. Crompton and W. H. Massey, my father supplied a launch engine, direct-coupled to a dynamo, for experiments in train lighting on the Metropolitan District Railway; and, in the same year, four direct-coupled generating sets, using modified launch engines, were supplied to Buckingham Palace for electric lighting. From this date, the use of this modified launch engine, known as the "Triple Tandem Special," for electric generating, outstripped its use for marine purposes, until, in 1884, the central-valve engine was introduced. In 1889, the works were largely destroyed by fire, the boat-building shed alone escaping. By this time, the demand for



PETER WILLIAM WILLANS, 1851-1892.

generating sets had become very great, and so the boat-building business was given up, the boat shed becoming a temporary machine shop.

From this time onward, my father was concerned with the development of the central-valve engine and, later, with a variation of the engine, with the line of valves outside the cylinders. In 1886, he read his first paper before the Institution of Civil Engineers on the electrical regulation of the speed of steam engines. In 1888, he read his classic paper on economy trials of a non-condensing engine; and a third paper on condensing trials would have been presented by him during the 1892-3 session, had he not died before it could be delivered.

At the time of his death, technical education was developing rapidly and, in view of this, and having regard to the important bearing which his paper on steam-engine trials had on the theory of steam engines, it was to be expected that the obituary notices of his career should lay stress on his ability in research. Looking back, however, and taking into account trends in the engineering industry, I feel that his reputation should rather stand on his introduction of interchangeable manufacture, as early as 1886. It is clear from a letter in my possession that, in October of that year, he was just completing the design of the first series of central-valve engines. This range covered engines with low-pressure cylinders ranging in diameter from 5 in. in the "A" size to 20 in. in the "I" size. These engines could be built as simple,

compound, and triple-expansion units with one, two or three cranks. Not only were all parts strictly interchangeable, but the low-pressure pistons of one size were used as intermediate-pressure pistons in a larger size, and high-pressure pistons in a size larger still. All the parts were made for stock and, when an order was received, the necessary items were drawn from the stores and assembled.

He was notable, too, for his ability to handle men; and, among his other characteristics, could, and did, give honest advice to competitors, taking the long view that, by helping them, he was bound to develop his own knowledge. His contributions to discussions at meetings of scientific institutions were marked by a perfect courtesy, and criticism that was invariably constructive. His dry, satirical sense of humour made conversation with him a delight and this, coupled with his geniality and rather old-world courtesy to his men, made his death a disaster to them, and led to unusual scenes of grief at his funeral, which was attended by the whole of the works personnel. The accompanying portrait—the last photograph of him that was taken—was reproduced from a works group and distributed to all the employees of the firm, together with a reproduction of the memorial brass that was placed in the church at Thames Ditton.

Had he lived, I feel sure that he would have concentrated still more on the development of good relations between the firm and their workpeople, and it is probable that he would have blazed as broad a trail in this direction as he did in steam-engine design. He died just as the results of his work were beginning to bear fruit. I am certain that he would have continued to benefit his workpeople in every possible way—while demanding, in return, a straight deal from them. After the fire in 1889, the engineering trades unions attempted to take advantage of the situation to obtain conditions which he considered unfair. A strike followed which he fought to a finish, and never afterwards would he employ a trade-unionist.

In addition to his steam-engine inventions, he was undoubtedly the true and first inventor of the epicyclic reverse gear for marine purposes, in which the thrust of the propeller is used to keep a friction clutch in engagement; this was patent No. 4340 of 1889. I think that he was also the first inventor of a magnetic coupling, his patent being No. 16347 of 1890. Couplings of this type were installed at Bankside generating station not long before his death, in connection with 350-kW central-valve engines.

P. W. Willans was a heavily-built man, standing 5 ft. 10½ in. in his socks, though he did not look his height. His hobbies were figure skating and fly-fishing, and he would think nothing of walking 12 miles to a stream, fishing all day, and walking 12 miles back. It was, perhaps, a pity that the growth of the electrical industry took his mind so completely off marine engines; had he continued to build them, the development of high-pressure high-superheat types might have been pioneered in this country, instead of on the Continent. As it was, his launch engines were such an advance on contemporary practice that he was compelled to build boats as well, to overcome the boat-builders' reluctance to install them.

PRINCESS AIR TRANSPORT COMPANY, LIMITED.—To study the factors affecting the operation of Saunders-Roe Princess flying boats, and in order to be in a position to tender for their operation should the opportunity arise, a company has been formed of which three-quarters of the share capital is being subscribed by Saunders-Roe, Ltd., Cowes, Isle of Wight, and one quarter by Airwork, Ltd., 15, Chesterfield-street, London, W.1.

FIRTH BROWN TOOLS, LIMITED: COLOUR FILM.—Messrs. Firth Brown Tools, Limited, Carlisle-street, Sheffield, E.4, have produced a colour film, entitled "First and Best," illustrating the manufacture and uses of their range of drills, reamers, shears, files, saws for hot and cold metals, and other engineers' tools. The film, which runs for about 35 minutes, was shown privately on November 6 at the Dorchester Hotel, London, W.1, to a large party of guests, who were received by Lord Aberconway, chairman, Mr. Eric Mensforth, managing director, and other members of the board. It was made by Mr. S. H. Thorpe, F.R.P.S., the firm's photographer, and is a notable example of colour cinematography under difficult conditions.

* For obituary notice of W. H. Massey, see *ENGINEERING*, vol. 149, page 529 (1940).

RAILWAY CIVIL ENGINEERING.

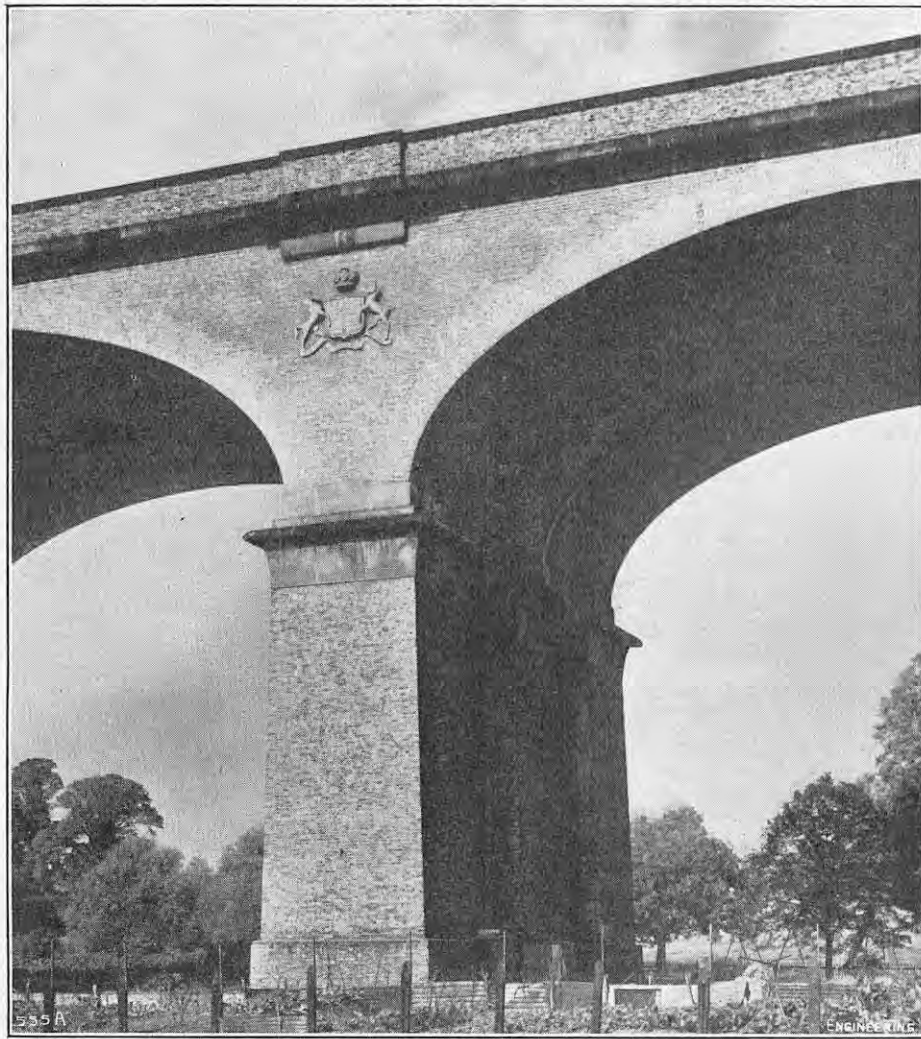


FIG. 1. THE WHARNCLIFFE VIADUCT.

THE INSTITUTION OF CIVIL ENGINEERS: PRESIDENTIAL ADDRESS.*

By A. S. QUARTERMAINE, C.B.E., M.C., B.Sc. (Eng.).

MR. V. A. M. ROBERTSON, in his presidential address in 1949, covered the progress of civil engineering on the railways of Great Britain during the past 20 years, and volunteered to leave sufficient matter for a future presidential address by a railway engineer. Knowing his generous nature, I sought for the leavings, but with little success. I was, however, heartened by Robert Stephenson's prophetic words, in his address to this Institution in 1856, when he said: "Our British Railways present a fertile theme for observation." I am accordingly venturing to take the early days of railway construction as a background, before making reference to some of the conditions with which we are now confronted. As so much of my life has been associated with what was formerly the Great Western Railway, it would, I feel, be appropriate to select as an example of early railway construction some of the works of that famous engineer, I. K. Brunel.

In March, 1833, Brunel was appointed engineer for the construction of a railway from London to Bristol, and it is noteworthy that he had refused to allow his name to be considered when it was proposed to select the engineer by means of a competition among the candidates for the lowest estimates for building the line. His views on the proposal were definite. "You are holding out a premium," he said, "to the man who will make you the most flattering promises. It is quite obvious that the man who has either the least reputation at stake, or who has most to gain by temporary success and least to lose by the consequences of disappointment, must be the winner in such a race." It is fortunate for us to-day that attention was paid to these words. Brunel was selected, and we are now reaping the benefit of his foresight and skill, and the hard work and careful thought he gave to the construction and future success of the railway.

* Delivered in London on Tuesday, November 6, 1951. Abridged.

Isambard Kingdom Brunel, born in 1806, the only son of Sir Marc Isambard Brunel, had the benefit of a liberal education, followed by engineering training under a father who was an engineer of exceptional ability. From the age of 17, young Brunel was regularly employed in his father's office, and at 20 was resident engineer during the later and more difficult period of the construction of the Thames Tunnel. This work involved so many difficulties, emergencies and failures that it is not surprising that Brunel learnt what was to serve him so well throughout his life—endurance and self-reliance. Although he had this good start in his career, his appointment as engineer to the Great Western Railway at the early age of 27 was remarkable proof of the directors' confidence in his strength of character and his ability.

Before the Bill for the railway could be deposited, full financial support was necessary, and, as this was not forthcoming in time, a Bill for a curtailed project was deposited in November, 1833; this was for one railway from London to Reading and another from Bristol to Bath. The Bill was thrown out by the House of Lords, but during its passage through committee in the Commons, Brunel, whose cross-examination lasted 11 days, excelled himself in dealing with the varied and violent opposition. Among the opponents were those interested in canals, rivers, and stage coaches; land owners and farmers near London who feared competition with produce from a distance; those who wanted the railway nearer to them, and those who wanted it farther away. By the following autumn, sufficient money had been raised to enable the directors to deposit a Bill for the complete line from London to Bristol, thereby avoiding one criticism of the previous proposal, that the railway had a head and a tail, but no body, and was neither "Great" nor "Western," nor even a "Railway."

The principal objection now centred on the location, which had been determined with that skill and courage displayed by Brunel in all his works. His idea was to build a line of very easy gradients and curves, except where this was physically impracticable towards the Bristol end of the line. Here he concentrated his rather steep gradients of 1 in 100 in two comparatively

short lengths totalling four miles, so that, if assistant engines were needed, their use would be restricted to this limited portion of the 118-mile journey. Apart from these two inclines, the gradients consisted of 71 miles of level or flatter than 1 in 1,000, and the remaining 43 miles not steeper than 1 in 660. Similarly, the curves for the first 100 miles from London were very flat, only a short length being as sharp as 85 chains radius, and the rest between 100 and 500 chains.

The opponents of the Bill contended that the railway to Bristol should be by means of an extension, from Basing to Bath, of the railway sanctioned in the previous session by the Southampton Railway Act. Brunel maintained that the gradients of a line from Basing to Bath would be unsatisfactory, but the opponents, while admitting that the gradients would be more severe, stated that they were so balanced that the rises and falls compensated one another and the line was therefore, in effect, practically level. The chairman of the committee commented that, on this theory, the Highlands of Scotland would be as good as anywhere for the construction of a railway.

Another strong line of attack was centred on the proposed tunnel of nearly two miles in length at Box, which was described as "monstrous and extraordinary" and "most dangerous and impracticable." Though Brunel's persuasive powers overcame this opposition also, it is recorded that, when the line was opened, many passengers left the train before reaching Box Tunnel, and finished the journey by road.

The greatest contest was in the House of Lords, where the battle was fought in committee for 40 days, the opposing counsel, Mr. Sargent Mereweather, delivering a four-day speech, during which he claimed that almost every conceivable injury would be inflicted by the G.W.R.—the Thames would be choked up for want of traffic, the drainage of the country destroyed, and Windsor Castle left without water. Eton College would be ruined, as London's most abandoned inhabitants would come down by train and pollute the minds of the scholars, and the boys themselves would run up to Town and indulge in all forms of dissipation. In spite of all these and many other gloomy prophecies, the Bill was finally passed, receiving the Royal Assent on August 31, 1835.

Construction of the railway then proceeded at a speed which we cannot fail to admire when we take into account the scarcity of assistants with engineering experience, and the almost complete absence of mechanical equipment. On the other hand, Brunel did not suffer from shortage of labour, or from the delaying action of Town and Country Planning Acts. Started late in 1835, the line from London to Maidenhead, 24 miles long, was opened in June, 1838; to Twyford, another seven miles, in July, 1839; to Reading, a further five miles, in March, 1840; and to Chippenham, a total of 94 miles, in May, 1841. The line from Bristol to Bath was opened in August, 1840, and the final line from Bath to Chippenham, including Box Tunnel, in June, 1841.

The first contract at the London end was for the viaduct across the Brent Valley near Hanwell, let in November, 1835, 2½ months after the Royal Assent to the Bill, and completed in 18 months. It is 300 yards long and 65 ft. high, comprising eight elliptical arches of 70 ft. span, each pier being formed of twin pillars slightly tapered on all faces, and surmounted by stone capitals. It was named the "Wharncliffe Viaduct" after Lord Wharncliffe, who was so helpful when the Bill for the railway was before the House of Lords Committee, and is illustrated in Fig. 1, on this page.

The next structure worthy of special mention is the brick arch bridge over the River Thames at Maidenhead, a standing tribute to the skill and courage of Brunel, and to his pleasing sense of proportion. The bridge is formed of two flat elliptical arches, each of 128 ft. span and a rise of 24 ft., with four semi-circular arches of about 28 ft. span at each end. The work was started in 1837 and the centering eased after 12 months, which operation delighted the critics, as the eastern main arch distorted slightly, though the western one was unaffected. The contractor admitted his error in easing the centering too soon, and rebuilt the defective portion of the eastern arch. The centering was then left in position until late in 1839, when it was blown down by a violent storm, leaving the critics once more in despair, as the arch and the whole of the bridge remained in perfect condition. Since then it has required only superficial maintenance, and carries to-day the heaviest modern locomotives and high-speed traffic. When it became necessary in 1890 to quadruple the line, the widening was carried out to the same design by an addition on each side, the stone string courses and capping being refixed or reproduced on the new up and down stream faces. Tie-rods 1½ in. in diameter were inserted at regular intervals across the bridge between the new spandrels, but not so as to show on either face.

Nine miles farther on, between Twyford and Reading, is the start of the cutting through Sonning Hill, nearly two miles long, with an average depth, for half a mile,

of nearly 60 ft., involving a total excavation of about 1½ million cubic yards. The first contractor started at the end of 1837, but failed to make the promised progress and was replaced by three others, one of whom also failed early, due to trouble with his men. The work was ultimately completed in December, 1839, by direct labour under a resident engineer, and included two bridges across the deepest part of the cutting, one a three-arch bridge for a turnpike road, and the other a typical Brunel timber bridge for a minor road.

From this point westwards to Box Tunnel, 100 miles from London, the works were considerable and varied, including lengthy and high embankments, and deep cuttings, many of which gave trouble due to the unstable nature of the clay; a variety of bridges, including two over the Thames at Basildon and Moulshford, each consisting of four 62-ft. brick arch spans; a stone viaduct just west of Chippenham, followed by a high embankment for over two miles, and then three miles of almost continuous deep cutting leading to the tunnel under Box Hill. This tunnel, the subject of so much criticism during the passage of the Bill, was the longest contemplated at that time.

The strata to be penetrated consisted of great oolite or Bath stone at the eastern end, followed westwards by light clay, inferior oolite and marl. The half-mile length through the Bath stone, forming Contract No. 1, was to be left unlined, the remainder, Contract No. 2, being lined with brickwork throughout. The six permanent and two temporary shafts, varying in depth from 70 ft. to 260 ft., were completed in time for the two contracts to be let for the tunnel construction in 1838. Apart from two steam pumps, to deal with the heavy influx of water, men with horses, manual tools, and gunpowder accomplished the work. The excavated material was drawn up the shafts by horses turning rope drums, and, at the peak of the work, 4,000 men and 300 horses were employed. The flow of water from numerous fissures impeded progress, and for eight months a section of the work was stopped, as the water gained on the steam pump, flooding the workings and rising to a height of 56 ft. in one of the shafts. This was eventually overcome by the installation of a second steam pump of 50 h.p. In February, 1840, when two-thirds of the tunnel was constructed, three additional shafts were sunk to provide more working faces, as completion was becoming increasingly urgent. Brunel and his resident engineer, William Glennie, forced the pace, and by continuous night and day work the tunnel was finished ready for the opening of the last section of the line in June, 1841.

The Inspector-General of Railways, Sir Frederick Smith, reporting on the line on June 28, 1841, described the unlined portion, which in places is 40 ft. high, as "formed by excavating the natural rock in the shape of a gothic arch, no part of which is lined with masonry." Much fear was entertained in regard to the safety of the tunnel, and this was increased by the statements of an eminent geologist, the Rev. Dr. W. Buckland, in May, 1842, when he expressed the view that those portions of the tunnel constructed through the great oolite and left unsupported were peculiarly liable to danger, and he feared that the vibration caused by railway carriages would tend to loosen and detach masses of stone. This resulted in a special examination being made by Sir Frederick Smith's successor, Major-General C. W. Pasley, who upheld Brunel's opinion, stating that he was perfectly satisfied with the security of the tunnel. After a severe frost in 1845, a small piece of rock fell from the bottom of one of the temporary shafts, and arches were turned under this and one other shaft. About 50 years later, a further section was lined after a fall following an exceptional frost.

The works between the tunnel and Bristol were generally more varied and heavy than those on the London side of Box. They include a second tunnel near Box, 200 yards long, a handsome arch bridge of 90 ft. span over the River Avon at Bathford, a long and high retaining wall holding up the Kennet and Avon Canal, two short tunnels and a viaduct of 33 arches, leading to an 88-ft. span arch bridge over the Avon at Bath station, which itself was built on arches. Leaving Bath, the railway again crossed the Avon by two 80-ft. span timber arches on a 60-deg. skew, followed by a viaduct of 71 arches, another part viaduct and part retaining wall one-third of a mile long, and a walled cutting leading to Twerton Tunnel, 264 yards long. After this there were two miles of high embankment, a deep cutting, Saltford Tunnel, 176 yards long, another long embankment and deep cutting, two short tunnels—subsequently opened out—and then a 1,000-yard tunnel at Brislington and two shorter tunnels, one of which was also opened out at a later date. Finally, in the last mile, there were bridges over the Avon, the feeder canal, and the Floating Harbour, leading to the terminus at Bristol, which, like the station at Bath, was built on arches. The original station at Bristol forms to-day the present Nos. 13 and 15 platforms, and the roof, still in good condition, is an example of handsome timber work.

(To be continued.)

LABOUR NOTES.

WILLINGNESS to co-operate with the new Government was expressed in an announcement issued by the General Council of the Trades Union Congress at the close of its meeting on October 31. Reference is made in the statement to the long-standing practice of the T.U.C. to work amicably with whatever Government is in power, and, through consultation jointly with the Ministers concerned and the other side of industry, to find practical solutions to the social and economic problems facing the country. In such joint consultations, as in all its other activities, it would be the constant aim and duty of the T.U.C. to ensure the steady progress and betterment of the general conditions of Britain and of British trade unionists. The T.U.C. would continue in that duty under a Conservative Government.

Since the Conservative administrations of pre-war days, the statement continues, the range of consultation between Ministers and both sides of industry had increased considerably, and the machinery of joint consultation had improved enormously. The T.U.C. expected of the new Government that it would maintain to the full this practice of joint consultation. On its own part, the T.U.C. would continue to examine every question solely in the light of the industrial and economic implications involved. It was necessary that the trade-union movement should always be free to formulate and to advocate its own policies. Over and above the main trade-union functions of improving wages and working conditions, the T.U.C. was concerned to develop the resources of industry generally, and to promote a higher standard of life for all.

In the future, as in the past, the statement concludes, the T.U.C. would urge upon the Government the acceptance of those policies which, from its own experience, the T.U.C. believed to be the best in the interests of the country as a whole. From the same standpoint, the T.U.C. would retain its right to disagree with the new Government, and publicly to oppose it, whenever, in the opinion of the T.U.C., the necessity for so doing existed. The issue of this announcement was felt in some quarters to indicate that efforts might be made by the T.U.C. General Council at an early date to resume discussions with Ministers on the subject of equal pay for women. It is also known that the General Council is anxious to press for the imposition of stringent measures for the reduction of the cost of living. The General Council has also announced that the Trades Union Congress for 1952 will take place at the Winter Gardens, Margate, from Monday, September 1, to Friday, September 5.

Warnings of the possibility of serious industrial unrest under the new Government are contained in the *Railway Review*, the official journal of the National Union of Railwaymen, for November 2. Mr. J. B. Figgins, the union's general secretary, and a member of the T.U.C. General Council, states that the possibility of such disruptions is widely feared, and that, unless Sir Walter Monckton, the Minister of Labour, can keep "a sharp eye on his colleagues in the Government, these fears may be transformed into living realities, as they were after the first World War." Referring to the union's claims for increased wages, Mr. Figgins considers that the Railway Executive did not appreciate the potential dangers to railway transport which are now becoming increasingly evident. The union has made up its mind that the present unsatisfactory state of affairs shall not continue, and it has resolved not to tolerate the persistent failure of the Executive "to face its responsibility to the men and to the nation."

Mr. H. W. Franklin, the President of the National Union of Railwaymen, and a member of the executive body of the Labour Party, in an article in the same issue of the *Railway Review*, suggests that the political changes which have taken place, as a result of the general election, meant that the union would need to make use of all its organised strength in order to safeguard the rights of its members. He considers that it would be extremely difficult for the union's negotiators to advocate more wages and better conditions under a Government which openly believed that wages must be related to revenue and profit. This was a serious issue confronting railway staffs.

To meet the electricity-supply situation, Clyde shipbuilding and ship-repairing firms returned to a five-and-a-half day working week on Monday last. The four-hour Saturday shift will be resumed tomorrow, November 10, and will continue throughout the winter. Last year, electricity officials drew up a scheme to show the day on which consumers in a particular area would be liable to a power cut, and, on the basis of that plan, it was agreed that each shipyard should work from 10 a.m. to 2.30 p.m. on the day on

which an interference with electricity supply was likely; the 44-hour working week being made up by the Saturday shift. The shipyard men do not like the scheme, however, and, on Monday of this week, nearly one thousand employees at the Dumbarton shipyard of Messrs. William Denny and Brothers, Ltd., went on strike for the day in protest against it. Another thousand men, employed by Messrs. Barclay, Curle and Co., Ltd., Glasgow, also staged a one-day token strike, on the following day, for similar reasons.

The practice of introducing Italians to make good man-power shortages is steadily spreading in a number of British industries. It was announced recently that some hundreds of Italians employed in steel and tinplate mills in West Wales during the past year are to be offered extensions to their contracts. As stated in "Notes from the Industrial Centres," on page 590, an additional 250 Italians are to be engaged for employment in various industries in South Wales in the near future. To meet the man-power needs of the Eastern, Southern, Western and London Midland Regions, Ministry of Labour permission has been granted for the employment of one thousand Italians by British Railways. The first 150 labourers under this scheme were due to arrive in Britain last Wednesday and are expected to be employed on permanent-way maintenance work for the Southern Region. No arrangements have been made for the technical training of these men, no special provision for their instruction in English, as their services will be used solely for unskilled manual work.

Demands for a token strike, to take place on Monday next, November 12, were made at a meeting at Salford last Tuesday of representatives of employees in the engineering and electrical industries. A resolution was passed calling upon the 150,000 operatives in these industries in the Manchester district to cease work for one hour at 4 p.m. on that day, in accordance with the recommendations of the Manchester federation of shop stewards. It was stated that such action would "demonstrate the determination of the men to secure the full 20s. a week wage increase" demanded by the Confederation of Shipbuilding and Engineering Unions. It may be recalled that a joint meeting of the two sides of the industry to consider this wage claim is due to take place on Wednesday next.

Normal working was resumed on Tuesday last by the employees at Tilbury docks who, since October 5, had been working to rule and refusing overtime. The dockers agreed to return to normal practices on condition that none of their number would accept permanent work until such time as a clear understanding had been reached between the employers' organisation and the union concerning the number of permanent workers whom the employers would be permitted to engage. The dockers have thus been successful in their endeavours to prevent the recruitment of additional men on a permanent weekly basis, until such time as they are satisfied that the employers will not engage too many gangs of such men. Nearly 1,900 dockers had been involved in the dispute. Threats by the employers to stop engaging men who would not conform to the "normal practices and customs of the port" were not generally put into practice.

As previously recorded in these columns, the restrictions in working were introduced as part of a protest by the dockers at Tilbury against the engagement of additional men on a weekly basis by one of the larger firms of master stevedores. The dockers and their Union have maintained that the use of permanent men was unfair, owing to the fact that the permanent gangs were almost invariably given the best and most profitable jobs. They feared that any considerable extension of the practice of employing some men on a weekly basis would lead to the remainder being left with only the "dirtiest" jobs. Another objection was the alleged reluctance of the employers to take the older dockers on to their regular staffs.

More than four thousand lightermen and tugmen at the Port of London, who have also been working to rule and refusing overtime, since October 12, have continued their go-slow policy. Discussions between representatives of the lighterage employers' organisation and officials of the Watermen, Lightermen, Tugmen and Bargemen's Union took place in London at the Ministry of Labour during the early days of this week, but without any apparent result. The go-slow action was taken by the men, with the approval of the union, in order to enforce claims for certain additional wage payments. In some instances, lightermen taking part in the go-slow movement have been returned by their employers to the dock labour pool for alleged breaches of their agreements. This dispute has resulted in considerable delays in the turn-round of shipping at the Port of London.

GAS TURBINES FOR ELECTRICITY AND PROCESS HEAT.

Fig. 1.

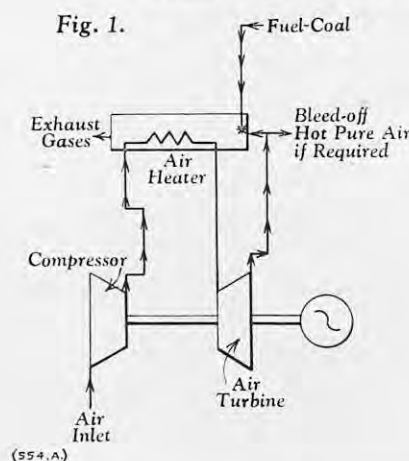


Fig. 2.

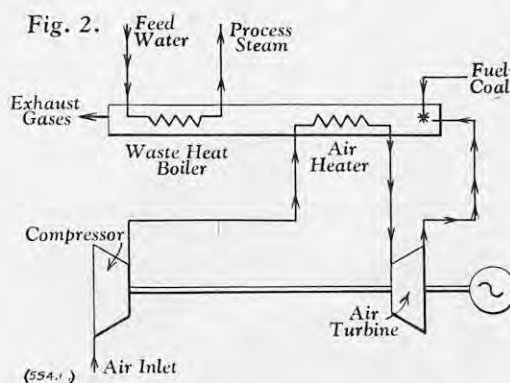


Fig. 3.

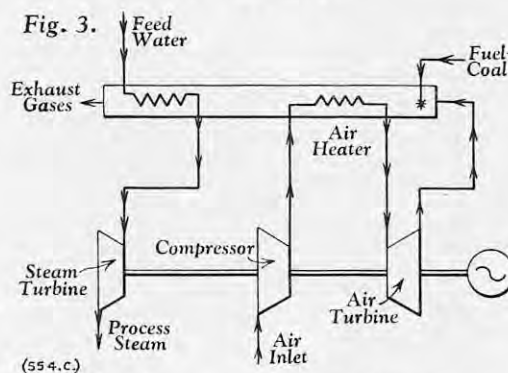


Fig. 4.

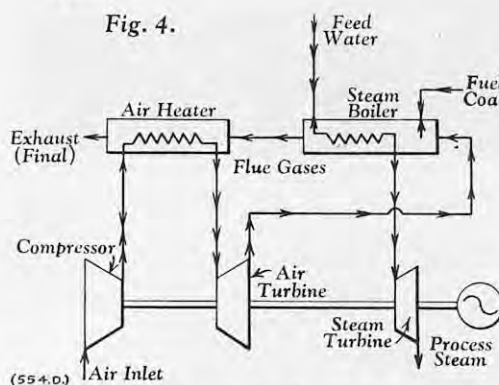


Fig. 5.

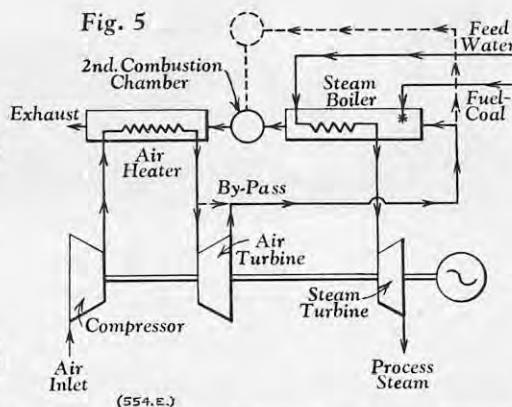
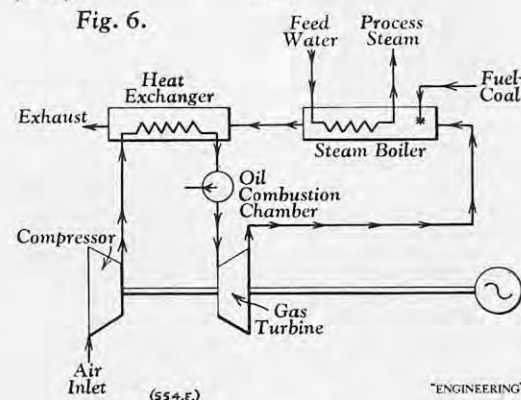


Fig. 6.



GAS TURBINES FOR ELECTRICITY AND PROCESS-HEAT PRODUCTION.*

By W. E. P. JOHNSON, A.F.C., C.P.A.

THE paper manufacturer requires steam for his processes and, if we accept that, we must turn our thoughts to the method of supplying steam by modifying the cycles we have considered. If we look at the cycle outlined in Fig. 1, we find that the cycle efficiency is 18 per cent. (with the figures already assumed). Therefore, it follows that apart from some small losses in the cycle due to leakages, radiation and friction, about 74 per cent. of the heat energy supplied by the fuel must be passing out from the exhaust. In fact, on the basis of the assumptions made, the exhaust temperature is about 350 deg. C. (662 deg. F.); thus, it is quite feasible to recover a proportion of this heat in some type of waste-heat boiler. Fig. 2 shows this elaboration of the previous cycle. The amount of recovery of heat from the exhaust in such a boiler will depend in large measure on the surface area furnished and therefore on the size and cost of the unit. Very tentatively, we can assume an efficiency of some 45 per cent., in which case the total efficiency of the cycle would be of the order of 51 per cent. if we total up power and process steam supplied. At the same time, it must not be overlooked that on the basis of the figures assumed there will be a definite relationship between the power supplied and the process steam supplied. In fact, for every 1,000 kW of power, we shall have roughly 5,700 lb. per hour of steam at 30 lb. per square inch and 15 deg. F. superheat. The ratio of power to steam heat will vary with the turbine inlet temperature and the heat extractions of both the air heater and the waste-heat boiler, though it is unlikely that the possible variation is going to be sufficient to satisfy all plants. Furthermore, the total thermal efficiency is not the best that can be obtained, although the result can be improved by raising the efficiency of the waste-heat boiler. Assuming that, in the unlikely case of more electrical power being required in relation to the processed steam than this scheme is capable of giving, we can arrange for this by incorporating a back-pressure turbine in the processed-steam supply line, as shown in Fig. 3. Although this means that we shall be back to the familiar schemes for this part of the power supply, it should be remembered that, due to the production

of power by the gas turbine, it would be unnecessary to pass any steam to a condenser.

The difficulty with the foregoing schemes, exemplified in Figs. 2 and 3, is that the thermal efficiency of the cycle is restricted by the high-temperature limitations of the air heater and turbine. It will be observed that, in one sense, the steam boiler and the air heater are really "playing out of position," in that the air heater is subjected to the high gas temperatures whereas the steam boiler operates at much lower exhaust temperatures. By reason of the better heat transmission from steam, the tube temperatures in a steam boiler are more nearly approaching those of the steam rather than the gas, whereas in an air boiler the reverse is the case. Consequently, in the schemes considered, apart from questions of efficiency, the air heater might easily be the stumbling block. In any case, it is certain that expensive materials would have to be used in its construction, which could well put the scheme out of court. There appears to be a solution, however, which has certain attractive features.

If the position of the air heater and boiler are reversed in the schemes considered, we then have the situation that it is the steam boiler that gets the high-temperature gas whereas the air heater gets the gas exhaust at a much lower temperature, as shown in Fig. 4. Thus, both units would be operating in conditions that experience has already shown us they can handle. The steam raiser ceases to be a waste-heat boiler but just another steam boiler, while the air heater becomes the customary heat exchanger used in many gas-turbine engines. There need be nothing special about the steam boiler other than that it is likely, in certain cases, to be required to have the rather unusual properties of a low thermal ratio or efficiency in order that enough heat may be left in the exhaust gases to supply the gas turbine. The proposition, in fact, appears to be a perfectly feasible one, based to a very large extent on existing knowledge. An approximate estimate of the total thermal efficiency of the cycle in Fig. 4 has been carried out, but without using a steam turbine (i.e., all steam to process). The following figures, together with reasonable practical pressure losses in the system, were used in the estimate:

Higher calorific value of coal	12,000 B.Th.U. per lb
Air: coal ratio in boiler	20:1
Air-heater thermal ratio	80 per cent.
Axial-compressor efficiency (polytropic)	86 per cent.
Gas-turbine efficiency (polytropic)	86 per cent.
Turbine inlet temperature	700 deg. C. (1,292 deg. F.)

Using these assumptions, it was found that the total thermal efficiency was approximately 75 per cent. The boiler efficiency required was found to be about 70 per cent. For 1,000 kW of power the process-steam supply at 30 lb. per square inch (gauge) and 15 deg. F. superheat would be about 32,000 lb. per hour. This ratio of power to steam supply could, of course, be

raised by putting in the steam turbine, as shown in Fig. 4.

We must consider, however, the question of control. In other words, having satisfied ourselves that it is possible to make out a scheme that has prospects of a good efficiency at the design load condition, we must consider what arrangements can be made to cover the case, for example, where process steam is to be maintained and power reduced, or vice versa. As the scheme stands in Fig. 4, we should have the position that as one item is reduced so is the other. The proportion of one to the other will not remain the same but, for any given percentage load in a given installation, the proportion will be fixed in advance by the design condition. To overcome this, it is suggested that we put in a second combustion chamber, as shown in Fig. 5. Alternative situations are shown for this combustion chamber, the first in the direct main stream of gases from the boiler to the air heater, and the second in a by-pass from the air-turbine exhaust leading into the main stream again before the air heater. The particular circumstances of a specific installation would probably determine which arrangement to use but, in either case, the effect would be that, if steam requirements fell in relation to power requirements, then the fuel supply to the boiler could be reduced and the power maintained or increased by burning fuel in the second combustion chamber. In the case where power is to be reduced whilst maintaining steam supply, of course, this could easily be achieved if the generator could be arranged to supply current to the grid. Alternatively, some waste seems inevitable, and it would have to be arranged to bleed off or by-pass the air turbine, thus leading the hot air directly into the furnace supply line. The loss of efficiency would not be great, since a good proportion of the heat energy in the air would be picked up again in the boiler and air heater.

The basic idea of combining steam and gas turbines seems to have interesting possibilities for waste-heat users, and there are probably many variants of the schemes shown which would be of use in certain circumstances. One other scheme of this type is as follows. In certain paper-mills it has been found economically advantageous to use Diesel engines to generate the power and to use steam boilers merely to raise the steam. If a straight gas turbine with direct oil burning and without a heat exchanger were to be used instead of a Diesel engine we could gain two advantages. Firstly, we should have a lower capital cost for our generating unit and, secondly, we could use the turbine exhaust to supply hot gases to the furnace. It is not possible to do the latter with a Diesel engine since practically all the available oxygen is burnt out of the air, but in a gas turbine only about one fifth of the oxygen would be removed, leaving four fifths to carry on the coal combustion. Thus, the furnace would be supplied with very hot air and the coal required for heating the boiler correspondingly reduced. It is true that the simple gas turbine would burn about twice as much oil as would the Diesel but,

* Excerpt from a paper on "The Applicability and Present State of Gas Turbine Technology," presented to the British Paper and Board Makers' Association at the 62nd general conference, held in Edinburgh on October 24.

whereas the Diesel would throw away some 60 to 65 per cent. of its heat in jacket-water heating and exhaust, the gas turbine would pass all its waste heat to the furnace with considerable saving in coal.

This type of plant would only find its application in cases where the power required did not exceed a certain amount in relation to the process steam required. For instance, a simple gas turbine giving about 500 kW would exhaust about 13 lb. per second of air and gas at a temperature of, say, 400 deg. C. (752 deg. F.). In this, we could burn perhaps 2,000 lb. per hour of coal, yielding 32,500,000 B.Th.U. to the steam, assuming a boiler efficiency of 73 per cent. and a heating value for the coal of 12,000 B.Th.U. per pound. This heat would generate about 29,000 lb. per hour of process steam at 30 lb. per square inch (gauge) and 15 deg. F. of superheat. The figures are approximate and would be capable of some variation but are accurate enough to give an idea of the power to process steam ratio. To make a considerable variation in this ratio, we should have to modify the arrangement in some way and would probably arrive at something closely approaching the arrangement in Fig. 4, not necessarily with the steam turbine but with an oil-burning combustion chamber as the main supply of heat to the gas turbine. Prior to the combustion chamber there would be a heat exchanger in the flue gases of the steam boiler which would have the effect of cutting down the oil required by the turbine by about one third. This arrangement is shown in Fig. 6, on page 601, without a steam turbine. Using this scheme (which should be quite flexible), if the boiler arrangement is varied, a high-efficiency installation can be obtained, probably at about the same cost as a Diesel-engine generating plant *cum* steam-boiler arrangement.

It will be seen that there are quite a large number of possibilities for incorporating a gas turbine into plants that require both electrical power and heat for process work. Even with the cycles touched upon, the field has been only sketchily explored. Very much more work requires to be done and specific cases considered. The best arrangement will no doubt vary from case to case and only a complete technical and economic investigation would decide the best scheme.

ANNUALS AND REFERENCE BOOKS.

Garcke's Manual of Electricity Supply.—The 48th edition of this well-known annual contains two important differences from its immediate predecessor. The section dealing with British electrical and allied manufacturing companies, which was a feature of earlier issues, has been restored and should prove as useful in the future as in the past. Particulars of all the operating districts within the respective sub-areas of the Area Boards have also been arranged in alphabetical order for greater convenience of reference. After a statistical survey of the progress of electricity supply in this country during 1949-50, some information is given regarding the position in foreign countries, together with extracts from the annual report of the British Electrical and Allied Manufacturers Association, which give a good idea of manufacturing developments. Details of Government departments and associations, institutions and societies connected with the electrical industry follow, after which come the main sections of the annual. The first of these deals with the constitution, duties and organisation of the British Electricity Authority and also gives particulars of the location, capacity and equipment of the generating stations; operating data are also included. Information regarding the 14 English Area Boards, the North of Scotland Hydro-Electric Board and the Area Consultative Councils is given, and on the electricity undertakings in Ireland, the Isle of Man and the Channel Islands. Next comes the section dealing with the finances of the electrical manufacturing and allied companies. Finally, there is a useful directory of executive personnel. The publishers are the Electrical Press, Limited, 23, Great Queen-street, London, W.C.2, and the price is 3l. 10s., carriage paid.

THE OLD CENTRALIANS.—The next monthly luncheon of the Old Centralians will be held on Wednesday, November 14, at the restaurant "Chez Auguste," 47, Frith-street, London, W.1, at 12.45 for 12.55 p.m. Lieut.-General Sir Humphrey Gale, K.B.E., C.B., will speak on "The Place of the Arts Graduate in Industry."

PRONE POSITION FOR AIRCRAFT PILOTS.—In a bulletin issued recently by the Society of British Aircraft Constructors, it is recorded that an RS4 Desford trainer aircraft, constructed by Reid and Sigrist, Ltd., Braunstone Works, Braunstone, Leicestershire, is carrying out flight trials at the Royal Aircraft Establishment with the pilot accommodated in a prone position, in which greater manoeuvring accelerations can be tolerated. For safety during the trials, a normally-seated pilot is also carried in a rear cockpit.

SMOKE-EXTRACTION UNIT FOR FIRE FIGHTING.

WOODS OF COLCHESTER, LIMITED, COLCHESTER.

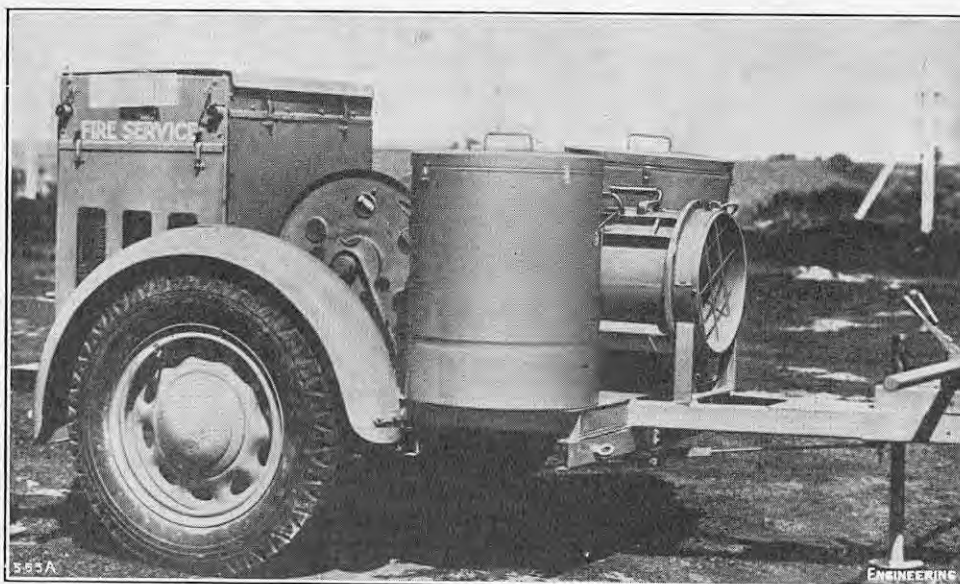


FIG. 1. FAN AND TRAILER UNIT.



FIG. 2. FAN CONNECTED TO FLEXIBLE DUCTING.

FUME AND SMOKE-EXTRACTION UNIT FOR FIRE FIGHTING.

ONE of the principle obstacles encountered in fighting fires is the dense smoke and fumes arising from incomplete combustion. To overcome this, a compact and easily transportable smoke-extractor fan mounted on a trailer has been constructed, at the request of the Ministry of Works, by Messrs. Woods of Colchester, Limited, Braiswick Works, Colchester, Essex, an associate of the General Electric Company, Limited. It is used most effectively in fires which break out in basements. The unit, which is shown in Figs. 1 and 2, herewith, consists of a 15-in. diameter aerofoil fan driven by a Buxton-tested flameproof motor suitable for operation in all Group II gases and vapours—i.e., hydrocarbon gases, those likely to be encountered in the petroleum industry, coal-tar products, cellulose-solvents and paint vapours.

Owing to its aerodynamic efficiency, it is claimed, the Woods fan has an extraction capacity about four times that of earlier types of fan which have been employed in fire-fighting. Depending upon the resistance of the duct, the rate of extraction varies between 2,000 and 5,000 cub. ft. per minute. The fan motor and impeller are housed in a portable steel case, 17 in. wide and 17 in. high, provided with handles so that it can be easily carried by two men. Fig. 1 shows the fan unit mounted in a cradle on a two-wheel trailer equipped with a petrol-driven generator set. On reaching the fire, the fan unit, to which is attached an electric cable coiled on a spring-loaded spool on the trailer, is lifted from its cradle and carried to the building. Fig. 2 shows the fan unit removed from the trailer and connected to a flexible duct, which can be extended as desired within the building. Two lengths of flexible ducting, of asbestos cloth internally rein-

forced by a coil spring, are carried on each side of the trailer. They can be clipped on to spigots at either end of the fan casing so that they can be used for sucking fumes and smoke away from the fire or for blowing them away by an air blast; the latter method, however, has the danger that the draught may increase the rate of combustion.

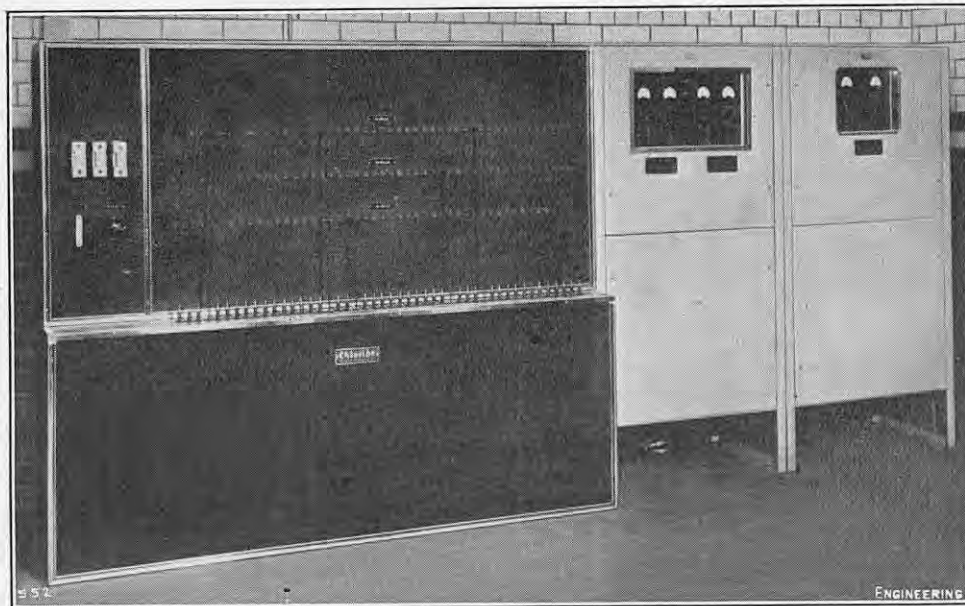
The Woods smoke-extraction unit, which has recently carried out successful fire-fighting trials, is still under development, and a more powerful 19-in. diameter aerofoil fan may be adopted.

H.M.S. "EAGLE."—This vessel, the largest British aircraft carrier afloat and the twenty-first ship of the Royal Navy to bear the name Eagle, was provisionally accepted at sea, on behalf of the Admiralty, on October 31. She was constructed at Belfast by Harland and Wolff, Ltd., her keel having been laid down on October 24, 1942. The vessel was originally named Audacious, but was renamed Eagle on January 21, 1946. She was launched on March 19, 1946, by H.R.H. Princess Elizabeth.

BROADCASTING IMPROVEMENTS IN NORTH-WEST ENGLAND.—Two more of the 12 low-power transmitting stations which the British Broadcasting Corporation are proposing to erect to improve the service in north-west England were recently brought into operation at Whitehaven and Barrow. Both transmitters are now radiating the North of England Home Service programme; Whitehaven at 434 m. (692 kc.) and Barrow at 202 m. (1,484 kc.). Ultimately, the power will be 2 kW, but, pending completion of the permanent installation, a somewhat lower power is being used temporarily. As announced on page 355, *ante*, three similar stations are already in operation in south-west England.

BATTERY-CHARGING EQUIPMENT.

CHLORIDE BATTERIES, LIMITED, MANCHESTER.



BATTERY-CHARGING EQUIPMENT FOR LABORATORIES AT IMPERIAL COLLEGE.

An interesting electrical installation has recently been completed by Chloride Batteries, Limited, Clifton Junction, near Manchester, at the Imperial College of Science and Technology, South Kensington, London. It consists of specially-constructed battery-charging and control gear and has been designed to provide direct-current supplies at various voltages for students working in the College laboratory. The original apparatus installed for this purpose had seen well over 20 years' service. The only part of the old system to be retained is a 110-volt battery which consists of 55 Chloride cells with a capacity of 300 ampere-hours at the 10-hour discharge rate. This has now been re-erected in a more convenient position and its associated apparatus has been dismantled to make way for a "Cycloc" automatic constant-voltage charger and a metal-clad voltage selection/distribution panel, which closely resembles a G.P.O. telephone switchboard, as will be clear from the accompanying illustration.

The battery is tapped at the positive end and at cells 12, 24 and 55 to give a nominal voltage range of 24, 48 and 110 volts. A Cycloc charger rated at 0 to 20 amperes at 2.3 volts per cell is connected across each of the tapped sections and is designed to maintain the output voltage at a constant level within narrow limits over a fixed range of current. Since each section of the battery is connected across its own individual rectifier, the load under normal conditions of up to 20 amperes is supplied by that rectifier, while the cells, receiving their trickle charge at 2.3 volts, are maintained in a fully charged condition. All loads in excess of the maximum rectifier rating, however, are automatically transferred to the battery.

The charging equipment is housed in two floor-mounted cubicles, the first containing the two rectifiers for the 12-cell sections of the battery, and the second, across which float the remaining 31 cells. The rectifier and battery circuits can be isolated if required, by means of a three-pole 60-ampere rotary switch. The voltage selection and distribution board is constructed in angle-iron with sheet steel panels finished in stoved black enamel. Along the front are three horizontal rows of plug sockets labelled "12 cells," "24 cells," and "55 cells," respectively. The sockets in each row are wired together at the back and taken through a switch to a terminal block, which is connected to the battery and rectifiers. A small shelf projecting from the front of the switchboard supports a group of counterweighted plugs numbered to correspond with the 47 bench positions served by the new system. By pushing the requisite bench position plugs into the correct selection sockets, therefore, a supply at any one of the three nominal voltages available can be provided at any or all of the various laboratory benches.

BRITISH STANDARD SPECIFICATIONS.

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

Flexible Polyvinyl-Chloride Film and Sheet.—A new specification, B.S. No. 1763, covering flexible polyvinyl-chloride film and sheeting (unsupported) has now been issued. It applies to two types of sheeting, namely, type 1: general-purpose plain (unprinted) film and sheeting, and type 2: printed film and sheeting of type 1. The specification covers material of nominal thickness in the range 0.004 to 0.015 in., and contains detailed clauses regarding the mechanical properties of the sheeting together with particulars of its colour stability and the colour stability of the print. Appendices concern methods of test. [Price 3s., postage included.]

Steel Tubes for Mechanical, Structural, and General Engineering Purposes.—A new specification, B.S. No. 1775, covering steel tubes for mechanical, structural and general engineering purposes, is the third of a series for steel tubes, the other two being B.S. No. 980, relating to steel tubes for automobile purposes, and B.S. No. 1717, concerning steel tubes for cycle and motor-cycle purposes. The new publication relates to plain carbon-steel tubes not exceeding 16 in. in outside diameter of six types, namely: hot-finished welded (referred to as type HFW), hot-finished seamless (type HFS), cold-drawn seamless (type CDS), electric resistance butt-welded (type ERW), cold-drawn electric resistance butt-welded (type CEW), and oxy-acetylene butt-welded (type OAW). Tubes of type HFW, HFS, CDS and OAW are specified in four grades, namely, 11, 13, 15 and 20; tubes of type ERW in grades 11, 15 and 20; and those of type CEW in grades 11, 15, 24 and 28, the numbers indicating the minimum yield strength in tons per square inch in all cases. The specification includes a number of general clauses, applicable to all types of tubes, and dealing with such matters as material, straightness, lengths, galvanising, and methods of test and inspection. Each type of tube is then dealt with in detail, and at the end of the specification are tables of dimensions, properties, etc. [Price 3s., postage included.]

Single-Bucket Excavators.—A new specification deals with crawler-mounted friction-driven single-bucket excavators comprising face shovels, dragline excavators, drag shovels, skimmers, grabbing cranes, lifting cranes and pile drivers, the shovel or bucket-capacity ratings ranging from $\frac{1}{4}$ to $2\frac{1}{2}$ cub. yards. The object of the specification is to secure the general observance of such fundamental principles as appear desirable to ensure reliability and safety without impeding the excavator manufacturer in his selection of the most appropriate design for a particular purpose. In general layout and contents, the specification follows lines substantially similar to the specifications dealing with cranes. Stability is dealt with in some detail, and careful consideration has been given to the arrangement of the controlling hand levers and pedals. [Price 6s., postage included.]

INSTITUTION OF MECHANICAL ENGINEERS: PRESIDENTIAL ADDRESS.*

By A. C. HARTLEY, C.B.E., B.Sc. (Eng.), M.I.Mech.E. (Concluded from page 585.)

THE most urgent requirement when I joined the Armaments Section of the Air Ministry was for a reliable gear to control a Vickers machine gun and enable it to fire between the blades of the tractor single-engine single-seater fighter aircraft which had then replaced the old "pusher" machines. The Vickers gun had to be within reach of the pilot, so that he could clear the stoppages which were so frequent with guns of that day. The gun had therefore to fire through the sweep of the propeller, and the first solution, fitting deflectors made of steel to the blades, proved useless because of the reduction in speed of the aircraft and the large percentage of the bullets deflected. British aircraft were designed to give the pilot the best field of view and the best manoeuvrability and performance. In some machines, the engine was forward of the main planes, and the pilot with the gun alongside him was behind. Thus long linkages with bell cranks, cross-shafts, etc., with bearings on the fuselage were necessary to connect the engine to the gun. The pilot frequently altered the engine revolutions during combat, and each resulting change of torque flexed the fuselage and frequently jammed the gears, with disastrous results. Step by step some slight improvements were being made, but the need for an effective gear became more urgent because the Germans had produced a very efficient one, the Fokker, and this was giving them great superiority in the air.

The German problem was simpler, because they had standardised a vertical engine, placed immediately in front of the pilot and with the machine-gun alongside the engine on the same mounting, so that a short rotary shaft, independent of the fuselage, was all that was required. When the situation became desperate, Hopkinson's methods came into play, and ensured the thorough examination and, subsequently, intensive development of an idea brought into the department by Mr. George Constantinesco. To many the idea would have at first appeared silly, but, as Sir Harry Ricardo has said, Hopkinson's method on occasion was to try something really silly and see what happened.

Mr. Constantinesco explained that he could, by hitting a piston at one end of a pipe full of oil under pressure, make a percussion wave travel along the oil column with the velocity of sound in oil, about 1,000 m. a second, and operate another piston at the far end. Hopkinson directed me to follow up this idea at an early stage in the experiments; and I will now describe some of the incidents of its development which illustrate the effective use of imagination under his leadership, without which it would never have become the successful "C.C." gear, as it was to be called.

The first models were too heavy, too clumsy, and also too complicated in the method of applying to the oil column the pressure which was necessary to put the gear in operation. But stage by stage a gear was produced which gave encouraging results with a gun in experimental aircraft, firing on the ground into a butt. Meanwhile, test benches were fitted up so that a gun could be fired through a tin disc rotated at a controlled speed, and belts of 200 rounds of ammunition were soon being fired through a single hole in the disc. In combat, however, a belt of ammunition is fired in short bursts, and at varying engine speeds; when this was tried on the test bench an alarming number of stray shots appeared in the tin disc, many of which would have holed the propeller.

Intensive experiments were made at varying speeds and number of bursts and the results analysed. The analysis showed that definite groups of strays occurred at constant revolutions with bursts of any length, and that, when the constant revolutions were reduced or increased, the angle of the group of strays relative to the timed group was reduced or increased.

It was soon found, by calculating the time from the angle between the groups, that this must be due to the percussion wave, after it had operated the "trigger motor" (Fig. 4, on page 604), being reflected back to the generator piston and forward again with sufficient power to operate the trigger motor a second and even a third time. (In Fig. 4, A is the initial clearance of 0.5 mm.; B is the tripping movement; C is the minimum over-run after tripping 1 mm.; and D indicates the trigger-motor push-rod, which had to be free of the joint-cover axis pin.) This defect in the trigger motor appeared most serious and almost fatal to further development, but the team suggested fitting at the end of the oil pipe near the trigger motor a damping valve with a small hole drilled through its head and down its stem (Figs. 6 and 7).

The valve would open and let the oncoming wave operate the piston and then close to damp out the

* Delivered in London, October 19, 1951. Abridged.

"SCIENTIFIC RESEARCH IN AUSTRALIA": ERRATUM.—In the left-hand column on page 565, ante, in the 20th line from the bottom of the column, the reference to "basic acid or borax" should read "boric acid or borax."

return of the wave through the small hole. This suggestion was immediately successful, but there still remained stray shots when short bursts were fired, and these were thought to be caused by slow or short first movements of the trigger motor as the oil pressure was being built up to start the gear. We were at once assured that the ammunition was beyond suspicion and was so designed that the percussion cap either detonated effectively or not at all; therefore it could cause a misfire but not a delayed or stray shot, and the strays must be due to the C.C. gear. However, "believing no man and desiring to prove all things" we took out the bullets and cordite from a number of rounds and touched them off on a Vickers gun lock, after we had inserted varying numbers of cigarette papers to prevent the extractor slide, through which the firing pin had to pass, from coming hard home against its stop (Fig. 7). With the first few pieces no perceptible differences in the detonation of the caps were noticed, but when more were added there was a most astonishing result. The firing pin was bent down and slowed down while being pushed through the hole in the extractor slide and, owing to its being out of line, the crisp, almost smokeless detonation became a low smoky "woof."

Some makes of ammunition were better than others, and an improved design of cap was made, but, meanwhile, it looked again fatal to our gear, because weak or short strokes of the trigger motor produced the cigarette-paper effect on the extractor slide, and badly timed and dangerous shots were the result. However, the team again provided a quick, simple, and fully effective solution for the difficulty by lengthening the trigger-motor piston so that, when at rest, it was pushed hard against the trigger-motor cylinder end to cover the oil inlet (Fig. 6). The end of the piston was thus made to act as a valve offering only one-quarter of its area to the impact of the wave.

If the wave was sufficiently strong to dislodge the piston from its seat acting only on one-quarter of the area, it ensured a full sharp stroke, and if not the wave was simply inoperative. Many similar flashes of imagination were necessary to produce the control mechanism which eventually enabled the pilot, with very light thumb pressure and no interference with his control of the aeroplane, to fire single shots or bursts of any length at will, and with two guns.

The wave generators were at first driven from engine power take-offs, and when there was a reduction gear between the engine and propeller its ratio in reverse had to be fitted between the engine and the C.C. gear. This became complicated, and, in fact, dangerous when epicyclic gears were used, as on some Rolls-Royce engines, with slightly different ratios with different "marks" of the same engine. Here again, the method of imaginative direct approach to the problem was applied, and the wave generator, cylinder, and piston were mounted on the engine casing, and the operating cam was fitted directly on the back of the propeller boss, thus cutting out all gears and timing directly from the propeller itself. There were many more difficulties to be overcome but they were all met in the same spirit, and the C.C. gear became remarkably reliable and almost universally used until well after the 1914-18 war.

After the 1914-18 war, I became a partner in the consulting engineering firm of Maxted and Knott, and was chiefly engaged on the building of cement works at home and abroad until, in 1924, I joined the Anglo-Iranian (then the Anglo-Persian) Oil Company. During the next 26 years, mainly at the head office in London, but with some spells in Persia, I have seen the oil production of the company increased from under 4 million to more than 30 million tons a year in Persia, and the company's interest in the Iraq and Kuwait Oil Companies developed on a very large and increasing scale.

During this period, under the inspiring leadership of the late Lord Cadman and of his successor as chairman, Sir William Fraser, C.B.E., and of many others, such as Mr. J. A. Jameson, C.B.E., who pioneered and developed the operations in Persia, teams drawn from every branch of engineering, science, physics, architecture, medicine, and, indeed, every walk of life have contributed to the building of Abadan as it is to-day, with a refining capacity of upward of 25 million tons a year and all the services required for a township of more than 150,000 people, on what was little more than a desert island 40 years ago.

During the period, geophysical methods for the search for oil have been used to augment the older geological methods; rotary or mud-flush systems of drilling have superseded the older cable tool or percussion system, enabling wells to be drilled faster and to greater depths; special methods have been developed, using advanced designs of mechanical equipment, to enable drilling to proceed under pressure, and the wells to be brought in without loss of oil even though pressures in excess of 6,000 lb. per square inch may be encountered. Multi-stage separators are used at the oil fields, with long horizontal steel vessels capable of working at pressures up to 1,500 lb. per square inch, to

reduce the well pressures and separate the gases with a minimum loss of the valuable light fractions.

Pipelines, which were 6 in. or 8 in. in diameter, of lap-welded steel with screwed joints, have been superseded by 12 in. to 16 in., or more, solid-drawn steel pipes with welded joints, and, later, by longitudinally-welded prestressed steel pipes up to 36 in. in diameter, also with welded joints. Main oil pipeline pumps were steam-driven and reciprocating. Later, steam turbine, internal-combustion engine and electrically-driven centrifugal pumps were used, and are now arranged on the largest pipelines, either as multi-stage in parallel, or single-stage in series. Distillation and refining plant, at first of the intermittent shell-still type, simply boiling the crude oil, have been replaced by large continuous pipe-still distillation benches with automatic control of fractionation, each with a capacity of more than 4 million gallons a day, and by complicated plants of which the most recent is the catalytic cracker, costing millions of pounds and giving new and improved products.

The first deep well to be drilled in Great Britain was at Portsmouth, in 1936, and when a depth of 249 ft. had been reached, the rotary bit, 23 in. in diameter, stuck at 206 ft. 6 in. during normal pulling-out procedure. After much pulling with the hoist, during which the bit was raised 3 ft., the 1½-in. diameter wire line on the blocks broke. The breaking load of the single line was 43 tons, but, as there were six lines on the blocks, a pull of 258 tons must have been applied. A new

Fig. 4. TRIGGER MOTOR ON VICKERS GUN.

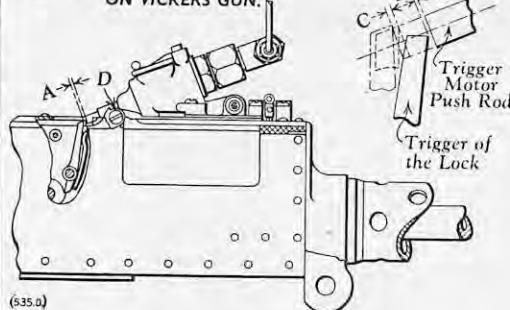
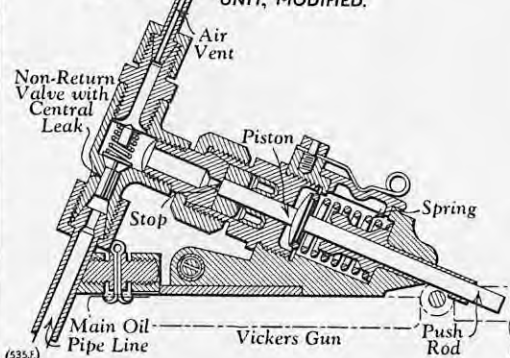


Fig. 6. TRIGGER MOTOR UNIT, MODIFIED.



wire was strung with eight lines on the blocks, but prolonged efforts failed to move the bit; and attempts to jar it down, combined with the application of the full torque of the rotary table, were equally of no avail. Hydrochloric acid was then pumped around the bit to dissolve the surrounding chalk, and pulling, jarring, and rotating were yet again unsuccessful. It was therefore decided to drill a hole through the obstruction alongside the bit, and the drill pipe was disconnected and clamped below the floor of the derrick to enable the rotary table to be used to drill the new hole. Several types of bit were used for enlarging the hole to 6 in. diameter and attempts were made to drill additional holes, but all efforts to free the stuck bit failed.

The situation became desperate and something had to be done. A review of the position showed that the hoist had not been able to apply sufficient pull, the rotary table could not supply sufficient torque, further holes could not be drilled round the bit, and further use of acid seemed useless. More power actually at the bit itself was obviously necessary. A great reservoir of energy was available in the six drilling boilers, but the hoist and rotary table could not apply sufficient of that energy where it was actually needed.

The idea then occurred of connecting the steam pressure to the pipe already in position alongside the bit and applying the energy direct as a steam jet. Urgent telephone messages established that the rotary flush armoured-rubber hose would withstand the steam temperature and pressure, and the depth of water in the hole would obviously not put too much back pressure on the jet. The application of steam caused sudden surges of fluid from the hole to be blown 30 ft. up the

derrick, and created such disturbances round the bit that it was freed completely in about 2 hours. Figs. 8 to 12, opposite, show the various methods tried.

My service with the Anglo-Iranian Oil Company was interrupted by periods of seconded service on work for the Ministry of Aircraft Production and with the Petroleum Warfare Department. During 1940, I was associated with a team on the development of a Royal Aircraft Establishment design for a stabilised automatic bombsight which was eventually used for high-altitude high-accuracy bombing with the largest bombs, and which was successfully used for sinking the Tirpitz in a Norwegian fjord. Here again, the imaginative direct approach was used when difficulty was experienced in getting reliable results in controlling the high-pressure air to the servo-motors through a valve which was operated by gyro-controlled low-pressure air acting on aneroid-type diaphragms. All the low-pressure air system was dispensed with, and the high-pressure air was controlled by piston valves, specially designed not to interfere with the gyro performance when attached to it.

In 1942, in anticipation of a successful invasion of the French coast, there arose an urgent operational requirement for a pipeline to supply petrol across the English Channel to support the advance of the allied armies across Europe. None of the usual methods for constructing a submarine pipeline could be employed because of tidal currents, the time factor, and the certainty of enemy interference. The successful use

Fig. 5. TRIGGER MOTOR UNIT, WITHOUT MODIFICATION.

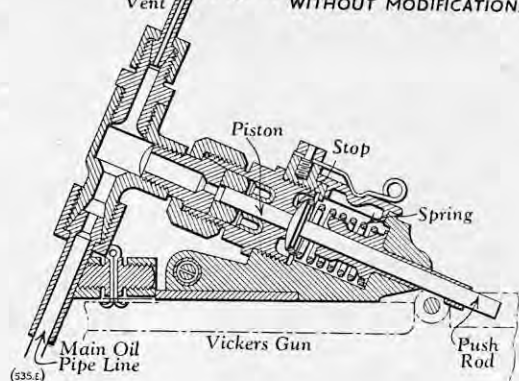
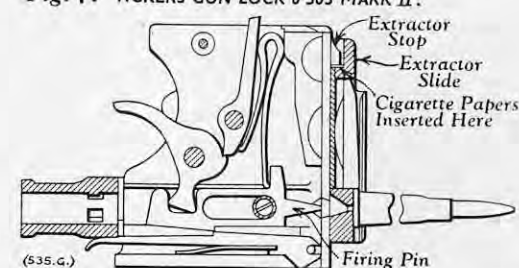


Fig. 7. VICKERS GUN LOCK 0-303 MARK II.



of a number of flexible pipes of small diameter, covered by the code name "Pluto," was described by me in detail in the 1945 annual lecture to the Graduates Section, London.

During the period 1942 to the end of the 1939-45 war, I had the privilege, as Technical Director of the Petroleum Warfare Department, of being associated with flame-weapon development, and with the development of means for clearing fog at airfields, to avoid the great losses being experienced by bombers on return from operations, and to enable operations to be carried out under previously impossible weather conditions. The problem had been under consideration for many years and the basic requirements of heat to establish clear visibility under various conditions had been determined. Some experiments had been carried out, but further development had been stopped in 1939 because of the great cost and of the difficulties in applying the required heat smokelessly.

In 1942, the need for fog clearing had become so urgent that cost no longer mattered, and intensive development was restarted, with the highest priority. The imagination and initiative displayed in the true Hopkinson spirit by the Minister responsible, the Rt. Hon. Geoffrey Lloyd, and by the Director-General, Major-General Sir Donald Banks, K.B.E., D.S.O., and their combined team from the fighting Services, Civil Service, civil scientists and engineers resulted in the installation within six months of an effective "Fido," as it was called, at an operational airfield. It was built with readily available tanks, pumps, and pipes alongside a runway in daily use. Experimental work was pushed forward at many establishments and in a wind tunnel, but the early success was achieved by making full-scale trials under service conditions with the keen co-operation of the Royal Air Force, long

METHODS OF FREEING AN OIL-WELL BIT.

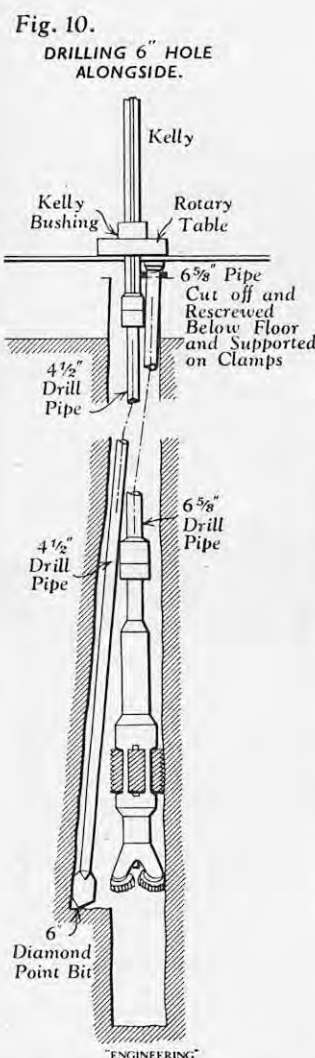
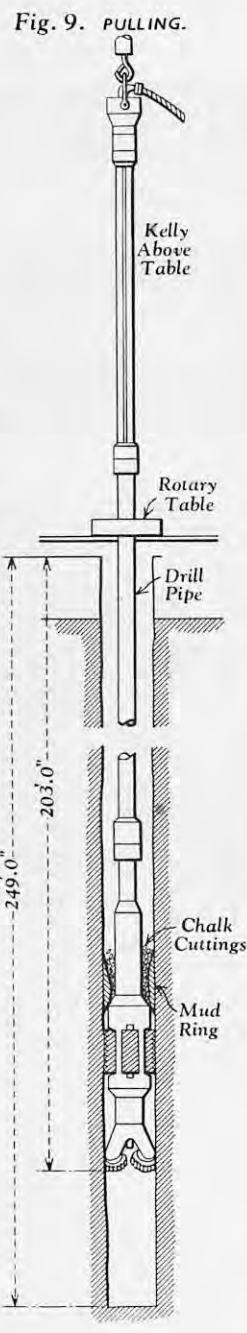
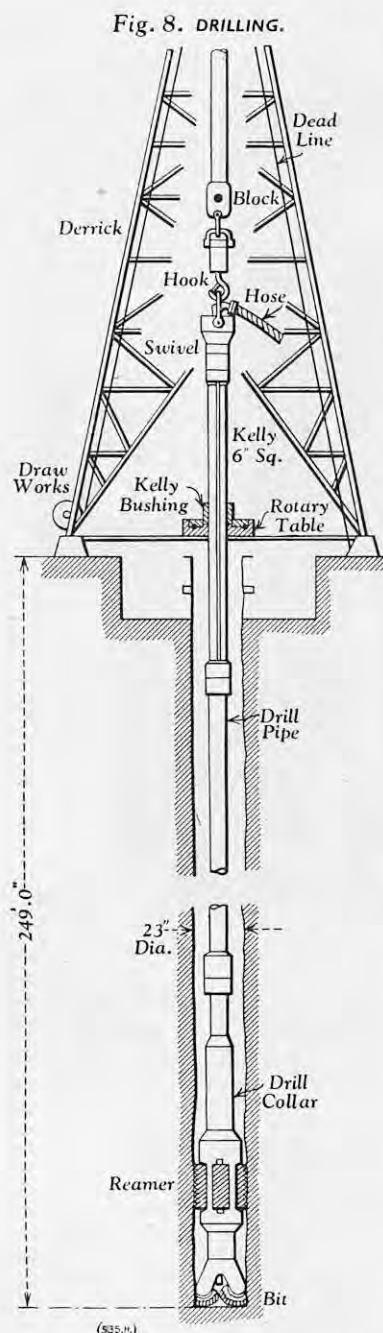


Fig. 11. ENLARGING HOLE TO 7 5/8\"/>

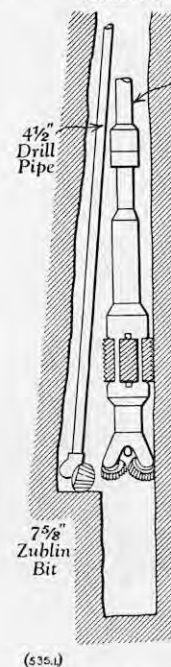
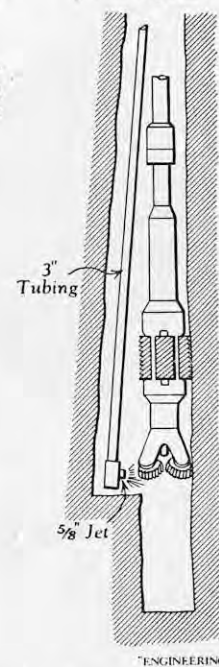


Fig. 12. JETTING STEAM.



ELECTRIC POWER SUPPLY IN EUROPE.

Two noteworthy decisions, one of which was designed to facilitate the exchange of electric power across the frontiers of European countries and the other to remove obstacles to the hydro-electric development of frontier waterways, were made at a meeting of the Committee on Electric Power of the United Nations Economic and Social Council, which was held in Geneva at the beginning of October. As regards the first, the Committee noted that existing legislative provisions regulating transfers of electric power were very old. It therefore reached the conclusion that comparable procedures should be adopted in each country to simplify the relevant formalities and thus to promote the rational utilisation of Europe's electric power resources. With this end in view, it was recommended that the following rules should be adopted by national legislatures. A "guaranteed exchange" takes place when the electric power exported is offset by the import of a quantity of roughly equivalent value in accordance with conditions laid down in a previously concluded contract. An "unforeseeable supply" occurs when emergency measures have to be taken to improve system operation or to cope with unforeseen circumstances. Contracts and, in general, all instruments giving rise to "guaranteed exchanges" shall be submitted to the Ministry in charge of electricity and shall not take effect until approved by that Ministry. Such approval may be subject to certain conditions and may be withdrawn for reasons of public policy. The Ministry in charge of electricity shall fix annually the quotas which may be freely imported or exported as "unforeseeable supplies," in both capacity and power, without prior ministerial authorisation being required.

As regards the facilitation of the hydro-electric development of frontier resources, the Committee noted that such development gave rise to so many political, legal and administrative difficulties that companies hesitated to undertake it and in some cases abandoned it. As the hydro-electric resources still undeveloped became fewer it was therefore more and more necessary to remove such obstacles, in order to satisfy the requirements of European economy. The committee therefore drew the attention of governments to the importance of introducing into conventions regarding such developments a clause laying down that, where neighbouring states participate in the construction of works, such works shall be treated by each state in the same way as if construction were taking place on their own territory, irrespective of the site chosen. It also pointed out that supplies of equipment and materials should not be charged either import or export duties, and that, if special taxation was imposed in either of the two states, adequate compensation should be granted to the other for any damage sustained by it or persons as a result. Finally, both states should grant the necessary residence, working, entry and exit permits required by persons needed by the concessionaire for the construction of the works.

It was recommended, as far as construction is con-

before such trials would normally have been considered possible or advisable. All complications were strenuously avoided, and simple burners were devised which would burn petrol smokelessly, after the preliminary heating period, at rates in excess of 25 gallons a yard an hour, thus supplying sufficient heat for any conditions. They were installed at 15 airfields in Britain, one in France, one in the United States, and one on the Aleutian Islands.

After the 1939-45 war, I returned to the Anglo-Iranian Oil Company and witnessed a period of great expansion in all phases of the petroleum industry, but particularly in the construction of large-diameter long-distance pipe-lines. Great attention has been given to the problems of dealing with expansion and contraction in these lines and to whether they should be built above or below ground. In the latter case, protection against corrosion becomes of great importance, and much attention has been given to pipe coatings and wrappings and to cathodic protection. Protection against corrosion is also a very serious problem in connection with all oil fields and refining plant, tanks, jetties, and, indeed, throughout the whole of industry, and offers a vast and important field for experiment and research.

Looking back now over the last 40 or more years, the most vivid impressions which remain with me are that I was extremely fortunate, first, in receiving a wide, rather than a too specialised, education, and, secondly, in coming later under the inspiring leadership at different times of many outstanding men. The ideal method of training an engineer will continue to provide material for discussion as long as there are

engineers to be trained; but, whatever changes may be made to meet changing conditions, I consider it fundamentally important, and indeed imperative, that all young men should be able to experience the influence of sound leadership at all stages in their education and training so that they may be inspired to use imagination and initiative and to develop self-reliance. It is our senior members who must provide this leadership, each in his own sphere of activity.

ELECTRICITY SUPPLY BREAKDOWN IN OXFORDSHIRE.—A breakdown occurred on the 33-kV system of the Southern Electricity Board at Sandford-on-Thames, Oxfordshire, on Sunday, October 28, owing to a length of steel wire being thrown over the overhead lines. As a result, the poles supporting the lines gave way and the conductors sagged over the road. A large area of South Oxfordshire and North Berkshire was without electricity until an alternative supply could be arranged.

REGULATIONS FOR ROYAL SHOW, 1952.—Revised regulations regarding the exhibition of implements, machinery, etc., at next year's Royal Show, to be held at Newton Abbot from July 1 to July 4, have just been issued by the Royal Agricultural Society. In general, the regulations follow the pattern for preceding years, the revisions referring to charges for space, tickets for exhibitors and their assistants, arrangement of stands, removal of exhibits and the provision of adequate guards on machinery in motion. The closing date for receipt of applications for space in the showground is given as November 19, 1951.

ULTRASONIC TESTING OF PNEUMATIC TYRES.

THE GENERAL ELECTRIC COMPANY, LIMITED, LONDON.

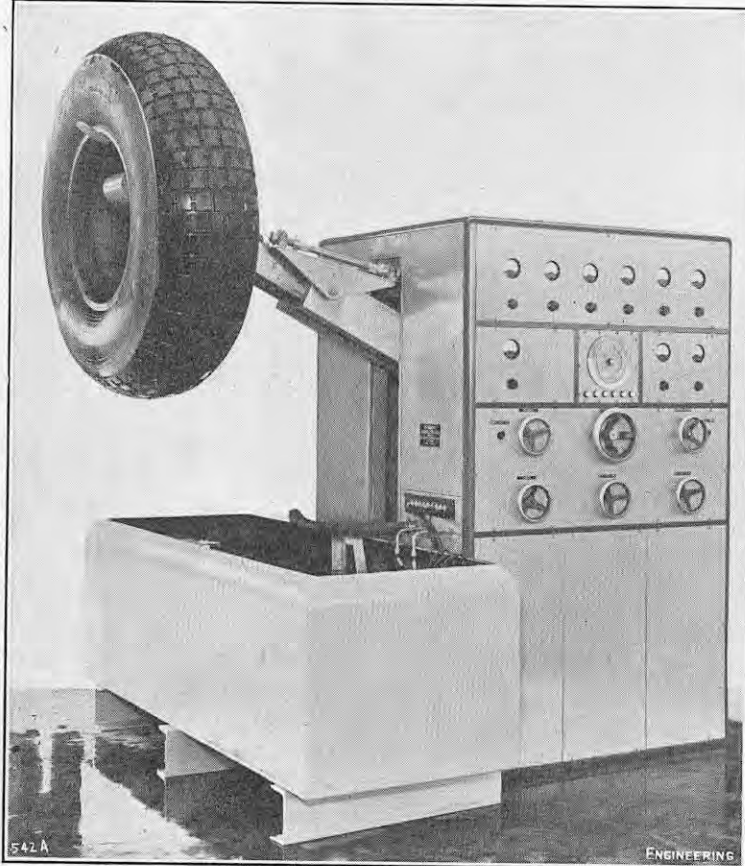


FIG. 1. GENERAL VIEW OF TESTING APPARATUS.

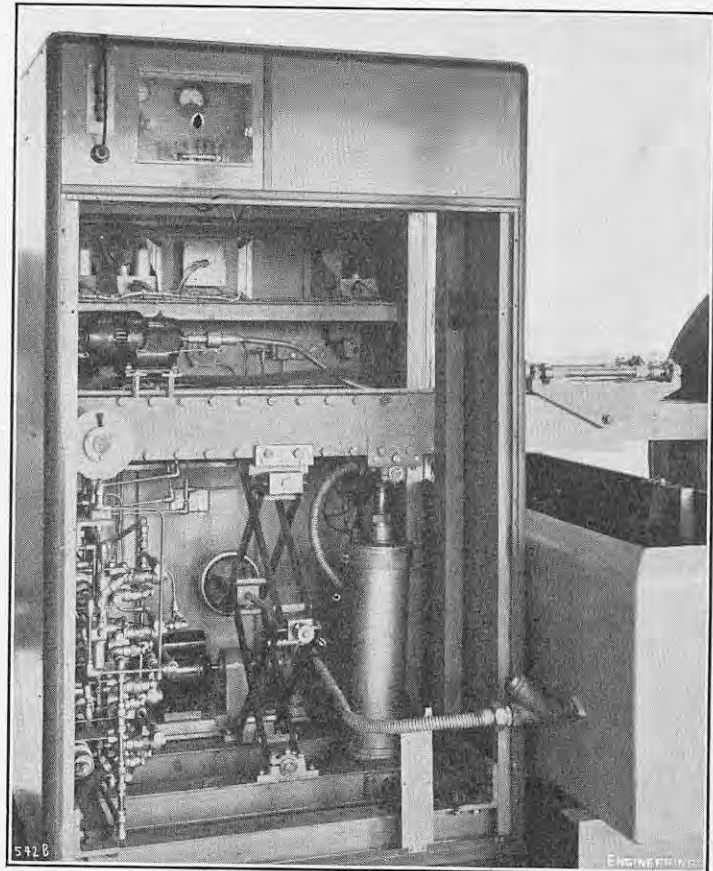


FIG. 2. BACK OF CABINET WITH COVER REMOVED.

cerned, that the best site should be selected after an examination of the locality by a joint commission composed of representatives of the two countries concerned. This examination should be conducted on the basis of technical considerations, irrespective of the position of the frontier. In the event of a country setting up several joint commissions with another country, that country's representatives on these various commissions should consist, in part, of the same individuals. With regard to operation, it was recommended that power allocated to one of the two states and produced on the territory of the other should be exempted from all taxation and legal restrictions and that the power allocated to one state should be exportable to the other in accordance with the provisions governing the export of power in force in the state entitled to the power. It was also recommended that if either state were unable to utilise the power allocated to it on its own territory, it should do nothing to prevent it being exported to the other state. Taxes on companies should be levied in accordance with the conventions on double taxation between the countries concerned, and where such conventions do not already exist they should be concluded. The joint concessionary undertaking should be provided with the necessary currency transfer facilities, both during the construction period and for operating requirements, and workers should be allowed to transfer their wages to their country of origin.

The Committee learnt with satisfaction that the secretariat had initiated two series of negotiations, one between Yugoslavia and Austria for the development of the hydro-electric resources of the River Drave, and the other between Yugoslavia and Italy to promote immediate exchanges of power between those two countries; and to study the possibilities of developing these exchanges in future.

A group of experts is to meet early this month to prepare an order of priority for the subjects contained in an initial plan on rural electrification. A detailed study on transfers of electric power across European frontiers has also been prepared by the secretariat. This contains an analysis of the factors leading to and impeding such transfers and of the various existing categories of supplies and exchanges. It also contains an examination of the probable trend of consumption and production. A special chapter is devoted to the influence of progress on production and transmission and to the utilisation of new sources of electric power. The Committee expressed the wish that this study, which it regarded as a very valuable source of informa-

tion, should be given general distribution as soon as possible, in view of its special interest.

This session of the committee was attended by 40 delegates, representing 13 countries, and by four observers from the International Union of Electric Power Producers (Uniped) and the World Power Conference. Mr. A. Smits (Belgium) and Mr. J. Etienne (Switzerland) were elected chairman and vice-chairman, respectively.

SCHOLARSHIPS IN NAVAL ARCHITECTURE.—The Council of the Institution of Naval Architects have awarded the following scholarships in naval architecture: the 1851 Exhibition Commissioners post-graduate research scholarship for 1949, to Mr. I. M. Yuille, for one further year; the 1951 Sir William White post-graduate scholarship to Mr. M. C. Eames; the 1951 Elgar scholarship to Mr. R. R. Phillips; and the 1951 Vickers-Armstrongs scholarship to Mr. G. A. Smith. The Aluminium Development Association research scholarship in the application of light alloys to ship construction, for 1949, has been awarded to Mr. J. B. Caldwell for a further year.

HEAT TRANSMISSION.—The Spiral Tube and Components Company, Limited, Osmaston Park-road, Derby, have sent us a copy of a small book entitled "Finned Tube," which they have compiled and published expressly "to fill a gap in the literature available to purchasers and users of heat-transmission plant." The book is not a catalogue of equipment but a short treatise on heat-transfer and its applications. Part 1 deals with design and begins with the theory of heat conduction and convection. The Reynolds, Prandtl, Nusselt, and other numbers are introduced and their significance explained in a simple and lucid way. Subsequent sections deal with condensation and boiling, the properties of gases and the evaluation of mean temperature differences. The significance of the finned tube is briefly explained. Part 2 deals with applications of heat-transmission plant. Tubular heaters working with steam or hot water are considered and hints are given on drainage and venting and on making provision for expansion and contraction of the tubes. Other sections deal with water and oil coolers, refrigeration, compressed-air coolers and corrosion. Part 3 contains a number of useful tables, including tables of saturated and superheated steam. The book is to be distributed widely, without charge, and the Company will be pleased to send copies of it to engineers and other technicians on receipt of a request made on their firm's notepaper.

ULTRASONIC TEST APPARATUS FOR PNEUMATIC TYRES.

IN 1943, owing to the scarcity of rubber, it became necessary to devise a non-destructive method of determining whether the internal structure of aircraft tyres had been damaged by landing stresses and whether they were therefore unfit for re-treading. As a result, a method was developed which depends on the fact that any internal discontinuity, such as the imperfect bonding between the rubber and fabric, which frequently occurs with used tyres, will lead to the presence of an air film and ultrasonic waves will be almost completely reflected from the boundary between this air and the rubber. This fact is made use of in a machine which has been jointly developed by the Dunlop Research Centre and the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, and has recently been installed at the Fort Dunlop Works of the Dunlop Rubber Company.

This machine, which has been designed for tyre testing on a production basis, can detect faults with an area of $\frac{3}{8}$ in. by $\frac{3}{8}$ in., or more. It consists of a steel cabinet containing an ultrasonic generator and valve amplifiers, as well as pneumatic-handling equipment for lowering the tyres into a tank of water, where they are tested. A general view of the machine, showing the pneumatic-loading equipment, is given in Fig. 1, Fig. 2 is a rear view of the cabinet showing the group of cam-operated valves referred to later. As will be seen, a pneumatically-operated extensible arm projects from the front of the cabinet and can be moved outwards so that a tyre can be loaded on to it. The arm then lifts the tyre, moves it inwards and lowers it on to two rollers, which are mounted in the tank above the water. These rollers are driven through gearing by a $\frac{1}{4}$ -h.p. motor and are used to rotate the tyre at speeds up to 10 r.p.m. during a test. This enables the tyre first to be rotated quickly so that it is wetted and then more slowly for the ultrasonic test. Finally, it is turned very slowly or stopped in order to locate the flaw precisely. A water bath is used to ensure a good transmission path between transmitter and receiver, as well as to ensure that there is negligible absorption, and reasonable acoustic matching or reflection at the boundary between the water and rubber. If a dry contact were used it would be practically impossible to exclude air, with the result that the wave would be almost wholly reflected.

As shown in Fig. 3, opposite, the ultrasonic transmitter is connected to a quartz crystal, which is $\frac{3}{8}$ in.

ULTRASONIC TESTING OF TYRES.

THE GENERAL ELECTRIC COMPANY, LIMITED, LONDON.

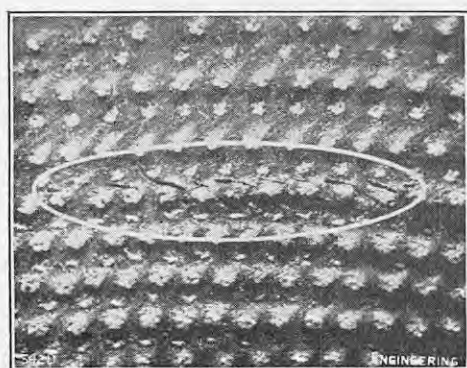
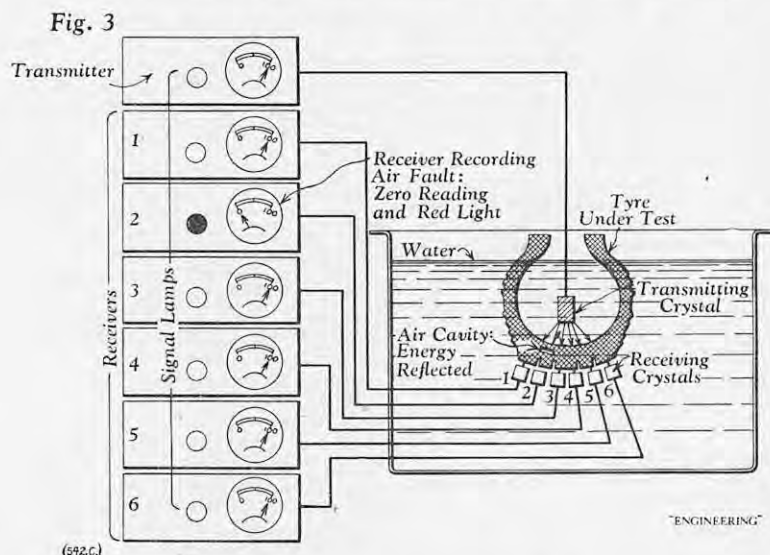


FIG. 4. CAVITY GIVING 50 PER CENT. SIGNAL STRENGTH.

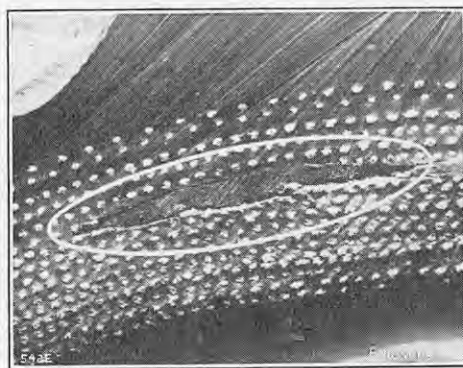


FIG. 5. CAVITY GIVING ZERO SIGNAL STRENGTH.

in diameter and is mounted in a brass holder at a distance of 1 in. from the rubber in the wall of the submerged tyre. The ultrasonic beam is radiated at an angle of 120 deg. and is picked up by a number of receiving crystals, which are spaced round the outer wall of the tyre. Leads are taken from each of these crystals to separate amplifiers, the outputs of which are used to give a visual indication on the meters as well as to operate six alarm circuits, consisting of a relay and a red indicating lamp. Each amplifier has independent controls so that its meter indication and the point at which the lamp lights can be set.

The frequency of the ultrasonic generator is 50 kilocycles per second and the output is about 1 watt. The choice of frequency has been determined by the fact that as the frequency increases the angle of the radiated beam decreases until at about 1,000 kilocycles it is almost parallel and its diameter is nearly equal to that of the transmitter crystal. Furthermore, the absorption of ultrasonic energy by rubber increases rapidly with the frequency, so that the practical industrial limit of the latter is about 500 kilocycles. As has been said, the instrument is designed to use about one-tenth of this value, the result being that the angle of radiation is wide and a single transmitter can serve six receiving crystals. Reasonable signals can also be obtained without using elaborate high-gain amplifiers.

As regards operation, after the tyre has been lowered into the tank it is rotated quickly, so as to wet it and remove any air bubbles. If desired, a small quantity of non-foaming wetting agent can be added to the water. The ultrasonic generator is then adjusted to give a meter reading of about 80 per cent. of full-scale deflection on each of the indicators. In this connection it may be pointed out that the apparatus does not depend in any way on absolute calibration, but simply upon the fact that a particular area of the tyre can be considered "good," and all other parts are tested relative to this portion. Next the speed of rotation of the tyre is reduced, the value chosen depending on its diameter and the size of the fault which is being sought. For instance, a large aeroplane tyre (or any tyre on which faults greater than 1 in. by 1 in. are being sought) can be rotated at 6 r.p.m., but lower speeds have been found to be better for smaller tyres and smaller faults. About a 90-deg. arc of cross-section is

scanned by the crystals at each revolution and means are provided so that the transmitter can be rocked about an axis by an electric motor, thus enabling the whole tyre to be examined in a few revolutions. Small variations in the tyre structure cause small and rapid variations in the meter readings, but, with experience, these can be easily distinguished from true faults, such as actual or incipient looseness between layers of fabric.

The pneumatic-handling equipment is supplied from the works compressed-air mains and is automatically controlled by cam-operated valves by means of which the loading and unloading speeds can be adjusted. The ultrasonic generator is provided in duplicate. There is also a spare receiver, amplifier and meter panel, so that the electronic equipment of the tester can be serviced without interruption. Fig. 4 is an illustration of a typical cavity which has been detected ultrasonically and would give a drop in signal strength of about 50 per cent. A drop in signal strength of about 100 per cent. would result from the cavity shown in Fig. 5. The first of these instruments to be installed at Fort Dunlop is being used for a range of tyre covers with rim diameters from 14 to 24 in., of widths from 4½ to 17 in., and up to 300 lb. in weight.

DUST PROBLEMS AND THE VENTILATING ENGINEER.—A course of ten extra-mural lectures on "Dust Problems and the Ventilating Engineer" will be delivered at the Royal Sanitary Institute, 90, Buckingham Palace-road, London, S.W.1, on Tuesdays, January 15, 22 and 29, February 5, 12, 19 and 26, and March 4, 11 and 18, 1952, commencing at 7 p.m. Different speakers will be responsible for each lecture, the subjects chosen being "Physical Properties of Dust and Aerosols," "Physiological Aspects," "Estimation of Dust," "Dust Explosions," "Protective Measures," "Electrostatic Precipitation," "Theory of Air Filtration," "Application of Air-Cleaning Devices," "Testing of Air Filters," and "Dust Conveying," in chronological order. The lectures, each of one hour's duration, are being held under the auspices of the National College for Heating, Ventilating, Refrigeration and Fan Engineering at the Borough Polytechnic. Tickets of admission may be obtained, free of charge, from the clerk to the Governors, Borough Polytechnic, London, S.E.1.

THE IRON AND STEEL INDUSTRY IN 1895 AND TO-DAY.*

By PROFESSOR R. HAY, B.Sc., Ph.D.

(Concluded from page 568.)

THERE have been great changes in the field of metallurgical education in Scotland. With the rise of physical chemistry during the early part of the century, the tendency has been to pass from the analytical to the physical-chemistry approach to metallurgical problems. When Glasgow University introduced the degree in metallurgy in 1912, it was under the name of "Applied Chemistry," thus emphasising the chemical importance of the approach to metallurgy. Physical metallurgy, however, was not neglected, and, under the able guidance of Dr. C. H. Desch, F.R.S., who was one of the pioneers of this branch of study, metallography occupied an important place in the teaching of metallurgy in Glasgow. This branch has been developed by the introduction of teaching in X-ray and high-vacuum techniques, but it has always been borne in mind that these are tools to the metallurgist, rather than that the metallurgist should be primarily a physicist by training and outlook. Evening-class education was developed along similar lines and for many years the College Certificate in Metallurgy was based upon a chemical foundation and received wide recognition. Because of this strong chemical bias, it was easy for students to obtain the qualification in metallurgical chemistry which was sponsored by the Royal Institute of Chemistry. To meet the ever-increasing needs of evening students, National Certificates in Metallurgy were introduced three years ago. In Scotland, these certificates are issued by a joint committee set up by the Institution of Metallurgists and the Scottish Education Department and follow the pattern already established in engineering and chemistry by having two standards, the Ordinary Certificate, awarded after three years of study in chemistry, physics, mathematics and metallurgy, and the Higher Certificate, awarded after a further two years' study in physical chemistry and metallurgy.

Sexton, in his presidential address in 1895, laid great emphasis on the development of a good metallurgical school in Scotland and asked for the support of the local industrialists to this end. To-day, in my opinion, we do possess a good metallurgical school in Scotland and we do receive strong support from the local industrialists. For many years, the system of governing the College has been through special departmental committees, which are composed of academic persons and leading industrialists. It is through these committees that the West of Scotland Iron and Steel Institute can bring its influence to bear on educational policy, the President of the Institute being an *ex-officio* member of this Committee.

Before leaving the educational side, I wish to mention a further development which I think will prove of the greatest importance in the future of the industry. In 1946, a new course of study was introduced in the Royal Technical College, Glasgow, with the object of adequately combining theory and practice. In developing this course I was very conscious of the fact that only in an industrial plant can a student receive a proper practical training. Furthermore, it was not reasonable to expect a firm to take college students and spend much time and money on their training. I have always found that firms are very willing to take students for practical experience in the long vacation, but in this new scheme I wanted something more. Therefore it seemed much better that the College should take the properly-qualified students from industry. The scheme was based on a fair distribution of time between college and industry, fixed at six months in college and six months in industry over a period of four years. As the principal lecture courses are given from October to March, this partition was comparatively easy to arrange. The curriculum is built on the principle of pure-science subjects followed by engineering and metallurgy in all its branches. The practical experience is arranged to dovetail into the theoretical training at each stage.

Just as there have been great changes in the composition of the industry and in the educational facilities, so there have been great changes in the approach to research. In the period of my predecessor, the research which interested the industrialists was entirely of a practical nature. It is true that Sir Lowthian Bell had been active just prior to this time in the study of blast-furnace reactions and had made assertions based on his work on efficient furnace operation and on the height of the furnace. Nevertheless, most of the papers presented to the Institute, and the discussion thereon, dealt with practice and operational experiences of the authors and members. Research, as we understand it to-day, was quite unknown, and no laboratories existed for this particular purpose. To-day, not only do the large producing firms possess well-equipped

* Presidential address delivered before the West of Scotland Iron and Steel Institute on Friday, October 19, 1951. Abridged.

research laboratories, but many of the larger firms who use the products of the industry are equally well-equipped. The same statement can be made concerning the principal refractory manufacturers in Scotland.

During the period of about sixty years which covers the whole life of the Institute, and of which I have outlined the conditions at the beginning and the end, the Institute has continued to grow and to meet the needs of its members. With the rapid change in conditions in recent years it is my opinion that a change on the emphasis of the work of the Institute will be necessary if continued health is to be expected. No longer are there the same number of practical experts available from which to draw for membership and for active support in papers and discussions. There is, however, an increasing supply of well-trained workers in the industry, and in industries which are closely allied to iron and steel production. It therefore seems logical that increasing attention will have to be given to the problems associated with the product and its uses. Papers dealing with the fundamental aspects of problems in which applied physics may largely feature will also have to be attracted to the proceedings of the Institute. Such topics should receive a good discussion in view of the increasing membership possessing suitable academic qualifications. It is hoped that a few such papers will be presented for discussion each year. The Institute must encourage its younger members to present papers by ensuring that a friendly but critical atmosphere prevails in discussion. By so doing the Institute will help to foster the spirit of self reliance in the younger members and from this may arise more of the spirit of adventure. It has long been one of the criticisms levelled at our technological staffs that they are slow in applying research discoveries to practical operations. There is a certain justification of this tardy outlook in so far as modern plant tends to very large throughputs and any wrong application may have dire results. On the other hand, with modern knowledge any such wrong applications can often be foretold and a frank discussion in the form of a paper to the Institute could be most helpful in this direction. It is interesting to note that this slowness in applying knowledge has persisted from earliest times. Had James Beaumont Neilson been a blast-furnace manager instead of a gasworks manager it is very probable he would not have invented the hot blast. In this same connection it is interesting to read in the discussion on Wiggin's paper (*Jour. of Iron and Steel Inst.*, vol. XLVIII (1895), p. 181) that R. M. Thompson, of New York, said "it almost seemed as if England knew how to produce good things but was not quite so ready to use them after they were produced."

LAUNCHES AND TRIAL TRIPS.

M.S. "PORT TOWNVILLE."—Single-screw cargo vessel, with accommodation for twelve passengers, built by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend-on-Tyne, for the Port Line, Ltd., London, E.C.3. Main dimensions: 460 ft. between perpendiculars by 64 ft. 6 in. by 41 ft. 6½ in. to upper deck; deadweight capacity, 10,790 tons on a draught of 28 ft. 9 in.; gross tonnage, 8,070; cargo space, 311,910 cub. ft. insulated and 292,850 cub. ft. uninsulated. Wallsend-Doxford six-cylinder opposed-piston reversible oil engine, developing 7,500 b.h.p. at 114 r.p.m., constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne. Speed, 15½ knots. Trial trip, October 22.

M.S. "JEPPESEN MÆRSK."—Single-screw cargo vessel, carrying twelve passengers, built and engined by Burmeister & Wain, Copenhagen, for Mr. A. P. Möller, Copenhagen, Denmark. Second vessel of an order for two. Main dimensions: 445 ft. between perpendiculars by 63 ft. 6 in. by 41 ft. 6 in. to upper deck; deadweight capacity, 9,625 tons on a draught of 27 ft. 8½ in.; cargo capacity, 635,450 cub. ft., bales. Ten-cylinder single-acting two-stroke Diesel engine, developing 9,200 b.h.p. at 115 r.p.m. Speed on trial, 17.25 knots, loaded. Delivered, October 24.

M.S. "STANBURN."—Single-screw cargo vessel, built by the Burntisland Shipbuilding Co., Ltd., Burntisland, Fife, for the Stanhope Steamship Co., Ltd. (J. A. Billmeir & Co., Ltd.), London, E.C.2. Main dimensions: 435 ft. between perpendiculars by 59 ft. 6 in. by 38 ft. 11 in. to shelter deck; deadweight capacity, 10,350 tons on a draught of 25 ft. 10 in.; gross tonnage, 5,575. Hawthorn-Doxford four-cylinder opposed-piston two-stroke Diesel engine, developing 3,300 b.h.p. at 110 r.p.m., constructed by R. and W. Hawthorn, Leslie & Co., Ltd., Newcastle-upon-Tyne. Speed, 12½ knots. Trial trip, October 29.

M.S. "PORT NELSON."—Single-screw cargo vessel, to carry twelve passengers, built and engined by Harland and Wolff, Ltd., Belfast, for the Port Line, Ltd., London, E.C.3. Main dimensions: 460 ft. between perpendiculars by 64 ft. 6 in. by 41 ft. 6 in. to upper deck; deadweight capacity, about 12,000 tons on a draught of 27 ft. 6 in.; gross tonnage, 8,375. Harland-B. & W. seven-cylinder single-acting two-stroke oil engine. Trial trip, October 30 and 31.

NOTES ON NEW BOOKS.

The Craft of the Metalworker.

By R. S. DUDDLE. Technical Press, Limited, Gloucester-road, Kingston Hill, Surrey. [Price 17s. 6d. net.]

ONLY in the technical college, school or home workshop can a man freely undertake, without trade-union objection, such varied metalworking processes as marking-out, scraping, drilling, grinding, engraving, turning, planing, sand-blasting, oxy-acetylene cutting, forging, embossing, rolling, drawing, riveting, moulding, hardening and tempering. These, and others, are the subjects of Mr. Duddle's book, and it is for such would-be craftsmen that he has written it. The scope is, perhaps, rather too wide for a book of 155 pages which also contains nearly 300 illustrations, but the author has countered this criticism in advance by giving a bibliography of books that are more specialised. As an introduction to many skills, however, it is a useful book which should contribute to the maintenance of the oldest tradition in mechanical engineering—the hand working of metals.

Symposium on the Identification and Classification of Soils.

Special Technical Publication No. 113, American Society for Testing Materials, 1916, Race-street, Philadelphia 3, Pennsylvania, U.S.A. [Price 1.65 dols.]

THE five papers in this symposium were presented at a meeting of the American Society for Testing Materials, held at Atlantic City, New Jersey, on June 29, 1950, under the chairmanship of Mr. G. W. McAlpin, principal soils engineer in the Bureau of Soil Mechanics, Department of Public Works, State of New York. The purpose of the symposium was to bring before the society some of the procedures in current use for identifying and classifying soils for engineering purposes. In the first paper, Professor D. M. Burmister gives his views on the principles of identification and classification of soils, emphasising the essential differences between these two concepts. He then describes, with examples, proposed systems of identification for granular and clay soils based on particle-size distribution and simple plasticity tests. The classification system proposed by the Bureau of Reclamation is described by E. A. Abdrin-Nar. This is a modification of Casagrande's classification system for airfield construction as used by the United States Corps of Engineers in the last war. The soil classification systems of the Highway Research Board and of the Bureau of Public Roads are described by W. F. Abercrombie and E. A. Willis, respectively. Both of these are modifications of the grouping of highway subgrade soils proposed by Hogentogler and Terzaghi in 1929, in which eight soil groups, designated A-1 to A-8, are defined. Finally, E. J. Felt outlines the identification and classification procedures of the Division of Soil Survey, U.S. Department of Agriculture. In this, the position of a soil stratum in the geological system is clearly defined, in addition to the characteristics of its particle-size analysis.

Chambres d'Equilibre.

By PROFESSOR ALFRED STUCKY. Ecole Polytechnique, University of Lausanne, Switzerland. [Price 15 Swiss francs.]

IN this monograph, the subject of surge tanks is presented as part of a course on the harnessing of water power. This branch of hydraulics is obviously of great importance to Swiss engineers and, consequently, is carried considerably farther than is usual in English texts. The book opens with a clear statement on the object of surge tanks and a simple explanation of the phenomena of water hammer. The treatment here is, in general, that given by MM. J. Calame and D. Gaden, simplified to suit the needs of students. The second chapter treats of surge tanks of special shapes and compares, for the case of total instantaneous closure of a valve in the pipeline, the methods of Pressel, Schoklitsh and a simplification of the former, due to the author. Chapter III deals with the oscillations in a surge tank of constant section, for total instantaneous and slow valve operation, explaining the semi-graphical method of Calame and Gaden. A weakness of the text is that a number of graphs are drawn from the *Théorie des Chambres d'Equilibre*, by these two authors, and there is now some difficulty in obtaining their book, which was published in 1926. The effect of the governing of the turbine on the motion in the surge tank is the subject of Chapter IV, and the final two chapters treat of tanks of expanding, throttling and differential forms. The book provides an excellent introduction to its subject, as a preparation for the study of papers by specialists. Readers who consult it in a library should note that, as issued by the Lausanne Polytechnic, it is accompanied by a foolscap list, in typescript, listing errata on 13 pages of the book.

BOOKS RECEIVED.

An Introduction to Applied Mathematics. By PROFESSOR J. C. JAEGER. Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4. [Price 35s. net.]

Department of Scientific and Industrial Research. Report of the Chemistry Research Board, with the Report of the Director of the Chemical Research Laboratory for the Year 1950. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 3s. 6d. net.] (See p. 563 ante.)

Ministry of Local Government and Planning. The Rag Flock and Other Filling Materials Act, 1951. Explanatory Memorandum. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 3d. net.]

Overseas Economic Surveys. Portugal. By M. S. HENDERSON. With annexes on Madeira and the Azores. [Price 3s. net.] *Honduras.* By G. E. STOCKLEY. [Price 1s. net.] H.M. Stationery Office, Kingsway, London, W.C.2.

Ministry of Transport. Railway Accidents. Report on the Collision which Occurred on 1st August 1951 at Dalguise in the Scottish Region, British Railways. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 4d. net.]

Mathematical Engineering Analysis. By DR. RUFUS OLDENBURGER. The Macmillan Company, 60-62, Fifth-avenue, New York, 11, U.S.A. [Price 6 dols.]; and Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 45s. net.]

Flow Measurement with Orifice Meters. By REID F. STEARNS, ROBERT M. JACKSON, RUSSELL R. JOHNSON, and CHARLES A. LARSON. D. Van Nostrand Company, Incorporated, 250, Fourth-avenue, New York 3, U.S.A. [Price 7.50 dols.]; and Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 56s. net.]

Note on Treated Wooden Transmission Poles in India. By D. NARAYANAMURTI. Indian Forest Bulletin No. 140. Forest Research Institute, Dehra Dun, United Provinces. [Price 1.10 rupees or 2s. 6d.]

United States National Bureau of Standards. Circular No. 513. Bibliography on the Measurement of Gas Temperature. By PAUL D. FREEZE. [Price 15 cents.] *No. 516. Selection of Hearing Aids.* By EDITH L. R. CORLISS. [Price 15 cents.] The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A.

United States National Bureau of Standards. Handbook No. 45. Testing of Measuring Equipment. By RALPH W. SMITH. The Superintendent of Documents, Government Printing Office, Washington 25, D.C., U.S.A. [Price 1.25 dols.]

Plastics Progress. Papers and Discussions at the British Plastics Convention, 1951. Edited by PHILLIP MORGAN. Iliffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.1. [Price 50s. net., postage 1s. 3d.]

A Guide to Plastics. By C. A. REDFARN. Iliffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.1. [Price 7s. 6d. net, postage 4d.]

Bautechnik-Archiv. No. 6. Wilhelm Ernst und Sohn, Hohenzollerndamm 169, Berlin-Wilmersdorf, Germany. [Price 8.60 D.M.]; and Lange, Maxwell and Springer, Limited, 41-45, Neal-street, London, W.C.2. [Price 15s. 1d.]

Die Stanzertechnik in der feinmechanischen Fertigung. By PAUL GABLER. Carl Hanser-Verlag, Leonhard-Eck-Strasse 7, Munich 27, Germany. [Price 21 D.M.]

Béton Précontraint. Étude Théorique et Expérimentale. By Y. GUYON. Éditions Eyrolles, 61, Boulevard Saint-Germain, Paris (5e). [Price 4,500 francs.]

Principles of Alternating Currents. By W. SLUCKIN. Cleaver-Hume Press, Limited, 42a, South Audley-street, London, W.1. [Price 10s. 6d.]

Electric Lighting. By C. E. GIMSON. Cleaver-Hume Press, Limited, 42a, South Audley-street, London, W.1. [Price 9s. 6d.]

Synthetic Resins and Allied Plastics. Edited by DR. R. S. MORRELL. Third edition, edited by H. M. LANGTON. Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4. [Price 50s. net.]

The Instrumentation of Open-Hearth Furnaces. The British Iron and Steel Research Association (Steel-making Division Open-Hearth Instruments Subcommittee). George Allen and Unwin, Limited, Ruskin House, 40, Museum-street, London, W.C.1. [Price 30s. net.]

Mathematics for Engineers. By RAYMOND W. DULL. Third edition, revised and edited by RICHARD DULL. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 7.50 dols.]; and McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 64s.]

National Physical Laboratory. Test Pamphlet (Schedule of Fees) No. 8. Measurement and Correction of Lead Screws. The Director, National Physical Laboratory, Teddington, Middlesex. [Gratis.]