

350-MW HYDRO-ELECTRIC GENERATING STATION AT HARSPRÅNGET, SWEDEN.

An outstanding event in the history of electricity supply was the opening in April of the 350-MW water-power station at Harsprånget, on the Stora Luleälv, 30 miles within the Arctic Circle in Sweden; and the transmission thence on the three-phase system, at 380 kV, of energy to the south of the country, a distance of nearly 600 miles. In the

on the engineers of the Swedish State Power Board and others who have been responsible for the work.

Before describing the Harsprånget station, the interior of which is illustrated in Fig. 1, it may be mentioned that the total water-power resources of Sweden would enable about 150,000 million kilowatt-hours of electricity to be generated annually, although the amount economically available is not more than one-third of that total. At the present time, the annual production of electricity from water power is some 20,000 million kilowatt-hours, while steam plant accounts for another

1,000 million kilowatt-hours. The State Power Board are responsible for about 44 per cent. of the total production and distribute electricity in bulk to local authorities, the railways, and to large industrial consumers, mainly in that part of the country which runs from east to west round Lakes Vänern, Vättern, Hjälmaren and Mälaren in central Sweden, and in the region north of the Indalsälven. The remaining 56 per cent. is generated by private companies, either for public use or for their own consumption, or by municipalities. The annual consumption amounts to about 2,800 kWh per head of the population.

The total generating capacity is 3,600 MW, of which 3,200 MW is installed in water-power stations. In addition to Harsprånget, there are other large stations in operation at Trollhättan (220 MW) on the Götaälv, at Krångede (210 MW) and Stadsforsen (130 MW) on the Indalsäven, and at Hjalta (120 MW), on the Faxälven. Stations are also being built at Kilforsen (240 MW), on the Fjällsjöälven, and at a number of other places. In all, there are, in fact, some 1,400 plants with individual capacities exceeding 75 kW. The large steam stations include those at Västerås (140 MW), Stockholm (100 MW) and Malmö (70 MW). There are also a number of smaller stations, containing a total of 125 MW of back-pressure turbines.

The energy generated in these stations is transmitted over an extensive primary network, consisting of lines operating at 220, 132, 77 and 55 kV and forming a connected system which stretches from Porjus in the north to Malmö in the south, a distance of rather over 800 miles as the crow flies. From Porjus, there is a connection to Narvik, in Norway, and in the south, one to Denmark by cables under the Öresund. There are at present six 220-kV lines, of which the first was erected in 1936. Four of these were constructed by the State, which in future will be responsible for all lines operating at this and higher voltages.

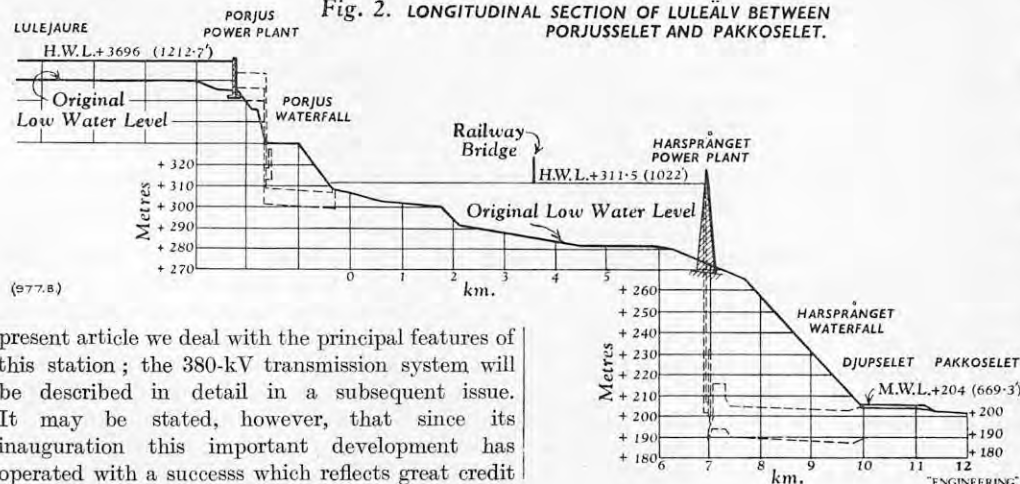
The location of the undeveloped water-power resources of the country in the north and of the principal load centres in the south, combined with a rapid increase in consumption, made it clear some time ago that it would be necessary to erect 300 miles of new 220-kV line every year. As an alternative to this, the possibility of using high-voltage direct current was investigated, but the conditions for its employment were found to be neither technically nor economically favourable. It was therefore decided to erect a three-phase line for normal operation at 380 kV, but with a maximum service voltage of 400 kV, over which power could be transmitted from Harsprånget to Hallsberg, a distance of nearly 600 miles.

As we have said, the 350-MW station at Harsprånget is situated on the Stora Luleälv and is the second of a group of seven which are to be built on that river between Lake Lulejaure and the Gulf of Bothnia. The name Harsprånget means "the hare's leap," and is derived from a legend that a hare, chased by a fox, leaped over the rapids at a point below the station, where a large rock stands up in the middle of the torrent. The station is situated in wild and desolate country, inhabited, before the construction camps were erected, only by a few nomad Lapps, engaged in herding reindeer. At present, only the station at Porjus (135 MW), which lies five miles upstream of Harsprånget and was opened in 1915, is in operation. The river drains a catchment area of some 4,000 sq. miles, and its flow varies from 42,700 cusecs in exceptional years to a normal high-water flow of 23,600 cusecs. The average winter flow is 8,800 cusecs in normal years and 7,400 cusecs in dry years; the mean annual flow is 9,000 cusecs. As a result of extensive regulation at the sources of the river, it is possible during the three winter months to maintain a flow of 9,500 cusecs in normal years and 8,500 cusecs in dry years. On occasion,



FIG. 1. GENERATOR ROOM AT HARSPRÅNGET.

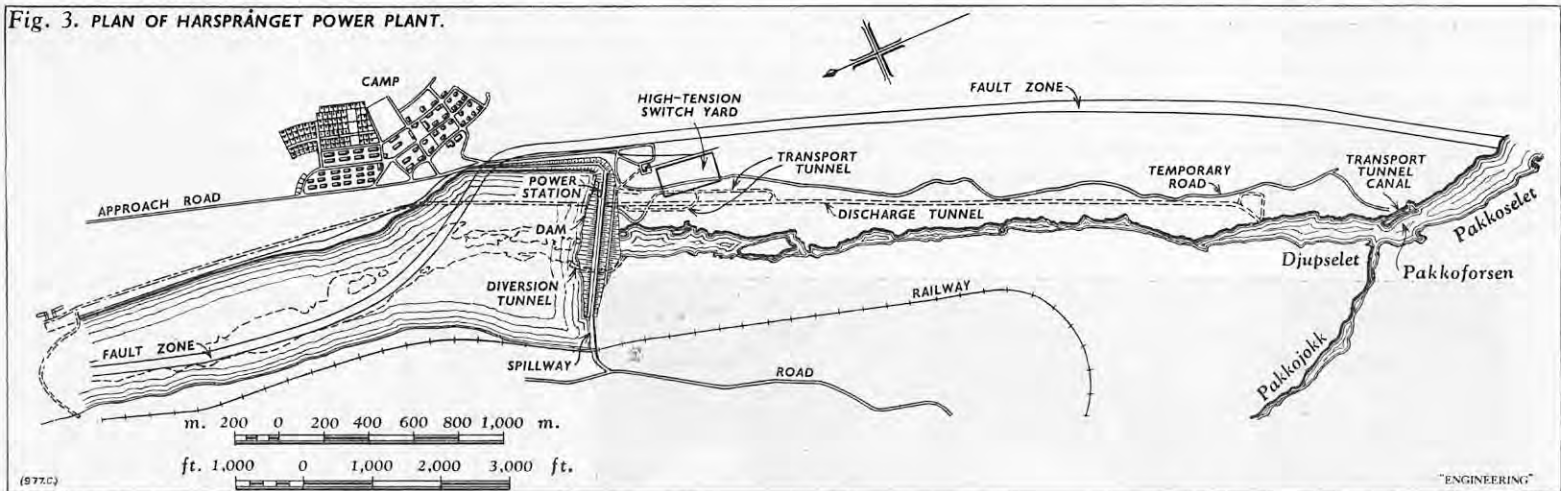
Fig. 2. LONGITUDINAL SECTION OF LULEÄLV BETWEEN PORJUSSELET AND PAKKOSELET.



present article we deal with the principal features of this station; the 380-kV transmission system will be described in detail in a subsequent issue. It may be stated, however, that since its inauguration this important development has operated with a success which reflects great credit

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Fig. 3. PLAN OF HARSPRÄNGET POWER PLANT.



however, it will be necessary to release more water than is required for power production, to assist log-handling to the pulp mills lower down the river. Under these conditions, it was considered advisable to design the station for a flow of 11,340 cusecs, which will be equally distributed over three units. After further regulation at the source, it should be possible to install a fourth unit of the same capacity.

A section of the river between Lulejaure and Pakkoselet is given in Fig. 2, on page 585, and a general map of the Harsprånget site is reproduced in Fig. 3, above. The station lies about 4.3 miles below the Porjus outlet tunnels. At this point a dam 2,560 ft. long and with a maximum height of 148 ft. has been constructed across the river, with a curtain wall 2,130 ft. long and 40 ft. high along the left bank. Preliminary investigation by diamond drilling disclosed the existence of a fault zone between Porjus and Harsprånget, in which the river had eroded a channel. This fault turns to the left just before the site of the dam is reached and then runs parallel with the course of the river. The curtain wall has been constructed so that it crosses this zone at a point where its depth is small, thus enabling the excavations for the penstocks, power station and tailrace tunnel to be effected in sound rock.

For constructional purposes a diversion tunnel, 820 ft. long and with a cross-section of 1,076 sq. ft., was driven in the right bank of the river. A vertical shaft was then sunk at a point a short distance downstream from the entrance to this tunnel for the installation of a gate, operated by machinery housed in a concrete tower at a height slightly above high water level. On the completion of the dam, the tunnel was sealed by a concrete plug and the gate removed. The inlet to this tunnel is illustrated in Fig. 4, on page 587.

In accordance with a common practice of the Swedish State Power Board, the major part of the dam is of rock-fill design. This has enabled the material that has been excavated to form the power station and tunnels to be used in its construction. This was an advantage because the impervious material available locally would not have been sufficient to provide earth and rock fill. The central portion has a comparatively thin reinforced-concrete core wall, which is shown in course of construction in Fig. 5, opposite. This wall is faced with clay to a thickness of from 10 ft. to 13 ft., and is supported on a concrete foundation block and by rock filling on the downstream side, as shown in Fig. 5 and Figs. 6 to 10.

It was intended originally to secure the core wall rigidly to the foundation block, and to build the latter to a height of from 10 to 13 ft. above the connection. It was also intended to incline the upstream face of this part of the foundation away from the core wall and to fill the space between

the two with shingle. It was assumed that, although this material would yield when thrust backwards by the water pressure, it would still offer sufficient resistance to reduce the bending moment at the point of connection to a large extent. To decrease the stresses in the core wall still further, it was decided to raise the height of the foundation block, so that the connection between it and the core wall would never be more than 115 ft. below the maximum water level. This course was adopted at places where the dam was highest and, as a consequence, it was necessary to fill many of the irregularities in the river bed with concrete. Moreover, by using well-packed moraine for the lower part of the filling immediately behind the core wall it was hoped that the deflection of the latter would be limited and that it would not be subjected to dangerous stresses.

To calculate this deflection, it was necessary first to ascertain the modulus of elasticity of the filling material in the downstream portion, as this had to resist the thrust of the core wall. Tests were therefore made at different pressures, assuming optimum compaction. The results enabled the maximum values of the modulus at different depths below the crest of the dam to be ascertained; and the dimensions of the core wall were calculated on the assumption that a modulus amounting to 70 per cent. of this maximum would occur in practice. Subsequent calculations of the deflection showed that the maximum stress in the concrete due to the overturning moment and vertical compression would be 2,130 lb. per square inch, assuming that heavy reinforcement were used. The vertical load was estimated to be equal to the weight of the core plus the frictional drag of the material on each side of the concrete core when settling. As, however, it was uncertain to what extent these assumptions with regard to load were correct, it was decided that a flexible joint should be included in the core wall just below the highest point of the foundation block, thus enabling the thickness of the core to be considerably increased. The design actually adopted is illustrated in Figs. 11 and 12, on page 587, which is a cross-section through the dam at the deepest part of the river, where it was estimated that the stresses in the concrete would not exceed 1,140 lb. per square inch.

Water-tightness has been ensured partly by mounting the core wall on a reinforced-concrete vertical slab, which, as also shown in Fig. 12, forms the upstream face of the concrete foundation; and partly by a clay core which was laid upstream of the core wall. Immediately behind the latter was placed a layer of fine sand, so that any particles of clay that might escape through possible cracks in the core would be trapped. The rock under the clay core was grouted with cement mortar, two lines of bore holes, one 26 ft. and the other 10 ft. deep,

being drilled for this purpose. Additional holes were also drilled at places where trial bores showed this to be advisable. To prevent uplift, wells 2 in. in diameter were sunk in the rock at 5-ft. centres to a depth of 16.5 ft. and at a distance of 6.5 ft. downstream from the upstream face of the concrete foundation. The mouths of these wells are surmounted by vertical pipes, as can be seen from Fig. 10, which extend upwards into a gallery in the foundation, access to which can also be obtained from the downstream side.

To increase the contact area between the clay and the rock and the clay and the concrete, and thus to decrease the risk of leakage along their adjoining surfaces, the clay core was carried down into a trench which was excavated to a depth of 6.5 ft. in the rock. Fissures and cracks in the bottom and upstream side of this trench were then opened up and filled with concrete or cement mortar. At certain places, where the rock was particularly unsound, a water-tight concrete wall of a total height of 6.5 ft. was built along the upstream face.

The clay core is 13 ft. thick at places where the depth of the river bed is greatest, but diminishes gradually to 10 ft. at a point 66 ft. below the top water level in the reservoir. Above this level the thickness is constant. The concrete used in the upstream portion of the foundation contained 465 lb. of cement per cubic yard, the maximum size of the stone aggregate being 3 in. In the downstream portion the cement content was reduced to 340 lb. per cubic yard and plenty of displacers were used. Contraction joints were inserted at intervals of 33 ft. The core wall and its supporting slab, however, have been constructed without such joints and the reinforcing bars pass through the construction joints. The concrete used for this portion of the work contained 550 lb. of low-heat cement per cubic yard, the maximum size of the stone aggregate being 2 in. The upstream surface of the core wall was coated with asphalt in order to reduce the friction between it and the clay, thus facilitating the settlement of the clay and increasing watertightness. The design of the joint between the core wall and the slab will be clear from Figs. 11 and 12, from which it will be seen that it widens gradually towards both edges and is filled with asphalt. This asphalt consisted of 14.2 per cent. by weight of both Trinidad and oil bitumen, 26 per cent. of cement, 43 per cent. of sand and 2.6 per cent. of cork. It will also be seen that the concrete just above and below the joint was heavily reinforced in a transverse direction, while the joint itself contains a light vertical reinforcement.

The fine-graded materials next to the core wall are separated from the rock fill by filters to prevent the penetration of the fines into voids in the coarser material. On the upstream side these filters consist of one layer each of sand, gravel

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FIG. 4. INTAKE OF DIVERSION TUNNEL.

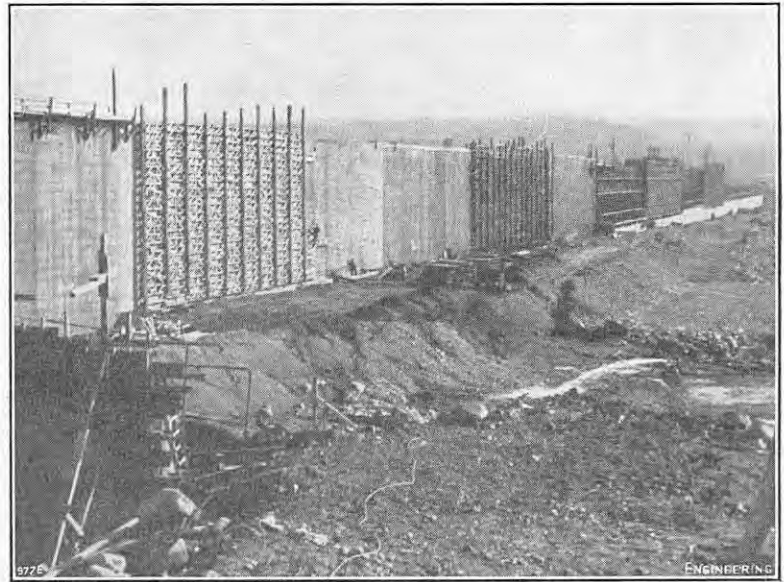


FIG. 5. CORE WALL IN COURSE OF CONSTRUCTION.

Fig. 6. UPSTREAM VIEW OF MAIN DAM.

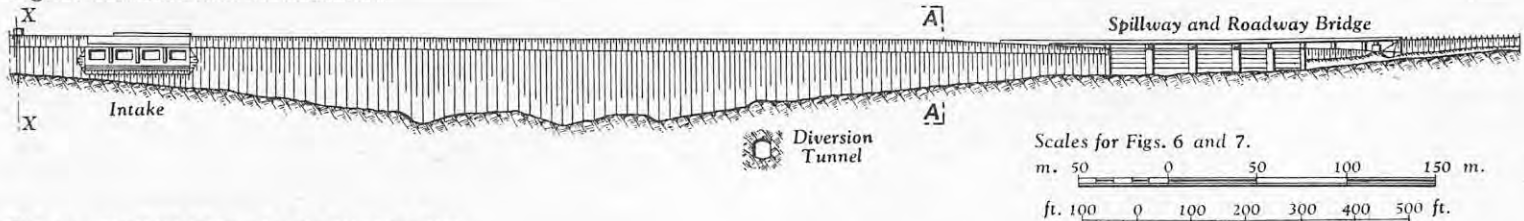


Fig. 7. UPSTREAM VIEW OF DAM ON LEFT BANK.

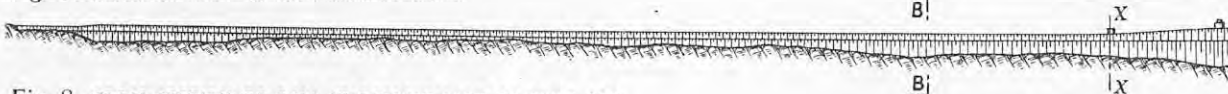


Fig. 8. CROSS SECTION OF DAM AT DEEPEST PART OF RIVER BED.

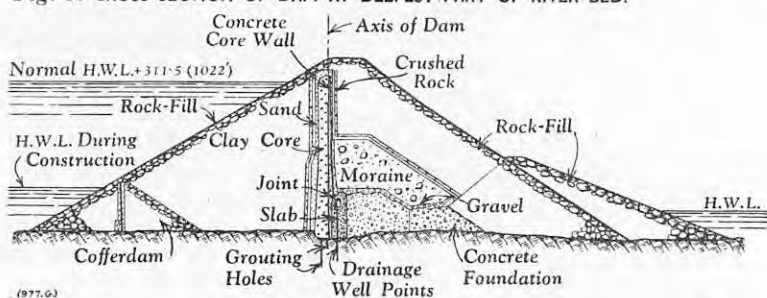


Fig. 11. DETAIL OF SEALING.

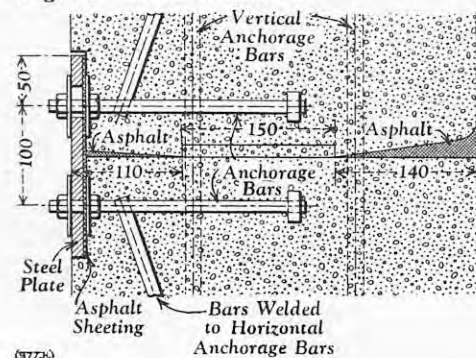


Fig. 12. JOINT BETWEEN CORE-WALL AND SLAB IN FRONT OF FOUNDATION.

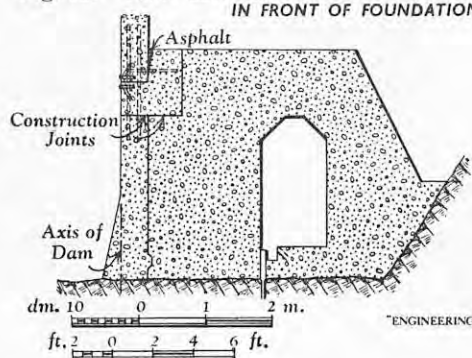


Fig. 9. SECTION A-A (FIG. 6)

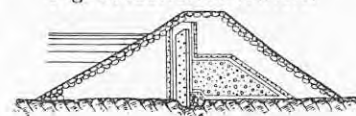
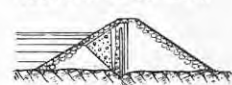


Fig. 10. SECTION B-B (FIG. 7)



Scales for Figs. 8, 9 and 10.
m. 20 0 20 40 m.
ft. 50 0 50 100 150 ft.

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and non-graded crushed rock, while downstream there is one layer each of gravel and non-graded crushed rock between both the sand and the rock fill and the sand and the moraine. Where the downstream fill is subjected both to water pressure and lateral earth pressure from the upstream fill, the materials were placed in moderately thin layers. The gravel and rock fill was then consolidated by washing, while the finer graded materials were moistened sufficiently to enable them to be compacted by rolling. The moisture content of the clay core was also adjusted to enable it to be

compacted by tractors. When the weather was too wet to enable this to be done, in spite of the erection of temporary roofing over the site, the clay was mixed with about 50 per cent. of dry gravel, thus giving a material with about the same permeability, compression and internal friction properties. To reduce the risk of the clay being suspended between the core walls and the filters, and thus forming voids, both the filters and rock in the upstream part of the dam were compacted less than those in the downstream portion.

(To be continued.)

PAINTING ASBESTOS CEMENT.—The precautions required to obtain satisfactory results when painting asbestos cement are described in Advisory Leaflet No. 28, *Painting Asbestos Cement*, issued by the Ministry of Works and obtainable from H.M. Stationery Office, Kingsway, London, W.C.2, price 3d. net.

LIGHTING EQUIPMENT FOR THE CORONATION.—The General Electric Co., Ltd., have arranged a special display of lighting equipment designed for indoor and outdoor illuminations in connection with the Coronation of H.M. the Queen next year. It is in a showroom at Magnet House, Kingsway, London, W.C.2. The wide range of fittings shown includes illuminated crowns, fleurs-de-lis, etc. These are made in Chrysaline, a new lighting medium which is weatherproof, non-inflammable and light in weight. Beverley Pick Associates, industrial design consultants, have been appointed by the company to advise and prepare schemes, when required, for decorative illumination.

STANDARDISATION OF HACKSAW BLADES.—The standardisation of the size of hacksaw blades is to become effective from January next. Negotiations were commenced in 1949, and agreement has just been reached between United Kingdom, American and Canadian manufacturers. Mr. W. A. Tuxford, of Sheffield, secretary of the British Hacksaw Makers' Association, states that the agreement will greatly benefit the engineering industry, and will be warmly welcomed by the distributive tool trade throughout the world. The new sizes will form the basis for a new British Standard specification for hacksaw blades which is being prepared.

LITERATURE.

Acoustics in Modern Building Practice.

By FRITZ INGERSLEV. The Architectural Press, 9-13, Queen Anne's Gate, London, S.W.1. [Price 35s.]

THE Scandinavian countries have played a prominent part in the application of acoustical principles to building design, and the author of this book, who has directed the Acoustical Laboratory at the Danish Academy of Technical Sciences since 1946, has been actively working on this subject and is one of the principal contributors to its progress. In the introductory summary of the properties of sound, definitions are given of sound energy, sound intensity and loudness level, together with methods for their measurement. The next chapter, on room acoustics, deals with the manner in which sound waves are reflected by, and absorbed at, the surfaces bounding the room or scattered from obstacles within it. Sabine's classical formula for reverberation time is discussed, together with Eyring's modification, and optimum reverberation times for speech and music are specified. To ensure an even distribution of sound throughout the seating area, particularly in large rooms, special attention should be paid to shape in order to take advantage of beneficial reflections to reinforce the direct sound without causing echoes. Methods of checking acoustical designs, involving the drawing of sound rays and wave fronts or the use of two-dimensional or three-dimensional scale models, are explained. In three lines on page 46 "chord" should read "cord" and the reference should be to Fig. 1.5 instead of Fig. 1.3. Chapter III, devoted to sound absorbing materials and the determination of their sound absorption coefficients, also contains a table of the values of these coefficients for a variety of building materials at frequencies from 125 to 4000 Hz. at octave intervals. A warning is given that the values usually quoted for glass are not valid for windows, and the suggestion that only one laboratory in each country should be empowered to make official measurements of absorption coefficients by the reverberation method, using an internationally-agreed standard procedure, is to be commended. Attention may be called to the use of Helmholtz resonators as absorbers and to the example of their application to cut down the unduly long reverberation times associated with normal modes of vibration at frequencies of 64 and 98 Hz in Studio I at Broadcasting House, Copenhagen.

Noise and noise abatement are discussed in Chapter IV, in which consideration is given to measures for reducing noise at its source. When everything possible has been done in this respect the problems of the transmission of air-borne and solid-borne sound and vibration remain. These are dealt with in the next two chapters. The importance of measuring the sound reduction factor of test walls under conditions resembling as closely as possible those encountered in practice is emphasised, and it is shown that materials with high absorption coefficients are not necessarily effective for sound insulation. It may be noted that equation (31.01), on page 191, does not agree with the preceding definition. Structure-borne sounds and vibrations are troublesome since they can travel over considerable distances with little attenuation. The standard procedure for measuring impact sounds is described and a timely caution is given that the provision of anti-vibration mountings may increase the vibration of the machine mounted on them. The concluding chapter is concerned with the control of noise in air-conditioning systems for which purpose ducts of rectangular section are more effective than those of square or circular section. Mr. Ingerslev has drawn on a wide experience in the application of acoustics in building practice not only in his own country but also in this country and America, to produce a

comprehensive and critical survey. The original Danish text has been admirably translated into English and revised by the author himself.

Helicopter Analysis.

By PROFESSOR ALEXANDER A. NIKOLSKY. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 7.50 dols.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 60s. net.]

UNTIL very recently, the number of scientists and engineers working on rotary-wing aircraft theory was small enough for knowledge to be exchanged by personal contacts, and by reports and articles in technical periodicals. The rapid growth in the importance of the helicopter in both military and civil aviation, and the corresponding increase in design activity, has led to a demand for courses of lectures on helicopter design theory and for textbooks to accompany them. Professor Nikolsky, after 13 years with the world's largest helicopter firm, Sikorsky Aircraft, went to Princeton University, where he has spent ten years leading helicopter research teams and instructing students in helicopter theory. He published, in 1946, under the title *Notes on Helicopter Design Theory*, a paper-backed booklet, based on his lectures, which was soon accepted as a standard work. He has now followed this with an expanded and more permanent version of his lecture notes.

The aerodynamics of the helicopter includes all the aerodynamics of the fixed-wing aircraft (the knowledge of aerofoil theory, of boundary layers, of compressible flow, of wing flutter, etc.) and applies it to a complicated system of aerofoils which are being whirled about their ends while attached to the rest of the aircraft only by a universal joint. Although a rotor blade is merely a wing, the airflow approaching it changes considerably along its length and, at any point, varies during the rotation from perhaps almost supersonic speed to a gentle flow from trailing to leading edge. These complications reduce largely to matters of solid geometry and long integrations, once the fundamental aerodynamic assumptions have been made.

Professor Nikolsky's book starts with a review of airscrew theory, which leads naturally to considerations of the helicopter in vertical flight. After an examination of the geometry of blade flapping and feathering, the forward flight condition is considered. The second half of the book deals with the stability of the single-rotor helicopter and ends with a chapter on the stresses occurring in a non-rigid blade. Numerical examples are used freely in the text to illustrate the use of the equations developed, but the reader may feel the lack of discussions on the significance of some of the parameters occurring. To avoid some of the complications, many sweeping assumptions about the airflow are made; for example, that the velocity induced through the rotor disc by the rotor thrust is either uniform or of a simple triangular pattern. No attempt is made to justify these assumptions or to say what the effect would be on the answers if the assumption failed. The notation adopted is mostly familiar to students of helicopter aerodynamics. The lists of symbols contain also an alternative "rational system" of notation which it is to be hoped will not be adopted; in it the rotor angular velocity ω becomes $\dot{\theta}_{za}$, and sideforce Y becomes F_{ry} . Even the simpler system adopted leads to stability derivatives such as $M_{\dot{\alpha}_0 \dot{\alpha}_0}$. The general reader must look elsewhere for a discussion of the problems of helicopter design, but the student of helicopter theory will find here a reference book of lasting value.

IRON AND STEEL CORPORATION OF GREAT BRITAIN.—A revised list of the publicly-owned and subsidiary companies of the Iron and Steel Corporation of Great Britain, 1, Chester-street, London, S.W.1, has now been published in pamphlet form.

HYDRODYNAMIC FORCES ON HYDRAULIC PISTON VALVES.

By T. E. BEACHAM, B.Sc., M.I.C.E., M.I.Mech.E.

ONE of the advantages of piston valves is that they can readily be designed so that there is no end thrust on the spool due to static pressure, and thus the only forces in the direction of movement are those due to friction and hydrodynamic effects, apart, of course, from any inertia effects due to the weight of the valve itself. With industrial valves the hydrodynamic force is usually less than that due to the friction. Nevertheless, these hydrodynamic effects frequently cause harmful vibrations, particularly where the valve is only partly open; similar troubles with aircraft hydraulic control valves have been referred to in a recent paper by Mr. F. J. Bradbury and Mr. S. M. Parker.*

There are at least three classes of piston valve where the hydrodynamic effect may constitute the major part of the total force on the valve. These are: valves of small dimensions with high power losses; valves in which special precautions are taken to eliminate friction (as, for example, for load-measuring devices and for certain types of servo-mechanisms); and valves in which the hydrodynamic forces are used to control the flow.

Forces on Four-Way Piston Valves.—The nature of the hydrodynamic forces can perhaps best be understood by considering how they act in an ordinary four-way control valve like that shown in Figs. 2 and 3. In the valve illustrated the ends of the lands are shown tapered to enable the rate of flow to be closely controlled by the operator. Fig. 2 shows the valve with its spool moved to the right of its centre position; the pressure liquid passes from port A through the valve opening to port B and thence to the load, returning to port C and passing through the valve again to reach the exhaust passage D.

In order to estimate the hydrodynamic forces accurately for any particular valve, it would be necessary to know the exact flow pattern through the valve, and in most cases this could only be obtained by experiment. However, in the absence of complete information, it is possible, by neglecting the factors of lesser importance, to make an approximate estimate of the force. In considering the flow from A to B in Fig. 2, if the cross-sectional area of the jet is small compared with that of the remainder of the flow stream, the momentum of the stream may be neglected except at the throat of the jet; further, it may be assumed that the whole of the jet reaction is borne by the spool, and that the circumferential component of the jet velocity is negligible. Then for the flow from A to B, Fig. 2, the force on the valve will be that due to the reaction of the jet, and provided that the distribution of this jet around the circumference is such that the radial components are in balance, the resultant force will be axial. It is immaterial whether the jet forms a complete annulus or whether there are a series of notches forming separate jets.

On these assumptions the axial force F_1 due to the stream flowing from A to B will be equal to the total jet reaction $\times \cos \theta_1$.

Let J = total jet force or reaction (i.e., sum of the forces from each element of the jet).

F = axial force on valve due to J .

Q = quantity flowing per second.

θ = angle of jet with valve axis.

p = pressure difference between the two sides of the jet orifice.

ρ = specific gravity of the liquid.

* Paper on "Powered Flying Controls: Some Design Considerations." *Proc. I.Mech.E.*, Part B, vol. 1 B, No. 4 (1952).

HYDRODYNAMIC FORCES ON HYDRAULIC PISTON VALVES.

Fig. 1.

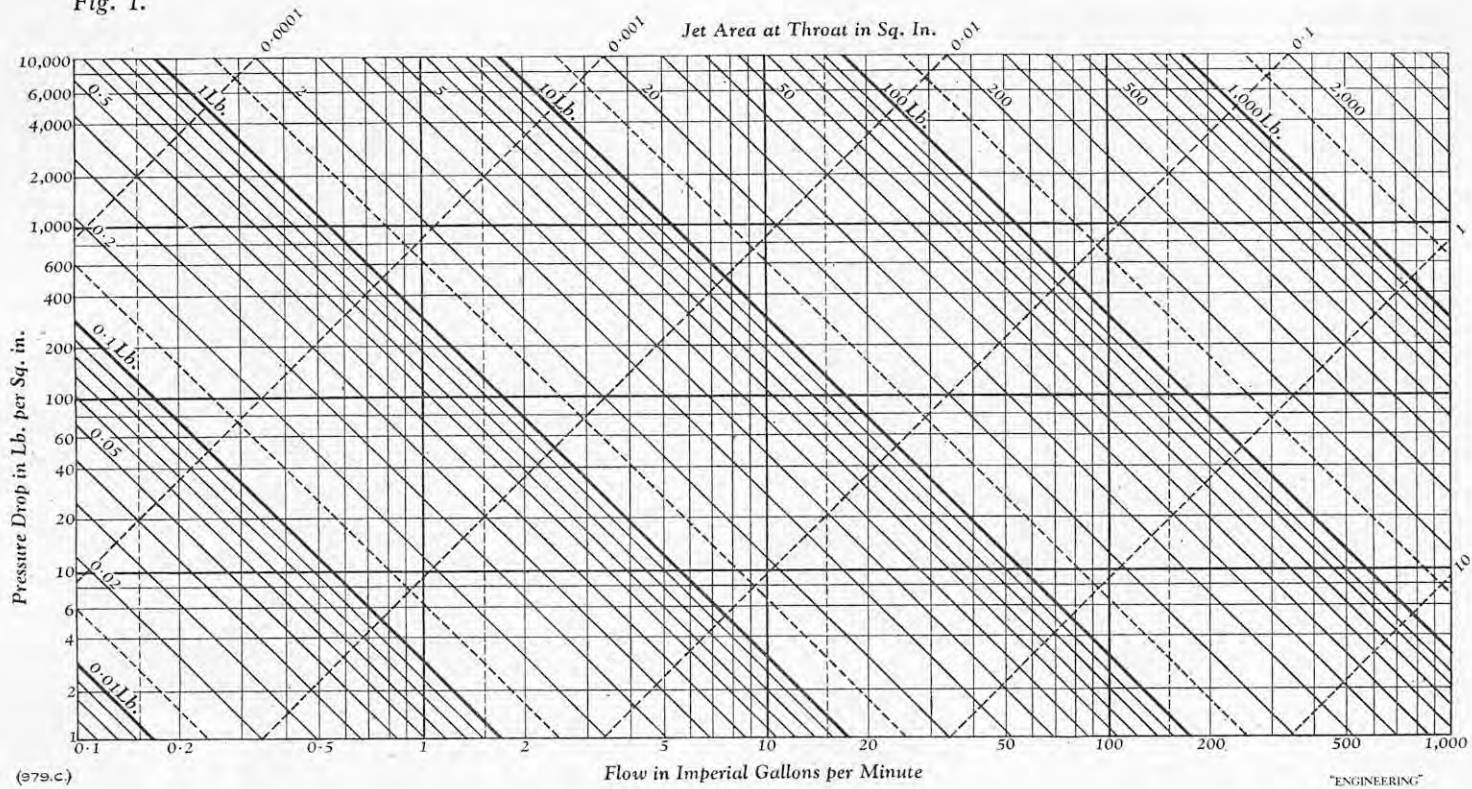


Fig. 2.

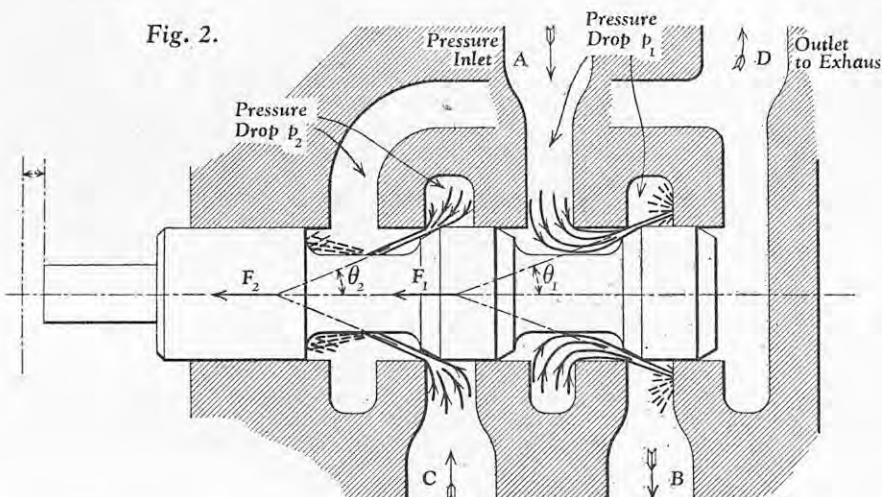


Fig. 3.

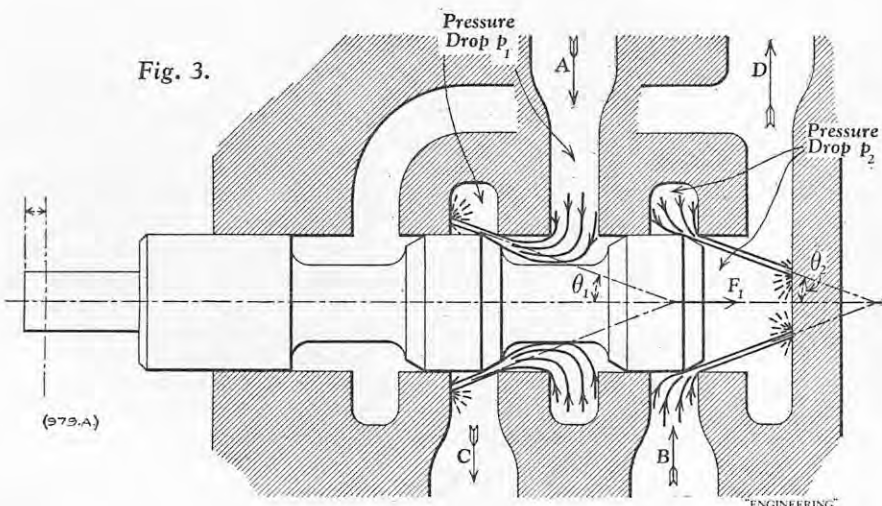


Fig. 4.

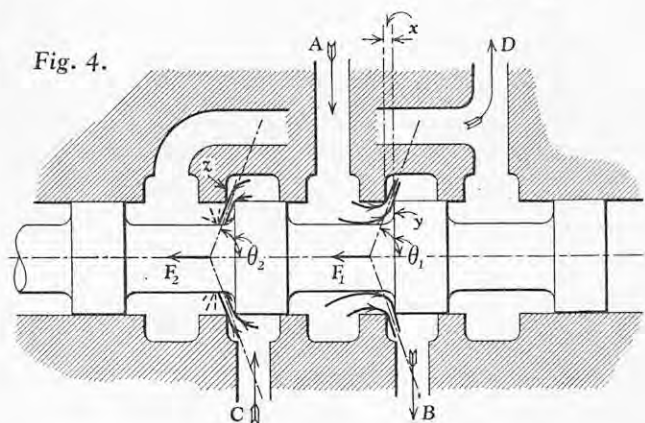
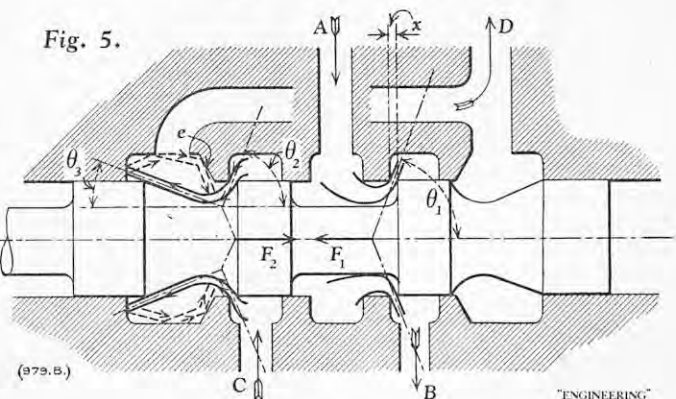


Fig. 5.



Now J = rate of change of momentum
 = mass flow per second $\times$ velocity, and if
 liquid friction be neglected, then velocity
 may be expressed in terms of p and ρ ;
 mass flow may also be given in terms of
 Q and ρ . Then in everyday units

$$J = 0.063 Q \sqrt{p \rho}$$

where Q is in gallons per minute, p in
 lb. per square inch, and J in lb., and
 F (in lb.) = $J \cos \theta = 0.063 Q \sqrt{p \rho}$
 $\cos \theta$.

The value of J may readily be found from Fig. 1,
 provided the quantity flowing, the pressure drop
 and the specific gravity of the liquid are known.

In Fig. 2, the diagonal force curves give the value
 of J , the total jet force or reaction. Note that this
 is not a resultant force, but the sum of the forces due
 to each element of the jet. The curves have been
 drawn for liquids of 0.87 sp. gr. For other liquids

multiply values of J by $\sqrt{\frac{\text{sp. gr.}}{0.87}}$ and values of jet
 area by $\sqrt{\frac{0.87}{\text{sp. gr.}}}$. Taking a specific example, if the

flow is 10 gallons per minute, the pressure drop
 500 lb. per square inch, θ_1 20 deg., and the sp. gr.
 of the liquid 0.85. Then, from the diagram,
 $J=13$ lb. Correcting for specific gravity brings this to

12.9 lb. so that force $F_1 = 12.9 \cos 20 \text{ deg.} = 12.1'$ say 12 lb. approximately.

Now consider the flow from C to D in Fig. 2. Here, as an approximation, it may be assumed that the whole of the reaction of the jet is taken on the fixed valve body and has no effect on the spool. The jet will strike the spool on its reduced diameter and some of it may be deflected on to the annular face as indicated. Assuming that all the momentum of the jet is destroyed before the stream passes in to the valve body, then the axial component of the jet force acting on the spool is $F_2 = J_2 \cos \theta_2$. Assuming the same values as before, i.e., $Q_2 = 10$, $p_2 = 500$, $\theta_2 = 20 \text{ deg.}$, sp. gr. = 0.85, then $F_2 = 12 \text{ lb.}$ in the same direction as F_1 ; thus the total force on the valve is 24 lb. It should be noted that the force tends to close the valve, and that both the flow and the force will vary with the valve opening. Thus, if for any cause vibration or oscillation of the valve is set up, this will be accompanied by pulsations in the flow.

If now, the position indicated in Fig. 3 be considered, in which the spool has been moved to the left of its central position, then it will be seen that the jet in the flow stream from B to D will not strike the spool but the casing, so that in this case, and using the previous assumptions, F_2 becomes zero and F_1 remains the only axial force on the valve.

Value of θ .—It will be noted from the foregoing that, in addition to the other assumptions, it is also necessary to estimate the value of θ ; the larger this is the more uncertain becomes the value of its cosine. A paper recently published by the A.S.M.E.* contains, among other interesting data, information concerning the value of θ for spools and valve bodies with square faces to the ends of the lands. The paper describes an investigation into the hydrodynamic forces on four-way piston valves with square-edged lands, having spools with a limited travel (up to 0.05 in. each way) of the type which can be operated by electromagnets controlled by thermionic valves.

Forces on Piston Valves with Square-Edged Lands.—For the type of valve shown in Fig. 4 the authors say that θ_1 depends on the angle of the face y on the spool and θ_2 on the angle of the face z on the valve body. For square faces at z and y the value of θ_1 and θ_2 is given as 69 deg. for both the inward and outward flows. The angle is independent of the valve opening x , provided that the corners of the spool and body are sharp and that the clearance is nil. If the ratio of valve opening to radial clearance is 10:1 the angles become about 61 deg., and if the ratio is 5:1, 57 deg. Rounded corners on the lands have effects of a similar type. One point of interest in the description of the investigation is that the value of 69 deg. was verified on a two-dimensional valve model with glass sides. This would seem to be a simple laboratory process which could be used to assess the value of θ for nearly any type of valve.

Method of Balancing Forces on Four-Way Valves.—The authors have devised an ingenious method of balancing the forces on valves of this type. Fig. 5 illustrates the construction. The jet in the return flow is gently diverted through approximately 90 deg. The combined effect of the jet originally striking the spool and the reaction of the jet on leaving the spool creates a force F_2 opposing F_1 . The force F_2 is increased by shaping the face e at an angle in such a way as to reflect the back eddy from the jet on to the spool again. Test results on an experimental valve are given in Fig. 6; this has been taken from the paper mentioned, and it will be seen that the construction enables the hydrodynamic forces for this type of valve to be very nearly balanced. Fig. 6 shows

HYDRODYNAMIC FORCES ON PISTON VALVES.

Fig. 6.

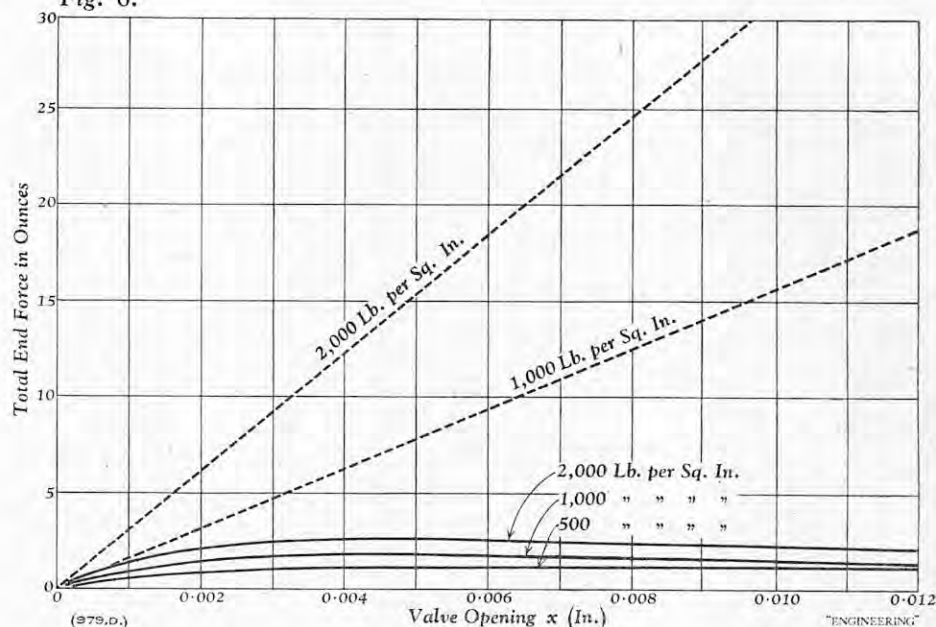
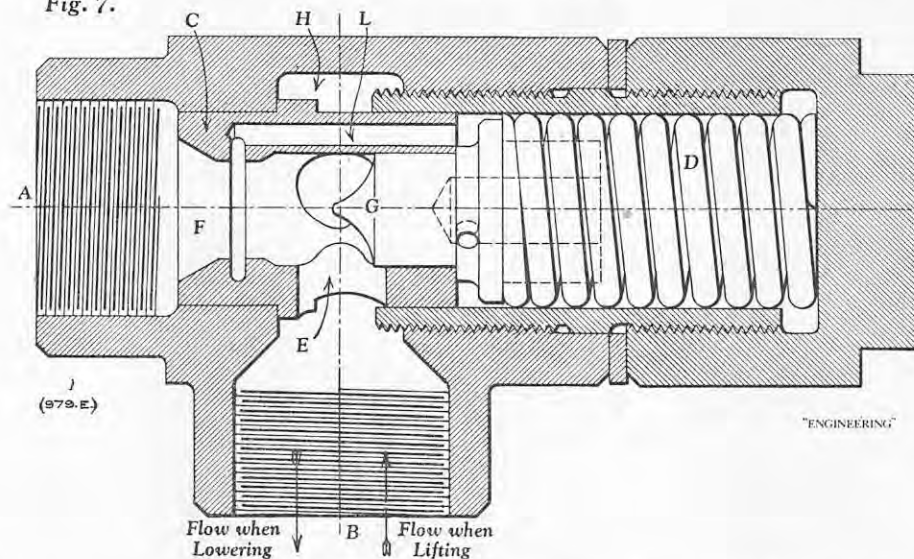


Fig. 7.



the performance of the first compensated piston valve made by Mr. Shih-Ying Lee and Mr. Blackburn. The full lines indicate the force with a compensated spool (as Fig. 5) and the dotted lines the force with a plain spool (as Fig. 4). Another method of eliminating or reducing the hydrodynamic thrust on the valve is to use a series of staggered holes to form the valve opening, the holes being either radial or inclined at a slight angle in order to bring the effective value of θ to 90 deg.

Automatic Flow Control Valves.—An example of the use of hydrodynamic forces to assist in automatic flow control is given in Fig. 7. This illustrates a valve manufactured by Messrs. Oswalds and Ridgway, Limited, which has been devised for use with hoists operated by hydraulic cylinders in which it is desired to limit the lowering speed to a predetermined figure. In the sectional view shown, A is connected to the hoist cylinder and B to the control valve. The body contains a sliding valve piston C which can move to the right by compressing the spring D. When moving to the right in this way the ports E are gradually reduced in area, thus restricting the flow through the valve. When lowering, liquid flows from A through the nozzle F, is deflected at G and passes through the ports E into the annular channel H, from which it passes to B. The throat of the nozzle is connected by the holes L to the spring chamber; thus, when lowering, the annular face of the valve piston C is subjected to the excess pressure necessary to force the liquid through the

nozzle; in addition to this, the whole of the jet force acts on the valve piston by reason of the impact at G.

There is a third force acting on the valve piston, namely, the axial component of the reaction of the jets caused by the flow through the partially-closed passages E. This third component depends not only on the lowering speed but also on the pressure drop across the orifices, which, in turn, depends on the load. The valve is normally made so that the lowering speed remains constant between zero and full load; for this condition it is necessary to arrange that the angle of the jets as they leave the valve piston is only slightly less than 90 deg. from the axis, the axial component of the jet reaction being approximately equal to the extra force exerted by the spring as it is compressed. It is possible, however, under certain conditions, to arrange that the lowering speed shall be higher for light loads than for heavy ones. This can be done by making the jet angle smaller and thus increasing the axial component of the jet reaction. The valve shown is designed for a lowering speed some 50 per cent. in excess of the lifting speed. When hoisting, the jet of liquid leaving at F, and travelling to the left, has a reaction which also tends to move the valve piston C to the right, but in this case the force is not sufficiently powerful to overcome the initial spring load.

In conclusion, it would seem that these hydrodynamic forces are a troublesome if minor problem for many designers of hydraulic equipment. The

* "Steady-State Axial Forces on Control-Valve Pistons" by Shih-Ying Lee and J. F. Blackburn. American Society of Mechanical Engineers, ref. 51-A 52.

THE "PRINCESS" FLYING BOAT.

SAUNDERS-ROE, LIMITED, COWES.

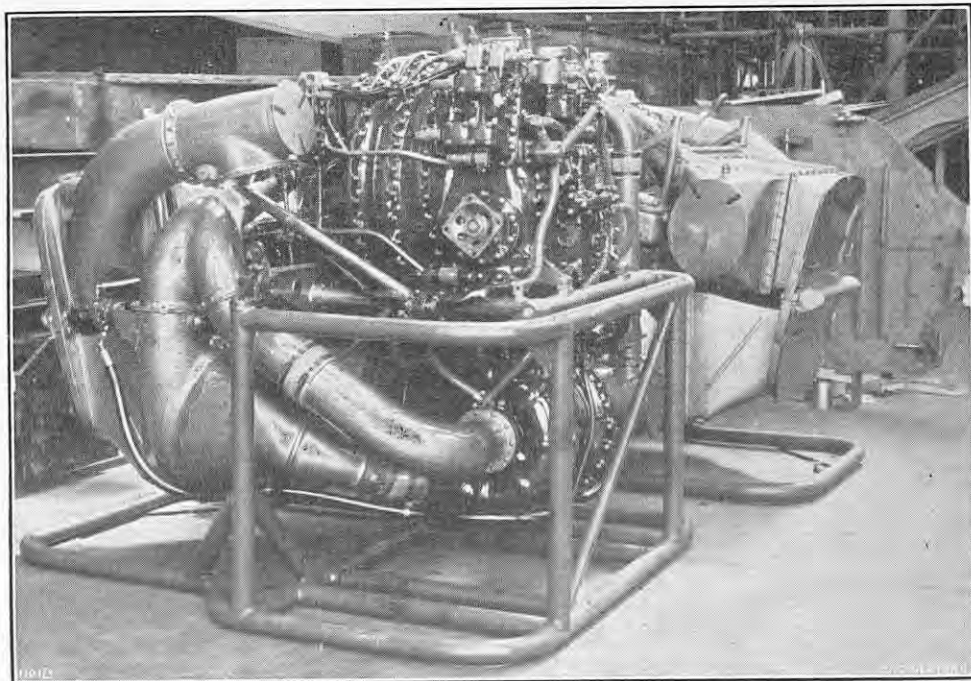


FIG. 35. CABIN AIR-CONDITIONING UNIT.

rough methods of estimating the forces which have been indicated in this article probably give results somewhat greater than the actual values; further research on, and scientific analysis of, the problem is needed for assessing the influence of the particular construction of the valve, and also of the viscosity of the liquid used. Further research of this kind would be of immediate practical value and possibly result in saving much of the time and money which is now being spent by individual designers, who, of necessity, must at present solve many of their problems by trial and error.

TRADE IN FERRO-ALLOYS FREED.—The Minister of Supply has decided to restore the right of individual manufacturers and merchants to import and distribute all ferro-alloys without exception. For some years past, licences for the importation of certain important types of ferro-alloys have been granted only to the central buying organisation of the British Iron and Steel Federation (B.I.S.C., Ltd.). The alloy metals affected are: Ferro-silicon, ferro-chromium, ferro-silico-chromium, silico-manganese, silico-spiegel, ferro-phosphorus, and calcium silicide. Applications for import licences should be addressed to the Board of Trade.

IRON AND STEEL ALLOCATIONS.—The Ministry of Supply announce that from January 1, no distinction will be made in allocation between alloy iron and steel and non-alloy steel. Consumers will then be free to choose how much of either material—within their total authorised tonnages—they wish to acquire, instead of having amounts specified for each. Tinplate, terneplate and blackplate, however, will remain separately allocated as at present. Those who already hold authorisations for periods in 1953 for alloy and non-alloy materials separately, will shortly receive authority to treat them as applicable to either type of material.

WIRING REGULATIONS OF THE INSTITUTION OF ELECTRICAL ENGINEERS.—Since the issue of the twelfth edition of the Wiring Regulations of the Institution of Electrical Engineers there have been a number of developments in practice and several matters which require review have been noted. The Council have therefore decided to proceed with the drafting of a thirteenth edition of this useful publication and invite suggestions for amendments. These should be addressed to the secretary, the Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2, before January 1, 1953. The new edition will not be issued before December 31, 1953, and in the meantime, of course, the present regulations will remain in force.

THE "PRINCESS" FLYING BOAT.

(Concluded from page 498.)

THE final article on the "Princess" flying boat deals with the fuel and oil systems, the air-conditioning system, the de-icing systems, and some of the pre-flight testing carried out on the various systems and components. Previous articles on the Princess appeared on page 289 of our issue of September 5, in which the structural features were described; on page 371 of our issue of September 19, which dealt with the powered flying controls; on page 429 of our issue of October 3, which covered the services for water operation, and the electrical system; and on page 495 of our October 17 issue, in which the power plants and propellers were described.

FUEL SYSTEM.

The fuel supply is carried in four tanks, arranged two on each side and integral with the wings. The inboard tanks, which each have a capacity of 3,480 gallons, are connected with the inboard coupled power units. The outboard tanks, of 3,770 gallons capacity, each serve both the centre coupled power units and the single outboard engines. Thus, the total fuel capacity of the Princess is 14,500 gallons. The contents of each tank is indicated to the flight engineer by Smith Waymouth electrostatic fuel-contents gauges. To provide for calibrating the gauges, a special computer is supplied with the aircraft, and in the port inner tank is fitted a "sampler" (for detecting and informing the flight engineer of changes in the specific inductive capacity of the fuel), and a fuel-temperature transmitter.

In each tank, two S.P.E. totally-immersed booster pumps are driven by squirrel-cage three-phase induction motors fed from the 115-volt alternating-current supply. A system of check valves, in conjunction with the tank baffles, ensures that the pumps are at all times completely covered by fuel, whatever the aircraft's attitude. The booster pumps feed fuel into the individual power-plant supply lines through the low-pressure fuel cocks, and thence forward, through the fireproof bulkhead, to the individual engines. Each power-plant supply line includes a flowmeter transmitter unit,

indicating at the flight engineer's station; in the inboard feed lines only is a delivery-temperature transmitter. All the fuel cocks are electrically actuated. A fuel-transfer pipeline, carried across the aircraft behind the rear spar, enables the tanks on the same side of the aircraft to be interconnected and, by opening a cross-feed cock which is normally kept closed, the port and starboard fuel systems to be interconnected. During flight, each tank normally functions as an independent unit, its "tank transfer cock" being closed. For transferring fuel, each tank is provided with an electrically-driven transfer pump of the same type as the booster pumps.

A pressure-fuelling system is provided. Two refuelling couplings on the starboard side of the hull feed, through refuelling cocks, into the port and starboard sides, respectively, of the fuel transfer line and to the corresponding wing tanks through tank-fuelling cocks, which are electrically connected with the fuel-contents gauges so that, during fuelling, they are shut off automatically when a pre-selected quantity of fuel, as set on the gauge, has been reached. Maximum-capacity warning lights, operated by fluid-level switches, indicate when any tank is 95 per cent. full.

The fuel system controls and instruments are at the flight engineer's stations (on the left in Fig. 38), except for the low-pressure fuel-cock switches, which are controlled only by the pilot, and the engine high-pressure fuel-cocks switches which can be operated by either the pilot or the flight engineer. In addition to these cocks, the controls consist of switches and failure-warning lights for the motor-generator sets operating the booster and transfer pumps; switches for the transfer pump, transfer cock and tank-fuelling cock in each tank, and their position indicators; the cross-feed cock switch, the fuel-contents gauges and maximum-capacity warning lights, and the gauge-amplifier change-over switch; the booster-pump switches and fuel-temperature gauges; the fuel-pressure gauges and meters, and various test switches.

OIL SYSTEMS.

The oil tanks for the power units are of welded light-alloy sheet construction, and are all mounted on the front spar, in the leading edge (except the engine oil tanks of the inner coupled units, which are carried on the rear face of the front spar).

In the outboard single engines, one 10-gallon tank supplies the entire engine and transmission lubrication and the propeller-feathering systems. The coupled power units are each served by three separate oil systems: two 7-gallon tanks feeding each Proteus unit, mounted side-by-side inboard of the engine bay, and one 10-gallon tank supplying the transmission gearing, the propellers, constant-speed units, and the propeller-feathering pumps. In each system oil is fed from the tank, by engine-driven oil pumps, through a filter and a shut-off cock in the tank outlet; and is returned, by engine-driven scavenge pumps, by way of one or more oil coolers. In the transmission oil systems of the coupled units, an anti-surge valve is fitted between the transmission scavenge pumps and oil cooler. The temperature of the oil can be regulated by varying the position of a hinged shutter in the cooler-outlet duct aperture, which is on the underside of the leading edge. The shutters are operated by linear electric actuators, controlled by switches on the flight engineer's oil-system instrument panel, on which are also mounted a shutter position indicator, and oil-temperature and oil-pressure gauges.

Each of the 10-gallon tanks has a separate compartment from which oil for operating the propeller-feathering pumps is drawn. The scavenge oil from the latter is returned to the main scavenge line, in the case of the single outboard units, and to the scavenge line from the contra-rotating gearbox of each coupled unit.

THE "PRINCESS" FLYING BOAT.

SAUNDERS-ROE, LIMITED, COWES.

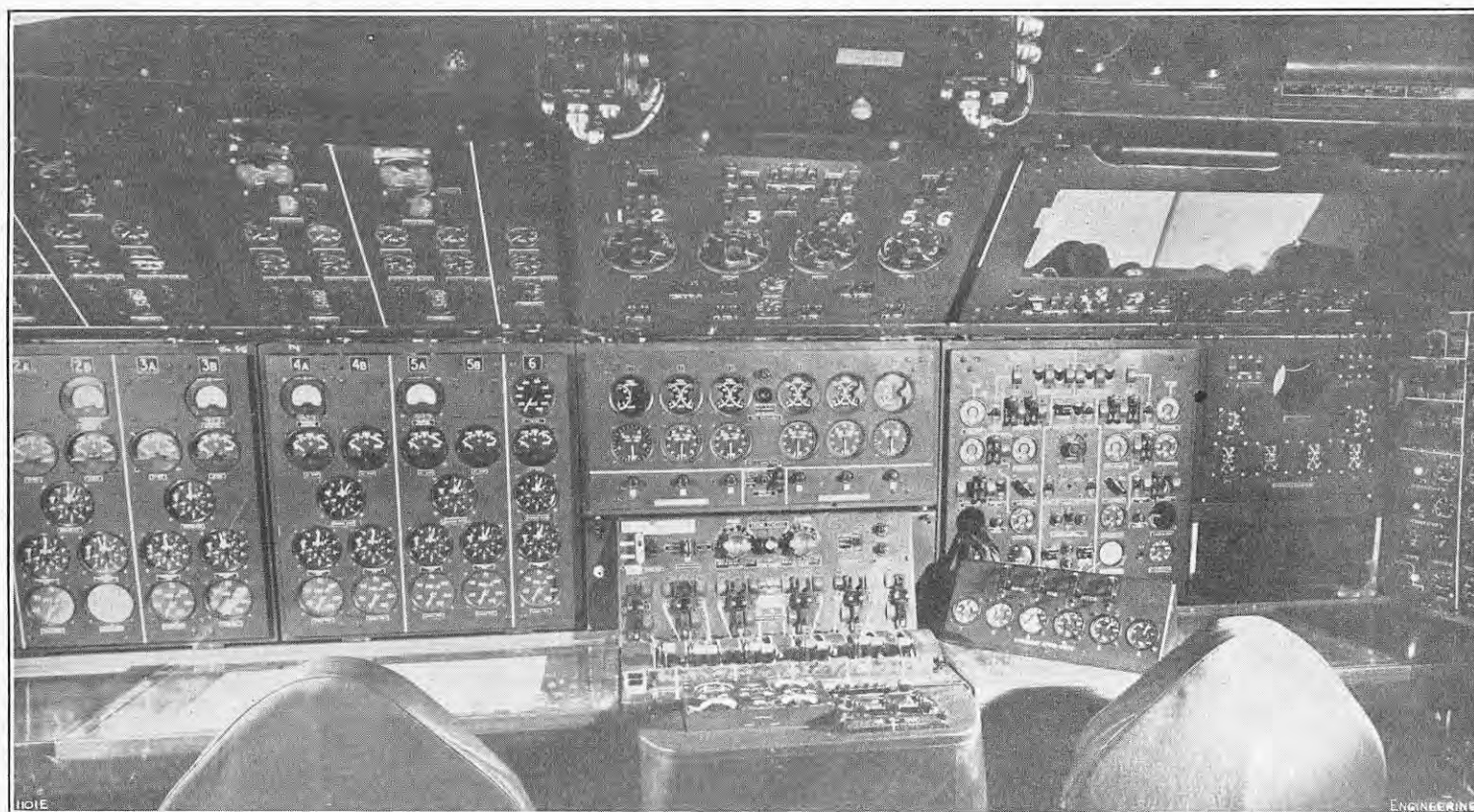


FIG. 38. FLIGHT ENGINEERS' STATIONS.



FIG. 39. "LUCAS" KEROSENE COMBUSTION HEATER.

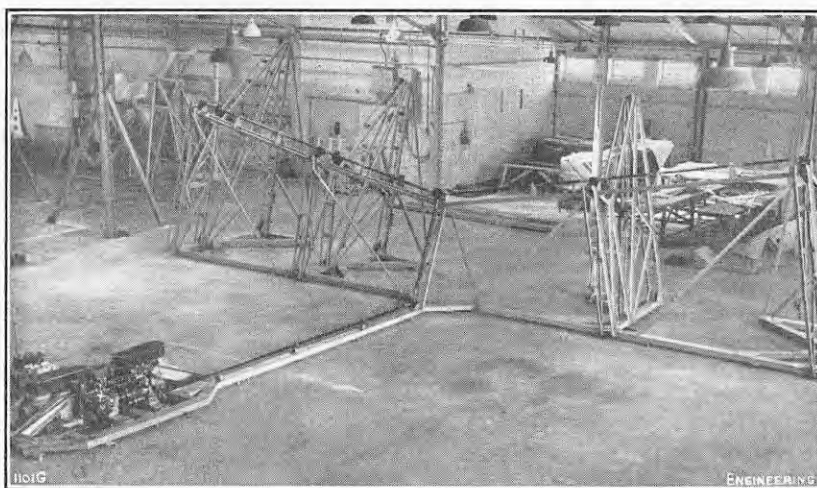


FIG. 40. TEST RIG FOR CONTROL TORQUE SHAFTING AND POWER PACKS.

open or close the throttle. As a safeguard against surging, which could arise when the flow through the blower is reduced below a certain value, depending on the speed, the spill valve and the refrigerator-by-pass valve are linked together and are also automatically controlled from the flow-control box. The spill valve can also be operated in emergency, by an independent solenoid-operated vane motor controlled by the flight engineer. This motor also closes the shut-down valve in the delivery ducting (Fig. 36).

Cabin Pressure, Temperature and Humidity Control.—The equipment for automatically controlling the cabin pressure is supplied by Normalair, Limited, Yeovil, Somersetshire, and consists of the four variable-discharge valves controlled, through pressure relays, by a pressure controller. The latter contains two capsules, one of which responds to changes in the cabin pressure, and can be given a predetermined setting by switches on the flight engineer's altitude selection panel. He can select the height at which to start pressurising the

cabin, and the rate of change of pressure within the cabin. The other capsule in the controller responds to the pressure difference between the cabin and the ambient air and, should this reach the maximum permitted value, it overrides the other capsule and opens the discharge valve. Two inwards relief valves are also fitted in the hull which open if the outside air pressure should exceed the cabin pressure by more than a safe amount, and which can also be opened slowly by the flight engineer during descent to avoid sudden changes in cabin pressure after alighting.

The temperature of the cabin can be controlled either by the flight engineer or by the steward, through a setting potentiometer in a Wheatstone bridge circuit, one arm of which contains the temperature sensing element, which is installed in the suction ducting in the cabin. The flight engineer's air-conditioning controls are grouped on panels which can be seen at the right of Fig. 38, which shows the two flight engineers' stations; the main pressure controller, however, was not

installed when this photograph was taken. The selection circuit also contains a stabilising element to reduce "hunting." The output of the Wheatstone bridge circuit controls two reversible electric actuators, one in each air-conditioning unit, in conjunction with a synchronising circuit which ensures that the heat outputs from both units are equal. In each unit, the temperature-control actuator drives a camshaft carrying three cams and a switch. The cams operate the control valves of the hydraulic vane motors actuating, respectively, the heat-exchanger control valve (Fig. 36), the cooler control valve, and the refrigerator by-pass valve. The switch operates the transfer valves controlling the flow of air through the refrigerator. The sequence of operation, assuming that the flight engineer switches over from "full heat" to "full cooling," is as follows: firstly, the heater control valve (shown in Figs. 36 and 37) is progressively closed; when fully shut, a micro-switch operates relays to open the tailpipe spill valves (Fig. 37). As the temperature-control actuator continues to rotate the camshaft, the

cooler control valve is progressively opened. When fully opened, the transfer-valve switch closes the transfer valves T1, T2 and opens T3 (the two latter are mechanically linked), so that part of the fresh-air supply passes through the refrigerator unit, the refrigerator by-pass line then being fully open. Further rotation of the camshaft progressively closes the by-pass so that the full air flow is ducted through the refrigerator. Under icing conditions, however, the flight engineer can arrange for the heater and the cooler to be operating simultaneously, in order to avoid icing-up the heater matrix.

The cabin humidifier system, which comprises two electrically-heated steam generators and spray nozzles, fed from a storage tank, is situated in the underwing compartment, and is controlled automatically by duplicated humidistats installed in the cabin suction ducting. These elements switch on the steam generators when the relative humidity falls below 30 per cent.; they also close the water-separator by-pass valves when the relative humidity rises above 70 per cent. The cabin humidity can also be manually regulated by the flight engineer.

ANTI-ICING SYSTEMS.

The outer-wing and tail-surface leading edges are provided with hot-air anti-icing systems, as are also the engine air intakes. Thermometer bulbs installed in the leading edges of each wing, each half of the tail plane, and the fin, give an indication of the skin temperatures at the flight engineer's station. The propeller blades and spinners have internal electro-thermal de-icer heating elements which operate on a 1-on 4-off cycle; and the pilot's wind-screen is fitted with electrically-operated alcohol anti-icing sprays and windscreens wipers.

Wing Anti-Icing.—Exhaust-heated air from the single power units and the outer units of the centre coupled engines supplies the outer-wing anti-icing system. Branch pipes are taken from the cooling shroud "snails" through a hot-air valve box adjacent to the outboard snail and into a hot-air duct which is led forward through the spar into the distribution duct in the leading edge of the outer wing. Throughout the length of the distribution duct, 1-in. and $\frac{3}{4}$ -in. diameter holes are cut to allow hot air to circulate, by way of the passages formed by the corrugations on the inner leading-edge skin, over the wing nose. It is finally discharged by seeping through the wing structure.

The valve box controlling the flow of hot air to the de-icing ducts incorporates two electrically actuated valves, one controlling the supply from each tail-pipe snail so that two degrees of heating can be applied, depending upon the ambient conditions. When both the valves are closed, the air is discharged through an aperture in the upper trailing-edge skin. The electric actuators are controlled by the flight engineer, all the de-icing controls and indicators being grouped on a de-icing panel. The flight engineer is warned when the temperature in the hot-air supply ducts exceeds 150 deg. ± 5 deg. C., by two red lights which are operated, through relays, by thermometer bulbs in each snail exit.

Anti-Icing of Tail Surfaces.—For supplying hot air to the anti-icing ducts in the tailplane and fin leading edges, which are similar to that of the wing, two independent Lucas combustion heaters, illustrated in Fig. 39, each developing 400,000 British thermal units per hour, are installed on the shear deck in the fin, together with their associated electrically-operated fuel pump and fuel-control and electrical-control units. The selection of combustion heaters, rather than an electro-thermal system, was dictated by weight considerations. The heaters burn kerosine from the main aircraft fuel system and, in order to guard against fire hazard arising from flame failure or from overheating, an elaborate system of fuel and air flow-control valves and ignition controls has been

developed. Each heater is equipped with a fire detector which operates a warning light on the de-icing panel at the flight engineer's station. The air supply for both heaters enters through an intake at the base of the fin leading edge. The intake comprises two concentric ducts, the inner duct supplying the air for combustion and for distribution, and the outer duct discharging the exhaust gases. The temperature of the air leaving the heater for distribution through the de-icing ducts is controlled by electrically-actuated butterfly valves, one in the heater intake and one in the exit duct. A single actuator operating these valves is controlled by a temperature-sensitive element in the exit duct. The valves are also closed automatically when the heater is shut down.

The fuel supply, taken from the transfer pipeline, is led through a fuel cock, to the aft end of the aircraft, by way of a pipeline in the planing bottom and through filters to the two gear-type pumps feeding the two heaters. When the system is in operation, the heater fuel pump delivers through an inlet valve, then by way of a "half-heat" jet or a "full-heat" valve, which meters the fuel, to a flow-control valve, and thence through a vaporising coil in the main burner. When the latter is alight, the vapour pressure operates a spring-loaded combustion-pressure switch which energises the main relay controlling the inlet valve and the fuel pump. Flame failure in flight would cause the combustion-pressure switch to open, de-energising the main relay and thus shutting down the heater.

The main relay is also controlled by a "ram-pressure" switch and an "overheat cut-out." The ram-pressure switch, operated by an impact tube in the branch air-inlet duct, causes the main relay to open if the airspeed falls below about 110 knots. The overheat cut-out, operated by a temperature switch, opens and cuts the heater out when the temperature in the air-exit duct exceeds 180 deg. C.

The "full-heat" valve is controlled by a two-position switch, operated by the flight engineer, giving "half" and "full" heat. In the half-heat position, the valve is closed and fuel flows to the burner at a reduced rate through the "half-heat" jet. In parallel with the "full-heat" valve is a "start" valve which is used to start the burner by directing fuel to a torch igniter. The full-heat valve is closed for starting. The start valve allows a restricted fuel flow through the half-heat jet to the main burner head, this fuel being vaporised in a coil surrounding the burner by a torch igniter. The starting sequence is controlled by a time-delay switch, which serves to energise the main relay for 17 seconds until the vapour pressure is established sufficiently to operate the combustion-pressure switch. If the burner has failed to light, the main relay will then open and shut off fuel to the burner. Some two seconds before the delay switch cuts out completely, it shuts off the fuel supply to the torch igniter.

TESTING PROGRAMME.

In conclusion, some brief notes on some of the comprehensive ground testing that has been carried out during the construction of the Princess may be of interest. The main structural-strength tests on a half-scale wing, including a portion of the pressurised hull, were carried out at the Royal Aircraft Establishment, Farnborough, as were also fatigue tests on the wing joints. The results of these tests were highly satisfactory. Messrs. Saunders-Roe, Limited, also carried out strength tests on a half-scale spar, in order to determine the necessary amount of local reinforcement at the tail-pipe apertures and similar critical points. Preliminary tests on the modes of vibration were made on a flexible model representing the distribution of mass of the wings, hull and tail surfaces.

The firm designed and constructed a small alti-

tude chamber for testing the operation of hydraulic and electrical components at pressure conditions equivalent to an altitude of 40,000 ft. and temperatures down to -70 deg. C. The refrigeration is provided by coils within the chamber, through which methylated spirit, cooled by passing over solid carbon dioxide, is circulated. Functional test-rigs were erected for carrying out full-scale endurance tests of the operation of the flaps (with air loads simulated by concrete blocks), the float-retracting mechanism, and the power-operated elevator-control circuit (with air loads represented by bungee cables attached to the elevator operating lever). The photograph reproduced in Fig. 40 shows one of the smaller mechanical rigs for testing flying control power packs and torque shafting. As already noted, extensive running tests were carried out on the generators and the electrical supply system. The integral fuel tanks were tested, under load and pressure, for leakage, and it was as a result of these tests that bolted joints instead of rivets were adopted throughout the tank structure. A representative tank specimen was also tested in various attitudes to check the operation of the pumps and fuel gauges.

We have already referred, on page 289, *ante*, to the pressure tests on the hull and the flight tests of the flying-control power packs and screw jacks on a Sunderland flying boat. In connection with these flight tests, it is interesting to learn that, during most of the tests, speed-proportional "hardening" of the controls was not provided. The test pilots were able, therefore, to make some assessment of the effect of eliminating "feel," and their conclusion after some 400 hours' flying is that lack of "feel" is not at all objectionable. A "feel" mechanism has, nevertheless, been adopted in the aircraft, partly to satisfy convention and partly to guard against inadvertent overloading.

The Princess is now starting her development flights. Three automatic-observer panels are installed in the aircraft, each equipped with some 70 to 80 instruments, and controlled from a master station equipped with flight instruments. Some 350 transmitting points are fitted on the aircraft, including extensive high-frequency engine-vibration pick-ups; acceleration pick-ups, symmetrically arranged about the aircraft centre-line, for measuring the structural vibration; control-surface angular-position transmitters; the usual engine instrument transmitters; and pressure and temperature transmitters for the air-conditioning and de-icing systems. The main electrical supply system, it is considered, has been adequately calibrated on the ground rig, but measurements of the consumption of the various services will be taken in flight to enable electrical loading data sheets for various flight conditions to be compiled. Instruments are also provided for recording the results of water-handling and stability. In addition to the photographic recording by the automatic observer, some of the instruments record, through mirror galvanometers, directly on sensitive paper.

MARKETING OF DIESEL ENGINES IN AMERICA.—R. A. Lister & Co. Ltd., Dursley, Gloucestershire, have announced that they have concluded an agreement with the National Supply Company, Springfield, Ohio, U.S.A., for the sole distribution of the Lister range of Diesel engines in America. Arrangements have been made for the National Supply Company to promote the sale of the Lister engines which are complementary to its own "Superior" and "Atlas" engines, but the Lister-Blackstone American Company will continue to handle other Lister and Blackstone products. Provision is made in the agreement between the English and American companies for a close working association with regard to research, production and distribution. Particular emphasis will be placed on the sale of the "Freedom" range of engines which, on arrival in the United States, will be equipped with American accessories, such as starters, generators, radiators, clutches, marine gears, etc., so as to minimise the service and replacement-part problems.

COLD RENDERING OF FATS FROM CELLULAR MATERIAL.

THE extraction of oils and fats from naturally-occurring cellular materials, a process known as rendering, has always been associated with heat and, from the earliest days, animal fats in particular have been extracted by cooking or roasting or by the use of hot solvents, all of which rely on heat to destroy the cell tissues and free the fat. It has long been realised, however, that the use of heat for this purpose is undesirable as it leads to a progressive increase in the noxious odours and contamination with degradation products. Accordingly, oil technologists have endeavoured to find means either to reduce the deleterious effects of heat or alternative methods of rendering the raw materials. Considerable interest attaches, therefore, to a new process of rendering developed by British Glues and Chemicals, Limited, 15, Kingsway, London, W.C.2, which is entirely independent of heat and uses only cold water allied with mechanical energy to open the fat cells and liberate their contents.

The new process, which bears the surname of Mr. I. H. Chayen, technical director and assistant managing director of British Glues and Chemicals, Limited, is based on a new principle known as impulse rendering. This consists of suspending the material to be rendered in a continuous stream of water, and passing the water and material through a vessel in which the water is subjected to a series of high-speed high-frequency mechanical impulses. When subjected to these conditions, the water disintegrates the cell walls almost instantaneously and their contents are washed away. In principle, the impulse renderer is analogous to a hammer mill as used for the grinding of feeding stuffs on farms, the mixture of material and water taking the place of the corn. There the resemblance ends, as the speed of rotation, the number of arms, ratio of water to material, size of material, clearance volumes, etc., are all critical in the working of the process.

So far, four plants employing this process have been put into commission, one in Canada and three in England, all of which have been designed for the degreasing of bones and the production of high-grade tallows. The four plants are generally similar, and in each case the bones, after being suitably broken up and crushed, are fed in a continuous stream of cold water through the impulse renderer at the rate of two tons an hour. The actual rendering operation takes less than a second and the fat leaves the machine as a bland white solid of high purity. As the fat and degreased bone leave the renderer they are separated by gravity and subsequently pass by separate routes through a series of washing and separating processes. The fat goes into storage ready for dispatch three minutes after the bone is fed into the plant, and the degreased bone is ready for glue-making or drying for dispatch within eight minutes, all operations being continuous and controlled automatically.

It is claimed that the process produces animal fats of a considerably higher quality than is achieved by other methods and that the products are already taking the place of imported high-quality fats. Although this improvement of quality is, possibly, the most important advantage of the new process, there are, of course, other gains. The advantages of using a continuous process that takes a few minutes, against the many hours occupied by the heat rendering processes in general use, are obvious; other advantages which come to mind are reduction of fuel costs, plant area and capital costs. The process is completely automatic and the materials untouched by hand; the working conditions are, therefore, improved. The principle can be applied to the complete range of fat and oil bearing materials and indications are that it will prove most useful in the fish-liver oil industry. Work is also in hand on the application of the principle to the herring industry with the object of producing high-quality oil and palatable odourless fish meal of low oil content, and it has been established that the principle is applicable to the vegetable-seed and nut industries.

PUBLIC WORKS AND MUNICIPAL SERVICES CONGRESS AND EXHIBITION.

(Continued from page 574.)

THE Public Works and Municipal Services Congress and Exhibition was opened on November 3 by the Rt. Hon. Harold Macmillan, M.P., Secretary of State for Housing and Local Government. The chair was taken by Major John B. L. Thompson, M.C., M.I.C.E., chairman of the Congress Council. Before declaring the Exhibition open, the Minister presented prizes to the successful authors of papers submitted to the Congress. Prize-winning authors who received the bronze medal of the Congress were Mr. A. Holroyd and Mr. H. Parker, for their paper "Further Investigations on the Dynamics of Aeration"; Mr. J. A. Kenyon, "Layout for Housing"; and Lt.-Col. J. R. Oxenham, "Restoration of Derelict Ground." Other prize-winners included Mr. John Harley, Mr. R. Nicholas, C.B.E., Mr. Charles C. Smith, Mr. J. H. R. Crabtree, Mr. W. H. Ward and Mr. H. Green, Mr. W. G. Phillips, and Mr. J. Lewis Womersley.

Our general description of some of the new exhibits and of others not previously described in *ENGINEERING*, is continued below.

RADIO EQUIPMENT.

Marconi's Wireless Telegraph Company, Limited, Chelmsford, Essex, are displaying lightweight, compact, very-high-frequency mobile radio equipment suitable for use on contractors' sites. The use of such equipment by the police, fire services and taxi fleets is now commonplace, but it also has much to offer to other municipal services and to public works contractors on large, widely-dispersed sites. The four main exhibits consist of a 10-watt fixed-station transmitter/receiver (type H.16A); two mobile transmitter/receivers of the kind used in vehicles and other mobile units (the 3 to 5-watt type HP.10 and the more powerful 10-watt type H.16); and the familiar "walkie-talkie" (type H.19). If these units are all operated on the same frequency, they may all be used in a common network. For example, the H.16A can be operated by an industrial or public concern as a control set at headquarters; officials at headquarters can then be in contact with street cars, each fitted with the HP.10 in the dashboard compartment, with larger service vehicles fitted with H.16 equipment, and with individuals in the area who are carrying "walkie-talkies."

OVERHEAD-BEAM 13-CUB. YD. SCRAPER.

Jack Olding and Company, Limited, Hatfield, Hertfordshire, have two stands at the exhibition; on one is a display of matched equipment for the Vickers-Armstrongs VR 180 tractor, and on the other stand there is a wide range of Barber-Greene Olding plant for highway engineering. The V.R. tractor was fully described in our issue of February 29, 1952. Six of these tractors are displayed, in conjunction with various items of plant, including the Onions 13-cub. yard overhead-beam scraper illustrated in Fig. 12, on page 600, and a new open-bowl scraper by the same maker and of the same capacity. Both these scrapers employ a three-piece cutting edge and are fitted with sloping tailgate. Lightness of construction has been achieved without sacrificing the strength necessary to operate at the high speed that the VR 180 tractor can reach when the going is suitable.

Smaller Onions scrapers, the 4-cub. yd. and 9-cub. yd. models, are shown as well as the Barber-Greene Olding 44C ditcher, suitable for general trenching on housing and factory sites. Fitted with a vertical boom, the ditcher can cut down to a depth of 8 ft. 3 in. at widths of either 18, 21 or 24 in.; as the boom is vertical, and therefore leaves no ramp, this machine is well suited to cutting trenches for foundations and footings. A machine of a rather different type is the "Elstree" heat planer, a self-contained unit with a bank of six individually-controlled furnaces, four hydraulically-controlled rotating cutters, a 360-gallon fuel tank and driven by a Petter Diesel engine of 40 brake horse-power.

"GALION 118" MOTOR GRADER.

The new "Galion 118" motor grader, built by Galion (Great Britain), Limited, Wakefield, which is illustrated in Fig. 13, on page 600, is fitted with a Leyland Diesel engine developing 100 brake horse-power. It embodies the latest features of grader design. The steering is hydraulically assisted and this, together with the large front wheels, of the same size as those in the rear, gives the driver easy digging control. In the event of the vehicle encountering an obstruction, an adjustable damper valve safeguards the steering wheel from whip. A constant-mesh transmission with six forward gears and two reverse gears has been provided; these permit a top speed of 21.5 m.p.h. for rapid travelling between sites and, together with a high "backing" speed of 10 m.p.h., the grader is able to take full advantage of good working conditions. The mouldboard, with a normal side reach of 44 in., may be turned through 360 deg. for reverse grading, and can be set in a nearly vertical position for high bank trimming. An additional hydraulic side shaft gives the mouldboard a side-reach of a further 40 in., without manual setting of the mouldboard.

CABLE CONTROL UNIT FOR TRACTORS.

A wide selection of earth-shifting and other constructional plant, including bulldozers, excavators, concrete mixers and pumps, is to be seen on the stand of Blaw-Knox, Limited, 90-94, Brompton-road, London, S.W.3. Many examples of the equipment made by this company can also be seen on other stands, where it is used in conjunction with other manufacturers' products, particularly tractors. Items on view include a new model "K" cable control unit, illustrated in Fig. 14, on page 600, which has been designed for use with tractors exceeding 75 brake horse-power, and the new BK-90 scraper, shown in Fig. 15, which has a struck capacity of 7½ cub. yards.

Features of the cable control unit are a modified design of the top deck standard that will permit full swivelling of the sheaves, and a generous increase in the size of clutches and brakes to give a well-controlled transmission of the heavy line pull required for the operation of the modern high-capacity scraper.

7½-CUB. YD. SCRAPER.

The BK-90 scraper embodies several improvements suggested by the company's wide experience in manufacturing and operating this type of vehicle. The blade, which is concave, is provided with a curved cutting edge that gives full "boiling" of the spoil throughout the period of loading. A new bowl design with a small tailgate travel and a large apron opening ensures a quick controlled discharge with even spreading of the load. The open-top design and low overall height give a low centre of gravity and when conjoined with the wide rear track, excellent working stability is achieved. A controlled movement between the scraper and the tractor, even when operating under bad conditions, is obtained through a recently developed ball-joint connection between the yoke and front axle. The construction of the yoke, closely following the outline of the bowl, permits close cutting to a bank or other obstruction, while the location of the yoke hitch point gives a well-balanced penetration, so increasing the efficiency of loading. A simple arrangement of reeving has been developed and all the sheave blocks are mounted on roller bearings that are easily lubricated. The weight of the empty scraper is just over 6 tons and the principal dimensions are as follow: length, 26 ft. 9 in.; width, 10 ft. 4 in.; height, 8 ft. 1 in.; wheelbase, 15 ft. 6 in.

DRILLS FOR MASONRY.

The Rawlplug Company, Limited, Rawlplug House, Cromwell-road, London, S.W.7, have a stand devoted to methods of overcoming the problems of fixing. In size, the exhibits on this stand range from the familiar household attachment to industrial attachments that will bear a direct load of 4 tons. A recent development on view is the "Rawlshield" designed to carry roof suspensions, so eliminating props in underground workings to give a clearer passage-way for men and

equipment. The company have also extended their range of devices for speeding the erection and striking of timber or steel shuttering in concrete construction. Hangers to pass over steel floor beams and terminating in screwed sockets that will receive the bolts which actually carry the underhung shuttering have been developed for this class of work. The resultant bolt holes can be plugged after the shuttering has been struck. Similarly, for fixing climbing shutters, "Rawloops" are available that work on the same principle.

To supplement the fixing attachments, the company have developed, and have on view, electrically-driven low-speed tool heads of different sizes suitable for use with the Durium carbide-tipped drills that they advocate for the speedy drilling of holes in masonry, concrete or brickwork. These drills can now be obtained in sizes up to 1 in. in diameter, and with long shanks for reaching through walls; a sample set of drills is shown in Fig. 16, on page 600. In this form the drills can also prove useful to plumbers and others who have to make passages for piping and other conduits.

TANDEM ROAD ROLLER.

The Marshall organisation has two stands exhibiting the products of two companies, Marshall, Sons and Company, Limited, Britannia Works, Gainsborough, and John Fowler and Company (Leeds), Limited, Leathley-road, Hunslet, Leeds, 10. The display centres on the Fowler series of crawler tractors, particularly the "Challenger 4," described in detail below, while other models on view include two Marshall road rollers, two earlier versions of the Challenger and the Fowler Mk. VF crawler tractor.

One model of the Road Marshall, type RD, series 2, and a Marshall tandem road roller, type RT. 508, shown in Fig. 7, herewith, represent the companies' products in this type of vehicle. Both are fitted with a Perkins industrial four-cylinder power unit with electrical starting equipment. The new RD. 2 series is built in 7, 8, 10 and 12-ton models; the all-up weight of the RT. 508 model is 8 tons.

"CHALLENGER" MARK 4 CRAWLER TRACTOR.

The Challenger series of crawler tractors on display includes the 50 brake horse-power Challenger 1, shown as a medium-size earth mover which can be equipped with a Bray hydraulic dozer or a Blaw-Knox type "A" cable control unit; Challenger 3, fitted with either a 95 brake horse-power six cylinder Meadows engine or a slightly smaller Leyland giving 84 brake horse-power at the drawbar; and the first production model of the 150 brake horse-power Challenger 4, illustrated in Fig. 8, herewith, the latest and most powerful tractor yet manufactured by John Fowler and Company. The leading features of Challenger 4 are, a Meadows 6DJ 970 Diesel engine giving 150 brake horse-power at 1,500 r.p.m.; C.A.V. fuel injection equipment; and starting by an auxiliary petrol engine or by an electric motor. The gearbox embodies six forward and four reverse gears and under favourable conditions the drawbar pull can exceed 30,000 lb.

The Meadows engine is a four-stroke Diesel unit, with direct fuel injection, governed to a maximum speed of 1,500 r.p.m. The crankcase is made as a single casting from which the cylinder blocks, fitted with renewable wet liners, can be detached in two pieces. The pistons, which with their connecting rods can be removed through the top of the cylinders, are of an aluminium alloy and each carries three compression and two scraper rings. A nitride-hardened steel has been used for the crankshaft, which is carried in seven main bearings. The fuel and air systems are protected against the entry of dirt and dust by the provision of multiple fuel filters and heavy-duty oil-bath air cleaners. A water-cooled, four-stroke petrol engine is used for starting; the cooling system of this engine is integral with that of the main engine and the heated water from the starting engine is thereby used to warm the whole unit and thus facilitating starting in cold weather.

The gearbox is flange mounted on the front of the bevel box and is connected to the main clutch, which is of the single dry-plate type, by a short propeller shaft. It is the same gearbox as is fitted

THE PUBLIC WORKS EXHIBITION, OLYMPIA.

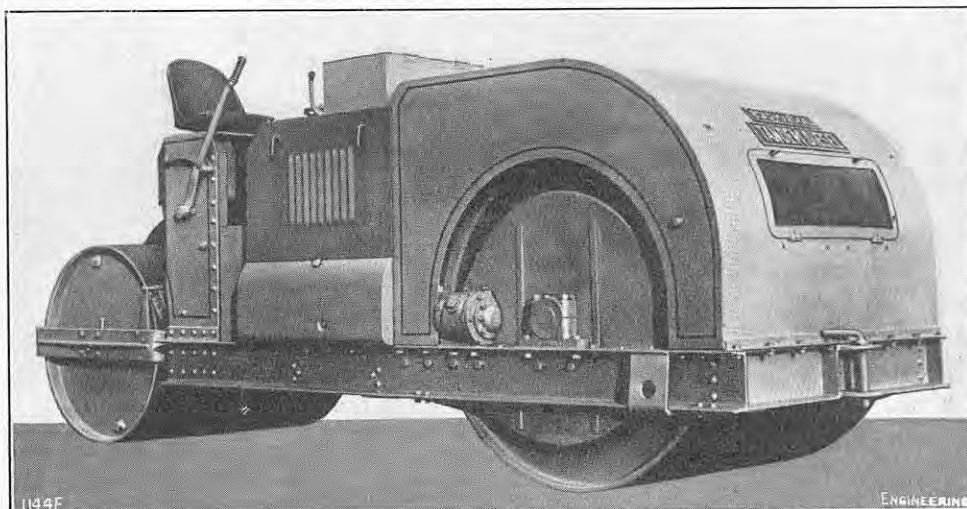


FIG. 7. TANDEM ROAD ROLLER; MARSHALL, SONS & CO., LTD.

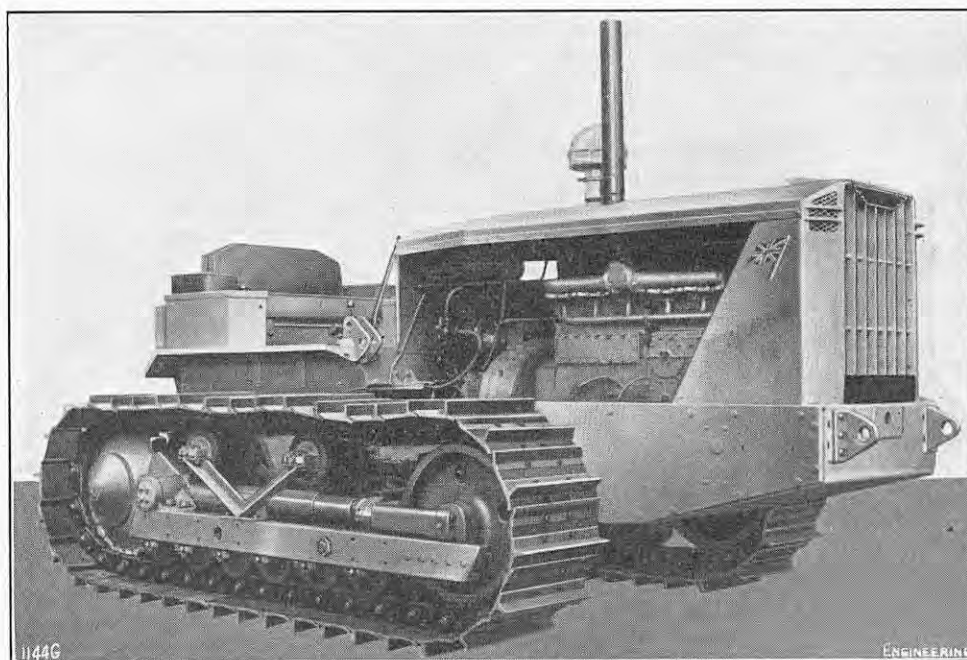


FIG. 8. "CHALLENGER" MARK 4 CRAWLER TRACTOR; JOHN FOWLER & CO. (LEEDS), LTD.

to the Challenger 3, with six forward and four reverse gears giving top speeds of 5.8 and 5.3 m.p.h., respectively. The bevel gearbox is an all-welded steel unit divided into three compartments by two bulkheads; the bevel wheel and pinion run in oil in the central compartment while each of the dry outer compartments contains a steering clutch and brake. The rear face of the bevel box is drilled to accommodate standard auxiliary equipment such as a logging winch or a power-control unit like the Blaw-Knox equipment shown in Fig. 14.

The main frame is of box construction comprising two 1-in. thick side plates running the whole length of the hull, cross braced by the fuel tank, the bevel box, and the top and bottom sealing tanks, with additional reinforcement by cross-beams and top cross-stays. There are no projections below the underside of the hull, with the exception of the mounting of the swinging drawbar. The ground clearance of the vehicle is 15 in. The track running gear and suspension unit are of a standard Fowler pattern, well designed to hold the track frames to their true alignment while allowing the tractor to work over the roughest ground.

Substantial mountings and multi-drilled face-plates permit the use of the full range of auxiliaries and matching equipment, such as bulldozer blades, front and rear power control units and the rear-mounted logging winch. The overall dimensions of the Challenger 4 are as follows: length, 16 ft. 1½ in.;

width, 8 ft. 4 in.; height (excluding the exhaust and air intake), 6 ft. 4½ in.; and weight, about 13 tons.

"CARLISLE" MOTOR GRADER.

The British-built Carlisle motor grader is distributed on a world-wide basis by John Blackwood Hodge and Company, Limited, Hunsbury, Northants; this machine, shown in Fig. 9, opposite, is of a basically conventional design but embodies several features that have been developed to ensure adequate strength and a general robustness. The chassis frame is formed by a welded box-section built-up from twin 12 in. by 5 in. rolled-steel channels with top and bottom ¼-in. plates. This compound section has been used to form a Y-yoke that underlies the engine frame in the front with the high over-beam tail carrying the blade of the grader. A Leyland Diesel engine, of a standard six-cylinder pattern with direct fuel injection, supplies the power through a Leyland clutch, a vertical gear train, gearbox and integral tandem drive, without differential gears, to all four driving wheels; a tandem drive without differential gears virtually eliminates wheel-spin. The machine is fitted throughout with heavy duty "rock-lug" tyres which have good ground contact and anti-skid characteristics. A Lockheed system of hydraulic braking has been fitted that operates independently of the grader control circuit, and steering is controlled through a Marles mechanical unit assisted

EXHIBITS AT THE PUBLIC WORKS EXHIBITION, OLYMPIA.



FIG. 9. "CARLISLE" MOTOR GRADER; JOHN BLACKWOOD HODGE & CO., LTD. FIG. 10. 4½ CUB. YD. SHUTTLE DUMPER; AVELING-BARFORD, LTD.



FIG. 11. AVELING-AUSTIN GRADER; AVELING-BARFORD, LTD.

by a "Keelavite" hydraulic system using rotary abutment pumps and motors. The blade, 12 ft. long by 2 ft. deep and controlled through a similar hydraulic system, can be rotated through 360 deg. to permit the grader to work in either direction and can be set for working at any angle up to the vertical on either side. All the controls are easily reached by the driver and the entire system admits of finger-tip control.

The machine is fitted with two pre-focus head lamps together with two rear warning lights at the extreme end of the chassis member; this combination, together with suitable trade plates, makes it possible for the machine to travel on the highway at night. The Carlisle is normally supplied with an open-type driving platform, but it may be obtained with any one of three types of cab, including a completely enclosed version of all-steel construction with fully-glazed observation panels, windscreen and fitted glazed doors.

" AVELING-AUSTIN " GRADER.

Aveling-Barford, Limited, Invieta Works, Grantham, are exhibiting six units from their range of civil engineering contractors' plant. The display comprises two rollers—a heavy Diesel-engine model weighing 9½ tons and a lighter petrol-engined machine of 30 cwt.—an Aveling-Austin 99-H grader, two dumpers—a large 4½-yd. machine and a smaller 1-yd. model—and a calf dozer. The principal

attraction on the stand is the 99-H power grader, illustrated in Fig. 11, herewith. This machine has the advantages of both four-wheel drive and four-wheel steering which, together with the hydraulically-assisted blade control, enable the driver to work to fine limits. The 13-ft. blade may be completely reversed or moved to any banking elevation, including the vertical, without the driver having to leave his platform; the extreme reach of the blade, beyond the rear wheels, is 10 ft. 1½ in. Alternative equipment available for use with the grader includes an 11-tine scarifier, bulldozer blade, an earth-loader and a snow plough. Overall dimensions of the grader, which is powered by a Leyland six-cylinder Diesel engine of 100 b.h.p., are: length, 24 ft. 3 in.; height, 10 ft. 1 in.; and width, 7 ft. 10¼ in. The wheelbase of the vehicle is 18 ft. 8 in. and the four-wheel steering permits a turning radius of 30 ft. 10 in.

4½-CUB. YD. SHUTTLE DUMPER.

The larger of the two Diesel Aveling-Barford dumpers at the exhibition has a capacity of 4½ cub. yard and is shown in Fig. 10, above. The special features of this new model include the mounting of the driver's seat and his controls on a turntable. The gearbox gives the dumper four speeds in either direction and the tipping and resetting of the hopper are operated through a power-assisted mechanism.

(To be continued.)

THE EDUCATION OF METALLURGISTS.

A survey of the whole field of the education and training of metallurgists has been made in recent years by a body known as the Joint Committee on Metallurgical Education, formed in 1945 by the Councils of the Iron and Steel Institute, the Institution of Mining and Metallurgy, the Institute of British Foundrymen, the Institute of Metals and the Institution of Metallurgists. The main purpose of the Committee is to advise the Councils on all matters concerning metallurgical education, with the exception of the National Certificates in Metallurgy. The Joint Committee on Metallurgical Education have now issued three reports, the first, on qualifications for entrance to university schools of metallurgy, appeared in February, 1948. The second report, published in 1950, made recommendations on university full-time degree courses in metallurgy. The third report, which has just come to hand, deals with metallurgical education in places other than universities, it being emphasised that, as more technologists are needed than the universities can supply, the remainder have to be trained in colleges of technology, technical colleges, and technical schools. As a result of their deliberations, the committee state that they are still definitely of the opinion that the universities are the chief source of high-grade metallurgical technologists and they doubt whether any other source of equal value can be developed. They recommend the university schools should expand the output of technologists to the utmost; that more university schools should provide instruction in industrial science; that education for management and administration should be given in all university schools of metallurgy and that the opportunities for the contact of undergraduates with cultural and humanistic subjects should be increased. They agree, however, with the recommendation that a few colleges of technology should be upgraded for the production of more high-grade technologists. They are of opinion that the present standard of staffing must be raised and that no other improvements in conditions will be worth while unless this is done. Furthermore, employers are recommended to collaborate actively with the colleges of technology in devising courses, facilitating the attendance of their employees and allowing members of industrial staffs to participate in teaching activities.

MAGNESIUM INDUSTRY PRODUCTIVITY TEAM.—A group of metallurgists representing various European countries is now in the United States to study productivity in the American magnesium industry under the auspices of the Organisation for European Economic Co-operation. The two English members are the secretary, Dr. J. L. Haughton, consultant, and Mr. E. F. Maillard, chief metallurgist, Essex Aero Ltd.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

BROADSIDE FILTER STATION.—The Broadside fully-automatic filter station of the Stirlingshire and Falkirk Water Board was inaugurated on October 30 by the Earl of Home, Minister of State, Scottish Office. It is capable of dealing with 12,650,000 gallons of water daily. The Earl set the plant in operation by pressing a button in a control panel, which allowed water to flow from the Board's Carron Valley reservoir, the capacity of which is 4,300,000,000 gallons, through the filter beds, chemical treatment units, and settling tanks. The plant has an electrical sequencing system by which the filters dial themselves in on the control panel. The station is designed to supply Falkirk, Grangemouth, and East Stirlingshire.

COAL EXPORTS.—Scottish coal exports during September totalled 98,283 tons, compared with 92,246 tons in August and 77,058 tons in September, 1951. This brought shipments for the year to 707,360 tons, against 586,848 tons in the corresponding period a year ago. Quality also improved. Whereas a large proportion of the 1951 shipments comprised silt, which commanded a very low price, the bulk of the tonnage this year consisted of trebles down to singles, with a proportion of washed smalls.

CONSTRUCTION OF SERVICE VEHICLES IN GLASGOW.—Heavy transport and fighting vehicles are to be mass-produced by Albion Motors, Ltd., Glasgow, in a large new factory at present being laid out at the site of the old Halley Company's premises, acquired by Albion Motors many years ago. Production will be concentrated on 10-ton and 3-ton Services vehicles.

OIL-WELL DRILLING BARGE.—The oil-well drilling barge built by Ferguson Brothers (Port Glasgow), Ltd., for the Shell oil interests, started on October 30 on the 5,000-mile tow from the Clyde to Venezuela. The barge, which we described and illustrated on page 583, *ante*, will be used in drilling for oil in the bed of Lake Maracaibo. The tow is being undertaken by the Dutch tug Rode Zee.

SALVAGE OF "JOHN RANDOLPH."—Arrangements are being made to save the half-hull of the Liberty ship John Randolph. The vessel was being towed from Iceland to Rosyth when the tow parted and she drifted ashore. It is intended to unload her cargo of scrap and send it south via Thurso.

THE LATE MR. T. DICKINSON.—The death occurred on October 20 of Mr. Thomas Dickinson, who, until his retirement some time ago, was chief surveyor for the Scottish district of the Bureau Veritas Register of Shipping and Aircraft. Mr. Dickinson was a native of Tyneside, but had resided in Glasgow for about 20 years.

DUMBARTON DRAINAGE WORKS.—Dumbarton burgh's new West Drainage Works were officially inaugurated on October 25 by the Provost, Mr. Allan McLeod. With the completion of this disposal and purification works it is considered that the burgh has now an appreciable reserve drainage capacity. The maximum flow to the new works, designed to deal with an ultimate population of 11,000, is about 2,730,000 gallons a day.

CLEVELAND AND THE NORTHERN COUNTIES.

DEFENCE ORDERS IN THE NORTH-EAST.—Mr. F. C. Wake, Northern Regional Controller of the Ministry of Supply, has refuted a suggestion made by the North East Engineering Bureau, reported on page 566, *ante*, that North-East firms were not receiving a fair share of work under the defence programme. The Bureau alleged that 42 per cent. of its 140 member firms were on the official Government list of contractors, but only 13 of these had been given defence contracts. The Bureau, it was stated, was taking up the matter with the Ministry of Supply. Mr. Wake commented that statements that the North-East was not receiving its fair share of work should be treated with great reserve. The fact was that more contracts were being allocated to the area than a year ago. Every effort had been made to assist small firms, but in some cases these were not able to carry out the work offered.

SHIPBUILDING ON THE TYNE.—The Tyne shipbuilding output for the first 11 months of this year will be brought up to 21 vessels, making together 161,500 tons gross by two launches due in November. On November 4, a tanker of 18,600 tons deadweight capacity was launched at Wallsend by Swan, Hunter,

and Wigham Richardson, Ltd., for the Hopemount Shipping Co., Newcastle, and on November 27, Princess Margaret will name the 8,000-ton Maori, under construction at the Walker Naval Yard of Vickers-Armstrongs Ltd. for the Union Steamship Co., New Zealand. In the first 11 months of 1951, 35 vessels, of 215,000 gross tons, were launched on the Tyne.

INDUSTRIAL DEVELOPMENTS IN NORTHUMBERLAND.—The development plan for the county of Northumberland, which covers the next 20 years, states that industry will be extended so as to occupy another 300 acres, mainly in the south-eastern area of the county. Major developments planned by the National Coal Board included extensions to new workings, new drifts in the Castle Ward rural district and at Morpeth, and new coal tips in the Seaton Valley urban area. A new electricity power station is proposed at Cambois, near Blyth. It is proposed to extend the gas plants at Alnwick, Berwick, Blyth, Hexham and Howdon and a new plant is proposed at Cambois.

PALLION TRADING ESTATE.—At a meeting of the Wearside District Advisory Committee of the Northern Regional Board for Industry it was reported that there were 2,695 persons employed in factories on the Pallion Trading Estate and that a further 642 would be needed when the factories were in full production. It was reported that, between July and September, the Board of Trade had issued nine industrial-development certificates covering 403,665 sq. ft., which would represent the employment of another 274 men and 485 women.

LANCASHIRE AND SOUTH YORKSHIRE.

IMPROVEMENTS TO SHEFFIELD WATER SUPPLY.—Extensions are to be made to the Sheffield Water Department's Bradfield filter station, which will increase the capacity of the Loxley Valley filtration plant by 4,000,000 gallons a day. Tenders are being invited for the construction of the building, which will house nine horizontal and four vertical filters.

SHEFFIELD GAS-MAKING PLANT.—The progress made with extensions to Sheffield's gas-making plant has been such that, unless unforeseen conditions occur, there will be little or no restriction on supplies during the winter. The output of gas during the next few months, it is estimated, will reach a record capacity of 72,000,000 cub. ft. a day. This winter, Sheffield will have the full benefit of two carburetted water-gas plants at Neepsend.

THE SCRAP POSITION.—Scrap merchants understand that, when Germany has delivered to Britain the 6,000 tons of arrears of scrap delivery under trade agreements, imports of German scrap will cease. The German Ministry of Economics has decided that no new commitments are to be entered into. Sheffield steelmakers are receiving fuller supplies of pig iron, but they need bigger supplies of scrap than are forthcoming from home sources.

WILLIAMS AND WOMERSLEY, LIMITED, WAKEFIELD.—In our reference in last week's issue, on page 571, *ante*, to the jubilee of Williams and Womersley, Ltd., we recorded that the occasion was celebrated in London on October 22, but omitted to mention that it was marked also by a dinner at the Mansion House, Leeds, on October 17, at which the whole of the employees were the guests of the company. All employees having 25 years' service or more with the firm received commemorative gold watches and a National Savings Certificate for each year of service. The recipients numbered 17 and their aggregate service amounted to 638 years.

THE LATE MR. FRANK CROFT.—We regret to learn of the death, on October 28, at his home in Grange-over-Sands, of Mr. Frank Croft, the eldest son of the late Mr. Frederick Lister Croft, founder of the firm of Crofts (Engineers), Ltd., Bradford. Mr. Frank Croft, who was 74 years of age, had spent the whole of his working life with the firm, and, on his father's death in 1920, succeeded him as chairman and joint managing director. He retired, for reasons of health, in 1936.

THE MIDLANDS.

STEEL WORKS EXTENSIONS.—Extension of the Normanby Park Steelworks of John Lysaght's Scunthorpe Works, Ltd., have just been completed, and the extended facilities have permitted the achievement of several records. In the week ended October 25, 10,900 tons of steel ingots were produced, this total exceeding the previous record established in August last, by 1,800 tons. Records were also achieved by the blast furnaces with a week's output of 6,900 tons

of iron, by the rolling mills with the production of 1,905 tons finished weight in 24 hours on the three-shift system, and by the company's ironstone mines with an output of 3,900 tons of ore a day.

PASSENGER TRANSPORT PLAN FOR WEST MIDLANDS.—The Birmingham Junior Chamber of Commerce have prepared a report on passenger transport in the West Midlands, and a commission, set up by the senior Birmingham Chamber of Commerce, is now studying its contents. The commission held its first meeting in Birmingham on October 29. The report suggests the formation of a single transport authority to plan, co-ordinate and integrate all road and rail passenger services in the area. As a long-term policy, electrification of all the suburban railways is urged, and for the present, the report puts forward many suggestions for improving the existing railway services. The report points out that, in the period 1931-51, many suburban railway stations were closed, and that the frequency of passenger train services within 25 miles of Birmingham had been reduced by 20 per cent. on the Western Region, and 40 per cent. on the London Midland Region. It is recommended that the possibility of re-opening some of the closed stations should be investigated and, wherever possible, road vehicles should act as feeders to suburban stations. Fast railcars could then be used to link these stations with the centre of the city.

ELECTRIC CABLES ACROSS THE SEVERN.—Two high-voltage cables, one to carry current at 33,000 volts, and one at 11,000 volts, were laid across the river Severn near Gloucester on October 26. The cables, which are about 200 yards upstream from Gloucester docks, were laid by the Midlands Electricity Board in a trench 3 ft. deep, dredged in the bed of the river.

FACTORY SAFETY.—An intensive safety campaign, which has been in operation at the Walsall works of the Talbot-Stead Tube Co. Ltd., for some time, has produced highly satisfactory results. In 1950, the total number of days work lost as the result of accidents was 1,411. In 1951, the figure was reduced to 756 days. One feature to which Mr. J. Seaman, the company's safety officer, has directed his attention is that of testing grinding wheels. Damage in transit has sometimes led to the bursting of wheels when they were first used. The company now test all their grinding wheels by running them at normal speed inside a safety cabinet for two minutes, before issuing them to the works.

SOUTH-WEST ENGLAND AND SOUTH WALES.

LIBERIAN IRON ORE.—Iron ore from Liberia has been landed at Newport for the Ebbw Vale works of Richard Thomas and Baldwins Ltd. This is the first consignment from Liberia to Newport. The ore came in the s.s. Oakland, which carried 10,140 tons from Monrovia. Further cargoes are expected.

RECORD STEEL PRODUCTION.—At the Cardiff works of Guest Keen Baldwins Iron and Steel Co., Ltd., "D" furnace, a 100-ton fixed furnace, recently produced 2,210 tons of steel in a week, which is claimed to be a new world record for this type of furnace. In the same shop, "B" furnace, a 200-ton tilting furnace, established its own individual record with a weekly output of 2,654 tons of steel.

TRANSFER OF CABLE FACTORY TO SOUTH WALES.—A large increase in the output of a wide range of covered wires at the works of Enfield Cables Ltd., over the past year is mainly due to the skilful transfer of part of the covered-wires factory from Brimsdown, Middlesex, to Blaenavon, Monmouthshire. Late in 1951 it became obvious that the increased production necessary could not be met satisfactorily at Brimsdown, so a new Board of Trade factory of 15,000 sq. ft. floor area, at Forgeside, Blaenavon, was acquired. It was decided, therefore, to close the Brimsdown factory at 5 p.m. on December 28, 1951, and resume production in Wales on January 14, 1952. As soon as the factory closed the dismantling and packing of machines began. The transport of machinery was undertaken by L.E.P. Transport Limited, and the Enfield design, development and contracts department was responsible for the re-erection of all machinery.

FILTON BY-PASS.—On October 31, the Minister of Transport, the Rt. Hon. Alan Lennox-Boyd, received a deputation from the Gloucestershire County Council, the Bristol Corporation, the Port of Bristol Authority, and the Thornbury Rural District Council, to discuss the provision of an alternative route to the Filton by-pass, which was cut when the runway of Filton aerodrome was extended in 1947. The deputation urged the early construction of an alternative route, north of the existing by-pass. The Minister undertook to visit Filton to examine the position.

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 10, 6 p.m., Victoria-embankment, W.C.2. Discussion on "The Teaching of Illumination Engineering," opened by Mr. S. S. Beggs. **North-Eastern Centre:** Monday, November 10, 6.15 p.m., Neville Hall, Newcastle-upon-Tyne. "Voltage Transformers and Current Transformers Associated with Switchgear," by Mr. W. Gray and Mr. A. Wright. **North Midland Centre:** Tuesday, November 11, 6.30 p.m., 1, Whitehall-road, Leeds. "Economics of Low-Voltage Electricity Supplies to New Housing Estates," by Mr. F. G. Copland. **Radio Section:** Wednesday, November 12, 5.30 p.m., Victoria-embankment, W.C.2. "Radio Telemetering," by Mr. E. D. Whitehead and Mr. J. Walsh. **Institution:** Thursday, November 13, 5.30 p.m., Victoria-embankment, W.C.2. "A 150-kV X-Ray Equipment for the Radiography of Circumferential Welds in Gas-Turbine Rotors," by Mr. F. W. Waterton.

INSTITUTE OF METALS.—Scottish Section: Monday, November 10, 6.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. "Properties and Engineering Applications of Electro-Deposits," by Mr. R. A. F. Hammond.

ILLUMINATING ENGINEERING SOCIETY.—Sheffield Centre: Monday, November 10, 6.30 p.m., The University, Western Bank, Sheffield, 10. "Modern Flash Discharge Tubes," by Mr. C. R. Bicknell. **London:** Tuesday, November 11, 6 p.m., 2, Savoy-hill, W.C.2. Three papers on factory lighting.

INSTITUTION OF PRODUCTION ENGINEERS.—Sheffield Section: Monday, November 10, 6.30 p.m., Royal Victoria Station Hotel, Sheffield. "Cemented Carbide Tool Developments," by Mr. F. Sheldon. **Yorkshire Section:** Monday, November 10, 7 p.m., Hotel Metropole, Leeds. "Effective Tooling for Production," by Mr. B. Holloway. **Nottingham Section:** Tuesday, November 11, 7 p.m., Welbeck Hotel, Nottingham. "Productivity and Costs," by Mr. W. S. Risk. **Dundee Section:** Tuesday, November 11, 7.30 p.m., Queen's Hotel, Dundee. "Mechanised Inspection," by Mr. J. Loxham. **Preston Section:** Wednesday, November 12, 7.15 p.m., Victoria and Station Hotel, Fishergate, Preston. Film Evening. **Cornwall Section:** Thursday, November 13, 7.15 p.m., Cornwall Technical College, Redruth. "Drop Forging," by Captain F. W. Spencer.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—Central London Branch: Monday, November 10, 6.45 p.m., St. Ermin's Hotel, Caxton-street, S.W.1. "Recent Developments in Fluorescent Lighting," by Dr. H. H. Ballin.

INSTITUTION OF WORKS MANAGERS.—Manchester Branch: Monday, November 10, 6.45 p.m., Grand Hotel, Manchester. Open Discussion. **Merseyside Branch:** Tuesday, November 11, 6.30 p.m., Adelphi Hotel, Liverpool. "Thoughts on American Management," by Mr. J. C. W. Stead. **Preston Branch:** Tuesday, November 11, 7.30 p.m., Storey Institute, Lancaster. "The Team Spirit and How to Get It," by Dr. Denis Chapman.

INSTITUTION OF THE RUBBER INDUSTRY.—Preston Section: Monday, November 10, 7.15 p.m., Bull and Royal Hotel, Preston. "Safe Working on Horizontal Two-Roll Mills," by Mr. H. Jackson. **Southampton Section:** Wednesday, November 12, 7.15 p.m., Polygon Hotel, Southampton. Discussion on "Compounding with Some New Fillers." **Trowbridge Section:** Wednesday, November 12, 7.45 p.m., George Hotel, Trowbridge. "Early Days in the Rubber Industry," by Dr. S. S. Pickles.

JUNIOR INSTITUTION OF ENGINEERS.—North-Western Section: Monday, November 10, 7 p.m., 16, St. Mary's Parsonage, Manchester. Ordinary Meeting. **Sheffield Section:** Monday, November 10, 7.30 p.m., Livesey Clegg House, Sheffield. "Smoke Abatement," by Professor R. J. Sarjant. **Institution:** Friday, November 14, 7 p.m., Townsend House, Greycoat-place, S.W.1. "Water Supply and Distribution," by Mr. N. E. Pillinger.

INCORPORATED PLANT ENGINEERS.—Dundee Branch: Monday, November 10, 7.30 p.m., Mather's Hotel, Dundee. "Something for Nothing in Heating," by Mr. H. W. L. Tuckey and Mr. H. F. Taylor. **East Lancashire Branch:** Tuesday, November 11, 7.15 p.m., Engineers' Club, Manchester. Film Evening. **Western Branch:** Tuesday, November 11, 7.15 p.m., Grand Hotel, Bristol. "An Engineer's Philosophy," by Mr. H. C. I. Rogers. **East Midlands Branch:** Wednesday, November 12, 7 p.m., Welbeck Hotel, Nottingham. "An Aspect of Fuel Economy," by Mr. H. E. Partidge. **Newcastle-upon-Tyne Branch:** Thursday, November 13, 7.30 p.m., Roadway House, Oxford-street, Newcastle-upon-Tyne. "Gas and Oil Engines," by Mr. A. C. Yeates.

INSTITUTION OF CIVIL ENGINEERS.—Railway Engineering Division: Tuesday, November 11, 5.30 p.m., Great George-street, S.W.1. "Some Major Problems in Railway Civil Engineering Maintenance," by Mr. A. H. Cantrell. **Midlands Association:** Thursday, November 13, 6 p.m., James Watt Memorial Institute, Birmingham. "Control of Concrete Quality," by Dr. L. J. Murdock.

INSTITUTE OF MARINE ENGINEERS.—Tuesday, November 11, 5.30 p.m., 85, The Minories, E.C.3. "Steam to Air Heaters for Marine Water-Tube Boilers," by Mr. W. J. S. Glass.

INSTITUTION OF CHEMICAL ENGINEERS.—Tuesday, November 11, 5.30 p.m., Geological Society's Apartments, Burlington House, Piccadilly, W.1. "Elimination of Carryover from Packed Towers, with Special Reference to Water-Cooling Towers," by Mr. H. Chilton. **London Graduates' and Students' Section:** Friday, November 14, 6.30 p.m., Caxton Hall, Westminster, S.W.1. "Naphtha Reforming," by Mr. D. J. Hardie.

INSTITUTION OF MECHANICAL ENGINEERS.—North-Western Branch: Tuesday, November 11, 7 p.m., Central Library, Burnley. "The Marine Gas Turbine from the Viewpoint of an Aeronautical Engineer," by Mr. A. Holmes Fletcher. **London Graduates' Section:** Wednesday, November 12, 6.30 p.m., Storey's-gate, St. James's Park, S.W.1. "New Ventilating Plant at the Institution Headquarters," by Mr. J. R. Calland. **Western Branch:** Wednesday, November 12, 7 p.m., Electricity House, Colston-avenue, Bristol. Repetition of Presidential Address, by Sir David Pye, F.R.S. **Southern Branch:** Wednesday, November 12, 7.30 p.m., Canteen of J. I. Thornycroft & Co., Ltd., Basingstoke. "Experiences During Twenty Years of Oil-Engine Development," by Mr. C. B. Dicksee. **Yorkshire Branch:** Thursday, November 13, 7 p.m., The University, Leeds. "Heavy Fuels for Medium-Sized Marine and Stationary Diesel Engines," by Mr. J. R. P. Smith. **Institution:** Friday, November 14, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. Thomas Hawksley Lecture on "Mechanism of Work-Hardening in Metals," by Professor N. F. Mott. **Scottish Branch:** Friday, November 14, 7.30 p.m., Robert Gordon's College, Aberdeen. Branch Chairman's Address, by Mr. E. Bruce Ball.

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—Midlands Centre: Tuesday, November 11, 7.30 p.m., Crown Inn, Broad-street, Birmingham. "Specialised Vehicles for Road Transport," by Mr. L. D. Watts. **East Midlands Centre:** Wednesday, November 12, 7.30 p.m., Mechanics Institute, Nottingham. "Plastics and Their Use in the Road Transport Industry," by Mr. A. Jones.

INSTITUTE OF PETROLEUM.—Wednesday, November 12, 5.30 p.m., 26, Portland-place, W.1. "Sulphur Compounds in Petroleum," by Dr. S. F. Birch.

NEWCOMEN SOCIETY.—Wednesday, November 12, 5.30 p.m., 4, Grosvenor-gardens, S.W.1. Annual Meeting. "Earl of Dudley's Level New Furnaces at Brierley Hill," by Mr. T. M. Hoskison.

BRITISH INSTITUTION OF RADIO ENGINEERS.—North-Eastern Section: Wednesday, November 12, 6 p.m., Neville Hall, Newcastle-upon-Tyne. "Radio Counter Measures," by Mr. H. J. Barton-Chapple.

ROYAL AERONAUTICAL SOCIETY.—Wednesday, November 12, 6 p.m., Vickers-Armstrongs Ltd., Weybridge. "Rex Pierson: An Appreciation and the Lessons of His Work," by Sir A. H. Roy Fedden.

INSTITUTE OF FUEL.—North-Western Section: Wednesday, November 12, 6.30 p.m., Engineers' Club, Manchester. "Feed-Water Conditioning for Steam Boilers," by Mr. C. W. Drane.

INSTITUTE OF BRITISH FOUNDRYMEN.—London Branch: Wednesday, November 12, 7.30 p.m., Waldorf Hotel, Aldwych, W.C.2. Discussion on "Research." **Lincolnshire Branch:** Thursday, November 13, 7.15 p.m., Technical College, Lincoln. "Casting Defects," by Mr. G. W. Nicholls.

ROYAL SOCIETY.—Thursday, November 13, 4.30 p.m., Burlington House, Piccadilly, W.1. (i) "Free Tidal Oscillations in a Rotating Square Sea," by Mr. R. H. Corkan and Mr. A. T. Doodson, F.R.S. (ii) "Generation of Waves by Wind," by Mr. J. Darbyshire.

INSTITUTION OF STRUCTURAL ENGINEERS.—Thursday, November 13, 6 p.m., 11, Upper Belgrave-street, S.W.1. "Design and Construction of a Three-Bay Aluminium Aircraft Hangar at London Airport," by Mr. L. E. Ward.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—Liverpool Branch: Thursday, November 13, 6.30 p.m., Radiant House, Bold-street, Liverpool. "Automatic Controls," by Dr. F. M. H. Taylor.

INSTITUTE OF WELDING.—South London Branch: Thursday, November 13, 6.30 p.m., 85, The Minories, E.C.3. "Site Welding," by Mr. A. Brewitt.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, November 14, 6.15 p.m., Mining Institute, Newcastle-upon-Tyne. "Structural Behaviour of the Main Engine Seating and Bedplate in a Cargo Ship under Static Bending Tests," by Mr. A. J. Johnson and Dr. J. E. Richards.

PERSONAL.

SIR PETER BENNETT has been appointed chairman of the new British Productivity Council, which, as foreshadowed on page 341, *ante*, is to replace the United Kingdom Section of the Anglo-American Council on Productivity. Mr. LINCOLN EVANS, chairman of the economic committee of the Trades Union Congress, has been appointed deputy chairman of the new Council.

SIR HARRY GARNER, K.B.E., C.B., Chief Scientist of the Ministry of Supply, is retiring early in the New Year. His successor is to be Dr. O. H. WANSBROUGH-JONES, C.B., O.B.E.

SIR DONALD MCL. SKIFFINGTON, C.B.E., J.P., M.I.N.A., director of the local and main boards of John Brown & Co. Ltd., Clydebank, has now relinquished his appointments after an active association with the firm extending over upwards of 50 years.

MR. F. W. HALLIWELL, M.I.Mech.E., M.I.Prod.E., has been re-elected President of the Gauge and Tool Makers' Association, Standbrook House, Old Bond-street, London, W.1, for the 1952-53 session. Mr. A. L. DENNISON, M.I.Prod.E., has been elected chairman. Mr. L. E. VAN MOPPE has been re-elected a vice-chairman, while Mr. S. J. HARLEY, B.Sc., M.I.Mech.E., M.I.Prod.E., has been elected to be the other vice-chairman. Mr. R. KIRCHNER, M.I.Mech.E., M.I.Prod.E., has been re-elected honorary treasurer. The immediate past chairman, Mr. H. S. HOLDEN, M.I.Prod.E., will continue to serve on the Council.

MR. ARTHUR DORMAN, M.A., has been elected President of the Cleveland Scientific and Technical Institution, Middlesbrough, in succession to MAJOR W. R. BROWN, D.S.O.

MR. GEORGE H. BURROWS, M.I.Mech.E., who has been chief mechanical engineer, Pilkington Brothers Ltd., Plate Works, St. Helens, Lancashire, for 33 years, has retired.

FIELD MARSHAL VISCOUNT ALANBROOKE, K.G., G.C.B., O.M., D.S.O., H.M. Lieutenant of the County of London, has appointed COLONEL ALAN RAYMOND MAIS, O.B.E., T.D., F.R.I.C.S., to be Deputy Lieutenant of the County.

MR. F. W. FRY, general manager, No. 3 Area, Durham Division, National Coal Board, has been appointed assistant production director at the divisional headquarters, Newcastle-upon-Tyne. Mr. R. S. McLAREN, general manager, No. 1 area, has been appointed general manager, No. 3 area. Mr. S. J. TEMPERLEY, production manager of the No. 4 area of the North-Eastern Division of the Coal Board, has been appointed to succeed Mr. McLaren. Mr. E. W. POTTS, production manager of Durham Division No. 5 area, has been transferred to the No. 3 area.

MR. R. KINGSTON, chief assistant blast-furnace manager, South Bank-on-Tees Works of Dorman, Long & Co. Ltd., has been appointed blast-furnace manager at the Skinningrove Iron Co. Ltd., Saltburn-by-the-Sea, and has taken up his new duties.

MR. L. ATHERTON, B.Sc., A.M.I.E.E., has joined the equipment division of Mullard Ltd., Century House, Shaftesbury-avenue, London, W.C.2, to take charge of the special-products commercial group which specialises in ultrasonic equipment and applications of electronic techniques. Mr. A. E. CRAWFORD, A.R.Ae.S., is now in charge of investigations of applications of ultrasonic and other electronic equipment.

MR. I. M. HARDACRE, manager of the Berwick undertaking of the Northern Gas Board for the past 17 years, has retired and has been succeeded by Mr. R. F. D. PAWLEY.

MR. J. NICHOLSON has been appointed manager of the Leeds branch of W. T. Henley's Telegraph Works Co. Ltd., in succession to the late Mr. L. BROOKE.

MR. H. A. HUTLEY, F.C.I.S., secretary of Prior Stokers Ltd., Prior Works, 1-3, Brandon-road, York Way, London, N.7, has joined the board and is now an executive director of the company.

MR. L. W. ACKROYD, B.Sc., of Leeds; Mr. C. E. ROBERTSON, A.M.I.C.E., of Sunderland; Mr. A. W. FINNIGAN, of Sheffield, and Mr. M. C. AYTON, B.Sc., of King's Lynn, have been appointed to the Colonial Engineering Service, Mr. Ackroyd to Nigeria, Mr. Robertson to Sarawak, Mr. Finnigan to Trinidad, and Mr. Ayton to Malaya.

MR. M. H. MORRIS-GOODALL has been appointed competitions manager to Jaguar Cars Ltd., Coventry.

The new factory of RANSOME and MARLES BEARING CO. LTD., Newark-on-Trent, now under construction at Annfield Plain, County Durham, is expected to commence production early next spring.

THE DOWSON AND MASON GAS PLANT CO. LTD., Alma Works, Levenshulme, Manchester, 19, state that they have been granted a licence, by Koch Supplies, Kansas City, Missouri, U.S.A., to manufacture, in Manchester, Koch smoke-house equipment.

EXHIBITS AT THE PUBLIC WORKS EXHIBITION, OLYMPIA.

(For Description, see Page 595.)



FIG. 12. OVERHEAD-BEAM 13-CUB. YD. SCRAPER ; JACK OLDING & Co., LTD.



FIG. 13. "GALION 118" MOTOR GRADER ; JACK OLDING & Co., LTD.

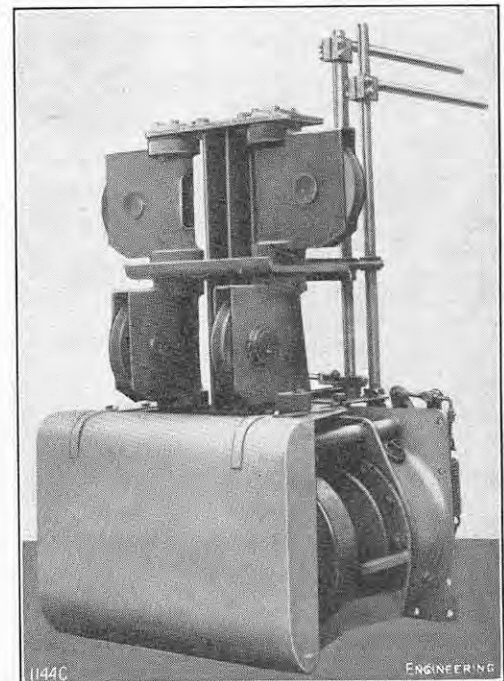


FIG. 14. CABLE CONTROL UNIT FOR TRACTORS ; BLAW-KNOX, LTD.



FIG. 15. 7 1/2 CUB. YD. SCRAPER ; BLAW-KNOX, LTD.

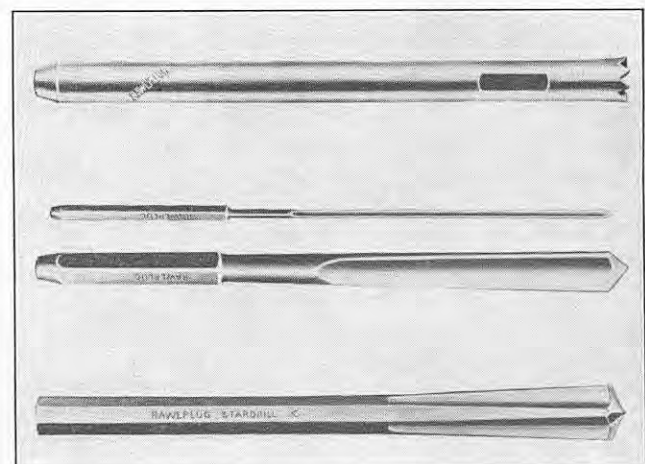


FIG. 16. DRILLS FOR MASONRY ; RAWLPLUG Co., LTD.

ENGINEERING

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

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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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For Canada	£5 5 0

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ADVERTISEMENT RATES.

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

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 10s. for the first four lines or under, and 2s. 6d. per line up to one inch. The line averages six words and when 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 14 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

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

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ENGINEERING

FRIDAY, NOVEMBER 7, 1952.

VOL. 174.

No. 4528.

A SUBJECT FOR RESEARCH.

IF there are any students (between 18 and 80 years of age) who are consumed with a desire to undertake research and experiment on a project of great scientific and possibly commercial interest, they will find it on page 607, in the report of a committee appointed to inquire into the possible uses of solar energy, and the methods and purposes considered are various enough to give opportunities to scientists and engineers of diverse qualifications and experience. They include water heating and house heating by means of collectors; cooking in a stove which uses a mirror; the cooling of air, for air-conditioning, using an ammonia absorption machine or the lithium-bromide water-vapour process; developing power by a steam, vapour or hot-air engine in conjunction with a mirror collector or a flat-plate collector; developing power by utilising the thermo-electric effect, a photovoltaic cell, or the photogalvanic effect; the production of fuel by photosynthesis in non-living systems, by growing plants specially for fuel, or by growing vegetable matter for fermenting to alcohol or for anaerobic fermentation to methane; the production of power for irrigation by means of wood-fired steam engines; the growing of special plants in tanks, to be continuously withdrawn and burnt, or fermented to alcohol (the continuous biological photosynthesis process); and the distillation of water, possibly by using a combination of solar heater and heat pump.

The committee rejected a high proportion of these possible methods; generally for sound technical reasons, but also, no doubt, because they were responsible for making recommendations as to whether research work should be undertaken or sponsored by a State-supported organisation—the Department of Scientific and Industrial Research. In these straitened times they were bound to be careful not to recommend any wild-

goose chases. Nevertheless, in an industrial laboratory or a university, or even in a private study-workshop, there may be someone who sees a glimmer of hope in following one of these avenues of inquiry. To such a speculator, some encouragement may be offered: that there are many precedents in the history of technology for embarking on a research which the authorities have pronounced futile. In thus suggesting the attractions of work on projects which have received unfavourable comment from the distinguished members of the committee, of course, the wisdom of the members is not impugned. They were required to report on behalf of the D.S.I.R.; if their terms of reference had been different, their report would doubtless have been different also, at least in its recommendations. Moreover, when a report of this nature is published, thousands of minds are attracted to it, and there is a chance that some will see an opening that was missed by a comparatively small committee.

The imagination is stirred by the prospect of using solar energy: it is fundamental, primitive, and, above, all, inexhaustible. Unfortunately, it is also intermittent, it is least available when most wanted for heating, and the capital cost of the collectors is high. The literature on the subject is large, but commercial applications appear to have been confined to solar water-heaters, which have been on the market in the United States for many years, though only on a small scale. However, the conditions governing the possibility of applying a theory to practical development change in the course of time. Established methods of achieving the same object may become too expensive; certain raw materials or fuel may become scarce. Moreover, a design which is not economic in a highly industrialised country may be worth considering in an under-developed country that is being industrialised. Such changes in what might be called the environment of a design come slowly. A watch can be kept on them, however, so that, when the time is propitious, commercial development can begin. A considerable amount of study and experiment has been devoted already to the subject, but no harm, and possibly much good, can come from publishing this balanced report.

The committee have recognised the potential applications overseas, for they refer frequently to opportunities for the harnessing of solar energy in India. It is not that the available energy in India is specially high; on the contrary, the total radiation received per day in England in the summer is said to be greater than in India, because of the greater length of the English summer day. In the sub-continent, however, the only practicable fuel for cooking is often cow dung, which might be better used for fertilising; and for irrigation pumping the committee find that steam engines fired by wood (grown as fuel, and therefore storing solar energy) compare favourably with the bullocks so widely used for water-raising. For cooking, a mirror of about 0.3 sq. m. is stated to be sufficient to provide heat equivalent to 100 watts, which would produce the temperature of boiling water and maintain it in an insulated stove. The Indian National Physical Laboratory have built a stove using a mirror and a pressure cooker, but it is doubtful whether such equipment can be made at a price that an Indian villager can pay. The committee recommend, however, that a contract be considered by the National Research Development Corporation in this country for the design of a stove which would be suitable for large-scale production.

The use of solar energy for refrigeration is regarded as impracticable, but for air-conditioning it is attractive, since it is not essential for the system to run continuously. Taking the case of a building in India, measuring 20 m. by 20 m. by 10 m. high, it is found that a collector with a surface about half the area of the roof would suffice to meet the

cooling load. If the lithium-bromide water-vapour process were used, or if only certain rooms were to be air-conditioned, the area required would be less.

The committee's examination of the potential development of power by the direct use of solar energy is not encouraging. Certainly, for large power plants the intermittency of the supply rules it out, but for small plants of, say, 1 kW, there might be a market in places where intermittent power is not a serious obstacle. Unfortunately, however, the area of mirror which would be needed for a small steam, vapour or hot-air engine is so large as to make the scheme too expensive for use in peasant agriculture. The committee were therefore "regretfully forced to the conclusion that orthodox heat engines driven directly by solar power are not an immediate practicable proposition." Three methods of generating electricity by solar power without first converting it to mechanical energy were considered. The utilisation of the thermoelectric effect was found to require equipment of considerable complexity, as well as a large amount of relatively expensive materials. The prospects of using photovoltaic cells are not regarded as good enough to justify their development for converting solar energy. Of the third method—the use of the photogalvanic effect—the committee say that "the little that is known about these systems makes it appear most unlikely that they could be developed into an efficient source of power."

The possible use of solar energy to produce fuel which is subsequently used in an engine is more hopeful. It is, indeed, what Nature has been doing for man for millions of years. The drawback of intermittency of power is obviated. Photosynthesis in non-living systems and continuous biological photosynthesis are not regarded as practicable for this purpose at the present time, but the growing of plants to produce fuel appears to be feasible. For irrigation purposes, the committee found that, assuming certain data, the amount of land required for growing fuel for a steam engine is about one-fiftieth of the area to be irrigated. This is an encouraging scheme. It compares favourably with the use of bullocks for irrigation pumping, and although there are factors in India (and, no doubt, elsewhere) which militate against the substitution of steam power for animal power, the committee suggest that a small steam engine fired by vegetable matter should be designed. The development of such an engine is being undertaken by Messrs. Ricardo and Company, Engineers (1927), Limited, for the National Research Development Corporation. The last possible use of solar energy examined in the report is for the distillation of water. For this purpose, it is stated, there is considerable scope for a combination of solar heater and thermal pump, since it would allow almost complete recovery of the latent heat of condensation, and would greatly increase the output for a given size of distilling plant.

The committee's general conclusion is that "it seems unlikely that solar energy can be an important source of heat or power in the near future, though some applications may be possible in specially favourable circumstances. In particular, it is possible that the availability of very modest amounts of power would have important and beneficial effects on the economy of tropical agricultural areas." These are guarded statements—doubly so when the statement is also made that "when in doubt we have taken an optimistic view, but even so, our conclusions are not encouraging." Nevertheless, it would be regrettable if this carefully considered and well substantiated report were to deter earnest students of the seemingly impracticable. In engineering, the impossible to-day is often possible to-morrow, and in the imagination and inventiveness needed for that kind of development British scientists and engineers excel.

PRODUCTIVITY AND THE ELECTRICAL INDUSTRY.

THE story is told of an old lady who provided herself with much mental solace by constantly repeating the word Mesopotamia. More than one moral can be drawn from this tale; among them being that self-hypnosis may produce unexpected results; and that the substitution of words for deeds may lead to a delusion of progress, which is not justified by facts. It was with these thoughts in mind that we reflected on the word productivity, a word with which we have recently been forced to become increasingly familiar. Productivity has been defined as the application of thought and invention to the solution of the problem of manufacturing the greatest number of goods from limited resources of capital equipment, materials and labour. Its basic implications have been exhaustively discussed in the light of this definition, but not all of what has been said is of equal value. It is generally admitted too that every effort should be made to produce more and more of the goods and services which are essential to maintain the standard of living, especially at a time when, in this country at least, capital equipment, many raw materials and man-hours are all in short supply, but there is no unanimity as to exactly what form these efforts should take. The result is that while much has been said, little, in proportion, has been done.

This being so, it was with some misgivings that we learnt that, with the co-operation of the electricity supply industry and the support of a number of other organisations, both electrical and non-electrical, the British Electrical Development Association had organised an industrial productivity conference. The function of the sponsoring body is, of course, to encourage the proper use of electricity in the national interest, and in so doing, it may be added, to increase the consumption of that form of energy, both of which are legitimate aims. We therefore feared that the proceedings at this gathering, which was held in London last week, might take the form of undiluted propaganda. This would have had the result of rousing the opposition of other interests and action would once again have been submerged in polemics. Fortunately, this fear was to a large extent unrealised, partly perhaps owing to the limited terms of reference; and the information given and the arguments put forward, although they had an electrical bias, were not unduly one-sided. They should, therefore, not only enable the position to be clarified, but, what is more important, indicate what has to be done.

Now, if it be postulated that electricity is "the very life blood for the arteries and veins of our productive being," to quote Sir Norman Kipping, it is essential that attention should be directed to restoring "a better supply of the red corpuscles known as kVA." Sir Norman was supported in this opinion by Colonel B. H. Leeson, who pointed out that "the placing of one kilowatt of electrical energy in the hands of a man is equivalent to increasing his capability to work by about 10 times." He also naturally received the assistance of Lord Citrine, who once again called attention to the fact that the present shortage of generating plant was due to unwise decisions taken 11 years ago. The obvious corollary is that, if greater productivity is to be obtained by electrical means, the present restrictions on the provision of new generating equipment must be abandoned.

Apart from plant shortage there are two other matters on the supply side of the industry which, we are glad to see, received attention during the conference. One is the necessity for improving the efficiency of generation and the other is the need to increase the utilisation of the plant to the greatest

possible extent. It is indeed desirable, if not essential, to organise industry on a two or three shift basis in the way that, as Mr. R. A. S. Thwaites pointed out, is more and more the practice in the United States. A careful examination of the part that can be played by privately-owned plant in the field of electricity supply is also necessary, and there should be closer collaboration between the supply authority and the consumer on technical and tariff problems, so as to secure the greatest advantages from the experience of each and thus assist progress. Criticisms, for which there may be some justification, of the British Electricity Authority on these matters, were put forward by more than one speaker. It may, however, be wondered whether the fault is all on one side. In any event, endeavours should be made to liquidate the antagonism which too often exists and to replace it by a willingness to see the opposite point of view. This can only be to the advantage of both parties and may lead the way to ultimate agreement.

Stress was rightly laid by more than one speaker on the part that mechanical handling, both inside and outside the factory, can play in increasing productivity. Much was also said, we are glad to note, about the importance of good lighting as an aid to progress in the same direction, since, as Mr. W. Robinson pointed out, there is little doubt that the potential contribution of artificial lighting to productivity is at present far from being fully realised. The success of any campaign to improve factory illumination is, however, dependent on the appreciation by those in charge of the benefits that can be obtained in this way, and on the establishment of channels of expert advice.

Taking the necessary steps to establish such channels might, in fact, prove to be one of the most fruitful results of this conference. We hope, therefore, that little time will be lost before something is done in this direction. As it is, the electrical industry, through its representatives, has put forward a strong case for the increased utilisation of electricity under the most efficient conditions, a case of which the consumers clearly recognised the soundness, even though they reserved their opinions on certain points of detail. It is therefore essential that everyone working in the industry, in particular those who come most closely into contact with the public, should be fully aware of the main arguments in favour of increased productivity, not only because this will enable them to deal successfully with those who are as yet unconverted, but also because it will add to their own basic knowledge and so increase their usefulness. For that reason we are glad to learn that the British Electrical Development Association is shortly to take steps to arouse greater interest in this matter, both in technical colleges and in factories; and to provide information, as has already been done to some extent by the publication of useful booklets, on the modernisation of industrial equipment and methods. Propaganda in aid of the objects the Association has in view is as necessary within the industry as outside it.

The importance of increasing the efficiency of industrial processes, whether by electrical or other means, should by this time be patent to all; it is emphasised, however, by recent returns, showing that exports are falling. Whether this is due to the fact that post-war demands are becoming satisfied or to increasing competition from other nations, the position cannot be regarded with equanimity. It is, on the other hand, a challenge to further effort, combined with a determination to utilise every means whereby the quality of our products can be improved and their cost reduced. That electricity can play a part towards the attainment of these ends is clear, but it is also essential that the examination of other possible methods which might tend to the same goal should not be neglected.

NOTES.

SIMPLIFICATION OF MACHINE TOOLS.

In opening the discussion at the Institution of Mechanical Engineers on Friday, October 31, Sir William Stanier, F.R.S., expressed the feelings of many members when he said that it was very refreshing to read a paper of such practical importance as that presented by Mr. C. A. Sparkes, M.I.Mech.E., on "Machine Tool Simplification, Especially as Applied to Horizontal Boring Machines." He also said that some machine-tool makers, not necessarily in this country, were rather inclined to listen to the electrical people; they were "plastering" their machine tools with electric push buttons and electronic equipment for doing work which could be more simply done mechanically. As a user, he objected strongly to such devices, because they all had to be maintained. Most of the other speakers in the discussion supported this view. Mr. Sparkes had described how a policy of simplification of design and construction had been applied to the horizontal boring machines built by Messrs. H. W. Kearns and Company, Limited, Manchester. He also described some single-purpose machines of novel design and devoted a large part of his paper to unit construction, i.e., the design of a full range of horizontal boring machines which were built of standard units. In concluding his paper he said that the sales department could assist the works by reporting the true requirements of the user, by discouraging requests for unnecessary accessories and by treating with caution demands for the fashionable streamlining originated by some industrial designers. "No objection," he said, "could be raised to the idea that art is best realised in perfect adaptation to purpose."

THE GREENWICH TIME BALL.

At 1 p.m. on Sunday, October 26, the Admiralty resumed the practice of dropping the time ball at Greenwich Observatory, which had been in abeyance since the Observatory was bombed during the recent war, except for a brief period at the start of the Festival of Britain in 1951. It is a hollow sphere, 5 ft. in diameter, sliding on a mast erected on the top of the Wren building, and was the earliest means of making Greenwich mean time known to the public. The ball, with its operating mechanism, was designed and made by Messrs. Maudslay, Sons and Field, the Lambeth marine and general engineering firm founded by Henry Maudslay (1771-1831), and was erected in September, 1833, after a temporary (fixed) ball had been tried in position for some time to ascertain its visibility from various reaches of the Thames, the primary purpose being to enable shipmasters to set their chronometers without actually taking them to the Observatory. Except for a slight modification made by Sir George Airy, who was Astronomer Royal from 1835 to 1881, the mechanism remains as originally constructed, though the catch which holds the ball at the top of the mast is now released electrically instead of by hand. The practice is to raise the ball halfway up the mast five minutes before one o'clock, and to the top at two minutes before the hour, and to drop it precisely at the hour. It drops freely for about three-quarters of its fall, and is then brought gently to rest by a dashpot consisting of a loosely-fitting piston which enters a bell-mouthed cylinder and is cushioned by the air trapped in the cylinder. The original intention was that the ball should drop at noon, but the Admiralty decided in favour of 1 p.m. The apparatus has functioned with the most commendable regularity. Quite early in its existence, however—on November 25, 1833—the ball was one minute late. *The Times*, in the ponderous journalese of the period, drew prompt attention to "the most calamitous results" which might accrue to ships if there were an error of even one second. No doubt, it was "of the utmost consequence that the ball should act at an invariable point of time," though the writer seemed to overlook the fact that the signal had only been available for a few weeks and mariners had managed fairly well without it. There was an occasion, too, within comparatively recent years, when the ball failed to drop; but, fully a century ago, the Admiralty had adopted the rule that, if a time ball

did not drop at the correct time, it would be kept at the masthead for 10 minutes, then lowered gradually, and raised and dropped by hand at the next hour. For all practical purposes, the signal has now been superseded by the six "pips" broadcast at stated times, and by the "speaking clock" of the General Post Office, but, nevertheless, there has been widespread satisfaction that the time ball is functioning once again at Greenwich.

SCHOLARSHIPS FOR SOUTH AMERICAN ENGINEERS.

In the early part of the present year a small mission (of which Sir Arthur Fleming, director of research and education, Associated Electrical Industries, and Mr. F. R. Livock, manager of education and training, General Electric Company, were members) visited nine Latin-American republics with the object of making the engineering training facilities available through the Federation of British Industries Overseas Scholarships scheme more widely known in that part of the world. This mission has had two important results. One is the publication of a report surveying conditions and emphasising the need for more publicity for British engineering products in the countries visited. The other is the announcement that the Federation is to award 50 scholarships for the training in individual British firms of engineering graduates from Latin America. These scholarships are additional to those already granted to natives of countries where natural resources are being developed and basic industries established. They will vary in value from 950*l.* to 600*l.* for a two-year period, although there will be a few at 300*l.* for shorter courses for more experienced men. It is hoped that, as a result, a number of young engineers will become familiar with British methods and equipment and acquainted with British industrialists and engineers, and thus may be favourably inclined to buy British goods and to avail themselves of British technical assistance. Similar schemes are already in operation in Germany, France, Sweden and the United States.

"TRAINING FOR INDUSTRY" EXHIBITION.

The City and Guilds of London Institute, of which H.R.H. the Duke of Edinburgh has recently been elected President, has organised an exhibition, entitled "Training for Industry," to illustrate the scope of its activities. This exhibition, which is being held at Goldsmiths' Hall, Foster-lane, London, E.C.2, and will remain open until Friday, November 14, is divided into three sections. The first shows, by means of charts and diagrams, the growth of the Department of Technology, which is at present responsible for the preparation of syllabuses and the holding of examinations in about 200 subjects, at which some 77,500 candidates (of whom 6,800 were located overseas) sat in 1952. The second section of the exhibition covers the work of students at the City and Guilds Art School, which was established in Kennington in 1879, while the third displays the activities of those attending the City and Guilds College, which was opened in South Kensington in 1884 and now forms the engineering section of the Imperial College. The electrical exhibits included a model network computer, in which specially-constructed transformers are used to represent a power network and a set of small motors and generators, which are connected to form a closed-loop system by which the position of a shaft can be controlled. The use of a 10-cm. wave oscillator for testing insulating materials is also being demonstrated. The contribution of the Aeronautics Department includes a smoke tunnel, whereby the air flow past wings and through ducts can be evaluated qualitatively. A supersonic wind tunnel, which was designed and constructed in the Department and produces an air stream up to 1.8 times the speed of sound, is also on view. An interesting exhibit, for which the Mechanical Engineering Department is responsible, is designed to show the development of the engine indicator. It includes one of the Richards pattern, as used by Unwin at the time of the opening of the Central Technical College in 1885, an example of the optical indicator designed by Dalby and a Farnborough electrical indicator.

INTERNATIONAL EXCHANGE OF TECHNICAL STUDENTS.

The fifth annual report of the International Association for the Exchange of Students for Technical Experience, which has just been circulated, records continued progress in this scheme of arranging opportunities for students to spend short periods abroad in industrial or commercial undertakings during their vacations. The value of such experience to a student is beyond question, but the success of the scheme depends on the willingness of employers in all the participating countries to take students into their businesses. It is gratifying, therefore, to learn that support for the scheme from industrialists continues to grow. During the past summer, 3,493 students from many countries left their homeland for short periods—generally about two months—to gain technical experience in industry and commerce abroad. This number was 1,060 more than in 1951. Yugoslavia, by joining the scheme in January, 1952, brought the number of participating countries to 17. In Britain, 24 universities and colleges now collaborate in selecting students to fill vacancies abroad, and 488 students had the opportunity to do so in 1952. This was an increase of 66 on the figure for last year. The number of students received in Britain from abroad during the same period was 602, an increase of 145 on the 1951 total. Mechanical engineering absorbed the greatest number of students, with electrical and civil engineering coming second and third, respectively. The number of firms in Great Britain who received students from abroad was 229, 53 more than in 1951. Reciprocity between firms in different countries being an essential part of the scheme, the Association asks that all employers who are willing to accept students in 1953 should indicate the fact by mid-December, 1952. Disparities between the costs of living in different countries have caused difficulties and are reflected in the substantial differences between the average weekly amounts paid to students; for example, the rate of 5*l.* 5*s.* in Britain compares with a dollar equivalent of 17*l.* in the United States. The Association records its appreciation of the generous co-operation of industrialists in this matter. It is hoped that the number of places available in America will be increased to at least 200 in 1953. The general secretary of the Association is Mr. J. Newby, Imperial College, South Kensington, London, S.W.7.

THE INSTITUTION OF MECHANICAL ENGINEERS: EAST MIDLANDS BRANCH.

The East Midlands Branch of the Institution of Mechanical Engineers held their annual dinner at the Grand Hotel, Leicester, on Wednesday, October 29. The chair was taken by Mr. W. N. Bray, B.A., and the guests included the President of the Institution (Sir David Pye, C.B., F.R.S.) and Lieut.-Colonel Sir Robert E. Martin, C.M.G., D.L., chairman of the Leicester County Council, who proposed the toast of "The Institution of Mechanical Engineers." Sir David Pye, who responded, said that the real life of the Institution was to be found in the ten branches which covered the country. The Institution, he added, was continuing to grow and now totalled some 38,000 members of all grades; but it was hardly to be expected that the recent rate of growth could be maintained—there would not be enough mechanical engineers in the country. He expressed the wish that more of the younger men would take part in the summer meetings of the Institution, and said that he would welcome any suggestions which might promote that end. Mr. Bray, in proposing the toast of "The Guests," which was acknowledged by Dr. Elfed Thomas, Director of Education for the city of Leicester, said that it was important that the public schools should develop such contacts with industry as they could. "We are going to need all the recruits from the public schools that we can get," he said, "if we are to fill the posts that are available with people who have a good broad basis to their education." He thought that insufficient consideration had been given to the possible means of introducing public-school boys into the engineering world without their having necessarily to take a university degree.

LETTERS TO THE EDITOR.

FULL EMPLOYMENT.

TO THE EDITOR OF ENGINEERING.

SIR.—I do not think that Mr. Bjorn Guy's letter in your issue of October 17, on page 508, *ante*, should pass unnoticed. The statement that certain sections of the working population will "not accept" this or that condition is frequently voiced, but seems to ignore the practical facts of existence. King Canute would not tolerate the rising tide, but nevertheless he had to do so. The argument is then usually drawn from this premise that another section of the public, i.e., the employers, desire unemployment. An argument based on a fallacy can itself only be a fallacy. No thinking people of any station of life desire to see unemployment, and much might be done by organised labour itself in relaxing lines of demarcation between different trades. At present, there is often the picture of one trade which is short of workers, while another has a surplus. The solution of moving the surplus into the area of shortage should not be beyond the wit of men of good will.

Finally, I do not feel that Mr. Guy's analogy of the ship's crew is a very happy one. There might have been a time when unemployment resulted in catastrophe (though I doubt it, so far as this country is concerned), but the social services of to-day make such an argument no longer true. I think a better analogy would be to liken the position to an overloaded vehicle proceeding up a steep incline. If the able-bodied passengers alight and walk up the hill, all may eventually reach their destination in safety, but if none will do this it is possible that the whole party may be stranded.

Yours faithfully,

C. H. SMITH,
M.I.E.E., A.M.I.Mech.E.98, West George-street,
Glasgow, C.2.
October 31, 1952.

STATIC ELECTRICITY IN INDUSTRY.

TO THE EDITOR OF ENGINEERING.

SIR.—In the summary of Mr. R. C. Smart's paper on "Static Electricity in Industry," which appeared in your issue of October 24, on page 548, *ante*, there were statements about "the printing of Cellophane wrapping." We think that there must have been some misunderstanding and shall be glad if you will publish this letter to correct it.

"Cellophane" is the registered trade mark of this company and covers wrapping material made from regenerated cellulose, and sold as plain or moistureproof films. Considerable quantities of these films are printed before use, but as far as we are aware no danger arises from static electricity during these operations and it is unnecessary to take the special precautions suggested. Cellulose films contain a proportion of water and the electrical conductivity is likely to be too high to permit the accumulation of any serious electric charge.

Difficulties with static electricity can arise with plastic films such as cellulose acetate, polythene and polyvinyl chloride, and we are wondering whether our trade mark has inadvertently been applied to them.

Yours faithfully,

E. H. DOCK,
Research Physicist.British Cellophane, Limited,
Bath-road, Bridgwater,
Somerset.
November 4, 1952.

LECTURES ON APPLICATIONS OF ELECTRONICS.—A series of seven special lectures on the applications of electronics in the engineering industry are being given in the South-East Essex Technical College and School of Art, Longbridge-road, Dagenham. The lectures are delivered on Tuesday evenings at 7 o'clock, and commenced on November 4. The fee for the series is 17. 11s. 6d., and inquiries should be addressed to the head of the Physics and Mathematics Department.

THE INSTITUTION OF
NAVAL ARCHITECTS
AUTUMN MEETING.

(Continued from page 498.)

THE second paper to be presented at the opening session in Genoa of the joint autumn meeting of the Institution of Naval Architects, under their President, Lord Runciman, and the corresponding Italian institution, the Associazione di Tecnica Navale, headed by their President, Dr. Ing. Alberto Della Ragione, was that of the veteran Italian naval architect, General Dr. Ing. Eugenio De Vito, on the subject of "Six Recent Atlantic Liners."

RECENT ATLANTIC LINERS.

The liners discussed in General De Vito's paper were the British vessels Caronia and Orcades, the Italian Giulio Cesare and Andrea Doria (the latter not yet in service), and the American ships Independence and United States. He recalled that he had read a paper before the Institution of Naval Architects on the subject of Atlantic liners in 1929 and another, in Rome, in 1938. In the present paper, which was prepared in March, he was unable to include many particulars of the United States, as very little information had been released about her at that time. The details given of the other ships, it was stated, were all taken from the technical Press, though some hypothetical ratios, etc., were either deduced from the published figures or from the author's general knowledge and experience. General De Vito dealt in turn with displacements, dimensions and speeds; length and breadth, and their ratios; draught, hull weight and cubic number; initial transverse stability; block coefficient; speed and power; and finally, with the propelling machinery. The figures were presented, for the most part, without comment, but the paper concluded with a summary designed "to consider fundamentally the possible further evolution of future liners." The general dimensions of liners, as the author pointed out, were governed by the need to enter harbours and docks. The displacements of future liners, he considered, were not likely to exceed 60,000 tons. Research on hull forms had attained a high degree of perfection, especially for the forebody; the afterbody, with its propellers and appendages, was worth further research, and so also was the gap between self-propelled tank tests and trial results at sea. Further progress in hull construction might consist in improving the process, extending the welded structures, eliminating the risk of fractures by research into the most suitable steel and perhaps a wider use of aluminium alloys, though in that field there were still many problems to be solved. It was technically possible to build twin-screw liners of 100,000 h.p. With internal-combustion engines, it might be possible to increase the power to 1,500 h.p. per cylinder.

DISCUSSION.

Dr. Pietro Donati said that General De Vito's paper was one of great encouragement to young technicians. He appreciated the convenience of turbine propulsion for ships requiring high power, though there were many examples of ships of fairly high tonnage propelled by Diesel engines. The saving of fuel when using Diesel engines for high-powered ships was remarkable; many studies had been made and published on the propulsion of big ships with Diesel engines, both through direct couplings and, more often, through hydraulic or electromagnetic couplings with a number of medium-speed engines. One way in which to reduce weight when using Diesel engines was to adopt the welded structure, as many leading Diesel engine constructors had been doing lately. One example worthy of notice was the Doxford opposed-piston balanced oil engine. It had perfect scavenging and, therefore, low consumption; the mechanical efficiency was high, the revolutions were low, and the engine had a most reliable performance. Messrs. Doxford had also considered, for the geared drive, the possibility of building a marine engine of medium speed (250 r.p.m.). An arrangement with four engines of that type on two shafts—two engines per shaft, connected through hydraulic or electromagnetic couplings—

could produce a fairly high power with a much-reduced weight and space. Further advantages would be low consumption of low-grade fuels, for the Diesel engine could now run on boiler oil; reliability in service; low weight; reduced space, for the medium-speed engines would be low in height; and low cost. Thus the field of high power was for the turbine, but for lower powers Diesel-engine propulsion would co-exist with, and, in some cases, compete with, the turbine.

Mr. J. M. Murray, M.B.E., referring to the hull structure of passenger liners, said that, with such ships, each design must be considered on its merits. This was shown clearly by the alterations which were made in the Europa before she was put into service as the Liberté in 1947. The ship was severely damaged when she was blown ashore at Le Havre in 1946, and when repairs were being made the opportunity was taken to make radical alterations to the design. The alterations were described in a paper on "The Refitting of the German liner Europa," by Mr. J. P. Ricard, delivered before the Association Technique Maritime et Aéronautique in 1950. Before the war, the Europa had shown evidence of main structural weakness, cracks having appeared from time to time in the strength deck. After 1939, the ship steamed at only 20 to 22 knots instead of the 26 knots for which she was designed, and therefore the efficiency of the final repairs was not proved. When she was reconditioned, the whole subject of structural strength was re-investigated. Calculations showed that, as a result of the concentration of fresh water in tanks at the end of the ship, the hogging stresses were extremely high. It was decided, therefore, not only to extend the reinforcement previously fitted on the strength deck, but also to alter the distribution of weights in the ship. This was done by reducing the quantity of fresh water carried from 4,800 to 1,800 tons, by installing evaporators, and fitting 2,500 tons of solid ballast towards amidships. In this way, the stress was reduced by about 20 per cent. Furthermore, by eliminating free surfaces and lowering the centre of gravity of the ballast, stability conditions were improved both at the beginning and the end of the voyage. This example indicated how the main scantlings of large liners must be related to the internal arrangements. The fitting of machinery at the after end of the ship was now commonly adopted in cargo ships, and had also been adopted in a French passenger ship about 400 ft. long, where a satisfactory profile has been achieved. That step, however, might induce difficulties in the way of large hogging moments and would need to be regarded from that aspect also.

Dr. Roberto de Pieri, of the Stabilimento Grandi Motori Fiat, was the next speaker. He spoke in Italian and, unfortunately, no translation of his remarks was made available at the meeting or subsequently. His remarks referred principally to the Diesel propulsion of liners, two examples of which—the Giulio Cesare and the Andrea Doria—were included among the six vessels discussed in the paper. One of these, the Giulio Cesare, was engined by Dr. de Pieri's firm, with double-acting two-stroke engines with a normal rating of 26,000 h.p., originally intended for re-engining the earlier liners Roma and Augustus, which were lost during the war.

Professor E. V. Telfer, speaking, as he said, "from the professorial standpoint," said that he had found General De Vito's previous work extremely useful in design lectures; both his work before the Institution of Naval Architects, relating to passenger liners, and his other work, presented to the Italian institutions dealing with smaller vessels. He thought it would be an excellent idea if the Institution of Naval Architects would try to obtain such a paper in their *Transactions* at intervals, discussing design trends in various types of ships. In connection with the treatment of weights, General De Vito had returned, as many others had done, to the use of the old cubic number. Dr. Telfer thought that the time had come when the cubic number should disappear from naval architecture and something more in line with modern knowledge of weight similarity should be adopted in its stead. In connection with the comparison of model and full-size ship results, he noted that

General De Vito was very emphatic that the model always underestimated the full-size ship results. Did that statement refer to the larger passenger ships, and to riveted ships rather than welded ships? Experience in England was changing rapidly as welding was extended and riveting reduced. With regard to the author's reference to the possibility that triple-screw propulsion might be more efficient than quadruple-screw propulsion, again Dr. Telfer thought that he might have been misled by model experiments. Such experiments would favour the central screw because of the high wake shown on the model, but the actual ship would lose much of the centre-line wake.

In response to the invitation of the chairman (Mr. E. L. Champress) to reply to the discussion, General De Vito intimated that he would do so in writing.

(To be continued.)

THE INSTITUTION OF CIVIL ENGINEERS: PRESIDENTIAL ADDRESS.*

By H. F. Cronin, C.B.E., M.C., B.Sc.(Eng.)

IN a few weeks' time there will occur the 50th anniversary of the passing of the Act which authorised the formation of the Metropolitan Water Board, and since I am proud to have spent over 32 years in the employment of that undertaking, it is natural to choose the water supply to London as the theme of this address. The Board is a public authority composed of 66 members, elected by the various local authorities and certain other bodies. When it came into being, it acquired by purchase the undertakings of the eight Metropolitan water companies, as well as those of the urban district councils of Enfield and Tottenham. At the present time, the Board have $6\frac{1}{2}$ million consumers, residing in an area of approximately 540 square miles. These and the industries in which they are employed required in 1951-52 an average daily supply of 316 million gallons. Added to this were bulk supplies of 6 million gallons per day, so that the total average daily demand was 322 m.g.d.—219 million from the Thames, 54 million from the Lee, and the remainder from underground sources. The principal works dealing with Thames water lie between Staines and Surbiton, though there are still filtration and pumping stations nearer to London at Barnes, Barn Elms, and Kew. In the Lee Valley, the works stretch from Hertford to Hackney.

Nearly two million persons live in the catchment area of the Thames above the intakes, and in that of the Lee the number is about 280,000. In consequence, all the river water is polluted or is liable to pollution and the treatment consists of retention in storage reservoirs, filtration, and chlorination. About three-quarters of the well water is sufficiently pure to be pumped direct into supply after chlorination, but the remainder is delivered into the New River and, mixed with River Lee water, is filtered at Hornsey and Stoke Newington. The whole of the supply to London is dependent on pumping and the magnitude of this operation will be appreciated when it is realised that from the Thames works alone about 1 million tons of water on a normal day, rising to $1\frac{1}{2}$ million tons on a peak day, have to be pumped into London.

The Board is one of the largest water undertakings in the world, supplying a population of $6\frac{1}{2}$ million persons—compared with 8 million persons supplied by New York. Owing, however, to the greater use of water in the United States, the consumption in New York is about 870 million gallons per day, while the city of Chicago, with 3.6 million consumers, requires no less than 734 million gallons per day, as against 316 million gallons for the Metropolitan Water Board area. All these figures are in Imperial gallons. Mere size, however, is no criterion of performance and it is upon the latter that a water undertaking is judged. So far as meeting the demands of the consumer is concerned, the Board has stood the test, but the inability to construct more reservoirs gives rise to some anxiety.

With regard to the purity of the supply, I cannot

do better than to quote from the Government White Paper of 1944, entitled *A National Water Policy*, in which it is stated: "Not so many years ago it was thought in responsible quarters that London would have to abandon the use of the Thames and Lee, but to-day 90 per cent. of London's water—bacteriologically one of the purest in the world—comes from these two rivers."

YORK BUILDINGS WATERWORKS.

In or about the year 1713, an important event took place, namely, the erection of the first steam-driven pumping engine in London. This was at the lower end of Villiers-street, at the York Buildings Waterworks, which were incorporated in the year 1675. The engine was a Savery engine, which has its modern counterpart in the Pulsometer pump. Very little is known about it, but it was not a success because the steam consumption was heavy, and it was taken out of use some time before 1727. Since the steam pressure is believed to have been about 100 lb. per square inch, it may be surmised that considerable trouble was experienced with the boiler. However, the York Buildings Company were not daunted and, in 1726, they erected another steam engine, this being the first Newcomen waterworks pumping engine in Great Britain. This also was unsuccessful, but the company persevered and, in about 1752, they installed a second Newcomen engine. This apparently worked well and it was later followed by a third, after which the company seem to have carried on their pumping arrangements satisfactorily until financial troubles overtook them and they were amalgamated in 1818 with the New River Company, the oldest of the eight London water companies, whose history formed part of the presidential address of Sir Jonathan Davidson in 1948.*

THE METROPOLITAN WATER COMPANIES.

In 1723, the second of the large water companies was formed, namely, the Chelsea Company, which retained its name and identity for 180 years. The company constructed an intake from the Thames at a point just east of Grosvenor-road railway bridge, and was followed nearly 60 years later, in 1785, by the Lambeth Water Company, which acquired land immediately downstream of Hungerford Bridge, on the site of the Royal Festival Hall. In the early Nineteenth Century, four more companies were established: the West Middlesex in 1806, with works at Hammersmith and later, in 1830, at Barnes; the East London in 1807; the Kent Waterworks, which took over the River Ravensbourne works at Deptford in 1809; and, in 1811, the Grand Junction Company.

In the meantime, steam pumps continued to make progress. In 1778, London's first Watt engine, with its separate condenser, was erected at Shadwell. Thereafter a considerable number of these engines were built, some of which had very long lives. For example, a Boulton and Watt engine, installed at Deptford in 1812 and altered in 1845, was not taken out of use until 1926. When it was broken up, parts of the parallel motion were incorporated in the handrailing of the new Kempton Park engine house. Two other Watt engines were supplied to the Grand Junction Company at their Chelsea works in 1820. Subsequently, in 1840-43, after the company had moved their intake to Brentford (Kew Bridge), these engines were re-erected there and worked until 1946. In 1846-48, they were rebuilt as Cornish engines and one of them is now preserved at Kew Bridge works, together with a 90-in. and a 100-in. Cornish engine, a Bull engine, and a converted Maudslay beam engine, to form a museum of old pumping plant.

In granting statutory powers to the various companies, Parliament had encouraged competition by allowing their areas of supply to overlap. After a time, the companies discovered that this policy did not pay and so, about 1815, certain of them entered into mutual agreements by which they undertook to refrain from competition where they had concurrent rights of supply. By this means each company created a monopoly in their own area and it was not long before the water charges, which

had been too greatly depressed during the period of competition, were increased. This, and the poor quality of the water supplied, gave rise to complaints, and in 1821 there commenced a series of inquiries by Select Committees of each and both Houses. Four Royal Commissions were held, legislation was enforced on the companies, and efforts were made to abolish them. These continued until the beginning of the present century, when, upon the recommendation of Lord Llandaff's Royal Commission, the Government introduced the Bill for the establishment of the Metropolitan Water Board.

The first Parliamentary Committee, appointed in 1821, was interested mainly in charges, but since nothing resulted from their labours, the water consumers were not satisfied. As a result of petitions presented in 1827 alleging, *inter alia*, "that the water supplied by the Grand Junction Company to more than 7,000 families had been pronounced by professional men of the first eminence to be a filthy fluid, loaded with decayed vegetable and other substances equally deleterious to health and unfit for domestic consumption," Parliament set up the first Royal Commission "to inquire into the state of the water supply of the Metropolis." The members of this Commission were William Thomas Brande, a well-known chemist, Dr. P. M. Roget (the author of *Roget's Thesaurus*) and Thomas Telford, the first President of this Institution. The Commission reported in 1828 and found that "the present state of the supply of water to the Metropolis is susceptible of and requires improvement . . . many of the complaints . . . are well founded and it ought to be derived from other sources than those now resorted to."

Again no action was taken, but in 1828 a Select Committee of the House of Commons recommended that Mr. Telford should be "instructed to report a practicable and efficacious plan for supplying the whole of the Metropolis with pure and wholesome water." This recommendation was adopted and on February 17, 1834 (the year of his death), Telford presented his report, recommending that water for the supply of the north side of London should be obtained from the River Verulam, near Watford, and for the south side, from the River Wandle at Beddington, at a total estimated cost of nearly 2,000,000*l.* Telford's report was referred to another Select Committee, but nothing more was done and the results of a House of Lords Committee of 1840 were equally ineffective.

The time was fast approaching, however, when Parliament was to enact general legislation dealing with matters of health. In 1847, the Waterworks Clauses Act was passed and this was followed in 1848 by the first Public Health Act. The London water companies did not escape attention and in 1852 the Government introduced a Bill which, passing into law, exercised a profound and far-reaching influence on the water supply to the Metropolis. Before dealing with the provisions of this Act, it is perhaps as well to say something about the events which led up to it.

LOCATION OF INTAKES AND TREATMENT OF WATER IN 1850.

Although the water in the Thames was in a bad state in the earlier part of the century and deteriorated as London expanded, it became very much worse after it had become permissive, and subsequently, in 1847, compulsory, to drain houses into the sewers, and as more and more cesspools were abolished. In the 1840's the intakes of the companies were in the tidal reaches of the river, the lowest downstream being an emergency intake of the New River Company at Broken Wharf in the City. It is true that this was rarely used, but when it was open the Thames water was pumped directly into supply through a 33-in. main which was connected to the distribution system in Cheapside. The normal sources of supply of this company were Chadwell Spring, the River Lee, and a few wells sunk alongside the New River. No filtration was employed, but the water was allowed to settle in reservoirs and ponds at Stoke Newington and at New River Head in Clerkenwell. A little higher up, but on the south side of the river on the site of the Royal Festival Hall, was the intake of the Lambeth Company, from which water was pumped

* Delivered at the Institution, Great George-street, Westminster, S.W.1, on November 4, 1952. Abridged.

* *Jl. Inst. C.E.*, vol. 31, page 1 (Nov., 1948); and *ENGINEERING*, vol. 167, page 18 (1949).

DIESEL-MECHANICAL LOCOMOTIVE FOR STEELWORKS.

ROBERT STEPHENSON & HAWTHORNS, LTD., NEWCASTLE-UPON-TYNE.

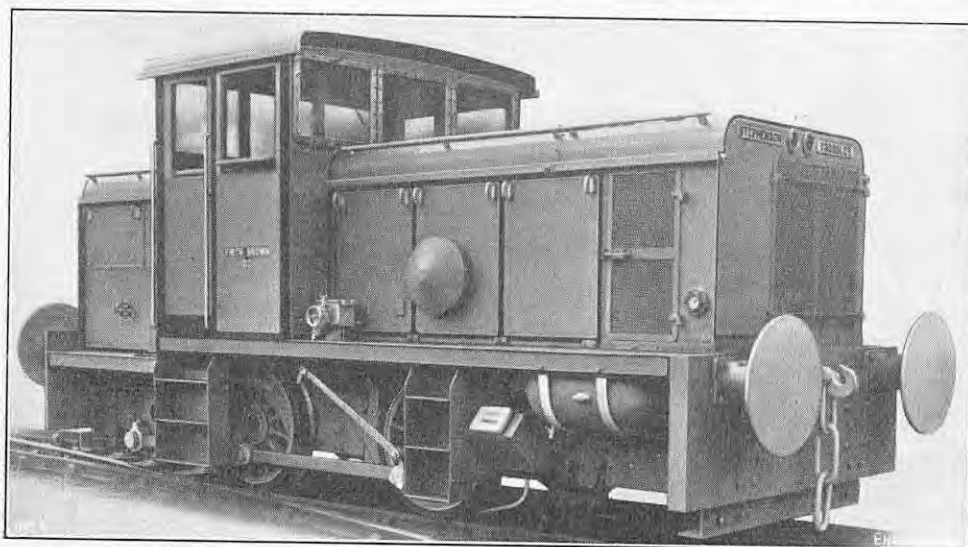


Fig. 1.



Fig. 2.

to reservoirs at Brixton and Streatham, being passed through what is described as a vertical gravel filter at the former. The water in the river at this intake had become so bad that James Simpson, who was the engineer to the company, as well as to the Chelsea Company, had advised the directors to move the intake to Ditton. In 1848, powers were obtained for this to be done.

The next two intakes were those of the Chelsea and the Southwark and Vauxhall Companies, which were nearly opposite each other. At that time the Chelsea works were still on the original site—now occupied by the carriage sidings of British Railways (Southern Region)—on which James Simpson undertook his historic experiments in filtration in 1827 and built the first slow sand filter in London. In the 1840's all the water supplied by this company was subject to settlement and to filtration.

The Southwark and Vauxhall Company was the last to be formed and came into being by an amalgamation in 1845 of the Southwark and the Vauxhall Companies. The new company built sedimentation reservoirs and filter beds at Battersea on land purchased by the Southwark Company in 1839, and which is now the site of the Battersea power station. Nearly six miles farther up the river was the intake of the West Middlesex Company at Barnes, where the water was passed through sedimentation reservoirs, but was not filtered before being pumped into supply from their works at Hammersmith. The Grand Junction Company's first intake on the Thames was constructed in 1820 at Chelsea, at the mouth of the Ranelagh sewer. On account of bitter complaints of the quality of the water, the works were moved in 1835-38 to Brentford, just above Kew Bridge, and from that time onward all the water supplied by the company was abstracted at this point and passed through settling reservoirs. The first filter bed to be constructed there was completed in 1845.

In the Lee Valley, the East London Waterworks Company came into being in 1807, when they absorbed the Shadwell and the West Ham waterworks. The new company built works at Old Ford and there abstracted water from the River Lee, but in 1829 they moved the intake to Lee Bridge, where they had purchased the Hackney waterworks. It was at Old Ford, in 1838, that Thomas Wicksteed, M.I.C.E., the engineer to the Company, introduced the Cornish engine to London and at these works his first Cornish engine performed on trial more than double the duty of the existing Boulton and Watt engines. Eventually, more than 50 engines of this type, including Bull engines, were erected in London.

The eighth Metropolitan Water Company was the Kent Waterworks Company, which obtained

its water from the Ravensbourne about a mile above its junction with the Thames at Deptford Creek. The company came into being in 1809 and the water first supplied from Deptford was subject to settlement only, but filter beds were completed at these works in 1844 and 1849. Thus, in or about 1850, three of the companies did not filter their water at all, and the process as applied by at least one other company was of doubtful efficacy. To give an idea of the amount of water supplied, the figures shown in the table, herewith, are taken from returns made in 1848 and 1849. In addition, the Hampstead Company (which was acquired by the New River Company in 1859) supplied 4,490 tenements, with an average quantity of 400,000 gallons per day.

TABLE.—London's Water Supply in 1848-49.

Company.	Total Number of Tenements.	Average Daily Supply, m.g.d.
New River ..	83,206	15.5
East London ..	56,673	9.0
Southwark and Vauxhall ..	34,864	6.0
West Middlesex ..	24,480	3.3
Lambeth ..	23,396	3.1
Chelsea ..	20,996	3.9
Grand Junction ..	14,058	3.5
Kent ..	9,632	1.1
Total ..	267,305	45.4

(To be continued.)

DIESEL-MECHANICAL LOCOMOTIVES FOR STEELWORKS.

THE 220-h.p. 0-4-0 Diesel-mechanical locomotive illustrated in Fig. 1, above, is one of two which have been supplied recently by Messrs. Robert Stephenson and Hawthorns, Limited, Newcastle-upon-Tyne, to Messrs. Thos. Firth and John Brown, Limited, for shunting in their Sheffield steelworks. Each is fitted with a Crossley "4ERT" direct-reversing Diesel engine of the four-cylinder two-stroke loop-scavenge type, which has a one-hour traction rating of 220 brake horse-power at 750 r.p.m. The drive is through a Vulcan-Sinclair hydraulic coupling and a Bostock and Bramley three-speed gearbox to a jack-shaft. The locomotive's wheelbase is 6 ft. and its wheels are 3 ft. 4½ in. in diameter; it will negotiate a curve of 47-ft. radius and it weighs 30 tons in working order. The weight of train that can be hauled in various gears and on various gradients is shown in the accompanying table. The speeds and tractive efforts in the three gears are: 1st, 3.82 m.p.h., 17,250 lb.; 2nd, 6.71 m.p.h., 9,850 lb.; 3rd, 11.1 m.p.h., 5,950 lb.

The convenient arrangement of the controls is illustrated in Fig. 2. The handwheel controls starting, stopping and reversing of the engine, reversing being carried out quickly and as simply as for a steam locomotive. There are, of course, no reversing gears. The only other engine control is that for controlling the speed from idling at about 300 r.p.m. up to full speed. Compressed air for starting is provided by three compressors. The Crossley engine has detachable liners in the cylinders and expansion slots in the outer walls of the cylinder heads. As there are no exhaust and air-intake valves in the heads, the latter are immune from cracking.

Gear.	Hauling Capacity, Tons.				
	On Level.	1 in 200.	1 in 100.	1 in 50.	1 in 33.3.
1st ..	1,407	783	502	283	191
2nd ..	790	434	274	148	96
3rd ..	465	250	153	78	46

The three-speed gearbox was designed and made by Messrs. Bostock and Bramley, Limited, Stalybridge, and follows the design of the 300/330-h.p. size which was fitted to a 0-6-0 locomotive previously built for the British Electricity Authority. It is of simple construction, only three gearwheels being in mesh in any gear. Large dry clutches of the multi-disc type are fitted to the 1st and 3rd gears, and an involute-tooth clutch, with a Bostock and Bramley synchronising or baulking ring between the driving and driven members, is fitted to the 2nd gear. The gearbox pneumatic control unit consists of a series of cam-operated air valves, which can be mounted at any point on the locomotive. This type of control requires little skill or effort on the part of the driver. Hand brakes and Westinghouse air brakes are provided. The cab is totally enclosed, but is designed so that the driver has a good view in both directions. The locomotive is equipped with C.A.V. electric lighting, a feature of which is that the head and tail lights are reversed automatically whenever the direction of travel of the locomotive is reversed.

RECORD OUTPUT OF CRUDE OIL.—The Iraq Petroleum Co., Ltd., have announced that during September of this year a total of over 1,600,000 tons of crude oil was pumped from their Kirkuk oilfield to the terminal ports of Tripoli in Lebanon and Banias in Syria, the record amount of crude oil to be obtained so far from this field. The monthly production at the Zubair field of the Basrah Petroleum Co., an associate of the Iraq Petroleum Co., was also a record, the output being 223,797 tons.

UTILISATION OF SOLAR ENERGY.*

THE committee was appointed to consider the possibilities of solar energy and to advise whether any substantial application is now possible, and whether any programme of research or development is desirable. We have confined our attention to the fairly direct applications of solar energy and have not considered sources such as windmills which are only indirectly related to the sun. The subject has a large literature,^{1, 2, 3} which records many small-scale projects, but so far as we are aware solar energy is nowhere used on any considerable scale for heating or for the production of power. The main reasons for this are the intermittency of sunlight, the fact that least energy is available when it is most wanted for heating, and the high capital cost of the collectors, which is a consequence of the large areas needed. A number of references are given [see page 608—Ed., E.], but no attempt has been made to compile an exhaustive bibliography.

We have proceeded by considering the various purposes for which heat and power are required and determining what are the limiting factors in applying solar energy. We have not entered into the details of design, and have assumed that purely engineering problems can be solved, so long as there is no conflict with natural laws. When in doubt we have taken an optimistic view, but even so our conclusions are not encouraging. It seems unlikely that solar energy can be an important source of heat or power in the near future, though some applications may be possible in specially favourable circumstances. In particular, it is possible that the availability of very modest amounts of power would have important and beneficial effects on the economy of tropical agricultural areas.

AVAILABLE ENERGY.

The amount of heat arriving from the sun at the outside of the earth's atmosphere varies only slightly, and is on the average 1.35 kW per square metre. The amount of energy reaching the ground near sea level depends on the sun's altitude, the cloudiness and the state of the atmosphere. The maximum of direct radiation on a surface normal to the sun's rays on very clear days reaches 83 per cent. of the incident energy (1.12 kW per square metre) at Ouargla in Algeria. At Kew it is 70 per cent. (0.94 kW per square metre); other stations give values between these.^{4, 5} However, these maxima are rarely attained and are only useful in estimating the maximum capacity of the plant necessary to make full use of the available energy. The average amount of energy received has been conveniently summarised by H. H. Kimball,⁶ who gives curves showing its distribution over the surface of the earth. The curves cover the sea areas only, but can probably be applied to the land without serious error. For the present purpose the variation with longitude can be neglected and the results summarised as in Table I. The figures are Kimball's figures for 20 deg. W longitude for a day of 24 hours, and include both direct and diffuse radiation. The averages for the whole year are the means of Kimball's figures for March 21, June 21, September 21 and December 21. It is remarkable that the total radiation received per day in England in the summer is greater than that received in India. This is due to the greater length of the summer day in England, as was first pointed out by E. Halley.⁷

The figures in Table I make no allowance for absorption by smoke and must be reduced by a factor, which may be as great as two, if the energy at a point in a large town is required. The figures

refer to a horizontal surface. When the sun is low a substantial advantage is gained by tilting the collector. This would be an important factor in a place in a moderate or high latitude with a high proportion of clear days in the winter. In England the winter climate is so overcast that this factor is not of much importance. Tilting the collector does not, of course, alter the area of ground required to collect a given amount of energy, but it does reduce the actual area of collector.

TABLE I.—Energy Received on a Horizontal Surface (kW per Square Metre).

Latitude.	Clear Day.		Day With Average Cloudiness.		
	June.	Dec.	June.	Dec.	Year.
60° N. . .	0.38	0.03	0.19	0.01	0.10
40 . . .	0.37	0.13	0.22	0.07	0.15
20 . . .	0.34	0.22	0.22	0.15	0.21
0 . . .	0.29	0.31	0.15	0.19	0.19
20 . . .	0.22	0.37	0.13	0.23	0.19
40 . . .	0.11	0.42	0.06	0.28	0.17
60° S. . .	0.02	0.43	0.01	0.16	0.08

From the above figures it is clear that, though the rate of receipt of energy may reach 1 kW per square metre, it cannot be expected in most places to average more than 0.1 to 0.2 kW per square metre. It will of course be zero for more than half the time. The use that can be made of this energy will now be considered.

HEATING.

Water Heating.—For domestic purposes water is required at about 55 deg. C. With an initial water temperature of 15 deg. C., this involves a 40 deg. C. rise in temperature. Estimates of the amount of hot water required by a household vary from 150 litres per person per day¹ to 45 litres per household per day.^{8, 9} Regarding a household as consisting of five people, this is a variation from 750 to 45 litres per household per day. The upper limit would only be reached in a building where unlimited hot water was available without extra cost to the tenant, and the lower only if there was no piped supply of hot water. We take 200 litres per day as representing the reasonable requirements of a household in a temperate country. This implies an average provision of 0.39 kW. The efficiency of collectors has been studied by many authors (e.g., H. C. Hottel and B. B. Woertz¹⁰); it is unlikely that in practice an efficiency of more than 60 per cent. will be obtained. Taking the average rate of receipt of energy at 0.15 kW per square metre (Table I), the heat usefully employed will be 0.09 kW per square metre and the area of collector is thus 4.3 sq. m. Such a system would provide more heat than was required in the summer but too little in the winter, and would have to be supplemented by a fuel-burning system. Some improvement in winter performance can be obtained by tilting the collector, but it is certain that a continuous supply in winter cannot be obtained by any practicable arrangement. Concentration by mirrors has no advantage when the collection temperature is less than 90 deg. C.

Practical results are rather less favourable than these calculations would suggest. Brooks showed¹ that in California a heater 6.6 sq. m. in area will provide domestic hot water for 270 days in the year, but that additional heating is required on the other 95 days. H. Heywood¹¹ states that in England 50 litres of water can be heated to 55 deg. C. for each square metre of receiving area on two-thirds of the days in the best five months of the year. This is equivalent to 0.097 kW per square metre on these favourable days. Hottel and Woertz obtained 0.052 kW per square metre during April to July, 1940, at Cambridge, Massachusetts.¹⁰

Solar water heaters have been on the market in the United States for many years but are used only on a limited scale. The reason is probably that the cost of water heating by other means is not high enough to make the capital expenditure on a solar heater and large storage tank, in addition to the normal gas or oil heater, seem worth-while. It is possible that in England, where fuel for private consumption is rationed, such heaters could be sold, but even here the competition from unrationed gas and electricity would probably be too severe. It seems unlikely that a campaign to encourage the

sale of such heaters would result in a large enough saving of fuel to justify the capital cost. There is no prospect of substantial improvement of existing equipment by research and development.

In the tropics, hot water can be obtained for shower baths, etc., by very simple arrangements. The factor limiting the wide use of such installations is probably the absence in many places of a piped water supply and the lack of demand for hot water.

House Heating.—Very similar considerations apply to house heating. In the tropics there is little demand. In temperate latitudes least heat is available when it is most wanted. Table I, with an efficiency of collection of 60 per cent., suggests that at 40 deg. N. a collector with an area of 24 sq. m. would be required to collect 1 kW in December. Trials in Boston, Massachusetts, have shown that a collector whose area is half the floor area of the house can provide most of the heating required, but that some extra heat must be provided in cloudy spells during the winter.

In view of these considerations, we do not think that any action is necessary to improve solar heaters for domestic heating. We would, however, draw attention to the simplest method of using solar heat for warming houses—that is, to let it in through the windows. In the past little attention has been paid to this in the design of houses, though substantial economies of fuel can be obtained on favourable sites by providing larger windows than usual and double-glazing them.

COOKING.

No one is likely to cook by solar energy if he can get gas, electricity, fuel oil, coal or wood. In some regions, however, none of these is freely available and it is possible that solar energy might find an application there. Indeed, in some places the only practicable fuel is cow dung, which would be better employed in fertilising the land. Cooking in itself does not consume much energy once the food has been brought up to the appropriate temperature. It might well be feasible to construct a solar stove which could satisfy part of the needs of the inhabitants of India, whose main meal is cooked at mid-day and generally consists of boiled rice or some kind of lentils. By designing a stove with suitable insulation to prevent excessive heat losses, it should be possible to reach and maintain temperatures of boiling water with 100 watts; this heat could be collected by a mirror of about 0.3 sq. m.

A stove using a mirror and a pressure cooker has been built by the Indian National Physical Laboratory. There is no doubt that it is technically possible to cook food in this way, but it is not certain that the machine can be built at a price which an Indian villager can pay. We recommend that a contract be considered by the National Research Development Corporation for the design of a stove which would be suitable for large-scale production.

REFRIGERATION.

It seems impracticable to use solar energy directly as the sole source of power for a domestic refrigerator for preserving food, since its operation must be continuous. If another source of power is available, the amount required is so small that it would not be worth using solar energy to save part of it. For areas where electric power is not available, refrigerators running on paraffin can be employed.

The use of solar energy for air conditioning is more attractive, as it is not essential that the system run continuously. There are well-known refrigeration cycles in which heat is pumped out at the cold end and absorbed into the machine at the hot end, so it would not be necessary to convert the heat into mechanical energy. It is difficult to estimate the amount of heat required without detailed consideration of a design. As a rough indication, the maximum cooling load for a building measuring 20 m. by 20 m. by 10 m. high may be taken as 40 kW. An ammonia absorption machine may be assumed to have a coefficient of performance of 0.5 (ratio of cold produced to heat put in), so that the maximum heat input required would be 80 kW. The incident radiation at noon during the hot weather in, say, India can be taken as 0.8 kW per square metre on a surface maintained normal to the sun's rays (this figure is higher than those in Table I, which are 24-hour means). If the rate of

* Report of the Committee on the Utilisation of Solar Energy, published by the National Physical Laboratory. Abridged. The committee's terms of reference were: To investigate the possibilities of utilising solar energy and to recommend whether research work on this should be undertaken or sponsored by the Department of Scientific and Industrial Research. The committee members were: Dr. E. C. Bullard, F.R.S. (chairman), Professor P. M. S. Blackett, F.R.S., Professor F. G. Gregory, F.R.S., Professor E. A. Guggenheim, F.R.S., Professor W. R. Hawthorne, Dr. H. Heywood, Professor Willis Jackson and Professor F. E. Simon, F.R.S. We comment on the report on page 601.

heat collection is assessed at 0.4 kW per square metre, a collector surface of 200 sq. m. would be required. This is half of the roof area, so that if the building were suitably orientated the incident solar energy would be sufficient to provide the requisite cooling effect. The lithium-bromide water-vapour process, which has a coefficient of performance of 0.7, would require a correspondingly smaller proportion of collector surface. In cases where only certain rooms have air conditioning, the proportion of the roof area required for collectors would be less than that calculated above.

(To be continued.)

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DOMESTIC ELECTRICAL ACCIDENTS.

Of 38 fatal electrical accidents, in 1951, officially described as "in the home," that is, not in factories or on commercial premises, three occurred to skilled men. In one case, a foreman electrician had fixed an infra-red lamp in his bathroom, the arrangement consisting of two lamps in series, the lamps being in screw-cap holders. The connections were arranged so that the unshielded caps were alive, and when in the bath the man touched one of the caps and was electrocuted. In the second case, a skilled wireless mechanic had constructed a television set so inefficiently that the aerial was alive with current from the main supply; he was killed while adjusting it. In the third case, a Post Office engineer was working on a fuse box in a friend's house. The pliers he was using touched a terminal block and he received a fatal shock. This accident may be put down to misadventure, and the other two to carelessness rather than ignorance, but when the activities of skilled men can lead to incidents of this kind, no surprise will be felt at the fact that a number of fatal accidents were due to wiring, or the adjustment of apparatus, being carried out by ignorant amateurs, as in the case of a child who was killed by touching a bell wire which had been used to connect up two lighting fuses. There is probably no means of preventing householders with no experience from carrying out small electrical jobs in their own homes, but in many cases fatalities directly caused by unskilled activities were really due to the carelessness of skilled men; four of the fatal accidents in 1951 were caused by control switches being located in the neutral conductor so that apparatus was alive when the user was justified in assuming that it was dead. Accidents arising from this cause would be eliminated if all apparatus and lighting fittings were controlled by double-pole switches, but a consummation of that kind is unlikely. Many accidents were due to defective apparatus caused by inadequate maintenance rather than design; this is a matter for individual householders and is uncontrollable by outside authority or regulations. In addition to the 38 electrical fatalities there were 24 known cases of death resulting from the ignition of clothing by inadequately-guarded electric radiators. This is not a purely electrical type of accident, as it also occurs with gas and solid-fuel fires. Electric radiators have, however, the advantage, which is sometimes a disadvantage, that they are portable: they can be placed in undesirable positions.

LABOUR NOTES.

BETTER offers than the wage increases of 7s. 4d. and 7s. 6d. a week put forward respectively by the employers in the engineering and shipbuilding industries, are to be sought by the Confederation of Shipbuilding and Engineering Unions. This decision was reached at a special conference of executive officials of the 38 unions affiliated to the Confederation, held in London on October 29. The motion asking for further approaches to the Engineering and Allied Employers' National Federation and the Shipbuilding Employers' Federation was moved by the Amalgamated Engineering Union. It also authorised the Confederation's executive council to decide what action should be taken after the replies from the employers' organisations had been received, without further reference to the affiliated unions. A suggestion that the offers already received should be accepted, and another, that the offers should be submitted to a ballot vote by the rank and file, for or against acceptance, were defeated by substantial majorities. A proposition for the imposition of restrictions on piecework and a ban on overtime, as a means of securing larger increases, was heavily defeated.

For the second time, the demand of the National Union of Mineworkers for an additional 30s. a week for its 700,000 members employed in Britain's coal-mining industry has been completely rejected. The claim was originally presented to the National Coal Board and rejected outright by that body on July 22. The union later submitted its proposal to arbitration and the decision of the industry's National Reference Tribunal, rejecting the claim, was announced on October 28. If conceded in full, the wages of underground employees would have been raised to a minimum of 8l. 10s. 6d. a week, and those of men engaged on surface work to 7l. 11s. 6d. a week. The addition to the industry's annual wage bill would have amounted to around fifty million pounds and the price of coal would have had to be increased by approximately 5s. a ton.

Both sides announced their acceptance of the Tribunal's decision at a joint meeting of representatives on October 30. They also appealed for its loyal acceptance by all engaged in the industry. In its award, the Tribunal refers to the high level of wages in the coal-mining industry at the present time and states that no other heavy industry showed as great an increase between October, 1948, and April, 1952. Whereas wages in the industry in 1938 were well below those of a number of other heavy occupations, by 1947 the industry had surpassed all its competitors in that respect and, since then, had continued to widen the gap. The Tribunal affirms that, in coming to a decision, it was in no way bound to conform to the suggestions of wage restraint urged by the Government, but the monetary position of the National Coal Board and the general economic position did require consideration.

The fact that a reconstruction of the industry's general wage position was under discussion also influenced the Tribunal's conclusions. While it was true that there had been some increase in the cost of living since the industry's wage agreement of December 31, 1951, came into force, the increase was small and had been to some extent discounted in advance by the wage increases accorded in that agreement. New proposals aimed at rationalising the industry's wage structure are already under way. Among other changes, the union is seeking an alteration in the bonus shift system, under which miners obtain payment for six shifts if they work five full shifts in one week. The men suggest that it is unfair that they should lose the bonus as well as a day's pay if they are prevented from working by unavoidable causes. It is also desired that youths should receive adult wages when reaching the age of 18, and not have to wait until they are 21, as at present. A special delegate conference of the union is being held in London to-day.

A steep upward trend in wage rates took place during September. No fewer than 2,110,000 workpeople in the United Kingdom received net increases

in their full-time weekly wages during that month. These increases amounted, in all, to approximately 707,000l., and represented an average of about 6s. 6d. a head. Among the persons principally affected were employees in the retail distributive trades, electricity and gas undertakings, privately-owned motor-omnibus services, municipal tramway, trolley-bus and omnibus concerns, laundries, and the furniture-manufacturing trade. Others benefiting from the increases included operating and maintenance staffs employed by the Road Haulage Executive and persons engaged on certain classes of food manufacture. For operatives employed in electricity-supply undertakings there was an increase in schedule rates amounting to 2d. an hour. In the gas industry, adults, other than craftsmen, received an advance of 2d. in their standard hourly rates of pay. For tramway, omnibus and trolley-bus staffs, other than skilled maintenance personnel, the increases amounted to 7s. a week.

A few small reductions in wages also came into operation during the month, under sliding-scale arrangements based on the interim index of retail prices, mainly among persons engaged in iron and steel manufacture, and in limestone and ironstone mining and quarrying. Altogether, however, only 12,000 workpeople were involved and their total loss was estimated by the *Ministry of Labour Gazette* for October to amount to no more than about 330l. Of the total wage increases of 707,000l. granted during September, about 466,000l. resulted from Orders made under the Wages Councils Acts, about 136,000l. from arbitration awards, and 61,000l. from arrangements made by joint standing bodies established by voluntary agreement.

During the nine months, January to September, 1952, some 7,963,000 workpeople in the United Kingdom were affected by increases in rates of wages, as a result of which their net weekly rates were increased by a total of 3,058,000l. In the building and contracting industry, 1,188,000 operatives received increases totalling 608,400l. a week, while, in the distributive trades, 1,562,000 persons obtained advances aggregating 547,000l. In the agricultural, forestry and fishing industries, 756,000 workpeople received increases amounting to 180,400l. Approximately 61,000 miners and quarrymen were granted advances totalling 23,400l. and 225,500 persons engaged on the treatment of non-metalliferous mining products other than coal received 87,900l. In the metal-manufacturing industry, 179,000 workpeople obtained increases amounting to 40,000l., in the transport and communications industries, 858,000 employees shared increases aggregating 390,500l., and, in the engineering, shipbuilding and electrical-goods industries, which the Ministry of Labour combine in one group, a total of 411,000 operatives received 182,500l. During the first nine months of last year, there was a net increase of 4,009,000l. in the weekly full-time wages of 8,972,000 workpeople.

Industrial disputes in progress in the United Kingdom during September appear to have been rather milder than in recent months. The Ministry of Labour records that 155 new disputes were reported during the month, which, with the 23 already in being when the month began, gave a total of 178 for the period. In these, 28,800 employees were involved and some 106,000 working days were lost. In August last, which also commenced with 23 stoppages in progress, 151 fresh ones were begun, making a total of 174 for the month, and in these no fewer than 45,000 workpeople were concerned and some 168,000 days lost. The comparative figures for September, 1951, were 177 strikes in progress, with 35,000 persons involved and 113,000 days lost. In September last, only 18 disputes, directly involving 3,400 people, lasted longer than six days. Of the 155 disputes which began in that month, eleven, directly involving 1,300 persons, arose out of demands for more pay; 49, directly involving 4,400 persons, on other wage questions; six, directly involving 1,500 persons, on questions as to working hours; and 86, directly involving 8,500 persons, on difficulties over working arrangements. Trade-union principles caused two of the strikes.

BENDING STRENGTH OF CORRUGATED PLATE.*

By J. B. CALDWELL, B.Eng., A.M.Inst.N.A.

SINCE the early days of iron ship construction it has been the practice to provide internal subdivision of the hull as a precaution in the event of damage. The first watertight subdivision bulkheads consisted of an area of thick plating fitted transversely across the ship, and stiffened by relatively light rolled sections riveted to the plating. Such a bulkhead resisted the lateral pressure of water mainly by the "diaphragm" effect of the distended panel; and from the evidence of casualties at sea it was apparent that the lightly stiffened panel was often deficient in strength. Towards the end of last century it was realised that a more efficient structure resulted from a combination of heavy stiffeners and light plating, giving increased flexural stiffness and reduced deflection under load. In 1890, a committee appointed to examine problems relating to the seaworthiness of ships proposed† that this form of construction should be adopted for all watertight bulkheads, and suitable scantlings for stiffeners and plating were tabulated. In 1916, these were modified‡ as a result of tests on stiffened panels representing typical ships' bulkheads; standards of bulkhead strength and stiffeners now required are based on these tests and the conclusions drawn from them.

The method of strengthening bulkhead plating by riveted stiffeners persisted for many years, although it was appreciated that the distribution of material in the stiffened plate was theoretically inefficient. A slight improvement was made possible by the development of welding technique, so that the riveted channel or Z-bar gave place to the toe-welded angle or T-section as the most common form of bulkhead stiffener. It was first suggested about 35 years ago that a better distribution of stiffening material was obtained by shaping the bulkhead plates to form troughs, thus making the plating self-stiffening. Tests on a shaped-plate bulkhead,§ in which the plates were curved to form circular arc corrugations, confirmed that a lighter bulkhead could be constructed in this manner having the required strength and stiffness of the standard form. The practical problems of construction and erection prevented a wider adoption of corrugated bulkheads until welding was more fully developed in ship construction. Then some builders in America and on the Continent developed straight-line corrugations suitable for both subdivision and tank bulkheads; more recently they have become fairly common in this country as a result of experience gained during the last war.

The classification societies accepted corrugated bulkheads provided that they conformed to the general standards laid down by the 1916 Bulkhead Committee for panels stiffened by rolled sections. The principal requirement for a subdivision bulkhead is that it will not fail under the lateral pressure arising when an adjacent compartment is flooded; a loading condition which rarely, if ever, occurs during the lifetime of the ship. Since in these circumstances the bulkhead may be expected to suffer severe distortion and permanent deformation, it is evident that this proof load defines the required ultimate strength of the panel as a whole. Tank bulkheads, on the other hand, must be designed to withstand the pressure of the contained fluid without either leakage or permanent deformation; in this case the working load defines the elastic strength of the panel.

Thus in either case the strength requirements of a corrugated bulkhead are generally known once

the overall dimensions have been fixed. There remains the determination of the most suitable shape of corrugation to provide the most efficient structure in terms of the ratio of strength to weight. In some cases instability of the component plates of a trough under bending conditions may cause premature failure of the bulkhead as a whole, and since the buckling stress is dependent upon the relative dimensions of the web and flange as well as the plate thickness, it follows that the mode of failure of a corrugated panel is materially influenced by the trough shape and dimensions. It is evident, therefore, that the so-called "engineers'" theory of bending is not generally sufficient to determine either the optimum proportions or the strength of

Fig. 1. TYPICAL FORMS OF CORRUGATED PLATE.

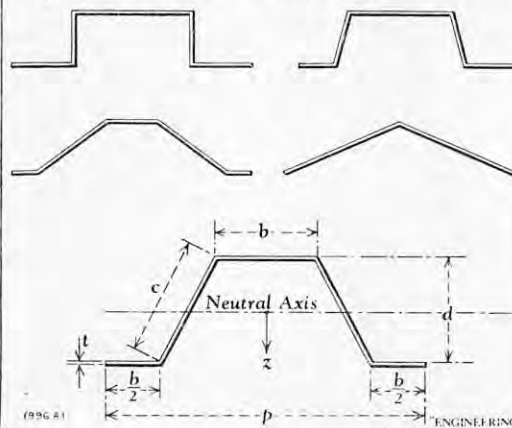


Fig. 2. SECOND MOMENT OF AREA OF A SINGLE CORRUGATION.

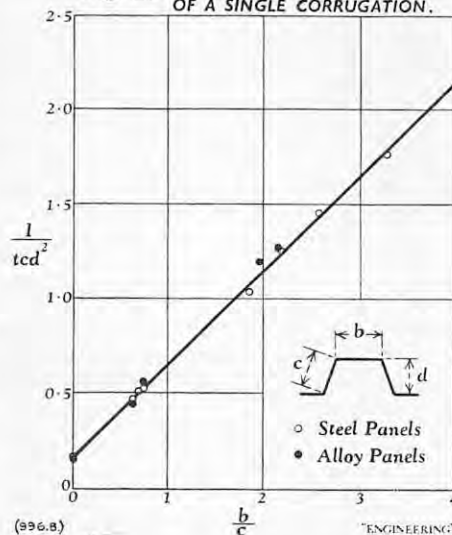
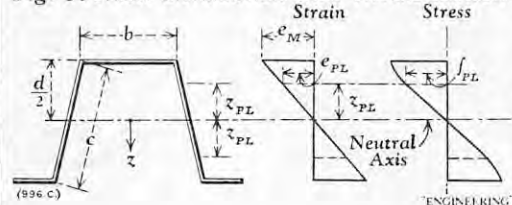


Fig. 3. STRESS DISTRIBUTION OVER TYPICAL SECTION.



a corrugated plate. The following notes discuss more fully some features of the behaviour of corrugated plating under bending conditions. Only straight-line troughs of trapezoidal or triangular form are considered.

Non-Buckling Behaviour.—The profiles of some typical corrugations are shown in Fig. 1. In the general section, let b = breadth of flange, c = length of web, d = depth of trough (between plate centres), t = thickness of plate, and p = pitch of troughs.

The geometrical properties of a single corrugation (defined as that material lying between two lines parallel to the troughs a distance p apart) can be determined by standard methods. If $\frac{t}{d}$ is

small, as is usually the case, it is sufficiently accurate to take:

$$\text{area of section } A = 2t(b+c);$$

$$\text{numerical first moment of area}$$

$$H = \frac{td}{2}(2b+c);$$

$$\text{modulus of section}$$

$$Z = \frac{td}{3}(3b+c);$$

$$\text{and second moment of area}$$

$$I = \frac{td^3}{6}(3b+c).$$

referred to
the
neutral
axis.

Tests on panels of steel and aluminium alloy corrugated sheet under transverse loads have confirmed that elastic stresses and deflections can be calculated from the theory of bending using the geometrical properties defined above. In Fig. 2 the theoretical variation of $\frac{I}{tcd^2}$ with $\frac{b}{c}$ is compared with values deduced from the measured elastic deflections of thirteen specimens. The bending moment M_{PL} under which extreme fibre stresses reach the limit of proportionality f_{PL} represents the limit of applicability of the simple bending theory, so that

$$M_{PL} = Zf_{PL}.$$

In most practical cases the shear stiffness of corrugated plate is such that deflections and stresses under shear loads are unlikely to be important. It can be shown that if F is the shearing force acting across a single corrugation perpendicular to the neutral axis of bending, the mean and maximum shearing stresses in the web are given closely by

$$q_{\text{mean}} = \frac{F}{2td}; \quad q_{\text{max}} = \frac{F}{2td} \times \frac{H}{Z}.$$

When a corrugated plate is subjected to a bending moment greater than M_{PL} , calculation of the moment of resistance of the plate requires a knowledge of the stress-strain relationship of the plate material. Moreover, since buckling of the compression flange of the trough occurs at a certain critical value of the maximum fibre strain, it is important that the variation of maximum strain with applied moment can be predicted with reasonable accuracy. The classical assumption that the relationship between stress and strain can be represented by two straight lines defining the fully elastic and fully plastic regions, is generally sufficiently accurate for structural mild steel which does not exhibit appreciable strain hardening and for which the yield stress f_Y is very little greater than the proportional limit stress f_{PL} . For materials such as the aluminium-magnesium alloys, which are generally accepted as being the most suitable light alloys for ship construction, there is a more gradual transition from elasticity to plasticity, and use of the idealised straight-line diagram to calculate moment of resistance would lead to an under-estimate of maximum fibre strains.

It is therefore necessary to express the relationship between stress and strain in a form which is amenable to integration. An expression which gives a good fit to a wide variety of stress-strain curves is:

For

$$0 < f < f_{PL}, \quad f = Ee;$$

for

$$f_{PL} < f < f_Y, \quad f = f_Y - \frac{E}{a} \exp. - a(e - e_{PL}),$$

where f and e refer to stress and strain, E is Young's modulus, e_{PL} is the strain corresponding to the proportional limit stress f_{PL} , a is a non-dimensional parameter, and f_Y is defined as the stress at which the slope of the stress-strain curve becomes zero. This will be termed the yield stress for both steel and aluminium alloy.

To calculate the moment of resistance of the cross-section of the corrugation using this expression it is convenient to make the further assumption that the properties of the material in tension and compression are similar. Then the distribution of stress across the section is at all times symmetrical with respect to the neutral axis, as shown in Fig. 3; and the moment of resistance of the corrugation, when

* Paper read before Section G of the British Association at Belfast on Tuesday, September 9, 1952.

† B. Martell, "Divisional Watertight Bulkheads as Applied to Steamers and Sailing Vessels," *Trans. Inst. N. A.*, vol. 33, page 121 (1892).

‡ J. Foster King, "Strength of Watertight Bulkheads," *Trans. Inst. N. A.*, vol. 58, page 150 (1916).

§ A. Hogg, "A Test of Watertight Bulkheads for Ship Subdivision," *Trans. North East Coast Inst.*, vol. 36, page 32, (1919).

the stress at a distance z_{PL} from the neutral axis is f_{PL} , is

$$M_R = \int_{-\frac{d}{2}}^{+\frac{d}{2}} f z dA$$

$$= \int_{-z_{PL}}^{z_{PL}} E e z dA + 2 \int_{-z_{PL}}^{\frac{d}{2}} \left[f_Y - \frac{E}{a} \exp -a(e - e_{PL}) \right] z dA$$

$$+ 2 \left[f_Y - \frac{E}{a} \exp -a(e - e_{PL}) \right] \frac{d}{2} b t.$$

If the strain at a distance $\frac{d}{2}$ from the neutral axis is denoted by e_M , it can be shown that

$$M_R = \rho H f_Y,$$

in which for a given material ρ varies with $\frac{e_M}{e_{PL}}$ and the ratio $\frac{b}{c}$. For ship quality mild steel it will

be assumed that $f_Y = 26$ tons per square inch, $E = 13,000$ tons per square inch, and the parameter $a = \infty$. Tests on samples of a typical aluminium-magnesium alloy indicate that suitable values are $f_Y = 15.0$ tons per square inch, $E = 4,300$ tons per square inch, and $a = 1,000$.

The variation of ρ with $\frac{e_M}{e_{PL}}$ is shown in Fig. 4 for steel, and Fig. 5 for aluminium alloy. The maximum fibre strain in the corrugated plate due to a given bending moment is thus defined by the corresponding value of ρ . For large strains ρ approaches unity; the ultimate bending strength of non-buckling panels is therefore

$$M_{ult} = H f_Y = \frac{t d}{2} (2b + c) f_Y.$$

This may be written

$$\frac{M_{ult}}{t d c f_Y} = \frac{b}{c} + \frac{1}{2},$$

a relationship which is shown graphically in Fig. 6, and compared with values deduced from tests on ten panels of steel corrugated sheet.

Local Instability.—It follows from the expressions for modulus of section and cross-sectional area of a corrugation that the ratio of strength to weight of a panel is independent of the plate thickness t . A thin plate with deep troughs is clearly more efficient in bending than a thick plate with shallow troughs, but the possibility of failure of the panel due to buckling of the component plates must impose a minimum on plate thicknesses.

When a corrugated plate is subjected to bending about an axis perpendicular to the direction of the troughs, the compression flange of each trough is stressed uniformly across its width, while the web is subjected to a stress varying linearly from a maximum compression at one edge to an equal tension at the other. Both forms of loading may lead to plate instability and expressions for the critical stress in each case have been given* by assuming idealised conditions at the boundaries of the plates. In the corrugated plate the conditions at the common edge of the web and compression flange are affected by the relative proportions of the component plates.

The determination of the critical stress in this case must take account of the interaction between the adjacent plates, and some assumptions concerning the buckled form of the section are necessary. Fig. 7, opposite, shows a corrugated sheet after buckling has occurred. Instability is characterised by distortions of the form shown in Fig. 8 and it may be assumed that after buckling the common edge of the adjacent plates remains virtually straight and that the original angle between web and flange is maintained.

A rigorous theoretical solution for the critical bending moment causing instability of a corrugated plate requires that the buckled form of the section should be expressed in analytical form. The fundamental equation which defines the deflected form of the web may be written

$$\frac{\partial^4 w}{\partial x^4} + 2 \frac{\partial^4 w}{\partial x^2 \partial y^2} + \frac{\partial^4 w}{\partial y^4} = (\alpha + \beta y) \frac{\partial^2 w}{\partial x^2},$$

where x and y refer to co-ordinate directions in the plane of the web, w represents the displacement of a point (x, y) perpendicular to the plane of the web, and α and β are independent of w, x or y .

A solution to this equation expresses w in terms of infinite series which prove unsuitable in subsequent analysis, so that an exact solution to the

Fig. 4. MOMENT OF RESISTANCE OF A SINGLE CORRUGATION, MILD STEEL.

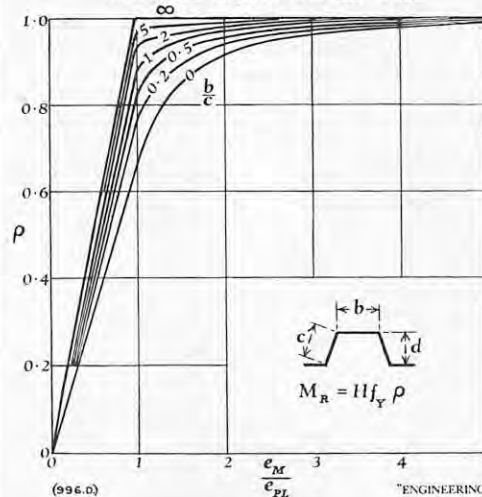


Fig. 5. MOMENT OF RESISTANCE OF A SINGLE CORRUGATION, ALUMINIUM ALLOY.

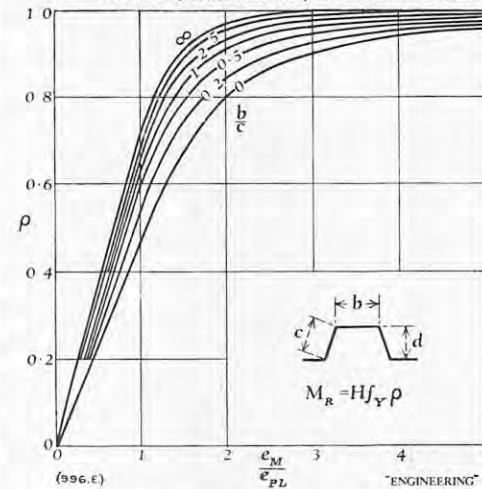
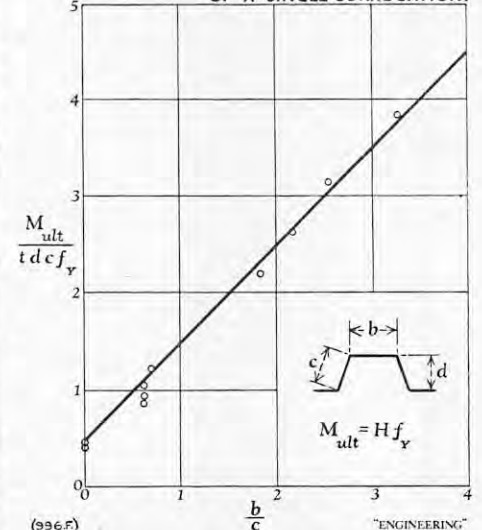


Fig. 6. ULTIMATE MOMENT OF RESISTANCE OF A SINGLE CORRUGATION.



problem is impracticable. By replacing the linear distribution of stress across the web by a uniform compression, the variable coefficient of $\frac{\partial^2 w}{\partial x^2}$ in the above equation is replaced by a known constant and a simpler expression for w derived.

If a long flat plate is subjected to stresses causing bending of the plate in its own plane, instability will occur when the compressive stress at one edge reaches a value

$$f_{cr} = \frac{K_c^2 D}{t c^2},$$

in which $D = \frac{E t^3}{12(1 - \nu^2)}$, t and c are the thickness and breadth of the plate, respectively, E is Young's modulus, ν Poisson's ratio, and K_c is a constant term depending on the ratio of length to breadth of the plate and the conditions at the edges of the plate. A plate of breadth c_1 with similar conditions at the boundaries but under a uniform compressive stress on two opposite edges will buckle when $f_{cr1} = \frac{K_{c1}^2 D}{t c_1^2}$. For the critical stresses in the two cases to be the same

$$f_{cr} = f_{cr1} \text{ or } \frac{c_1}{c} = \frac{K_{c1}}{K_c} = \lambda.$$

This suggests that by replacing the web of breadth c by an equivalent web of breadth λc , the corrugated section may be treated as being subjected to a uniform compression, the value of λ being chosen so that in the equivalent section the stress causing instability of the reduced web alone is the same as that for the original web under bending conditions. This treatment of the problem is illustrated in Fig. 9, opposite. Since the method takes no account of the different wavelengths of the buckled form of the original and reduced webs, it does not give an exact solution, and the most suitable value of λ must therefore be determined by experiment.

The equivalent section may now be analysed by methods which take account of the interaction between web and flange. The differential equation which defines the deflected form of both the web and compression flange is

$$\frac{\partial^4 w}{\partial x^4} + 2 \frac{\partial^4 w}{\partial x^2 \partial y^2} + \frac{\partial^4 w}{\partial y^4} = - \frac{f t}{D} \frac{\partial^2 w}{\partial x^2},$$

in which f = longitudinal compressive stress, and t = thickness of flange and web plates.

Assuming that the loaded edges of the plates are simply supported and that both web and flange buckle in m half-waves in the x direction and one half-wave in the y direction, an expression for w may be found which satisfies the above equation and the specified conditions. This expression contains four unknown constants which must be different for each of the two component plates. The eight constants can be related by eight boundary conditions which must be satisfied. Using the notation of Fig. 9, these are:

For the flange:

- (1) at $y = 0$ there is no shearing force on the plate;
- (2) at $y = 0$ the slope of the plate, $\frac{\partial w}{\partial y}$, is zero.
- (1) and (2) follow from considerations of symmetry;
- (3) at $y = \frac{b}{2}$, $w = 0$.

Interaction conditions:

- (4) the slopes of flange and web are equal at the common edge;
 - (5) the bending moments in the two plates are equal at the common edge.
- Conditions (3), (4), (5) and (6) follow from the assumption of the buckled form (Fig. 8).

For the web:

- (6) at $y = 0$, $w = 0$;
- (7) at $y = c_1$, $w = 0$;
- (8) at $y = c_1$, there is no bending moment.

Conditions (7) and (8) result from the replacement of the original web by the equivalent web.

By writing these conditions in terms of derivatives of the deflection functions, eight equations expressing linear relationships between the eight unknown constants may be obtained. A solution of these equations which gives non-zero values of the constants leads to an expression for the critical stress f_{cr} in the form

$$f_{cr1} = \frac{k_b^2 D}{t b^2} = \frac{k_{c1}^2 D}{t c_1^2},$$

in which k_b varies with the ratio of flange breadth b to web depth c_1 , and the ratio of length of plate

* S. Timoshenko, *Theory of Elastic Stability*. McGraw-Hill (1936).

BENDING STRENGTH OF CORRUGATED PLATE.



FIG. 7. CORRUGATED PANEL AFTER BUCKLING.

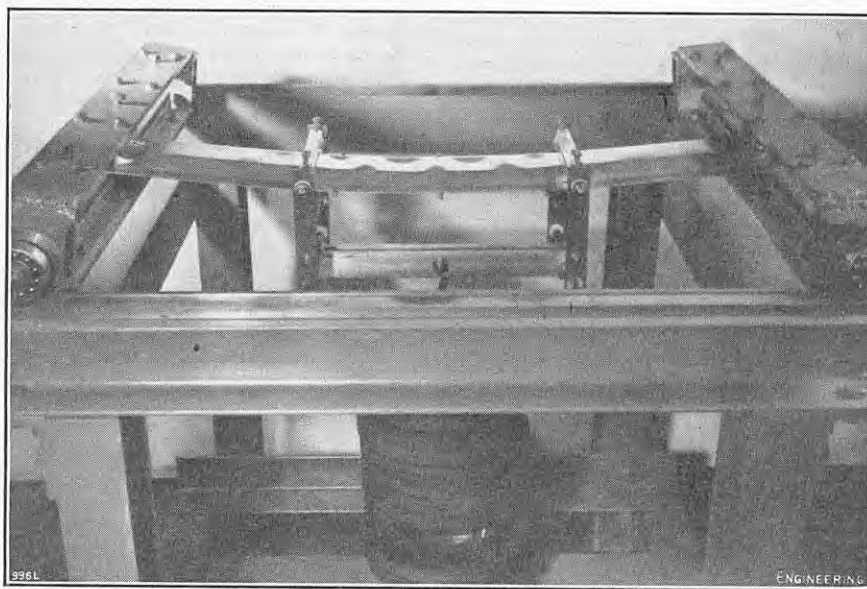


FIG. 11. APPARATUS FOR TESTING SINGLE CORRUGATIONS.

to b . In most practical cases the ratios of length of panel to the breadths of the component plates are such that k_b , and hence the critical stress, becomes virtually independent of the latter ratio, and instability is governed only by the material properties and the ratios $\frac{b}{c_1}$ and $\frac{t}{b}$. In Fig. 10, the result of the foregoing analysis is presented, showing the variation of k_b and k_{c_1} with $\frac{b}{c_1}$ or $\frac{b}{\lambda c}$. By assigning a value to λ and replacing the relationship between k_b or k_{c_1} and $\frac{b}{c_1}$ by that between K_b or K_c and $\frac{b}{c}$, so that $K_b = k_b$ when $\frac{b}{c} = \frac{\lambda b}{c_1}$, the critical stress in the compression flange for the original corrugation under bending conditions may be written

$$f_{cr} = \frac{K_b^2 D}{t b^2} = \frac{K_c^2 D}{t c^2}.$$

The foregoing theory is based upon the assumption that stresses in the plates nowhere exceed the proportional limit for the material. If $f_{cr} > f_{PL}$ it is necessary to replace E by a modified value of the elastic modulus, and experimental work has

Fig. 8. BUCKLED FORMS OF CORRUGATED PLATE.

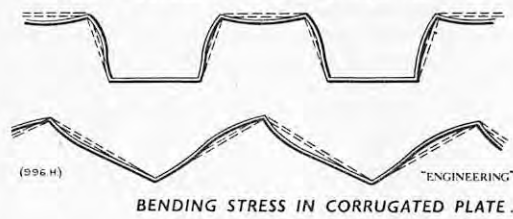


Fig. 9.

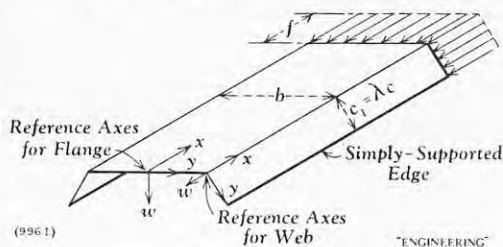
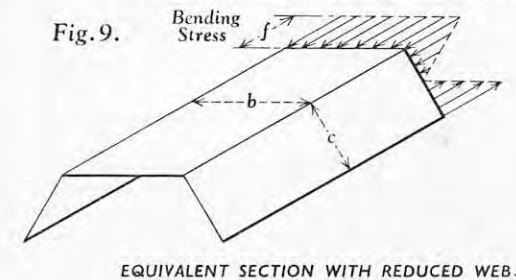


Fig. 10. CRITICAL STRESS FOR REDUCED SECTION.

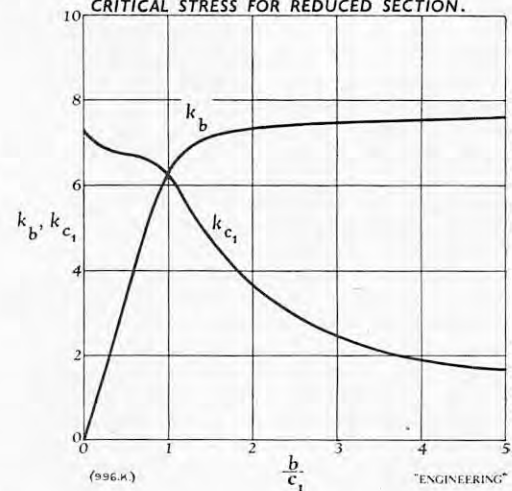
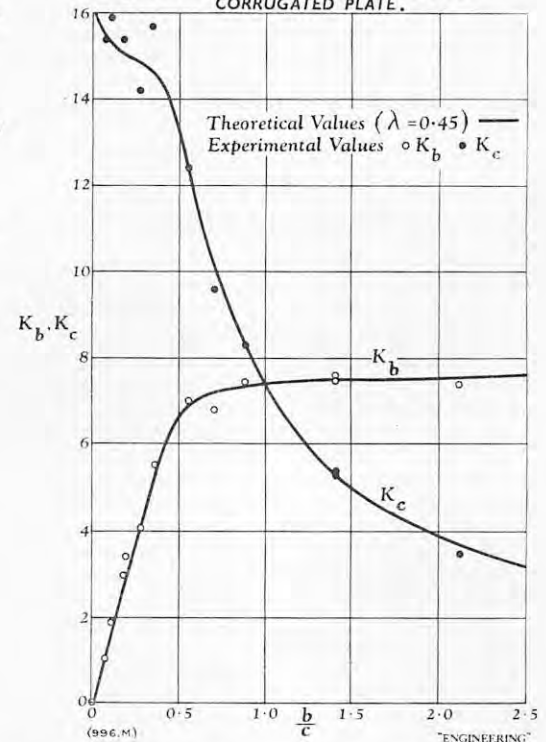


Fig. 12. CRITICAL BENDING STRESS FOR CORRUGATED PLATE.



was characterised by increasing waviness of the compression flange as illustrated in Fig. 11. By measuring the deflection of the flange relative to its junction with the web, the critical load could be determined using the method developed by Southwell.* The relationship between load and strain was obtained by measuring the curvature of the deflected panel, and hence the critical strain was deduced.

From these results and the known dimensions of the panel, the values of K_b and K_c were calculated. These are compared in Fig. 12 with the theoretical relationship between the buckling constants and $\frac{b}{c}$, using $\lambda = 0.45$. It is evident that the semi-empirical method of solution is justified, and that the curve of Fig. 12 may safely be used to estimate critical bending strains.

The critical bending moment M_{CR} can now be calculated. The variation of maximum fibre strain with applied moment is maximum from Fig. 4 or Fig. 5, opposite, and the moment corresponding to the critical strain is readily obtained.

Choice of Trough Form.—Thus, for a corrugated panel of known dimensions the bending moments M_{PL} , M_{ult} and M_{CR} may be calculated. The mode of failure of the panel is governed by the relative values of these moments. If $M_{CR} < M_{PL}$ additional

confirmed that if f_{cr} is not very large compared with f_{PL} , use of the secant modulus E_{sec} gives fairly reliable values for the critical stress. But since by definition

$$E_{sec} = \frac{\text{stress}}{\text{strain}} = \frac{f}{e},$$

then the critical strain in the compression flange which causes local instability of the corrugated plate is

$$e_{cr} = \frac{K_b^2 t^2}{12(1 - \nu^2) b^2} = \frac{K_c^2 t^2}{12(1 - \nu^2) c^2},$$

a formula which is applicable both in the elastic and plastic ranges.

The reduction factor λ was determined from tests on corrugated sheet under pure bending conditions. The apparatus is shown in Fig. 11. A series of single corrugations, in which the ratio $\frac{b}{c}$ varied from 0 to 2.15, were loaded by deadweights until buckling occurred over the centre section. It was found that when the critical stress exceeded the proportional limit stress for the material, instability caused immediate collapse of the specimen, so that the critical load was clearly defined. Elastic instability

* R. Southwell, *Proc. Roy. Soc.*, vol. 135, page 601 (1932).

load is carried after buckling and ultimate failure is due to yielding of the distorted section. If $M_{PL} < M_{CR} < M_{ult}$, the ultimate strength of the panel is M_{CR} ; if $M_{CR} = M_{ult}$ the panel will fail by yielding of the material leading to ultimate collapse due to instability. In ships' corrugated bulkheads elastic instability is inadmissible in view of the importance of ensuring watertightness of joints and planarity of the bulkhead surfaces. In tank bulkheads, therefore, the dimensions of the corrugation must be such that $M_{CR} > M_{PL}$. Moreover, since the ratio of bending strength to weight of panel is independent of the thickness t , and M_{CR} increases with t , it follows that the most efficient bulkhead results from making $M_{CR} = M_{PL}$. In subdivision bulkheads the working load defines the collapse load of the panel. In order that the full bending strength of the corrugated plate is developed M_{CR} should not be much less than M_{ult} . Thus, in either case a relationship between the variable trough dimensions b , c , d , p and t is provided by consideration of efficiency of the panel. Furthermore, since the actual value of M_{CR} or M_{ult} is known from the loading conditions, and the geometry of the section requires that

$$p = 2b + 2(c^2 - d^2)^{1/2},$$

three equations relating the five variables may be obtained. In many practical cases some dimensions are limited by space and convenience of connections to adjacent structure, and the remainder may be then determined to provide the most efficient trough form.

PRODUCTIVITY IN STEELMAKING.

THE hard fact that has emerged from the report of the iron and steel productivity team which visited the United States recently is that the output of steel ingots in America, whether measured by man-hours or by furnace productivity, is greater than that of the United Kingdom by a factor of two. This statement by Sir Charles Goodeve, F.R.S., the leader of the team, provided a stimulating challenge at a conference held by the British Iron and Steel Research Association at Ashorne Hill on October 1 and 2, to discuss the observations and recommendations of the report. The conference was attended by 114 delegates from 35 steelmaking companies, representing over 90 per cent. of the open-hearth steelmaking capacity of Great Britain.

Among the conclusions generally agreed to at the conference were that all new basic open-hearth furnaces in this country should not be smaller in tapped-steel capacity than 150 tons for cold-metal charged furnaces, between 200 and 250 tons capacity for fixed low- or moderate-phosphorus hot-metal charged furnaces, and between 300 and 400 tons for tilting high-phosphorus hot-metal furnaces. The minimum number of furnaces desirable in a melting shop, to give an even flow of steel to the rolling mills, was generally accepted as being six, and it was felt that this was also the maximum number for economic operation in one shop, if interference between different units and the unwieldy multiplication of charging and shunting capacities were to be avoided. The conference generally agreed that there was much room for improvement in the design of melting shops to obtain rapid charging rates. This might be accomplished by the adoption, among other things, of larger charging pans, a better packing of the pans and better scrap preparation. Attention was drawn to the fact that perhaps the most important difference between United Kingdom and American practice, in the use of refractories, was the attitude to roof life. In the United States it was considered that the roof could be replaced in a very short time, as compared with the time required to replace other parts, and the roof had to adapt itself to the production tempo of the remainder of the furnace.

An interesting point brought out in connection with furnace operation was that, in America, it was noticeable that oxygen was losing its popularity as an aid to rapid refining. Moreover, it was more general now to use sinter, instead of either ore or scale, as a bath charge, to overcome the disadvantage of the high silicon of the Mesabiores. On the tapping side it was usual to employ

larger moulds and nozzles in the United States than were commonly utilised in this country; for the same size of ingot a nozzle six times greater than that normal in the United Kingdom might be used. Another observation was that ingot-mould life was shorter in the United States than it was over here, and that, while graphite was the most popular of the mould washes in use, the application of these products had been abandoned in a number of plants.

THE ST. LAWRENCE SEAWAY.*

(Concluded from page 551.)

GROWING PRESSURE FOR THE ST. LAWRENCE PROJECT.

BEHIND the increasing Canadian pressure for the St. Lawrence power and navigation project lie two important economic facts—the acute post-war shortage of power in Ontario and the opening-up of the Quebec-Labrador iron-ore deposits. The St. Lawrence project was once regarded chiefly in terms of cheaper freight rates for outbound Prairie wheat; but, important as this consideration still is, the project's potentialities as a source of power for the growing industrial needs of central Canada and as a means of getting the new supply of high-grade ore cheaply to interior steel furnaces now tend to overshadow it. Indeed, the down-bound movement of grain once visualised as the main item of traffic through the Seaway is now expected to be exceeded by the big upbound movement of iron ore originating at Seven Islands.

The Great Lakes-St. Lawrence System, with its drop of over 600 ft., is one of the major power sources of the continent. It is capable of developing economically perhaps 9 million h.p., two-thirds of it Canadian and one-third American. The harnessing of Niagara's potential 3½ million h.p. is now well advanced, but in the St. Lawrence River only a fraction of the available 5½ million h.p. has so far been put to use. At Beauharnois, in the Soulages section of the River, the basic installations for an eventual development of more than 2 million h.p. were constructed 20 years ago and work is now proceeding which will bring the actual generating capacity above 1½ million h.p. The Seaway, as now proposed, would permit the development of 1.2 million h.p. at Lachine; but the Quebec Government, with other sources of power available, including the remaining part of Beauharnois, have not yet indicated whether they will co-operate in a joint power and navigation project or let the Federal Government carry through the navigation project alone and postpone the power development until it is needed. No such uncertainty attaches to the construction of the proposed 2.2 million h.p. of capacity at Barnhart Island, half on the New York side of the river and half on the Ontario side, for which both New York State and the Province of Ontario have been pressing for several years.

The demand for power in Ontario has been increasing. In the winters of 1947-48 and 1948-49, restrictions on power use had to be imposed and, despite an active hydro-electric expansion programme that has increased the Province's generating capacity by over 50 per cent. since the end of the war, resort to higher-cost steam power has been necessary. Even with the completion of the generating station now under construction at Niagara, the Ontario Hydro-Electric Commission expect by 1957 to fall short of the 10 per cent. reserve of power considered necessary in a large power system.

An even newer consideration is that the Seaway will greatly enlarge the market for the vast reserves of iron ore now known to exist in Quebec-Labrador. Reserves in the Lake Superior region of the United States, which for years has been supplying four-fifths of the iron-ore needs of the United States, were heavily drawn upon during World War II. Remaining reserves, though extensive, are becoming less easy to mine and more costly. The participation of six United States steel and ore companies in the Quebec-Labrador undertaking, the development

of Venezuelan and Liberian deposits by United States interests, the expansion of iron-mining and the widening search for new deposits in Ontario, the substantial sums that have been spent to find a commercial process for making the low-grade taconites of the Superior region suitable for use in steel furnaces, all testify to the increasing seriousness of the iron-ore situation. The National Security Resources Board of the United States estimated in 1950 that, in ten years, a minimum annual import of 25 million tons of iron ore would be required to operate the United States steel industry at capacity, and that, in 20 years, the figure would rise to 48 million tons or more.

When the 360-mile railway from Quebec-Labrador deposits to Seven Islands is completed in 1954, Canadian ore, moved down the coast by ocean freighter to such United States ports as Baltimore for use by Atlantic Coast steel mills or rail shipment inland, will be in a position to compete with other foreign ores, and two large freighters for this movement are now being built for the interests controlling the iron-ore deposits. There are limitations to this market, however, both because of competition from Venezuelan ore and because of the length of the rail-haul inland. On the other hand, to reach the great ore-consuming areas round the Great Lakes under present transportation conditions would involve trans-shipment from ore-carriers at Montreal, and either a long rail-haul inland or bypassing the rapids of the St. Lawrence and another trans-shipment to large Lake freighters for the rest of the journey to Great Lakes ports. The recently issued Report of the Materials Policy Commission to the President of the United States on the United States outlook for domestic supplies and imports of vital raw materials, states, "Construction of the proposed St. Lawrence Seaway is necessary if ore is to move in quantity from Labrador to mills in the Midwest. The seaway, with its 27-ft. channel, would make it possible to transport ore in large carriers directly from Seven Islands to lower Lake ports. It would reduce the cost of the all-water route by more than 25 per cent., permit a fourfold expansion of these shipments, and exercise pressure on rail rates from Montreal and Baltimore to Pittsburgh and points west."

While there is some difference of opinion about the value of the Seaway from a defence point of view, its advocates stress the advantages of increased supplies of power, easy access to ample and readily expanded supplies of high-grade iron ore, an alternative transportation route to relieve pressure on the railroads, and the fact that it would permit large ships to be built in the comparative safety of inland waters. On the other side it has been pointed out that the new power and navigation works would be vulnerable to air attack.

THE ECONOMIES OF THE SEAWAY.

In the past, the savings in transportation costs anticipated from the Seaway were seen largely in terms of getting grain to the seaboard at the lowest possible cost. The savings that would result from an uninterrupted movement of grain in large bulk carriers from the head of the Lakes to lower St. Lawrence ports have been estimated by the United States Department of Commerce at from 5 to 7 cents a bushel, even allowing for a considerable upbound movement of ships in ballast. The heavy upbound movement of iron ore now envisaged, which might in time reach as much as 20 million tons a year, suggests a possible more efficient use of shipping. Returning ore-carriers would likely be able to offer favourable rates on downbound cargoes of coal from lower Lake ports, and they might well find it feasible also to proceed to the Lakehead, cleaning ship *en route*, and carry grain on the down trip.

These three major bulk cargoes have been mentioned in particular, since they would likely make up the major part of the traffic moving through the Seaway. Current estimates suggest a yearly volume of traffic for the new waterway, available soon after its completion, of 40 million tons or more, consisting in round figures of up to 20 million tons of iron ore, up to 10 million tons of grain and grain products, perhaps 4 million tons of coal, 1½ million tons of paper, pulpwood and wood-pulp, and possibly 8 million tons of miscellaneous

* From the *Monthly Review* of the Bank of Nova Scotia, Toronto, Canada; No. 74 (July-August, 1952). Abridged.

cargo. Substantial transportation savings would result from the avoidance of costly trans-shipment and from continuous carriage through the Seaway in the large bulk carriers which provide one of the cheapest methods of transportation in the world. The saving on the volume of traffic mentioned above has been officially estimated at 45 to 50 million dols. a year. The net saving depends, of course, on the levels of tolls. It is provided in the St. Lawrence Seaway Authority Act that these shall be sufficient to cover the cost of maintaining and operating the Seaway, of paying interest at current rates on the funds borrowed, and of amortising the investment over a period of 50 years, which has been estimated at a total of around 20 million dols a year.

Since there is thus a considerable margin between estimated transportation savings and estimated annual charges, it would appear to be practicable to make the navigation works self-liquidating; but, of course, the complicated problem of setting toll schedules has still to be worked out. The St. Lawrence Seaway Authority Act stipulates that the tolls shall be "fair and reasonable." The general principles advanced by the United States, which it is reasonable to suppose will still apply, were that tolls should be such as to encourage the use of the Seaway, that they should favour agricultural and industrial raw materials, and that in no case should they exceed 1.25 dols. a ton. This suggests low rates for bulk commodities like ore, grain and coal, and higher rates for manufactured goods. It seems fairly obvious that the volume of traffic attracted to the Seaway will depend to a considerable degree on whether the size of the transportation saving after payment of tolls is sufficient to induce shippers to break customary shipping connections. Of course, competitive rate reductions by established carriers are to be expected.

Certain interests—notably some of the east coast ports, the railroads, the Lake carriers and the coal industry—have traditionally opposed the Seaway because of the injury they feared from it. It is worth noting, however, that some of this opposition has tended to die down in recent years. The port of Montreal is now less concerned over possible loss of traffic; and in some quarters, indeed, it is believed that the Seaway will mean a greater volume of business for the port. Nor are some of the lake carriers as strongly opposed as they once were; the large freighters are very efficient carriers and a considerably bigger fleet is likely to be required to handle the expected volume of traffic.

It would, of course, be idle to deny that some injury may result to particular groups. The Cape Breton coal industry will be faced with increased competition from United States coal in its present Quebec market. Similarly, the inland shipyards will be subject to competition from coastal yards and perhaps also from overseas yards, though they may get an increased volume of maintenance and repair work. Again, it is clear that the "canalliers" will be up against most unequal competition, once large freighters can pass freely up and down the St. Lawrence.* Generally speaking, however, fears of injury from the Seaway have probably been exaggerated. The United States coal industry, which opposed the Tennessee Valley Authority as it now opposes St. Lawrence power, found that, far from being decreased, consumption of coal was enlarged in the area served by the T.V.A. because of the industrial stimulus provided by cheap water-power. As for the railroads, it is perhaps not inappropriate to recall that the fears of the United States railroads, that they would be ruined by diversion of traffic through the Panama Canal, proved groundless. In the case of the Seaway, the Canadian railroads will undoubtedly lose a considerable amount of bulk traffic, but the general stimulus to industrialisation resulting from the power and navigation project may before long bring a compensating increase in other types of freight. The President of the Canadian National Railways was taking this broader view when he said, speaking of the Seaway, "Whatever tends to open Canada up and help it grow is good for this railroad."

* The maximum carrying capacity of the dry-cargo "canalliers," built for the 14-ft. canals, is 3,000 tons, whereas that of the largest "upper Lakers" exceeds 20,000 tons.

THE IRON AND STEEL INSTITUTE.

THE autumn general meeting of the Iron and Steel Institute will be held on Wednesday and Thursday, November 26 and 27, at the offices of the Institute, 4, Grosvenor-gardens, London, S.W.1. The President, Captain H. Leighton Davies, C.B.E., will occupy the chair.

The meeting opens at 10 a.m. on the first day, when, after the transaction of some formal business, Dr. R. T. Fowler and Mr. L. H. W. Savage will present a paper, "Cooling of Rimming-Steel Ingots in a Casting Pit." This paper will be discussed in conjunction with the following papers: "Time Studies from Casting to Rolling," by Dr. A. V. Brancker, Mr. J. Stringer and Mr. L. H. W. Savage; "Mould and Ingot Surface Temperature Measurements," by Dr. A. V. Brancker; and "Ingot-Mould Temperature Measurements," by Dr. R. T. Fowler and Mr. J. Stringer. After a brief interval, a series of papers to initiate and promote a discussion on "The Thermodynamics of Steelmaking" will be presented. The first of these will be "Development of Active-Mixer Practice at Appleby Frodingham," by Mr. A. Jackson, Dr. F. D. Richardson will then act as *rapporteur* for the remaining nine papers in the series, namely, "Thermodynamic Properties of Silicon Monoxide," by Mr. N. C. Tombs and Mr. A. J. E. Welch; "Phosphorus-Oxygen Equilibrium in Liquid Iron," by Mr. J. B. Bookey, Dr. F. D. Richardson, and Mr. A. J. E. Welch; "The Free Energies of Formation of Tricalcium and Tetra-calcium Phosphates," by Mr. J. B. Bookey; "The Free Energy of Formation of Magnesium Phosphate," by Mr. J. B. Bookey; "Effect of Sodium Oxide Additions to Steelmaking Slags. II.—Dephosphorisation of Steel by Soda Slags," by Dr. W. R. Maddocks and Mr. E. T. Turkdogan; "Phase Equilibrium Investigation of the $\text{Na}_2\text{O}-\text{P}_2\text{O}_5-\text{SiO}_2$ Ternary System," by Mr. E. T. Turkdogan and Dr. W. R. Maddocks; "Thermodynamics of Substances of Interest in Iron and Steelmaking. III.—Sulphides," by Dr. F. D. Richardson and Mr. J. H. E. Jeffes; "A Stoichiometric Combustion Method for the Determination of Sulphur in Slags," by Mr. C. J. B. Fincham and Dr. F. D. Richardson; and "The Thermodynamic Calculation of Slag Equilibria," by Mr. H. Flood and Mr. K. Grjotheim. The afternoon will be devoted to the discussion of the papers.

Three papers are on the agenda for discussion during the morning of November 27. The first is "Addition of Boron to Steel by Reduction from Boron Oxide," by Mr. G. E. Speight; the second is "Effect of Direction of Rolling and Stressing and of Ageing on the Mechanical Properties of a Mild-Steel Plate," by Mrs. C. F. Tipper; and the third, "Rapid Softening of Cold-Drawn Austenitic Stainless Steels," by Mr. F. A. Hodiernie and Dr. C. E. Homer.

HEAVY-DUTY ENGINE OILS.—The Ministry of Supply Lubricant Engine Testing Advisory Panel has now completed its first year of service. Since the panel first met in September, 1951, it has studied reports, and made recommendations to the Director of Chemical Inspection, on some two dozen different lubricants submitted for type approval against the requirements of specification DEF/2101. To ensure that similar acceptance standards are maintained for both the British DEF/2101 and United States MIL-0-2104 specifications, members of the panel have visited the United States to study the American methods of assessment. To further this objective, a joint meeting with members of the United States Army Ordnance Reviewing Committee was held in London in June, 1952. As a result of this close co-operation, any British engine-test laboratory approved by the British panel will be accepted by the American authorities. In general, the panel has adopted the existing American procedure and has recommended approval of oils not only on the direct results of fuel tests but also by a system of approving the re-branding and re-blending of previously-tested and approved oils; this latter procedure is of particular value to companies not equipped to carry out all the relevant tests. The panel has given advice regarding revision of specification DEF/2101 and has suggested the establishment of an independent engine-lubricant test laboratory under Government auspices. Proposals for the use of British engines for oil testing are also under consideration.

REPAIR OF A CAST-IRON BRIDGE GIRDER.

AN interesting repair of a cast-iron girder in a bridge carrying a busy road over the railway has been carried out recently at Northwich Station, Cheshire, by British Railways, London Midland Region. The bridge has two spans, one of 27 ft. 1 in. over the up and down main lines, and one of 17 ft. 8 in. over a loop line; it is 25 ft. between parapets, and has a footpath 5 ft. 5 in. wide on one side only. The deck of each span is supported by seven identical cast-iron girders placed longitudinally at 4 ft. 6 in. centres with jack arches between them. The girders are of a familiar cast-iron type, hog-backed, with bottom flanges bowed in plan, and with cast stiffeners at intervals along their length.

One of the girders in the longer span, under the traffic lane and close to the kerb, was found to have a crack, about $\frac{1}{8}$ in. wide, in the bottom flange, adjacent to the centre stiffener. After the road traffic had been restricted to one half of the bridge in order to relieve the defective girder of live load, the roadway surfacing was opened-up in an attempt to ascertain whether the fracture could be traced in the top flange. This was found to be impracticable owing to the presence of a nest of nine Post Office cables in steel tubes embedded in concrete, which lay immediately over the girder and its adjacent jack arches. Detailed examination revealed that the girder had a sag of about 1 in., but no appreciable cracks were found in the jack arches. It seemed certain that the crack extended right through the section of the girder and that it had been prevented from falling only by the combined action of the jack arches and surrounding backing. While in all probability the girder would have remained in position under deadload conditions alone, it was important to restore the full road width to traffic quickly, which meant that some temporary strengthening was necessary until such time as the bridge itself could be reconstructed.

The normal course would have been to replace the defective girder, but the cost of such a repair would have been heavy, because not only would the Post Office cables have needed support and possibly some temporary diversion, but the demolition of the jack arch on the footpath side would have entailed temporary support being given to other services under the footpath. In addition, the footpath would have been so reduced in width during the occupation that it might have been necessary to provide a temporary footbridge. The only alternative method to offer substantial advantages was to restore the live-load carrying capacity of the girder, by introducing a compressive force in the bottom flange by means of high-tensile steel rods stretched between anchorages attached to each end of the girder. Although it was realised that the design problem was not capable of a precise solution, it was considered that there was a reasonable chance of success, and it was decided to proceed with this scheme.

It was evident that the dead load previously carried by the girder had been transferred to the jack arches and surrounding material, and it was, therefore, clear that the high-tensile steel rods would have to be sufficiently loaded to induce a compressive force in excess of that due to both dead and live loads. Four high-tensile steel rods $1\frac{1}{8}$ in. in diameter were placed with their centres 2 in. above the underside of the bottom flange, two rods on each side of the girder. The rods were each jacked to 45 tons, the nuts tightened against welded headstocks and the jacks slackened. The residual load in each bar was then 42 tons, thus inducing a compressive force in the girder of 168 tons. Under this eccentrically-applied load, assuming a homogeneous section—which would be a reasonable assumption if the crack closed completely—the compressive stress in the cast iron would be well below the usually accepted safe limit under dead load plus the Ministry of Transport live load. The crack did, in fact, appear to close, though it could not be established that it closed completely; therefore it would be reasonable to assume that the compressive stress in the cast iron under certain conditions of loading may be high, but it seems unlikely that it could reach unduly high proportions,

since some assistance would be offered by the jack arches and backing material. Moreover, the calculated extension of the rods under the jacking load, after making allowance for elastic shortening of the girder and steel headstocks, plus $\frac{1}{8}$ in. for the width of the crack, was checked and found to be correct within ordinary limits of measurement.

The rods were connected at each end to stiff welded-steel headstocks bearing against the "closed" ends of the cast-iron girder. The headstocks were placed in position from the top without disturbing the tubes of the Post Office cables, and the rods were threaded through the headstocks from under the bridge. Since the rods were delivered to the site by road, and might have sustained damage if each had been in one length, they were supplied in two lengths and coupled together on site before erection. The jacking operation was carried out from one end in two stages, the two inner rods being jacked simultaneously and then the two outer rods. It was considered advisable to build a small access chamber around each headstock to allow the anchorages to be inspected and adjustments made if necessary. Furthermore, when the time comes for reconstructing the bridge, the demolition work will be rendered much easier than if they had been concreted in. The projecting screw threads and nuts were, of course, heavily coated with grease. Although the high-tensile steel rods are somewhat more resistant to corrosion than mild steel, they are in a vulnerable position where they are subjected to locomotive exhaust. They were therefore wrapped and coated with a bitumen compound.

The work was carried out under the direction of the bridge assistant to the civil engineer of the London Midland Region of British Railways, and the full width of the roadway was restored to traffic one month after the discovery of the crack. Interference with rail traffic was limited to one period of six hours complete possession of the up and down lines on a Sunday and one period of four hours on a weekday.

RAPID RE-LINING OF A BLAST FURNACE.

A BLAST furnace at the Appleby-Frodingham branch of the United Steel Companies Limited, Scunthorpe, Lincolnshire, has just been re-lined in what is claimed to be the world-record time of 24 days. The furnace, designated No. 9, was taken off blast on Saturday, September 27, and, during the subsequent 36 hours, 426,000 gallons of water were put in to cool the contents. Demolition then began and by Friday, October 3, 1,400 tons of old burden, bricks and rubbish had been carted away. The total amount of material removed from the furnace, prior to re-lining was of the order of 3,000 tons, and, in addition, several hundred tons of steelwork had to be dismantled. Special railway lines were laid for conveying materials, and the skips normally used for charging the furnace were utilised for the removal of old burden and the delivery of new refractory bricks. For the re-lining operation carbon blocks were used for the hearth and bosh of the furnace and refractory bricks for the remainder of the stack. At the same time the opportunity was taken to enlarge the furnace to a diameter of 25 ft., as compared with 22 ft., before re-lining. It is estimated that this increase in size will enable an additional 600 tons of pig iron to be produced weekly in excess of the previous normal output of 3,800 tons. The furnace was re-lit at 10.30 a.m., on Monday, October 20. It is of interest to record that when this furnace was last re-lined, in 1946, the task occupied 56 days, while the time taken to re-line a similar furnace (No. 10), some years ago, was 43½ days. It is pointed out that the national average for this type of operation is four months, or 120 days.

THE B.R.M. CAR.—Rubery Owen & Co., Ltd., Darlaston, have confirmed that they have bought the assets of the British Racing Motors Trust, Ltd. The B.R.M. Trust will remain in being, and the purchasers do not intend to enter into the motor manufacturing business, or to engage in racing. A new engine may be designed for international Grand Prix racing, but if so, no announcement will be made until the engine is ready to race.

ALUMINIUM-SHEATHED ELECTRIC CABLES.

PIRELLI-GENERAL CABLE WORKS, LTD., EASTLEIGH.

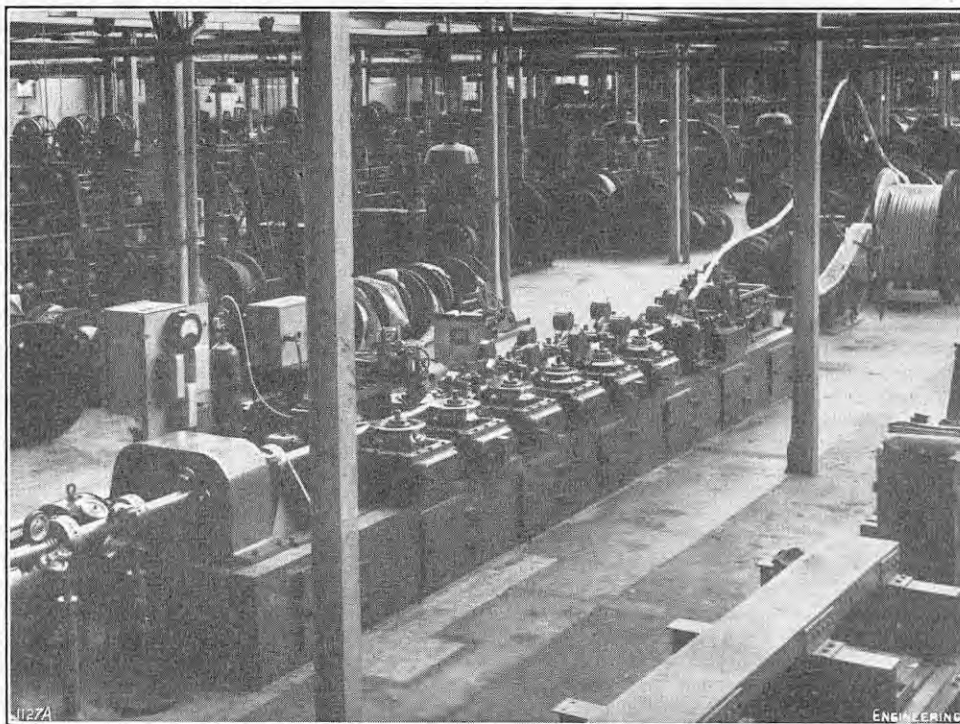


FIG. 1. SHEATHING MACHINE.

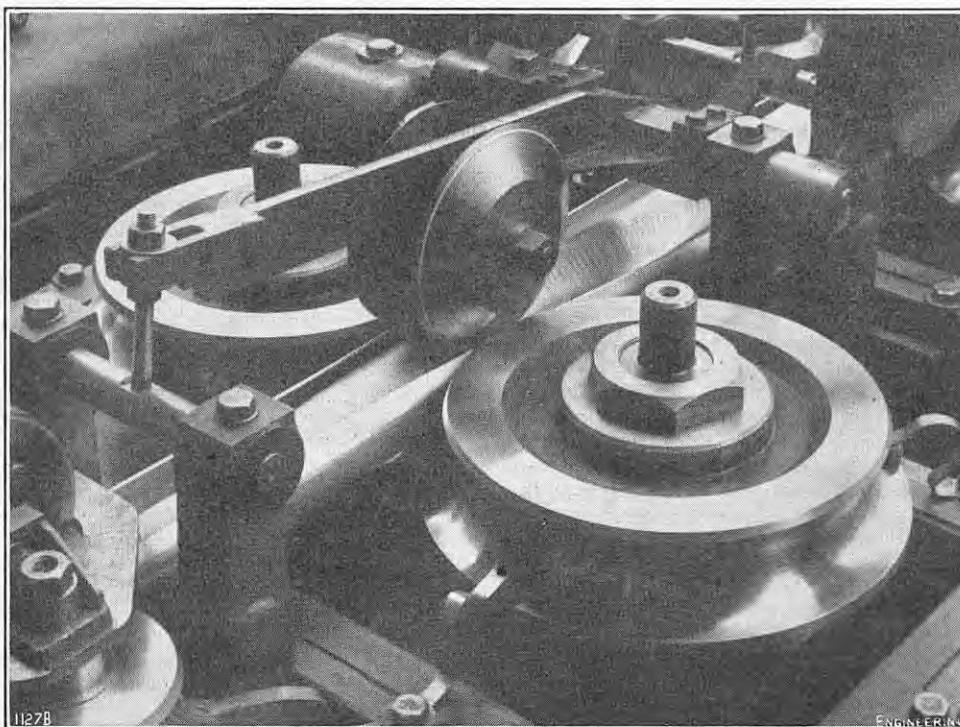


FIG. 2. TUBE-FORMING ROLLS.

THE MANUFACTURE OF ALUMINIUM-SHEATHED ELECTRIC CABLES.

RESEARCH into the possibilities of using aluminium instead of lead for sheathing electric cables has led to the development of several methods of overcoming the disadvantage of the high softening temperature of the former metal. Among the most prominent of these is the drawing of the insulated core into a pre-extruded tube of large diameter and then shrinking the latter down to the required size, as described on page 404, *ante*. Alternatively, an oversized tube can be extruded on to the core and cold reduction carried out simultaneously. A third method, which has been brought to the stage of commercial production as the result of work by the Pirelli-General Cable Works, Limited,

Eastleigh, and in the research laboratories of the General Electric Company, Limited, is to produce a tube from aluminium strip, close the butt joint by a longitudinal weld and then reduce the oversized sheath either by rolling down or corrugation. In this way, it is claimed, aluminium-sheathed cables with cores protected by any of the standard types of dielectric can be produced in lengths up to the maximum which it is convenient to handle and with diameters from about $\frac{1}{2}$ in. to 3 in. A further feature of this method is that the degree of flexibility can be varied between that obtainable with cold-drawn aluminium tubes and that of the traditional lead sheath.

In the manufacture of sheaths of this type, the aluminium strip is fed from a coil, of sufficient length for the cable in hand, into rotary shears. These shears cut the material to the exact width and trim both its edges so as to provide the clean

ALUMINIUM-SHEATHED ELECTRIC CABLES.

PIRELLI-GENERAL CABLE WORKS, LTD., EASTLEIGH.

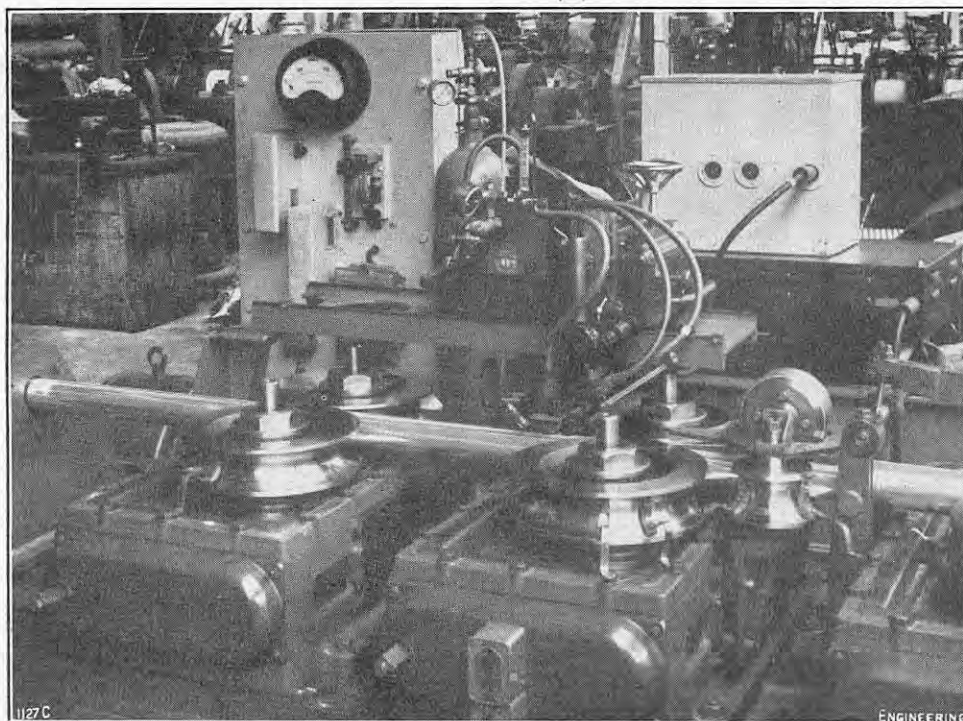


FIG. 3. TUBE-CLOSURE ROLLS AND WELDER.

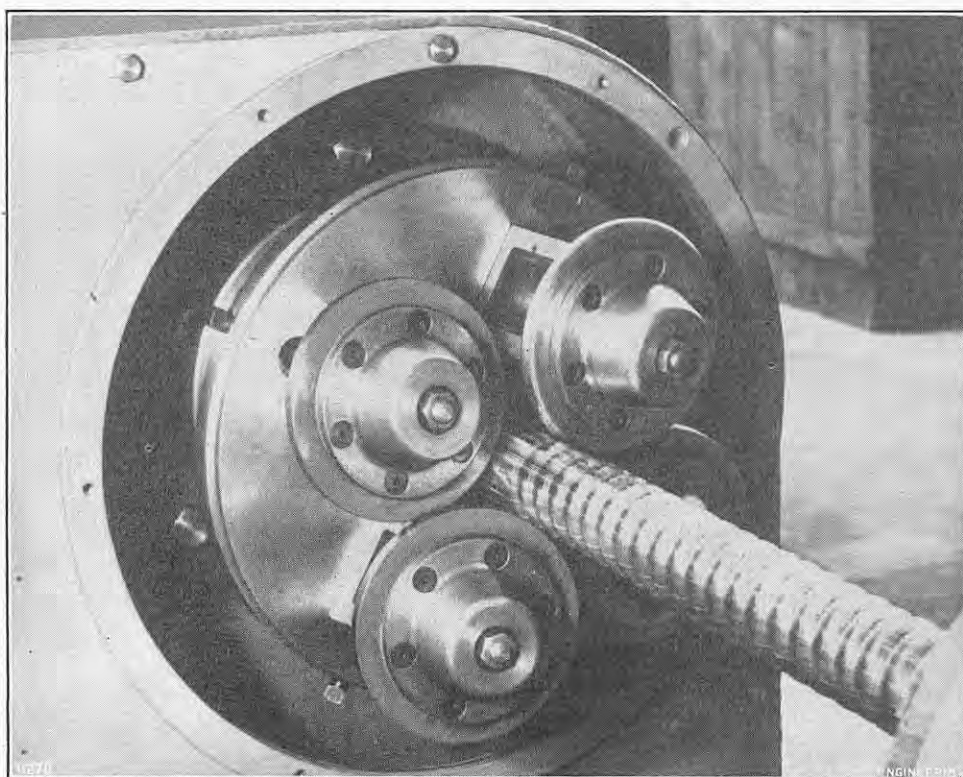


FIG. 4. CORRUGATING HEAD.

surface essential for welding. The external surfaces are then scrubbed by high-speed rotary scratch brushes and the strip is next passed to horizontal forming rolls where the cable core is inserted. In the next stage, the sheath is progressively closed in five further sets of rolls during the last of which the seam is closed for welding. A general view of the sheathing machine is given in Fig. 1, opposite, and Fig. 2 shows the rolls themselves, which are designed so as to prevent damage to the butting edges.

The next operation is to pass the formed and closed strip under a twin electrode argon-arc welding torch, which, as shown in Fig. 3, is mounted vertically above the closed seam and is attached to a compound slide so that it can be moved both longitudinally and transversely. The torch itself is supplied

from the mains through a three-phase to two-phase Scott-connected transformer, and its equipment includes a high-frequency spark discharge unit which allows the arc to be struck without the tungsten electrodes coming in contact with the work. This method enables an optimum weld contour to be obtained and allows its width to be varied to suit particular conditions.

In order to prevent contact between the core and the bead of molten metal under the weld, which would cause damage to the insulation and the liberation of harmful gases, a shaped metal shoe is inserted between the sheath and the core. This shoe may either be water-cooled or used to supply inert gas to the underside of the weld. Immediately after welding, the sheathed cable is passed through horizontal positioning rolls, so that any tendency

for the sheath to rotate and displace the seam in relation to the arc is counteracted.

The sheath diameter can then be reduced to the necessary value by rolling it down in a machine incorporating four curved-tapered rolls of deep section, which are driven at a fairly high speed. In this method the sheath is reduced in diameter without any alteration of form or appreciable increase in length, the surplus metal being absorbed in the sheath wall. With this process a useful range of cable diameters can be covered by a single size of strip. Alternatively, the internal diameter of the sheath can be reduced by corrugation, the pitch radius and depth of the corrugations being graded in relation to the external diameter of the cable so that the sheath just embraces the core. This is effected by the use of a radiused indenting roll and three thrust-opposing rolls which are driven at a speed determined by the pitch of the corrugation required. The corrugating head is illustrated in Fig. 4, on this page. This operation produces a cable which requires little effort to bend, and this bending can be effected repeatedly on diameters appropriate to lead-sheathed cable without damage or undue distortion. In fact, the bending performance is so good that this method is recommended for all cables where the design of the dielectric permits the use of an internally-corrugated sheath. An advantage claimed for both methods is that a single size of welded tube can be used for a range of core diameters by varying the amount of rolling down or corrugation.

Performance tests consisting of three reverse bends on a drum with a diameter 20 times that of the cable, have been made with a rolled-down sheath with satisfactory results. A corrugated-sheathed cable 1.6 in. in diameter was also subjected to six reverse bends on a drum with a diameter 12 times that of the cable. This more severe test was made to discover whether a corrugated sheath equalled or surpassed a lead-sheathed cable in bending capacity without showing cracks or excessive local distortion. The depth, radius and pitch of the corrugations are based on this requirement.

Tests have also shown that the central fusion zone of the weld, on account of its greater thickness, is stronger than the parent metal and that the portions adjacent to it are only slightly weaker than the remainder of the sheath wall. It has been found, moreover, that the sheath will function satisfactorily on oil-filled or gas-pressure cables without external metallic reinforcement. Even the initial volumetric expansion associated with the corrugated construction is negligible at the maximum working pressures so far employed in such cables.

Aluminium-sheathed cables manufactured in the manner just described have been used on the distribution system required for the recent extensions of the General Electric Company's estate at Wembley. The bulk of the cables employed, which included over 1,000 yards of 11-kV ring main, were buried directly in the ground. Some difficult duct runs, however, were successfully negotiated, the work being greatly facilitated by the flexibility and lightness of the corrugated cables used. There was no difficulty in making the necessary joints.

LIGHT-WEIGHT FIGHTER AIRCRAFT.—Folland Aircraft Ltd., Hamble, Hampshire, are to manufacture, as a private venture, prototype light-weight fighter aircraft which, it is estimated, will have a speed and climb performance equal to that of existing fighters and their immediate developments, and will be adequately equipped and armed for most of the duties of a single-seat fighter but at a cost of about one-third of that of contemporary fighter aircraft. The design, it is stated, makes use of the latest developments in aerodynamics and advanced methods of construction.

ELECTRICITY SUPPLY IN SCOTLAND.—The North of Scotland Hydro-Electric Board have published particulars of an extension to their Cowal hydro-electric scheme which was officially opened in September, 1951. This consists of the construction of a number of aqueducts and short tunnels which will collect the head waters of small streams at present flowing into Loch Riddon. Loch Riddon and Loch Striven will be connected by a tunnel and water will flow thence through an aqueduct and pipe to the existing power station on the shores of the lake. It is estimated that this extension will enable the output to be increased from 14 million to 18.6 million kWh per annum.

NOTES ON NEW BOOKS.

Machine Design Drawing Room Problems.

By PROFESSOR C. D. ALBERT, M.E. Fourth edition, revised John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, N.Y., U.S.A. [Price 5 dols.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 40s. net.]

It is something of a feat, in these days, to produce a book on machine drawing and design that is markedly different from other works on this subject; and almost equally unusual to review one which, while being based on college lecture notes, definitely offers something of interest to the draughtsman who already has reason to count himself skilled. Professor Albert, who is emeritus professor of machine design at Cornell University, produced the fourth edition of his book in 1948, but has now revised it by rewriting one chapter, adding a number of new "problems," and incorporating in his text the new Unified Standards for screw threads. The feature of the book which makes it particularly useful is that he has not been content merely to deal with the familiar and often too-elementary examples, but discusses a series of fairly complex designs (for example, the Hydra-matic automobile transmission and a thrustor-operated industrial brake, to mention only two at random) which are much more typical of the kind of problem actually encountered in drawing offices.

Die Gasturbine.

By DIPL.-ING J. KRUSCHIK. Springer-Verlag, Mölkerbastei 5, Wien I Austria. [Price 107s.]

SOME of the earliest published work on the gas turbine (notably that of Holzwarth) appeared first in German, and it was to be expected that German engineers should take a keen interest in the latest developments of this form of prime mover. Those who are reasonably familiar with the language will find in Dipl.-Ing. Kruschik's book a detailed and painstaking survey of those developments, backed by a fairly comprehensive bibliography and covering both theory and practice in every field in which the gas-turbine has been tried. Entropy diagrams, etc., are included, on folding plates at the end of the book; bound in place, unfortunately—they would be more convenient to use if supplied loose, in a pocket. A minor point for criticism is the small size of some of the line illustrations, but in general they are sufficiently clear for their small size to be no serious handicap. Some errors appear in the references given in the bibliography, but they are mainly in the spelling of names and of titles other than German; the numerical references to volumes and pages seem to be correct enough, so far as we have checked them, so that readers using them should not be misled.

Adhesives for Wood.

By R. A. G. KNIGHT, B.Sc.(Eng.), M.I.Mech.E. Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 25s. net.]

DURING recent years, great progress has been made in the development of adhesives, and for this the urgent needs of the aircraft industry have provided a powerful incentive. Much of the work has been done under the aegis of the various forest-products laboratories, and Mr. Knight, who is in charge of the Composite Wood Section at the laboratory at Princes Risborough, under the control of the Department of Scientific and Industrial Research, is able, therefore, to write upon the subject from extensive first-hand knowledge, which is reflected in the practical character of this book. It is vol. III of the series of "Monographs on Metallic and Other Materials," published under the authority of the Royal Aeronautical Society. The main divisions of the text, following the introductory chapters on adhesives and their use, glues of natural origin, and the synthetic-resin adhesives, deal at length with "Factors in Gluing Technique," a "Survey of Conditions under which Adhesives are Used," and "The Testing of Adhesives." Bibliographies are appended to the various chapters, and there is a useful glossary of the special terms peculiar to the art and practice of gluing—using that word in its widest sense.

Spindle Moulding.

By A. H. HAYCOCK. The Technical Press, Limited, Gloucester-road, Kingston Hill, Surrey. [Price 10s. 6d. net.]

THIS book is one of a series on "Principles of Machine Woodworking," and, in general, is planned on similar lines to the author's previous books in that series, which dealt, respectively, with *Sawing and Planing* and *Tenoning, Mortising and Boring*. It is a thoroughly practical work, starting with a description of the machine (with particular emphasis on the need for care in its use) and proceeding to consider in turn the various tools and attachments that can be employed; their design, maintenance and applications; the spindling of straight and curved work; spindling across the grain of the wood, and the methods of working with jigs. Line illustrations are liberally used, and are notably clear; indeed, the simplified style of these line drawings is one of the notable features of the book. Quantity-production woodworking has been so greatly extended in recent years, and the spindle moulder has contributed so much to that extension, that this book should be assured of a wide market.

TRADE PUBLICATIONS.

Engineering Plant.—Illustrations and brief descriptions of their principal products are given in a booklet received from Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, 17.

Stop Watches and Chronographs.—A brochure published by Camerer Cuss & Co., 54-56, New Oxford-street, London, W.C.1, deals with the selection and use of stop watches and chronographs, particularly for time-study and other industrial purposes. It also gives specifications of a number of Swiss instruments of this type and of wrist chronographs.

Tungsten-Carbide Burs.—A life of between 50 and 100 times that of steel burs is claimed for the Prolite cemented tungsten-carbide burs listed and illustrated in a booklet issued by Protolite Ltd., Central House, Upper Woburn-place, London, W.C.1. These burs are machine-ground from the solid, ensuring uniform cutting angles and perfect balance. They are available in a wide range of shapes and sizes, up to $\frac{1}{4}$ in. in diameter, and are suitable for working on very hard or tough materials. They are run at speeds up to about 75,000 r.p.m. The booklet also mentions a bur-resharpening service.

Building Boards.—A broadsheet has been issued by Celotex Ltd., North Circular-road, Stonebridge Park, London, N.W.10, describing a building board, Celobestos, made with a cane fibre core and surfaced with asbestos, that has high fire resistant and thermal insulation properties.

Sea-Water Trunking.—Imperial Chemical Industries Ltd., London, S.W.1, have issued a small booklet concerning Klimifer 5, a copper-nickel-iron alloy, with a high resistance to corrosion by sea-water. Available as either tube or sheet, and capable of being worked either hot or cold, of being welded or machined, this material is suitable for the construction of trunking or general pipe-work for marine use.

Electrical Equipment.—A pamphlet, entitled "Versatility," which has been received from Lancashire Dynamo and Crypto Ltd., Trafford Park, Manchester, 17, illustrates various applications of their electric generating plant and motors.

Portable Dictating Machines.—Leaflets giving details of their Emidicta portable dictation machines have been received from E.M.I. Sales & Service Ltd., Emidicta Division, 363, Oxford-street, London, W.1.

Concentric Connectors.—A range of extra-high tension connectors is described in a brochure received from the Plessey Co. Ltd., Ilford, Essex.

V-Belt Drives.—J. H. Fenner & Co., Ltd., Hull, have issued a comprehensive catalogue and handbook on their power-transmission equipment. In addition to giving detailed technical information on their standard V-belts and pulleys, variable speed drives, solid woven belting, mechanical rubber products, leather washers, friction clutches, etc., the publication includes a section containing drive design data and formulae.

Ventilating Equipment.—We have received from the Sturtevant Engineering Co., Ltd., Southern House, Cannon-street, London, E.C.4, an illustrated brochure describing their fresh-air "positive" ventilation plant. The cold-air douche system of positive ventilation employs a centrifugal fan which draws air from outside the building and distributes it through ducts and adjustable downcomers placed at local hot spots.

Fluorescent Lighting Tubes.—Details of their white and coloured fluorescent lighting tubes are given in a leaflet received from the General Electric Co., Ltd., Kingsway, London, W.C.2.

BOOKS RECEIVED.

Charbons Activés. (Adsorption des Gaz et des Vapeurs.) By PROFESSOR C. COURTY. Gauthier-Villars, 55, Quai des Grands-Augustins, Paris (6e). [Price 4,500 francs.]

Ministry of Civil Aviation. Civil Aircraft Accident. Report on the Accident to Viking G-AHPD near Bordeaux-Mérignac Aerodrome on 8th May, 1951. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1s. net.]

Some Investigations into the Behaviour of Compound Beams in Pure Bending. By DR. E. C. B. CORLETT. Research Report No. 14. The Aluminium Development Association, 33, Grosvenor-street, London, W.1. [Price 7s. 6d.]

Nigeria. Annual Report of the Department of Civil Aviation, 1950-51. C.M.S. Bookshops, Lagos and Port Harcourt; S.I.M. Bookshop, Jos; and the Crown Agents for the Colonies, 4, Millbank, London, S.W.1. [Price 9d. net.]

Metal Industry Handbook and Directory. 1952. The Louis Cassier Company, Limited, Dorset House, Stamford-street, London, S.E.1. [Available only to subscribers to *Metal Industry*, at a combined subscription of 52s. per annum.]

The Design of Switching Circuits. By WILLIAM KEISTER, ALISTAIR E. RITCHIE, and SETH H. WASHBURN. D. Van Nostrand Company, Incorporated, 250, Fourth-avenue, New York 3, U.S.A. [Price 8 dols.]; and Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 60s.]

Portugal. Ministério das Obras Públicas. Laboratório de Engenharia Civil. Publicação No. 20. Principais Aspectos do Problema da Protecção das Madeiras, em Especial Contra o "Hylotrupes Bajulus." By TOMÁS J. E. MATEUS. Laboratório de Engenharia Civil, Av. Rovisco Pais, Lisbon, Portugal.

Swedish State Committee for Building Research. Bulletin No. 19. Om brobjärs stabilitet i vertikalplanet. (On Vertical Stability of Bridge Arches.) By SVEN G. BERGSTRÖM. With a summary in English. Offices of the State Committee, Arsenalsgatan 1, Stockholm. [Price 9 kronor.]

Sweden. Institution of Structural Engineering and Bridge Building. Bulletin No. 4. Dynamic Influences of Smoothly Running Loads on Simply Supported Girders. By ARNE HILLERBERG. (In English.) Institutionen för Brobyggnad, Stockholm, Sweden.

Basic Road Statistics, Great Britain. 1952. British Road Federation, 4A, Bloomsbury-square, London, W.C.1. [Price 1s.]

Manual of Seamanship. Vol. II. B.R.67 (2/51). H.M. Stationery Office, Kingsway, London, W.C.2. [Price 20s. net.]

Chemical Engineering Techniques. By PROFESSORS B. E. LAUER and RUSSELL F. HECKMAN. Reinhold Publishing Corporation, 330, West 42nd-street, New York 36, U.S.A. [Price 6 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 48s. net.]

"Maisie." Words and Music. By "L.B.S.C." Percival Marshall and Company, Limited, 23, Great Queen-street, London, W.C.2. [Price 12s. 6d. net.]

Report of the Chemistry Research Board with the Report of the Director of the Chemical Research Laboratory for the Year 1951. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 4s. 6d. net.]

A Half-Size Total Heat-Entropy Chart for Steam. Edward Arnold and Company, 14, Maddox-street, London, W.1. [Price 3s. 6d. net.]

Sub-Station Practice. By T. H. CARR. Second revised edition. Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 55s. net.]

The British Electrical and Allied Industries Research Association. Technical Report No. C/T 105. An Extension of the Momentum Theory of Wind Turbines. By H. H. ROSENBROCK. [Price 6s.] No. J/T 151.

Factors Influencing the Creep Resistance of Wrought Carbon Steels. By C. H. M. JENKINS and H. J. TAPSELL. [Price 21s.] No. L/T 251.

Dipolar Permittivity and Structure in Ketone-Paraffin Mixtures. By DR. V. DANIEL and K. H. STARK. [Price 9s.] No. L/T 278.

The Electrochemistry of Non-Aqueous Solutions. By DR. I. G. ROE. [Price 15s.] No. O/T 7.

The Bond-Strength of Galvanized-Steel Angle in Concrete. By DR. G. MOLE. [Price 12s.] No. U/T 125.

The Effect of Inductance on the Fine Transfer between Platinum Contacts. By J. WARHAM. [Price 12s.] Offices of the Association, Thorncroft Manor, Dorking-road, Leatherhead, Surrey.

Productivity Team Report. Zinc and Aluminium Die Casting. Report of a Productivity Team representing the British Zinc and Aluminium Die Casting Industry which visited the United States of America in 1951. Anglo-American Council on Productivity, 21, Tothill-street, London, S.W.1. [Price 4s.]

United States National Bureau of Standards. Applied Mathematics Series 25. Tables of the Bessel Functions $Y_0(x)$, $Y_1(x)$, $K_0(x)$, $K_1(x)$, $0 \leq x \leq 1$. The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 40 cents.]