EFFLUENT-TREATMENT PLANT FOR TANK FACTORY.

During the second World War, the Cadillac Motor Car Division of the General Motors Corporation devoted its whole productive capacity to armaments. In particular, the Detroit plant was engaged in the building of M-5 and M-24 tanks. Immediately after the end of the war, the Cadillac Division was appointed design agency for the United States Army light-tank team. Matters progressed slowly at first, but in 1949 the company undertook a detailed study of tank production, in particular of engines, and in August, 1950, received a contract from the Army Ordnance Corps to build the 25-ton T41-E1 Walker Bulldog tank. A disbanded works known as the Bomber Plant was made available for the setting-up of a manufacturing works. At that time the 2 million sq. ft. site contained no machinery and was being used as a store, but during the second World War it had been occupied by an aircraft assembly plant. The site is situated at the south-western edge of Cleveland, Ohio, and is about ten miles from Lake Erie. This situation and the fact that the plant was located in the State of Ohio imposed rigid conditions in connection with the disposal of works' effluent, and resulted in the design and construction of a treatment plant of unusual size and particular interest. The General Motors Corporation had, in the past, devoted much attention to the question of river pollution and had installed treatment plants in many of its works. It was known, however, that river-pollution laws of the State of Ohio were unusually strict and it was realised that elaborate plant for the treatment of the works effluent would have to be installed. Apparently no attempt had been made to deal with the matter when the aircraft assembly plant was in operation, but that is sufficiently explained by the difficulty, or impossibility, of obtaining the necessary equipment during the war and also by the fact that a degree of pollution will be tolerated during war which would not be permitted in peace time. Furthermore, the volume and quality of effluent from an aircraft-assembly plant would be very different from that produced by the machine shops of a tank-building factory.

Fig. 1. General View of Plant.

Fig. 2.

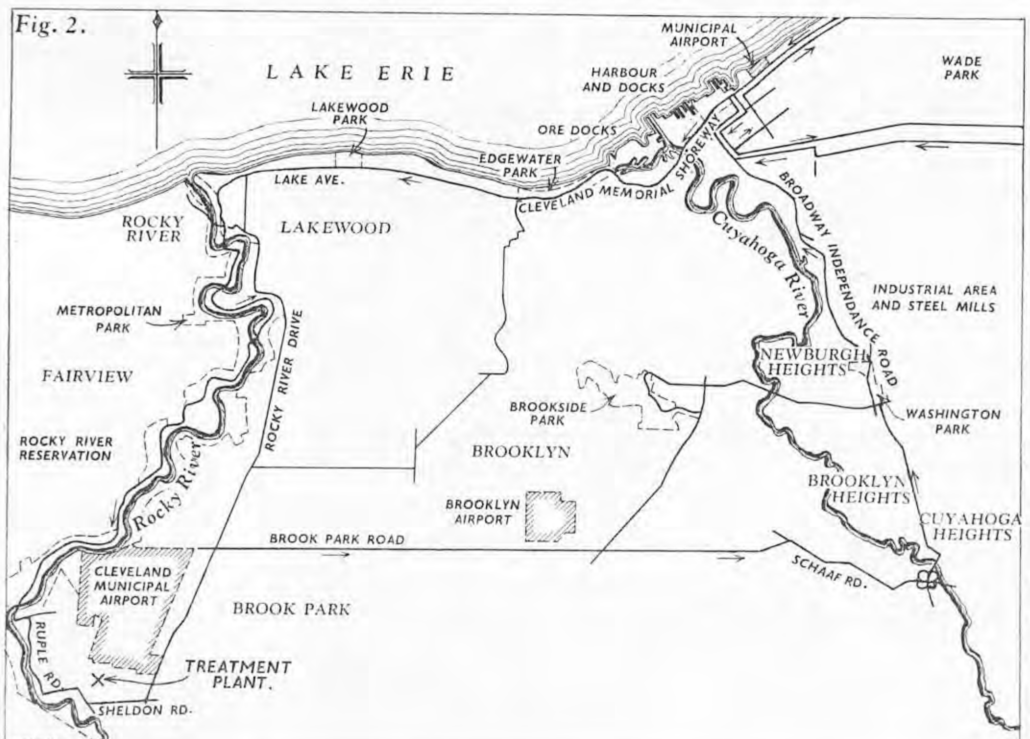
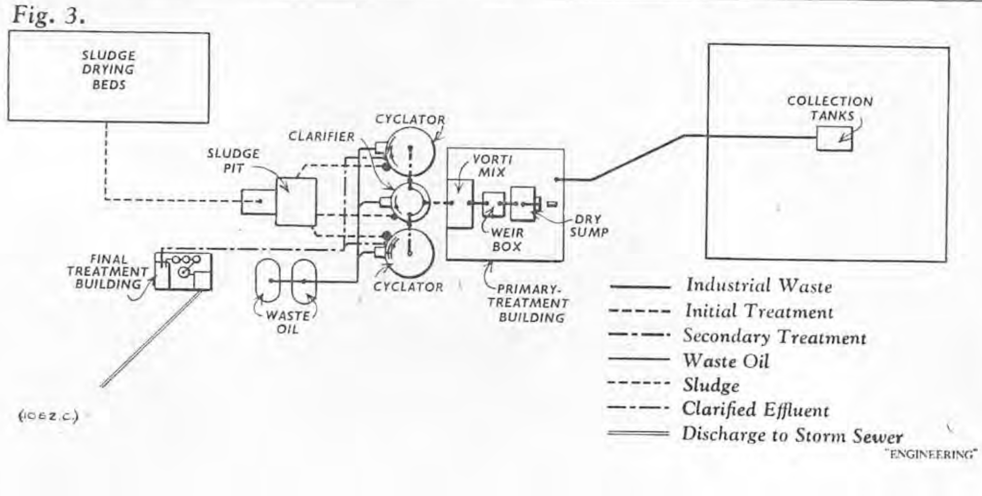


Fig. 3.



The importance of this question on river and stream pollution will be evident from the map reproduced in Fig. 2, on this page. This shows that the south-western edge of the city of Cleveland is particularly well supplied with parks and recreation centres. The bathing and other facilities on the south shore of Lake Erie would be unfavourably affected by any serious pollution of the Rocky River, and that river itself is enclosed in a 14,000-acre recreational reserve which is administered by the Cleveland Metropolitan Park Board. In the interest of fish preservation, this Board has imposed anti-pollution regulations even more strict than those of the State of Ohio. The plant is actually situated on, and discharges into, a stream known as Abrams Creek. This is not shown on the map, but it is a tributary of the Rocky River.

The treatment plant was required to deal with 550 U.S. gallons per minute of works effluent on a 24-hour basis; or 792,000 gallons per day. Actually, as constructed, it is capable of handling 750 gallons per minute, or 1,080,000 gallons per day. The effluent to be dealt with has as its main constituent an aqueous mixture or emulsion, containing a major portion of soluble cutting oils. No electroplating operations are carried on in the works, so treatment of the waste product from this type of operation has not to be provided for. The city sewers were so over-loaded that discharge from the works could not be dealt with even in purified form. This being so, it was necessary that arrangements should be made for discharge to the river. The purification standards of the Ohio State Department of Health were therefore studied and, on the basis of these, a treatment plant was designed. The procedure adopted was to break up the emulsions by adding acid and iron salts, separate the oil by gravity, and then cause the residue to flocculate and form a sediment by adding more iron salts. The liquor was then rendered alkaline with activated silica and lime and discharged to the river at a pH value of 10.

It was only in November, 1950, after the details of this plant had been worked out, that General Motors became aware of the fact that the quality of discharge to the Rocky River was controlled by the regulations neither of the State of Ohio nor of the city of Cleveland, but by those of the Cleveland Metropolitan Park Board, which had independent authority over the Rocky River and its surrounding 14,000-acre park land. The interests of this authority are particularly concerned with fishing, but the whole of the recreational facilities with which it administers would be unfavourably affected by the pollution of Abrams Creek and the river. There is a Girl Scouts' camp close to the tank factory. The regulations of the Cleveland Metropolitan Park Board are so severe that the General Motors Corporation formulated a protest; this, however, was ineffectual and the regulations had to be accepted and obeyed, and additional features were added to

EFFLUENT-TREATMENT PLANT FOR TANK FACTORY.

Fig. 4. SECTION A-A.

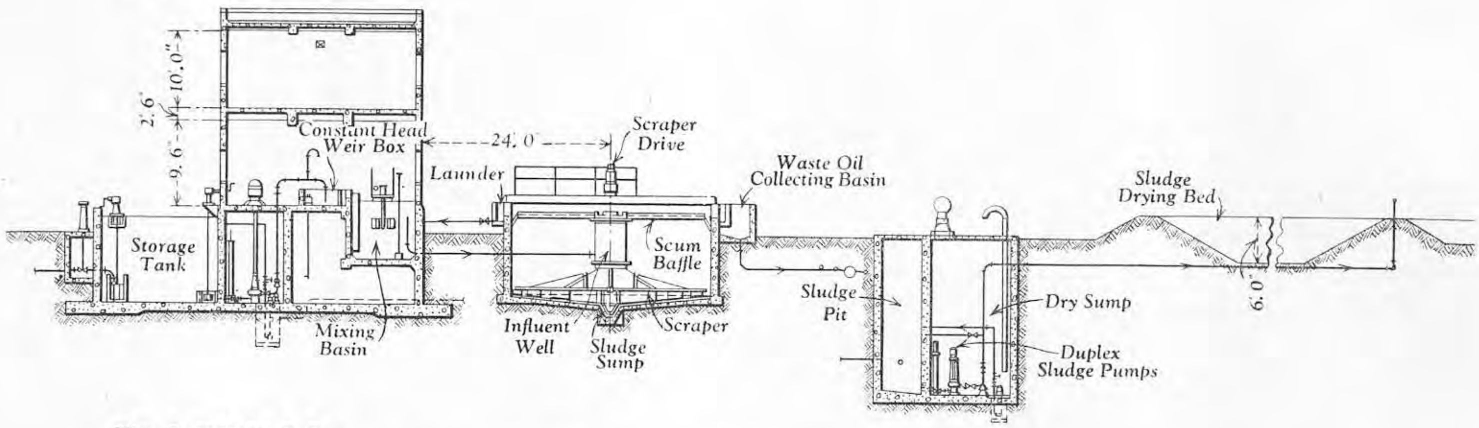


Fig. 5. SECTION B-B

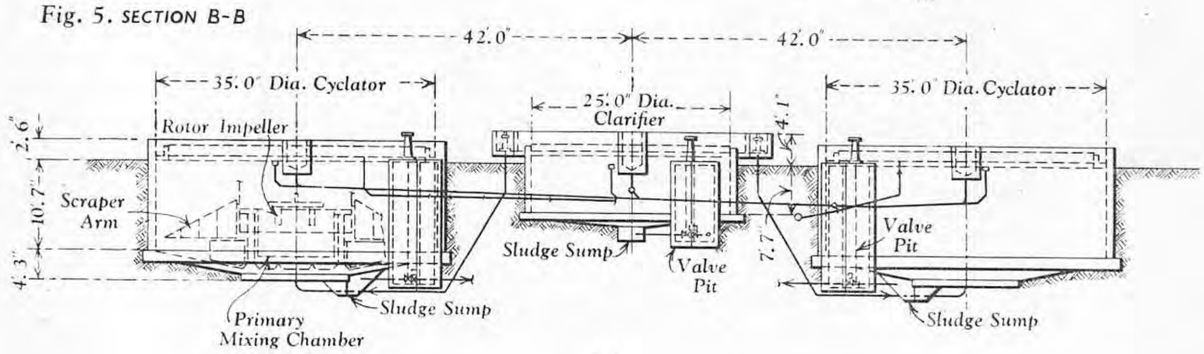
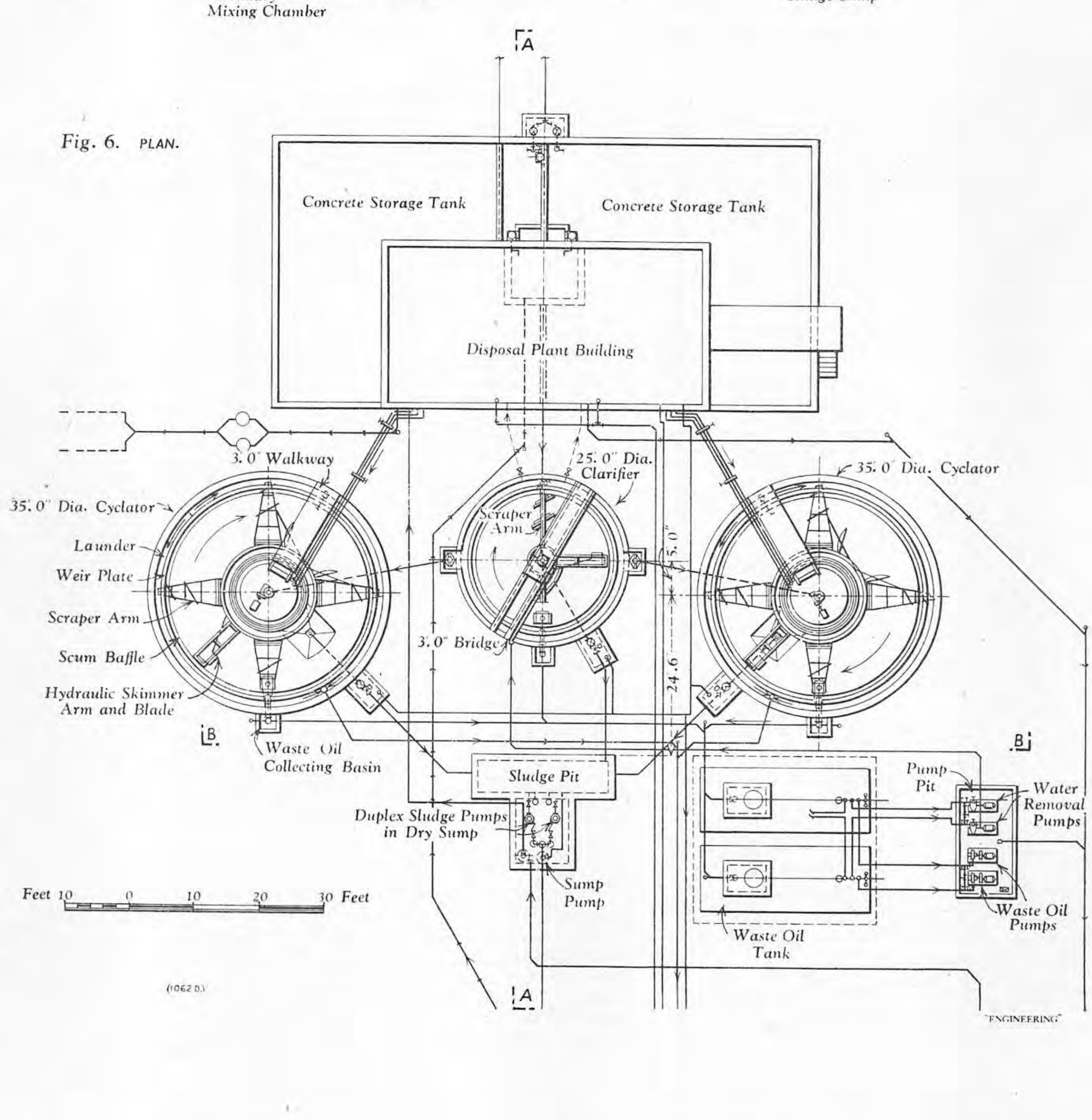


Fig. 6. PLAN.



ENGINEERING, NOVEMBER 28, 1952.

EFFLUENT-TREATMENT PLANT FOR A TANK FACTORY.

(For Description, see Page 681.)

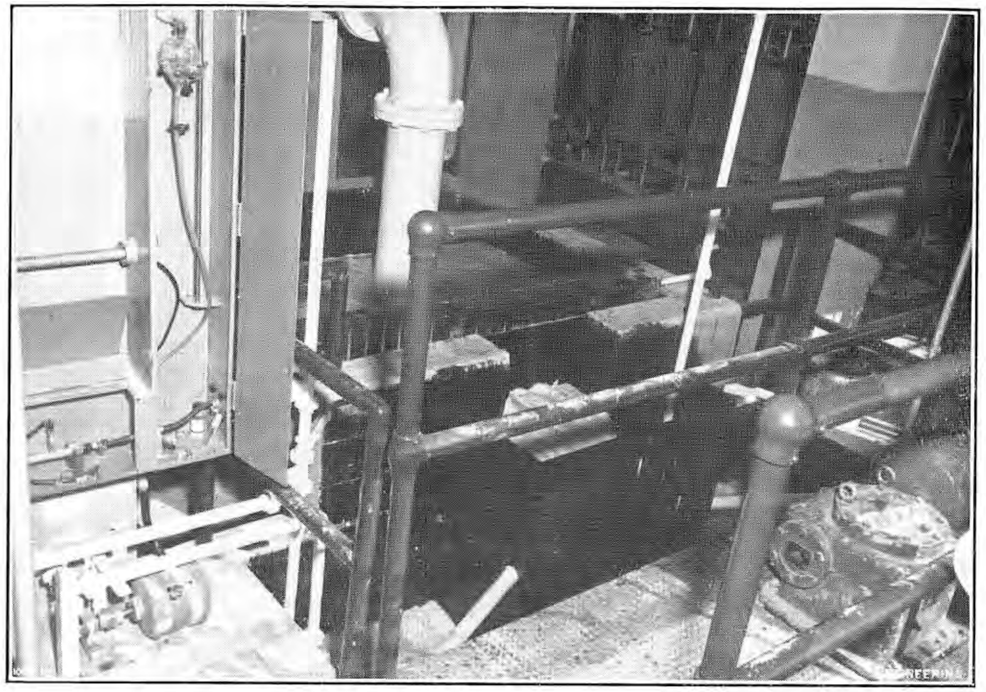


FIG. 7. MIXING BASIN.

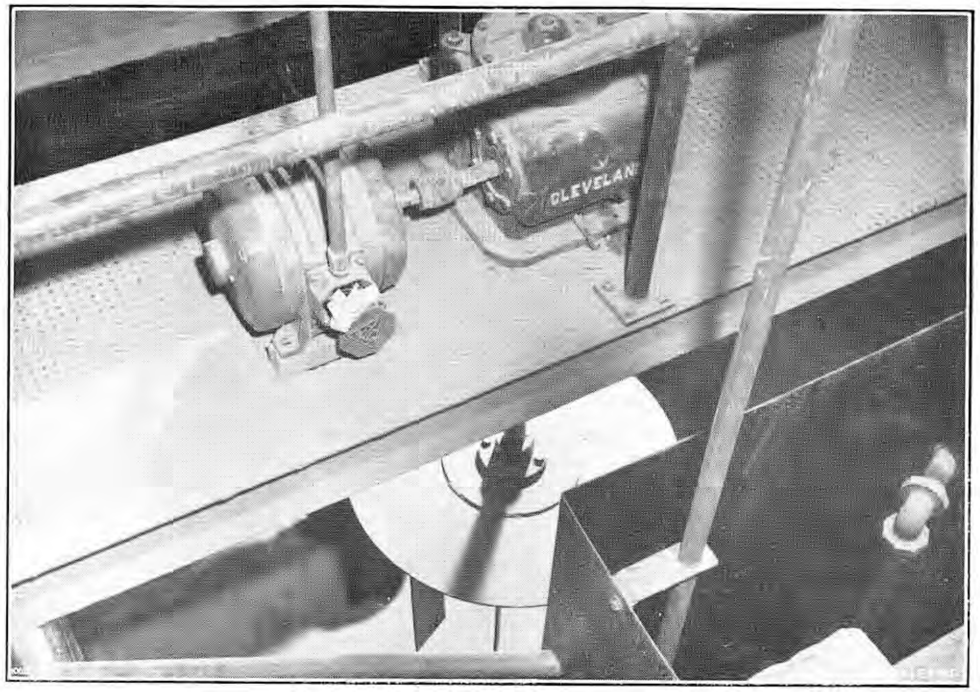


FIG. 8. MIXING PADDLE.

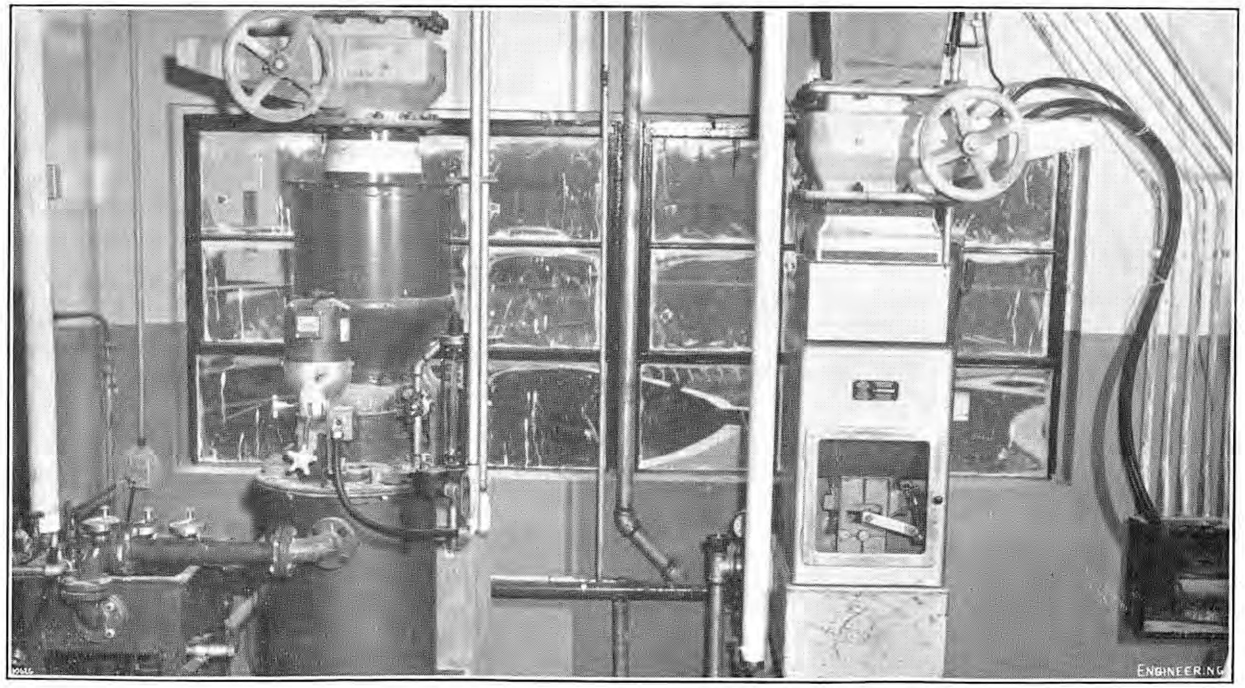


FIG. 9. ROTATING DISC FEEDER.

FIG. 10. FERRIC-SULPHATE FEEDER.

EFFLUENT-TREATMENT PLANT FOR A TANK FACTORY.

(*For Description, see Page* 681.)

Fig. 11. Cyclator and Clarifier.

Fig. 12. Sludge Beds.

Fig. 13. Pressure Filters.

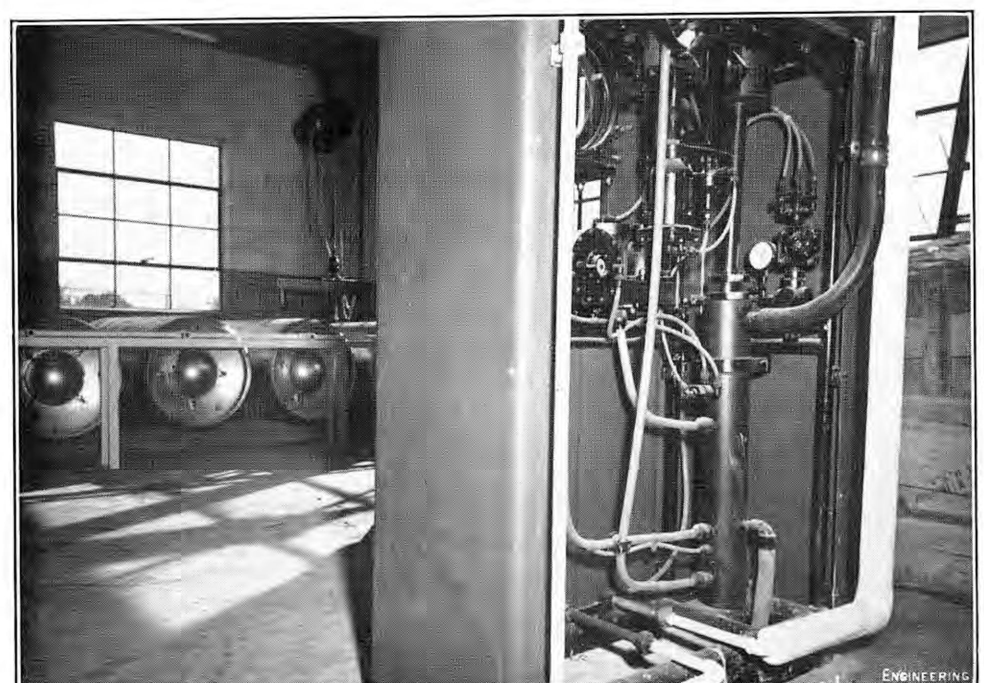


Fig. 14. Chlorine Feeding Apparatus.

(To face page 682.)

EFFLUENT-TREATMENT PLANT FOR TANK FACTORY.

Fig. 15.

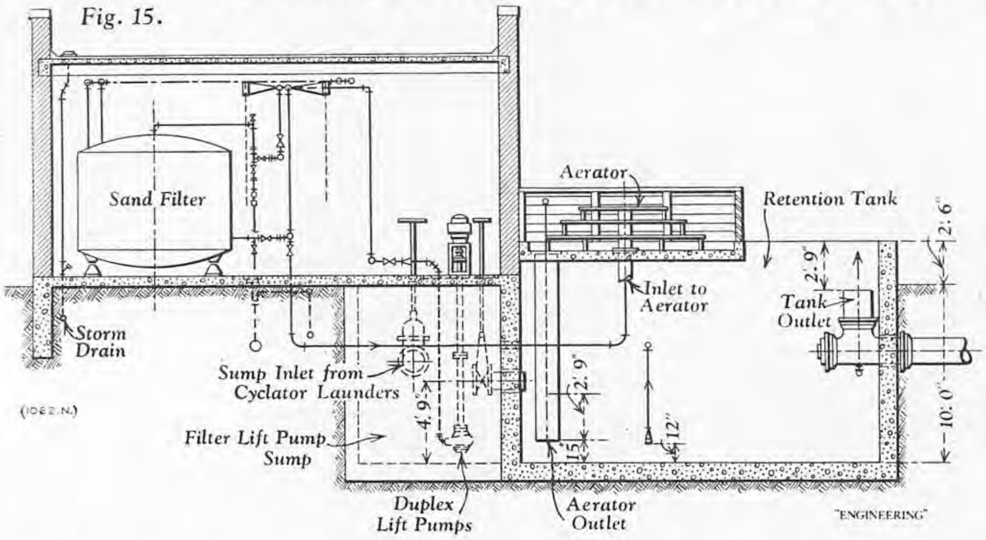


Fig. 16. Cascade Aerator.

the plant covering further filtration, chlorination and aeration.

The Park Board require that effluent discharged into any "river, brook or stream" in its lands shall be in accordance with the following specification:

Specification of Purity.

1. No sanitary sewage shall empty into the industrial disposal waste.
2. Temperature of effluent as it enters the storm sewer, not to exceed 90 deg. F.
3. Turbidity, not over 25 p.p.m.
4. Colour, not over 50 p.p.m.
5. Dissolved oxygen, not less than 6·0 p.p.m.
6. Biochemical oxygen demand (5 day at 20 deg. C.), not over 10 p.p.m.
7. Coliform bacteria, not over 1,000 per 100 ml.
8. Suspended organic solids, not over 15 p.p.m.
9. Free acid, none.
10. pH, not less than 6·5 or over 10.
11. Visible oil, none.
12. Ether soluble matter, not over 15 p.p.m.
13. No inflammables.
14. No bulk solids produced in solid or semi-solid form.
15. No sludges or trash of any kind.
16. Upper limits of metals as follows:—
    Iron as Fe, 5 p.p.m.
    Chromium as Cr (hexavalent), 3 p.p.m.
    Zinc as Zn, 4 p.p.m.
    Copper as Cu, 1½ p.p.m.
17. Cyanides, not over 0·15 p.p.m.
18. Phenols, not over 50 parts per billion.
19. Chlorides as Cl, not over 250 p.p.m.
20. Sulphates as (SO_4), not over 300 p.p.m.

The figure of 1,000,000 gallons of water per day, carrying used cutting-oil emulsions, appears, and possibly is, extravagantly large, but in view of the very rigid conditions which have been imposed, it has been necessary to err, if at all, on the safe side. Actually, from a commercial point of view, the expense of this elaborate installation is not the concern of the General Motors Corporation. The United States Government owns the former Bomber Plant site and its permanent installations and as a consequence it is the Government which is required to pay for any permanent addition, such as the water-treatment plant. The cost of operating the plant falls, however, on General Motors, but it has been so designed that it is largely automatic in operation and labour costs are not heavy.

An outline sketch showing the main features of the plant is given in Fig. 3, on page 681, and a general view is given in Fig. 1. Briefly, it consists of two collecting tanks at the machine shop from which the liquor is pumped to the primary-treatment building in which sludge and oil are separated from the mixture, the residue passing to the final-treatment building in which it is chlorinated and aerated. Fig. 1 shows the primary-treatment building; the circular tanks in front of it are oil-recovery and sludging vats. Part of the final-treatment building can be seen on the left; the louvred casing houses the spray-type aerator which provides the final treatment before the refined effluent is discharged to the river.

Primary Treatment.

A cross-section of the primary-treatment building and the oil-recovery vat, which stands centrally in front of it, is given in Fig. 4, on page 682. Fig. 5 is a cross-section of the two sludging vats and the oil-recovery vat which lies between them and Fig. 6 is a plan of the building and vats. The two collecting and storage tanks situated below the machine shops each have a capacity of 120,000 gallons. As waste emulsion and other aqueous and oily wastes flow to them, a certain amount of preliminary mixing automatically takes place. The liquor is pumped to two 40-ft. by 40-ft. by 12-ft. deep concrete storage tanks in the primary-treatment building; they can be seen in Figs. 4 and 6. From these tanks, the liquor is pumped over a metering weir into a mixing basin fitted with a mixing paddle driven by an electric motor through gearing. The basin can be seen in Fig. 4, and Fig. 7, on Plate LV, shows the upper part of the basin and the weir on the right. The gearbox of the mixing paddle can be seen on the bridge on the right-hand side of this figure and is more clearly seen, together with the motor and paddle, in Fig. 8, on the same Plate.

Ferric sulphate and, when necessary, sulphuric acid, are added to the liquor in the mixing basin. The quantity of ferric sulphate is controlled by a rotating-disc type feeder situated on the upper floor of the building. It is shown at the left-hand side of Fig. 9, on Plate LV; the pillar on the right houses the automatic controller for the supply of lime to one of the sludging vats; it will be referred to later. The ferric-sulphate feeder is automatically controlled, in terms of the pH value of the effluent, from a pH indicator and recorder. This instrument is actuated by glass electrodes placed in a sampling line from the incoming stream. Sulphuric acid is supplied from the cylindrical tank to be seen in the right background of Fig. 10, on Plate LV. The acid is delivered by a pump, the operation of which is also controlled by the pH value of the effluent.

From the mixing basin the liquid flows continuously to the 25 ft. diameter oil-recovery vat, termed a clarifier. In the course of the operation carried on in the mixing basin, the emulsion begins to break up into a predominantly oily upper layer and a predominantly watery lower layer. This process continues in the clarifier, which is fitted with a rotating skimming blade which collects the surface oil and directs it to a side basin from which it passes to the waste-oil tanks, as indicated in Fig. 3. A proportion of the sludge settles in the clarifier and is directed to a central sump by a rotating scraper. It is then pumped to a large sludge pit situated below ground and in front of the clarifier, as shown in Figs. 4 and 6. After this separation, the liquid in the clarifier consists of an acid watery mixture containing broken emulsion. The liquid then passes to two sludging vats, termed cyclators, each 35 ft. in diameter. They are situated one on each side of the clarifiers. Fig. 5 is a cross-section through the cyclators and clarifier, and a view showing part of the clarifier on the right and part of one of the cyclators on the left is reproduced in Fig. 11, on Plate LVI.

More ferric sulphate, activated silica and sulphuric acid are added to the liquid in the cyclators. Lime is also continually supplied from the pillar controller shown on the right of Fig. 9. The lime feed is automatically controlled in terms of the alkalinity of the liquid, a pH value of about 10 being maintained. The iron salts in the alkaline solution precipitate as a spongy floc and tend to fall slowly to the bottom of the vessel. The floc tends to carry with it many minute particles of oil or other substances which are so nearly of the same specific gravity as water that they might take days either to float to the top, or sink to the bottom if left to themselves. The iron sludge is continually recirculated by currents of liquid in the tank, with the idea of more rapidly entangling and carrying down a large proportion of the oil or other non-aqueous particles. The cyclators are fitted with scraper arms which collect the sludge and direct it to a central sump. From here, together with its entrained particles, it is pumped to the sludge pit. The cyclators, like the clarifier, are furnished with rotating skimming blades which collect any surface oil in side compartments, from which it is pumped to the waste-oil tanks, as indicated in Fig. 3.

From the sludge pit, the sludge is pumped to two drying beds shown at the right-hand side of Fig. 4, in the background of Fig. 11, and in Fig. 12, on Plate LVI. Clay-pipe drains under these beds collect the watery fraction which drains from the sludge and return it to the mixing basin for complete re-treatment.

Final Treatment.

The effluent from the launders with which the cyclators are fitted passes through a 15-in. cast-iron drain to a retention tank in the final-treatment building; the tank is fitted with an overflow pipe leading to the storm sewer. Depending on the nature of the effluent at this stage, further ferric sulphate and lime may be added, the building containing a mixing basis fitted with a saddle to incorporate intimately these materials in the liquid, which is then forced through pressure filters. There are three of these operated in parallel. One can be seen in the cross-section through the plant shown in Fig. 15, on this page, and a view of the battery of three is given in Fig. 13, on Plate LVI. The filters each contain 20 tons of sand and gravel, the liquid being forced downward through a bed of progressive fineness. If, after this treatment, samples of the effluent show too high a bacterial count or too much oil or dissolved impurities, it may be returned to the primary-treatment building forre-circulation through the complete cycle.

This arrangement for re-treatment also applies after final treatment by chlorination and aeration. Both liquid chlorine and a solution of sodium chloride are added. The chlorine feeding apparatus is shown in Fig. 14, on Plate LVI, with the 2,000-lb. tanks of liquid chlorine behind. The cascade aerator, with which final treatment is carried out, is shown at the right-hand side of Fig. 15 and in Fig. 16, on page 683. It consists of three shallow trays made of copper-bearing steel arranged concentrically one above the other. The liquid enters from below through a central pipe. The trays have weirs around their circumferences, and the liquid, entering at the top through a spray nozzle at low velocity, cascades in a thin stream from one tray to the next. Final discharge is through an 18-in. stoneware pipe several hundred feet in length, which connects to a concrete sewer leading to the river. The plant was designed by Infilco, Inc., of Tuscan, Arizona, this company also supplying the cyclators, pressure filters, aerator and other items. Constructional work was carried out by the Birmingham Construction Company, of Birmingham, Michigan. The pumps were supplied by the Chicago Pump Company, of Chicago, Illinois.

LITERATURE.

Soil Mechanics, Foundations and Earth Structures.

By Professor Gregory P. Tschebotarioff. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 36, U.S.A. [Price 7 dols.] and McGraw-Hill Publishing Company, Limited. 95, Farringdon-street, London, E.C.4. [Price 59*s.* 6*d.*]

The author of this comprehensive treatise is professor of civil engineering at Princeton University. He has had extensive experience of civil engineering in Egypt and in the United States, as well as of teaching and research; in consequence, his book is essentially practical in its outlook, drawing freely upon experience to demonstrate the application of soil mechanics principles and of test results to engineering problems. The first chapter is introductory, and the second describes the geological formation of soils, with special reference to the geology of the United States. The succeeding eight chapters are devoted to the theory of soil mechanics: properties of particles, density, permeability and ground-water movements, consolidation, shearing strength, stability of slopes, stress distribution in soils, bearing capacity and earth pressure. Then follow chapters on the compaction and stabilisation of soils, and on site exploration and soil classification. The remainder of the book is devoted to the practical application of soil mechanics to engineering construction. Considerable space is given to the subject of foundations, from both design and constructional aspects, and further chapters deal with retaining walls, cofferdams, tunnels, dam construction, the effects of vibratory and repeated loading on soils, and the soil-engineering aspects of highway and airport construction.

The mathematical treatment is kept as simple as possible, and the practical applications of the various principles are always given prominence. Some instructive demonstration models, designed and used by the author at Princeton, are described, and should be of special interest to teachers of soil mechanics. Professor Tschebotarioff has made a life-long study of earth structures, and in the chapter on "Lateral Earth Pressures" he gives an extended account of theoretical and experimental work on this subject. The value of this chapter would have been enhanced by a critical review of the data presented, but this omission is partly offset by the subsequent chapter on the design of earth-retaining structures, in which he presents theories, based on his own researches, for the bracing of cuts in clay soil and for the design of anchored bulkheads. The subject of soil classification comes in an unusual place, about the middle of the book, following upon site exploration and sampling, though the closely-associated subjects of classification tests and particle-size classification appear much earlier in the book. There is no reference to the soil classification system given in the British Code of Practice, *Site Investigations*, though elsewhere in the book British sources are frequently quoted. The book is well illustrated, and most of the chapters end with some practice problems, with answers and, in many instances, with full solutions. There is a comprehensive bibliography.

Les Machines Thermiques.

By Dr. Paul Chambadal. Collection Armand Colin No. 276. Librairie Armand Colin, 103, Boulevard Saint-Michel, Paris 5e. [Price 260 francs.]

No adequate understanding of the operation of heat engines is possible without a knowledge of the thermodynamic principles exemplified in ideal and real power cycles. It is with this aspect of thermodynamics that Dr. Chambadal is mainly concerned in this recent addition to the engineering section of the "Collection Armand Colin." After considering the fundamental reversible isothermal and adiabatic transformations of ideal gases, the more general polytropic changes governing the actual compressions and expansions of real gases are discussed when these are, respectively, reversible and non-adiabatic, irreversible adiabatic and irreversible non-adiabatic.

Methods of estimating efficiency are then given for complete cycles as well as for the individual irreversible transformations making up actual cycles. Two chapters are occupied with the construction and use of indicator, temperature-entropy, Mollier and other diagrams for gases and vapours. Chapter V deals with steam cycles, with special reference to those of Rankine and Hirn, and explains the advantages to be derived from superheating and regenerative feed-water heating. This is followed by a chapter on gas engines, covering the Otto and Joule cycles, and containing an analysis of the performance of open-cycle and closed-cycle gas turbines in which the effects of reheat and intercooling are taken into account. Chapter VII affords an interesting survey of two fluid cycles which are designed to utilise more effectively the temperature difference between the hot and cold sources and to reduce the difference between the Carnot and Rankine efficiencies as the temperature of the hot source is increased. The thermodynamic properties of water vapour become unsatisfactory at high temperatures and, in spite of some shortcomings, mercury reasonably fulfils the requirements of a second fluid. Descriptions are given of mercury-water and gas-water cycles and mention is made of a new type of cycle proposed by M. Mercier.

Refrigerating plants using vapour compression, vapour absorption and permanent gases are dealt with in the first part of Chapter VIII, the second part being devoted to the features which, under appropriate conditions, can make the heat pump so attractive. The two following chapters deal briefly with the performance of internal-combustion engines and with velocity diagrams pertaining to steam and gas turbines. The last chapter outlines the mode of action of centrifugal and axial compressors. A surprising amount of material is contained in this small volume, and, though the exposition is compact, it is by no means superficial, but is well abreast of modern developments. Dr. Chambadal has done for applied thermodynamics what the late Professor Fabry's earlier volume did for pure thermodynamics. His book will serve as an indispensable companion to the volumes on internal-combustion and steam engines that have already, appeared and to others that are projected in this series.

Concrete Roads.

By F. N. Sparkes, M.Sc., M.I.C.E., and A. F. Smith, B.Sc., A.M.I.C.E., A.M.I.Mun.E. Edward Arnold and Company, 41, Maddox-street, London, W.1. [Price 80*s.* net.]

The authors of this work (which is Vol. XI of the Roadmakers' Library) are well qualified to deal with their subject, as they occupy responsible technical positions with, respectively, the Road Research Laboratory, where Mr. Sparkes is head of the Concrete Section, and the Surrey County Council, with whom Mr. Smith is serving as assistant county engineer. In publishing the results of their close study of the design and production of good concrete, and of the behaviour of indifferent concrete on ill-prepared foundations, they have succeeded in exposing the underlying causes of the shortcomings of much of the material broadly classified as concrete in the past, and have traced its evolution from a slumpy agglomeration of one part cement, two of sand and four of aggregate to its present uniformity, which can be achieved with almost mathematical precision by the application of the basic rules of water-cement ratio, and by batching by weight. The case for a strict control of quality is ably stated and is well illustrated by the fact that, whereas the total variation allowed by the British Standard in the tensile strength of mild steel is 13 per cent., the crushing strength of cubes made from the concrete may vary from the mean on one job by 100 per cent., or even more.

In arrangement, the book is rather curiously irregular; for example, Chapters 5 and 13 describe modern machinery as applied to road-making, and current practice in the design of concrete roads (with special reference to the thickness of concrete slabs and base courses) is expounded in Chapters 2, 10 and 11. A more logical sequence might have been to consider in order survey, design and construction, leaving to the last (as, in fact, the authors have done) the consideration of prevalent defects in existing roads and the methods adopted in repairing them; but this is largely a matter of individual preference. American experience is drawn upon extensively, but reports and papers published elsewhere are also cited, and are conveniently listed in the bibliography. The book should commend itself to highway authorities, and to municipal and resident engineers, in spite of its high price.

Electricity Supply in New Zealand.—The report of the general manager of the State Hydro-Electric Department of New Zealand for the year ended March 31, 1952, records that, during the year, 3,362 million kWh were generated, an increase of 7·7 per cent. over the figures of the previous year. Of this total output, 3,040 million kWh were produced in the State water-power stations. A considerable amount of constructional work is being carried out and more is being planned.

Design of Steel Structures.—The British Constructional Steelwork Association, Artillery House, Artillery-road, Westminster, S.W.1, have issued their Technical Brochure No. 5, entitled *The Collapse Method of Design*, setting out the application of the plastic theory of bending to the design of mild-steel beams and rigid frames. The fundamental principles of the theory are discussed in Chapter I, together with their application to the cases of simply-supported and fixed-ended beams; later chapters are devoted to continuous beams, rectangular portals, non-rectangular portals and to the design of members subjected to an axial load as well as a bending moment. Sixteen worked examples are given in the text to illustrate the use of the method in frequently occurring design problems. Copies of the brochure may be obtained from the Association at the above address.

SOLVING VIBRATION PROBLEMS.

Fig. 5. (a) (b)

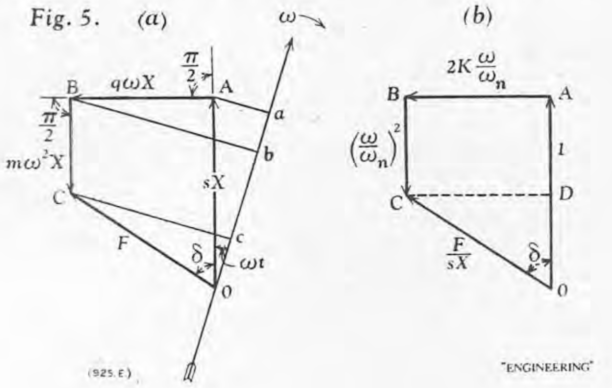


Fig. 9.

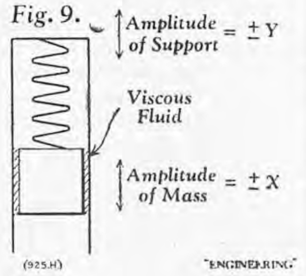


Fig. 6.

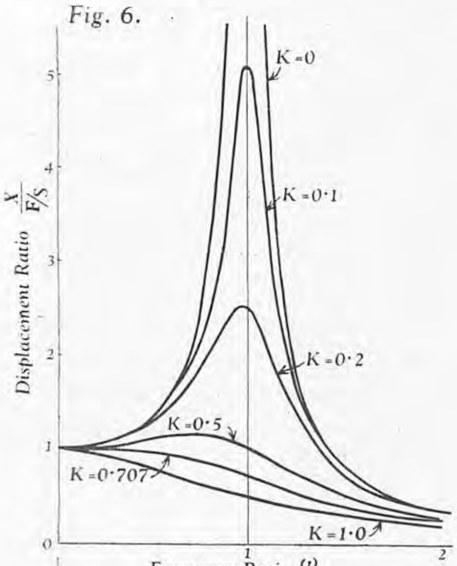


Fig. 7.

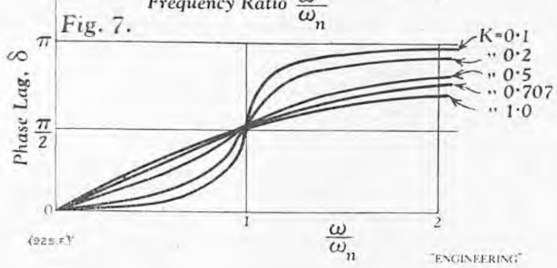


Fig. 8.

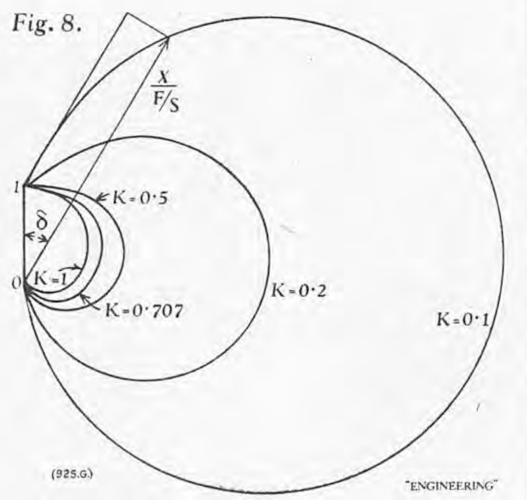
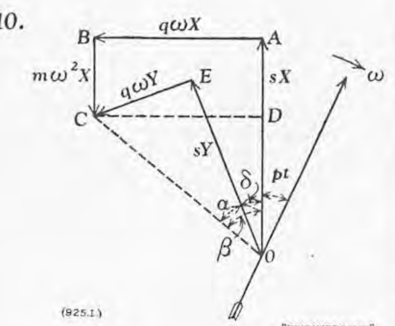


Fig. 10.



A VECTOR METHOD OF SOLVING VIBRATION PROBLEMS.

By C. H. Helmer, B.Sc., A.M.I.Mech.E.

(*Concluded from page 621.*)

Forced Oscillation.—As will be seen in the following cases, the vector method has its greatest value in the solution of problems of forced oscillation.

Case (i).—Consider again the simple system of Fig. 1, and assume that because of a disturbing force acting on the mass it oscillates in a steady state of simple-harmonic motion as described by the equation $x = X \cos \omega t$. Let f denote the instantaneous value of the external force applied to the mass to maintain the oscillation; then, equating the algebraic sum of the forces to the product of the mass times the acceleration, we have

$$f - q\dot{x} - sx = m\ddot{x}$$

or

$$m\ddot{x} + q\dot{x} + sx = f \quad . \quad . \quad . \quad (9)$$

Substituting the values for x, $\dot{x}$ and $\ddot{x}$ for simple-harmonic motion, we have

$$m\omega^2 X \cos(\omega t + \pi) + q\omega X \cos\left(\omega t + \frac{\pi}{2}\right) + s X \cos \omega t = f \quad . \quad . \quad . \quad (10)$$

The three terms on the left side of equation (10) could be represented by three vectors spaced successively at right angles in the same way as was done in Fig. 2 for undamped oscillation, but it is more useful to set them out in the sequence shown in Fig. 5 (*a*), above.

O A represents s X, the maximum value of the force exerted by the spring, drawn vertically (i.e. $\beta = 0$, compared with Fig. 2) for simplicity.

A B, drawn at 90 deg. counter-clockwise, represents $q\,\omega$ X, the maximum value of the viscous damping force, and, likewise, B C represents the maximum value of the force required to accelerate the mass, namely, $m\,\omega^2$ X. The instantaneous value of each of these forces is shown, as before, by their projections O a, $a\,b$, $b\,c$, respectively, on the time line which revolves clockwise at an angular rate ω, the angular frequency of the forced oscillation. Since equations (9) and (10) require that at every instant in the cycle the sum of the three forces represented by the terms on the left side of the equations, and hence by the lengths $b\,c$, $a\,b$ and O a, must be equal to the external force f as represented by the length O c in Fig. 5 (*a*), the vectors representing the maximum values must form a closed figure. The vector O C will, therefore, represent the maximum value F of the applied force, and its instantaneous value is $f = F \cos(\omega t + \delta)$, where the angle A O C = δ is the phase lag between the applied force vector O C and the corresponding displacement vector O A.

The quantities represented by the vectors in Fig. 5 (*a*) may with advantage be made non-dimensional by dividing the value of each by s X, as has been done in Fig. 5 (*b*). The displacement vector becomes unity, and the velocity and acceleration vectors are, $\frac{q\omega X}{sX} = 2K\frac{\omega}{\omega_n}$ and $\frac{m\omega^2 X}{sX} = \left(\frac{\omega}{\omega_n}\right)^2$, respectively, using the relationships of the above section on natural damped oscillation. The applied-force vector becomes $\frac{F}{sX}$ and its inverse is $\frac{X}{\frac{F}{s}}$, respectively, the "force ratio" and the "displacement ratio." The force ratio is the ratio between the maximum value F of the applied harmonic force and the force s X which would be necessary to give the system a static displacement X. The displacement ratio is the ratio between the amplitude X of the harmonic displacement, and $\frac{F}{s}$ the displacement which would be produced statically by a steady force F applied to the spring of stiffness s. The values of these two ratios can be found very easily from the geometry of Fig. 5 (*b*). Draw a line, C D, perpendicular to O A. Then, from the right-angled triangle O C D, we obtain the force ratio

$$\left(\frac{F}{sX}\right)^2 = \left\{1 - \left(\frac{\omega}{\omega_n}\right)^2\right\}^2 + \left\{2K\frac{\omega}{\omega_n}\right\}^2$$

Hence, by taking the square root and then inverting, we get the displacement ratio

$$\frac{X}{\frac{F}{s}} = \frac{1}{\sqrt{\left\{1 - \left(\frac{\omega}{\omega_n}\right)^2\right\}^2 + \left\{2K\frac{\omega}{\omega_n}\right\}^2}} \quad . \quad (11)$$

Also, from the same triangle O C D, the phase lag δ is given by

$$\tan \delta = \frac{2K\frac{\omega}{\omega_n}}{1 - \left(\frac{\omega}{\omega_n}\right)^2} \quad . \quad . \quad (12)$$

The value of $\frac{X}{\frac{F}{s}}$ from equation (11) plotted against the frequency ratio $\frac{\omega}{\omega_n}$ gives the familiar resonance diagram shown in Fig. 6 for different amounts of damping, expressed by the value of K. It will be observed that at low values of the frequency ratio the displacement ratio is little different from unity. When the frequency of the applied force is equal to the natural frequency, i.e. when $\frac{\omega}{\omega_n} = 1$, the system is said to be in resonance. Equation (11) shows that, at this frequency the displacement ratio is $\frac{1}{2K}$* and unless the damping factor, K, is fairly high, the amplitude of vibration will be relatively large. This condition is obviously a critical one, since the large displacements involved produce correspondingly high stresses and must, in most cases, be avoided or damage will result. At higher frequencies, however, the amplitude of vibration falls considerably—the displacement ratio tending to zero.

Fig. 7 shows the phase lag, determined from equation 12, plotted against the frequency ratio. With low values of the damping factor K, the phase lag δ remains small until the frequency approaches resonance, at which it is 90 deg. and then tends to 180 deg. at higher frequencies. It may appear strange that a force can be almost in opposite phase to the displacement produced. The explanation is that at high frequencies the force is mainly used to accelerate the mass and in the case of simple-harmonic motion this acceleration is always directed toward the mean position, attaining its maximum value when the displacement is a maximum. Fig. 8 is a polar diagram of the displacement ratio $\frac{X}{\frac{F}{s}}$ plotted against the phase lag δ.

Case (ii).—The graphical solution of a vibration problem which occurs in practice even more frequently may be obtained by considering the analogous idealised system shown in Fig. 9. A mass is suspended on a spring and damping is provided by lubrication between the mass and the guides, as indicated in the figure, or by a suitably arranged

* The maximum value is very slightly greater than this and occurs at a slightly lower frequency. This fact has, however, little practical value when the damping is slight.

dashpot. We assume that the support is moved in vertical linear harmonic motion $y = Y \cos(\omega t + \delta)$ and that the mass responds with simple harmonic oscillation of the same frequency, viz. $x = X \cos \omega t$. The problem is to find the relationship in amplitude and phase between the movement of the support and that of the mass. This system has a practical counterpart in numerous cases of machine parts, instruments, etc., mounted on a floor, deck, bulkhead or other support when the latter is set in oscillation by some extraneous disturbance. The important case of a vibrograph will be discussed later.

Referring to Fig. 9, let the instantaneous displacement of the support be denoted by y and that of the mass be denoted by x, both measured from the mid-position. The forces acting on the mass are $s(y - x)$ due to compression of the spring and $q(\dot{y} - \dot{x})$ due to viscous drag.

Hence, equating the sum of the forces to the product of the mass and the acceleration, we have

$$q(\dot{y} - \dot{x}) + s(y - x) = m\ddot{x}$$

which on being re-arranged becomes

$$m\ddot{x} + q\dot{x} + s x = q\dot{y} + s y.$$

By substituting for displacements, velocities and the acceleration, we get

$$m\,\omega^2 X \cos(\omega t + \pi) + q\,\omega X \cos\left(\omega t + \frac{\pi}{2}\right) + s X \cos \omega t = q\,\omega Y \cos\left(\omega t + \frac{\pi}{2} + \delta\right) + s Y \cos(\omega t + \delta) \quad . \quad . \quad . \quad . \quad (13)$$

This equation can be represented by the vector diagram shown in Fig. 10. The maximum values of the three terms on the left side of equation (13) are represented by the three vectors, O A, A B and B C, as in case (i), and the maximum values of the two terms on the right of the equation are represented by the two vectors O E and E C at right angles to one another. The latter are drawn in the positions shown in Fig. 10, since their resultant O C must be equal to the resultant of the other three vectors. The amplitude and phase relationship can be found easily from the geometry of this vector diagram as follows.

Since

$$(O\,D)^2 + (D\,C)^2 = (O\,C)^2 = (O\,E)^2 + (E\,C)^2$$

we may write

$$(s X - m\omega^2 X)^2 + (q\omega X)^2 = (s Y)^2 + (q\omega Y)^2$$

or

$$\left\{(s - m\omega^2)^2 + (q\omega)^2\right\} X^2 = \left\{s^2 + (q\omega)^2\right\} Y^2$$

The non-dimensional form of the displacement ratio is obtained by dividing the last equation by s^2, re-arranging and taking the square root. Thus,

$$\text{since } \frac{q\omega}{s} = 2\,K\,\frac{\omega}{\omega_n} \text{ and } \frac{m\omega^2}{s} = \left(\frac{\omega}{\omega_n}\right)^2$$

$$\frac{X}{Y} = \sqrt{\frac{1 + \left(2\,K\,\frac{\omega}{\omega_n}\right)^2}{\left\{1 - \left(\frac{\omega}{\omega_n}\right)^2\right\}^2 + \left(2\,K\,\frac{\omega}{\omega_n}\right)^2}} \quad . \quad . \quad (14)$$

Plotting $\frac{X}{Y}$ against the frequency ratio $\frac{\omega}{\omega_n}$, gives the family of curves shown in Fig. 11. The general shape at the lower frequency ratios is much the same as in Fig. 6, but, in contrast, all the curves pass through the same point at $\frac{\omega}{\omega_n} = 1{\cdot}414$, after which the higher values of K give larger amplitudes than the lower values.

The phase lag between the maximum displacement, Y, of the support and the maximum displacement, X, of the mass, as shown by the angle δ, can be found from the fact that $\delta = \beta - \alpha$, where β is angle A O C and α = angle E O C, which are given by the relationships, easily obtained from the geometry of Fig. 10,

$$\tan \beta = \frac{q\omega X}{s X - m\omega^2 X} = \frac{2\,K\,\frac{\omega}{\omega_n}}{1 - \left(\frac{\omega}{\omega_n}\right)^2}$$

$$\tan \alpha = \frac{q\omega Y}{s Y} = 2\,K\,\frac{\omega}{\omega_n}$$

In order to illustrate the effectiveness of the methods described to solve vibration problems, the case of the vibrograph may be considered. This instrument is used for recording the vibrations of a floor, deck or other structure in situations where no rigid base is available for the drum carrying the paper on which the record is to be made. The instrument is shown diagrammatically in Fig. 12. The nearest approach to having a fixed base for the drum is obtained by supporting it on springs of comparatively low stiffness in order that this part of the instrument will have a natural frequency ω_2, much lower than ω, that of the vibration to be

Fig. 11.

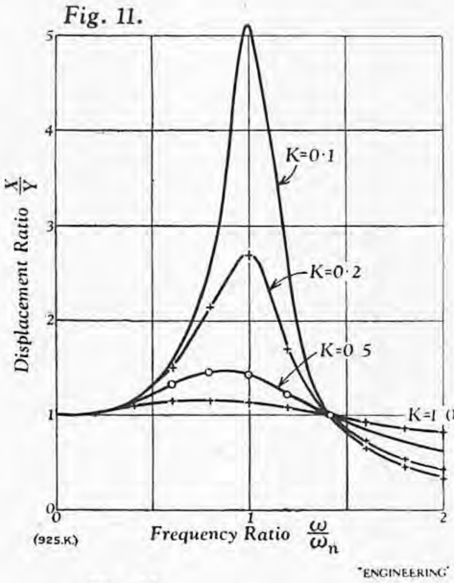


Fig. 12.

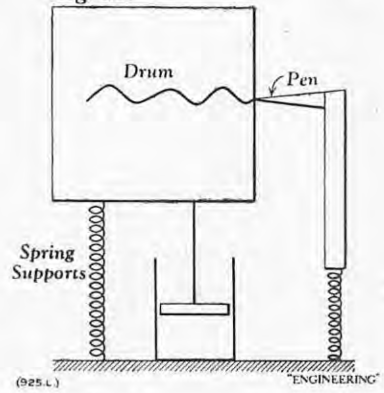
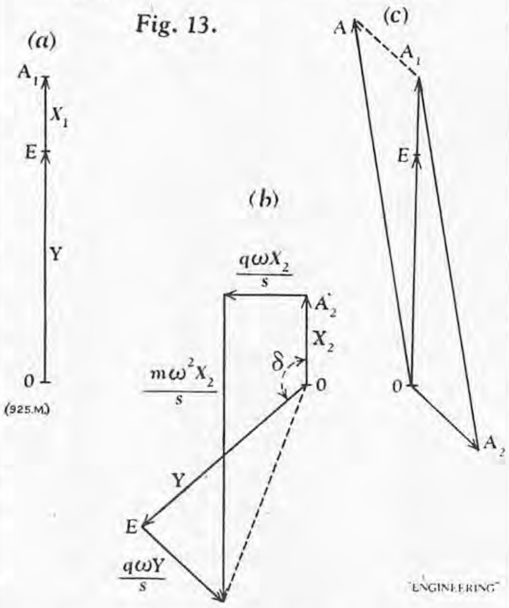


Fig. 13.



recorded. The ratio $\frac{\omega}{\omega_2}$ will then be high and the movement of the drum relatively small as is clear from Fig. 11, which also shows that the damping should be a minimum. The recording pen, Fig. 12, is required to give a faithful record of the vibration of the floor, or other structure, and it should consequently have a natural frequency ω_1, much higher than that of the vibration to be recorded, i.e., $\frac{\omega}{\omega_1}$ should be much less than unity. It will be noticed that essentially the same arrangement is used in a seismograph, and in the torsiograph, an instrument used for recording torsional oscillations of shafts.

Assume, for the purpose of the illustration, that the natural frequencies of the recording pen, and of the drum, are $\omega_1 = 150$ cycles per second and $\omega_2 = 15$ cycles per second, respectively, and that the record shows a simple-harmonic oscillation of 30 cycles per second. The problem is to find the true amplitude of the oscillation and, as it may sometimes be important, its phase in relation to the record given.

The instrument consists of two separate oscillatory systems: the drum and its supports and the pen and its support, the response of each system to the vibration of the floor being determined separately. In each system the disturbance is transmitted to the mass through the supports and they are, therefore, in the second category of forced oscillations previously considered, the general form of the phase diagram being as shown in Fig. 10, and the amplitude relationship is given by equation (14).

Using the figures suggested above we have, for the pen, $\frac{\omega}{\omega_1} = \frac{1}{5}$ and, assuming the damping of its support is negligible, $K = 0$. The phase diagram is shown in Fig. 13 (a), O E representing Y, the amplitude of the disturbance and O A_1, the amplitude, X_1, of the pen, both relative to a fixed reference point. These two displacement vectors are in phase, since it has been assumed that there is no damping in this system, and the ratio of their magnitudes is, from equation (14),

$$\frac{X_1}{Y} = \frac{1}{\left(1 - \frac{1}{25}\right)} = 1{\cdot}04.$$

Referring now to the drum, $\frac{\omega}{\omega_2} = 2$ for the figures given, and from equation (14), assuming the damping to be such that $K = 0{\cdot}2$,

$$\frac{X_2}{Y} = \sqrt{\frac{1 + 0{\cdot}64}{(1 - 4)^2 + 0{\cdot}64}} = 0{\cdot}41$$

where X_2 is the amplitude of vibration of the drum. Also from equations (15) and (16) $\tan \alpha = 0{\cdot}8$, hence $\alpha = 38$ deg. 36 min. and $\tan \beta = -0{\cdot}266$ from which $\beta = 165$ deg. 6 min., and since $\delta = \beta - \alpha$ we get $\delta = 126$ deg. 30 min. The phase diagram for this part of the instrument is shown in Fig. 13 (b), where O E is the amplitude, Y, of the disturbance and O A_2 the amplitude, X_2, of the drum, both relative to a fixed point.

Fig. 13 (c) shows the displacement vectors for the two systems in the same diagram. O E represents the disturbance and O A_1 and O A_2 are the responses of the pen and drum, respectively. The vector O E of Fig. 13 (b) has been turned clockwise through an angle δ to coincide with the direction of O E in Fig. 13 (a) and O A_2 has, of course, been turned through the same angle. This superposing of O E is necessary because the trace made by the pen on the drum is the motion of the pen relative to the drum which is given by the difference between the vectors O A_2 and O A_1, i.e. by the line A_2A_1 in Fig. 13 (c). This line transferred to the origin as O A represents the record made by the instrument and should be compared with O E which represents the actual vibration. The record will be a harmonic or cosine curve which has as its ordinates the instantaneous values of the displacement of the pencil relative to the drum, shown in the phase diagram by the projection of O A on to the time line as the latter revolves clockwise at the uniform rate ω. A simple calculation from the geometry of Fig. 13 (c) shows that the record has an amplitude 26 per cent. greater than the actual vibration. If the frequency of the vibration were near either that of the pen or the drum this error would have been larger. It is evidently necessary to estimate the error of the record in any given case before placing too much reliance on it and the above provides a comparatively simple and expeditious way of doing this.

The vector methods of solution described in this article are capable of further extension; for example, to the transient conditions which occur on starting a vibration, and of application to a variety of problems, such as the response of relays and servo-mechanisms, but it is hoped that sufficient has been given to introduce the methods and to demonstrate their effectiveness.

NIAGARA POWER DEVELOPMENTS.

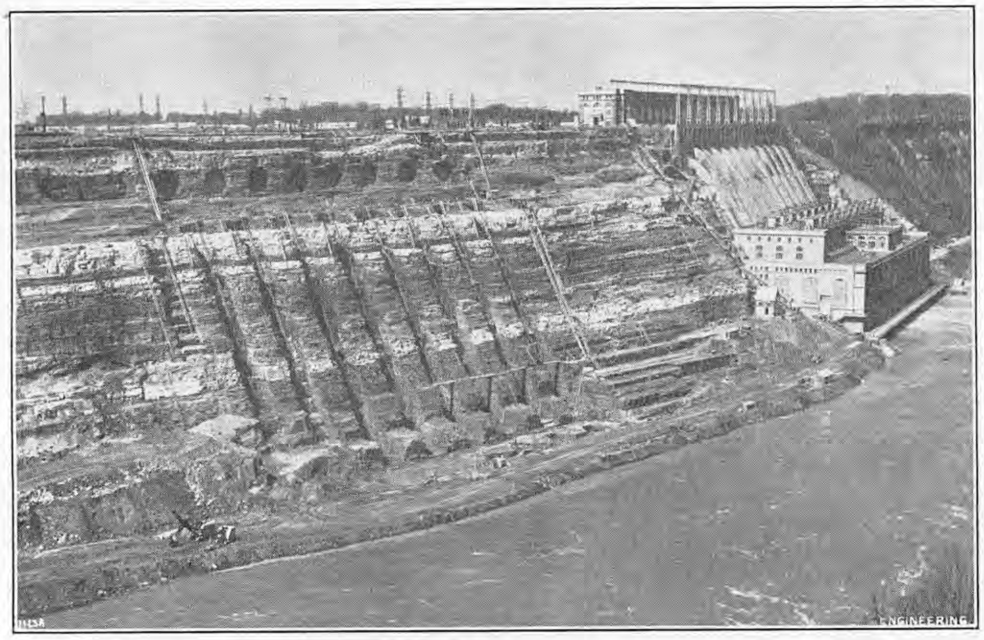


Fig. 1. Construction of New Station: Existing Station on Right.

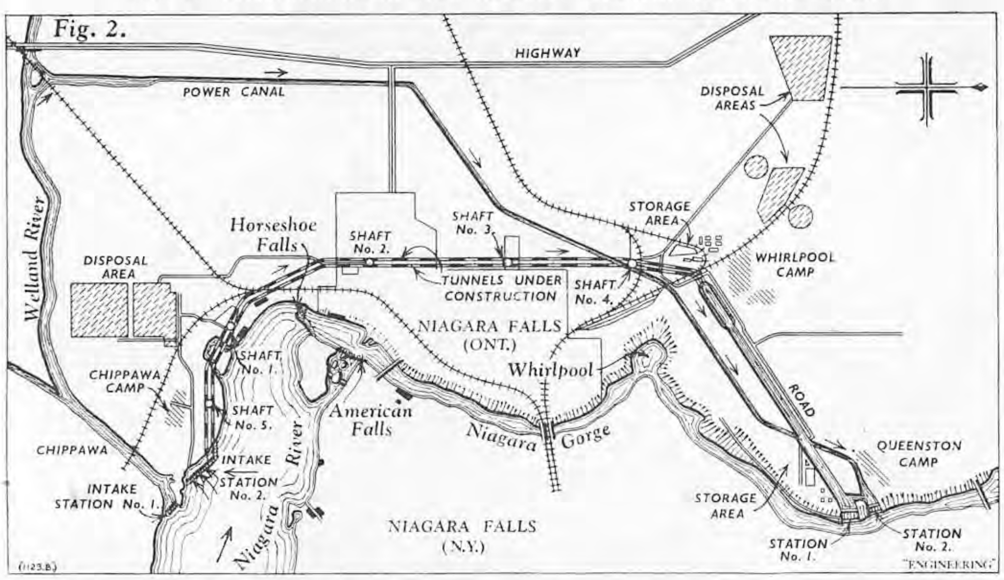


Fig. 2.

HYDRO-ELECTRIC POWER DEVELOPMENTS AT NIAGARA FALLS.

Work is now proceeding rapidly at Niagara Falls on a hydro-electric project of outstanding magnitude, which will ultimately increase by 1,200,000 h.p. (900 MW) the power derived from the Niagara river. The scheme, for which the Hydro-Electric Power Commission of Ontario is responsible, was started in January, 1951, after negotiations between the Canadian and United States Governments had led to a treaty defining the manner and extent to which each country might make further use of the water-power resources of the river for the generation of electricity. The agreement also ensured that any action which might be taken would not diminish the scenic grandeur of Niagara Falls. Briefly stated, the Canadian project involves the abstraction of water from the river at a point two miles upstream from the Falls, and its conveyance, by means of underground tunnels and an open canal, to a point adjacent to the existing power station at Queenston, six miles below the Falls. There, a new power station, to be known as the Sir Adam Beck-Niagara Generating Station No. 2, is to be constructed beside the other at the base of the 300-ft. cliffs of the Niagara Gorge. The progress of the work at the site of the power station is illustrated in Fig. 1, herewith, which also shows the adjacent No. 1 station, which went into service in December, 1921. It was described in Engineering, vol. 104, page 31 (1922). When the new station comes into use, the two will operate in conjunction, under unified control. This is expected to result in a considerable saving in operation and maintenance costs.

The general lay-out of both schemes may be followed from the map reproduced in Fig. 2. The water intake for the existing station is at Chippawa, at what was formerly the mouth of the Welland river. The flow of the latter, however, was reversed for a distance of $4\frac{1}{2}$ miles, to a point whence a canal, $8\frac{1}{2}$ miles long, was constructed to conduct the water to a forebay and gatehouse on the cliff top above the No. 1 power station. The intake for the new station is comparatively near that of the old, about a quarter of a mile downstream from Chippawa. Before its location was finally settled, extensive tests were made with the aid of a model of the upper Niagara, which was used also to determine the best type of intake structure. The initial requirement is an intake of 20,000 cub. ft. of water per second from the Niagara river, to be conducted to the power station through a single tunnel and an open canal. The intake for the tunnel will consist of a gathering tube 500 ft. long, lying in the river bed and parallel to, but at some distance from, the shore line, in the main current of the river. It will be a box-like structure of reinforced concrete and will have a maximum height and width of 45 ft. The water will be admitted through a series of ports arranged along the tube and these will always be at least 8 ft. below the surface of the river, so that the entrainment of ice during the winter seasons will be avoided. A short conduit will convey the water from the gathering tube to the tunnel. The final scheme involves an intake of 40,000 cub. ft. of water per second and the construction of a second and similar tunnel running parallel to the first, but separated from it by a distance of approximately 250 ft.

At present, a cofferdam is being built as a necessary preliminary to the construction of the gathering tube and conduits. In this work, large quantities of timber, employed in previous hydro-electric schemes, are being used, together with rock excavated on the present project. When the cofferdam is completed, a quadrilateral area of 14 acres will be enclosed, and this will have to be pumped dry. The bed of the river in the immediate vicinity of the intake will be dredged so as to form a funnel, which will improve the flow of water to the gathering tube and assist the passage of icefloes downstream in winter. Upstream, the shore line will be straightened by filling in a small bay and constructing a retaining wall 1,300 ft. long from the upstream end of the gathering tube.

Each of the two tunnels to be constructed, which will be the largest of their kind in the world, will be over 5 miles long and will pass directly under the city of Niagara Falls and the existing canal which feeds the No. 1 station. The depth of the tunnels has been dictated largely by the requirement that there should be a minimum thickness of 10 ft. of limestone rock over each tunnel to provide a solid roof and avoid interference with the development of the city. To facilitate the excavation of the tunnels, five vertical access shafts have been constructed at the positions indicated in Fig. 2. The shafts, the depths of which vary from 200 ft. to 330 ft., are spaced approximately 6,225 ft. apart, along a line midway between the two tunnels, and are connected to them by cross-cuts from working chambers excavated at the shaft bottoms. When the tunnel at present being constructed is completed, the cross-cuts leading to it will be sealed with concrete, thus leaving the shafts available for the construction of the second tunnel. Approximately 5,000,000 tons of rock must be excavated, and removed through the access shafts. For this reason, and also to permit the ingress and egress of workmen and machinery, each shaft is equipped with a cage containing skips, suspended from a 125-ft. high head-frame. The available lifting capacity in each case, with full allowance for safety, is approximately 50 tons per lift.

Each of the tunnels will have a rough diameter of 51 ft., and a finished diameter, when lined, of 45 ft. It has been estimated that 490,000 cubic yards of concrete will be needed to line each tunnel. The construction of the first tunnel is being undertaken in two stages. To expedite the work, excavation is being confined in the first place to the upper half of the tunnel. When this is complete, work will begin on the lower half. The driving equipment includes a drilling carriage or "jumbo," mounted on rails and supporting a number of hydraulically-operated drifter drills, so arranged that work can be carried on at three levels simultaneously. After the insertion and firing of the charges, the loose rock is picked up by electrically-operated shovels, having buckets of $2\frac{1}{2}$ cubic yards capacity, and is loaded into Diesel trucks which convey it to the nearest exit shaft. At the surface, the debris is transferred from the skips to a fleet of trucks and removed to one of the disposal areas. Fig. 3, on page 688, shows preliminary work in progress with a makeshift jumbo.

For most of their length, the tunnels will be about 250 ft. below ground level. They will be connected to the water-intakes by inclined tunnels, and similar tunnels will bring the water to the surface again before it enters the open canal through a gate, at a height not very different from that of the inlet. The canal will run from a point near the Niagara whirlpool to a forebay above the new generating station and will be in two sections. Its total length will be $2\frac{1}{4}$ miles, approximately. The first part, the construction of which is well advanced, will be 2,200 ft. long and will have a trapezoidal cross-section. This portion will traverse an ancient gorge full of glacial debris and will require to be walled with concrete. The remainder of the canal will have a rectangular section, about 200 ft. wide, and will be cut through solid rock, so that it need not be lined. The mean depth of the canal will be

70 ft. The work of excavation is illustrated in Fig. 4, herewith. Approximately 16,000,000 tons of earth and rock will have to be removed, but the finished canal will be capable of passing 40,000 cub. ft. of water per second, so that, when the project is completed by the construction of the second tunnel, it will not be necessary to construct a second canal.

Near the forebay, the canal will intersect the existing canal which conveys water to the Sir Adam Beck-Niagara No. 1 generating station, so that redistribution of the water between the two canals will occur. The situation is complicated by the fact that the water in the existing canal flows at 12 ft. per second, whereas the flow in the new canal will be at only $7\frac{1}{2}$ ft. per second, under full-load conditions. The construction of a hydraulic model of the intersection enabled those concerned to find a solution of the full-scale problem in which excessive turbulence and loss of velocity-head at the junction will be avoided. A final redistribution of the flows in the two canals will be made possible by a canal which will interconnect the forebays of the two stations. The headworks at the existing forebay include a large and prominent superstructure employed to raise and lower the gates. The corresponding structure at the new station will be smaller and less obtrusive. A gantry will be employed to lift the racks. At the existing station, the transformers and much of the switchgear are enclosed. In the case of the new installation, the transformers will be in the open, between the superstructure and the edge of the cliff, and the switchgear will be at the top of the escarpment on an island between the two forebays.

Before the construction of the power house could be started, it was necessary to blast and remove approximately 1,250,000 tons of earth and rock from the cliff face. The excavation of the powerhouse foundations has now been completed, together with tunnels and trenches for nine of the 12 penstocks, as may be seen from Fig. 1, which is a view from the American side of the river. To assist the work, the Commission built an access road, wide enough for two lines of traffic, which descends the flank of the cliff nearly to river level and continues to the village of Queenston. The penstocks will be constructed in steel and encased in concrete. Each will be about 500 ft. long, with an inside diameter of 19 ft., and will weigh 500 tons. The angle of descent to the turbines will be 60 deg. When the first stage of the project is complete, the powerhouse will contain seven turbo-generators having a total capacity of 525 MW (700,000 h.p.), and the powerhouse will be 570 ft. long, 60 ft. wide and 60 ft. high. When a further five units are added to complete the project, the total capacity will be 900 MW (1,200,000 h.p.) and the powerhouse will be 830 ft. long.

The site of the generating station permits 292 ft. of the 315 ft. difference in level between the intake and the powerhouse to be utilised. By this means, 50 per cent. more power will be produced than if the generating station had been built immediately below the Falls. It is estimated that four of the generators will be in operation by 1954 and a further three by 1955. The second stage of the project, which was authorised in June, 1952, is expected to be completed during 1956 or 1957. The cost of the first seven units is estimated to be 185,000,000 dollars and the total cost of the project 314,000,000 dollars, including generators, step-up transformers and high-voltage switchgear at the site. About 5,000 men are expected to be employed on the project at the peak of the construction periods. To accommodate them, three camps have been constructed, at Chippawa, the Whirlpool, and Queenston, respectively. These camps are virtually self-sufficient, and have fire protection, sanitation, catering, recreational and welfare facilities. A fully-equipped hospital containing 30 beds has also been built at the second camp. In order to dispose of the vast quantities of earth and rock which will be excavated, four main disposal areas have been established on the outskirts of the city, on land judged to be of low value. These areas, amounting to 640 acres, will provide sufficient space for the whole of the material and, upon completion of the project, they will be graded and improved in appearance by landscape gardening. Over 25 miles of roads have been built for the conveyance of material to the disposal areas. An automatic concrete-mixing plant to serve the project has been constructed near the site of the powerhouse, and another will be built at Chippawa. A total of 850,000 cubic yards of concrete will be needed.

NIAGARA POWER DEVELOPMENTS.

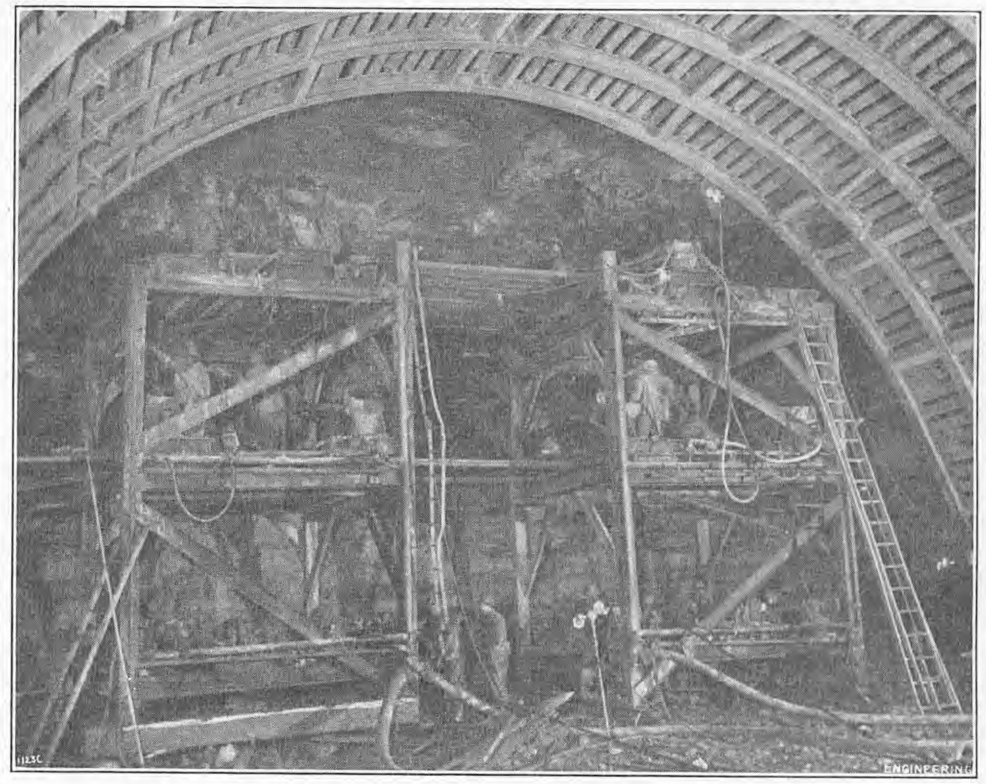


Fig. 3. Excavation of Water Tunnel.

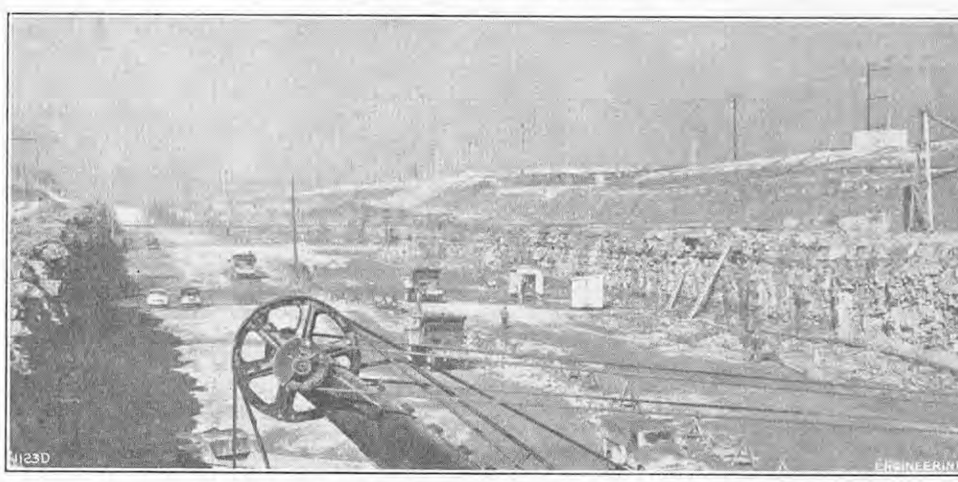


Fig. 4. Construction of Canal.

Mention was made earlier of the agreement between the United States and Canada on the further use of the Niagara river for power generation. Under the terms of this agreement, known as the Niagara Diversion Treaty, at least 100,000 cub. ft. of water per second must pass over the Niagara falls during the daylight hours of the late spring, summer, and early autumn seasons. This amount was judged necessary to preserve the scenic beauty of the Falls, which are a tourist asset of considerable value. During every night throughout the year, and in the daylight hours of the late autumn, winter and early spring, only 50,000 cub. ft. of water per second need pass over the Falls. This will allow both countries to make greater use of the river for power generation, particularly during the winter months when the demand for electricity is highest. The treaty also requires that remedial works be constructed in the rapids above the Falls to distribute the decreased flow of the river more evenly over the crests of the cataracts. Without these, 90 per cent. of the water would flow over the Horseshoe Falls, and 65 per cent. of this amount over the middle third of the cataract, leaving the flanks dry during periods of low water. The remedial works will distribute the water more evenly along the 2,600-ft. crest of the Falls and will lessen the erosion at the centre, besides ensuring that the grandeur of the Falls will be preserved.

Statistics show that the province of Ontario increased its urban population by 659,605 between 1941 and 1951, an increase of 25·4 per cent. This was the largest numerical increase of urban population in any Canadian province, but was closely followed by that in the neighbouring province of Quebec, where the increase was 640,371. Ontario also had the largest gain in rural population in the same period, the number, 150,282, representing a gain of 12·5 per cent. The mineral production of the province increased to a new high level in 1951, its value amounting to 437,085,000 dollars as compared with 366,802,000 in 1950, or 35·6 per cent. of the total for the Dominion. These figures indicate the growing prosperity of this, the most thickly populated region of Canada. The additional vast amounts of cheap electrical power which will be available when the new station comes into operation will undoubtedly bring an added stimulus to industrial development in Ontario and, although the resources of Niagara will then have been drawn upon almost to the maximum extent, the St. Lawrence river remains as a further potential source of supply of great magnitude.

SYMPOSIUM ON THE PROPERTIES OF METALLIC SURFACES.

We gave, on page 667, *ante*, a report of the preliminary proceedings of a general meeting of the Institute of Metals, held at the Royal Institution, London, on November 19, to discuss a series of 13 papers on "Properties of Metallic Surfaces." Two technical sessions, one in the morning and the other in the afternoon, were held and seven papers, which dealt with methods of examining metal surfaces and with the characteristics of those surfaces, were discussed at the morning session. They were: "Specialised Microscopical Techniques in Metallurgy," by Professor S. Tolansky, F.R.S.; "Radioisotopes in the Study of Metal-Surface Reactions in Solutions," by Dr. M. T. Simnad; "The Crystalline Character of Abrasive Surfaces," by Dr. P. Gay and Dr. P. B. Hirsch; "Diffusion Coatings," by Mr. D. M. Dovey, Dr. I. Jenkins, and Mr. K. C. Randle; "The Nature and Properties of the Anodic Film on Aluminium and Its Alloys," by Mr. H. W. L. Phillips; "Chemical Behaviour as Influenced by Surface Conditions," by Dr. U. R. Evans, F.R.S.; and "The Effect of Method of Preparation on the High-Frequency Surface Resistance of Metals," by Dr. R. G. Chambers and Dr. A. B. Pippard.

Professor A. H. Cottrell, Ph.D., B.Sc., who acted as *rapporteur* and introduced the seven papers, said that, in his paper, Professor Tolansky had considered the four main functions of the microscope, namely, magnification, resolution, contrast and topography. He had mentioned, in passing, Dr. C. R. Burch's reflecting objectives which used a mirror instead of a lens, and enabled one to obtain reasonable magnifications, such as 750 diameters, with a working distance of 14 mm. from the specimen. That technique would be used very much by metallurgists for studying the structures of metals at high temperatures where the ordinary methods became very difficult. Professor Tolansky then went on to discuss the methods of studying the features on the surfaces of metals, and he had divided these into two classes: "amplitude features," which revealed themselves by reflecting light having a different amplitude from the surroundings; and "phase features" which reflected light with different phases. A contrast of amplitude could be obtained by various methods, namely, dark ground illumination, oblique "pencils," and polarised light. The contrast of phase features was somewhat more difficult. The phase differences had to be turned into amplitude differences, and there were two main methods for doing that: they were the phase-contrast method and multiple-beam interferometry. Both were extremely sensitive and could reveal height differences of only about 5 Å.

The paper by Dr. Simnad, dealing with "Radioisotopes in the Study of Metal-Surface Reactions in Solutions," was a very comprehensive review; it contained 195 references. The most interesting feature in the paper was Dr. Simnad's experimental work on the study of passivity in chromate solutions. There were three theories to explain why exposing a metal in a chromate solution would render it chemically inert. First, there was the theory of Dr. T. P. Hoar and Dr. U. R. Evans, who stated that the chromium entered pores or cavities in the oxide film and sealed up those weak regions. The second theory was that the chromate formed a tight molecular film over the whole surface and prevented the corrosion molecules from reaching the metal. The third theory was that the chromate ion was adsorbed on the metal surface in such a manner as to satisfy secondary forces on that surface and, as a result, give the metal a low chemical affinity to its surroundings. Dr. Simnad had carried out experiments to test these theories, using a chromium tracer and various basis metals. With the chromium tracer he had measured the pick-up of radio-activity after immersing these metals in chromate solutions for various times, and his auto-radiographs showed quite definitely that the chromium concentrated at the anodic areas. This gave substantial support to the theory of Hoar and Evans.

The next paper was that by Dr. Gay and Dr. Hirsch, and was on "The Crystalline Character of Abraded Surfaces." These authors had conducted experiments with calcite crystals on which they had started by cleaving a surface. They had shown that this cleaved surface had a perfect crystal structure. They had then worked that surface by polishing and other means, followed by examination by electron diffraction technique. They had found that very soon a surface layer was created having either a liquid structure or a very fine crystalline structure, the size of the crystals being only a few atoms across. Drs. Gay and Hirsch had also shown that mechanical working of the surfaces penetrated to a depth of between 1 and 10 microns.

The next paper, by Mr. Dovey, Dr. Jenkins and Mr. Randle, dealt with diffusion coatings. Their main consideration comprised the various industrial processes for treating the surfaces of metals and alloys in which first some coating material was supplied to the surface, was then adsorbed in the surface, and subsequently diffused into the metal. Numerous important commercial processes were based on this method, such, for example, as the gas-carburising of steel and the Chromising process. The authors gave particular prominence to the method of exposing heated metals to volatile compounds, and suggested that when the molecules of coating metal got to the surface, the basis metal atoms were replaced by those of the coating metal.

Mr. Phillips, in his paper on "The Nature and Properties of the Anodic Film on Aluminium and its Alloys," stated that the anodic process was used in electrolytic condensers where the oxide film acted as the dielectric. It was used for protecting the metal against corrosion, and also for decorative purposes, because these films could be dyed with various colours. Considerable interest had been shown in the structure of the oxide film, and it was generally considered that the material in the film was basically non-conducting, and that it was porous. There was much interest in the question of the chemical constitution of the film. It was, of course, known that it consisted of aluminium oxide or aluminium hydroxide, together with adsorbed water. An unpublished work of the Research Laboratories of the British Aluminium Company suggested that freshly-deposited film contained two molecules of alumina combined with one of water, and that the film, in that condition was highly absorbent and that was why it would take up almost any dyestuff or similar materials.

The next paper was that of Dr. U. R. Evans on "Chemical Behaviour as Influenced by Surface Condition." Dr. Evans had emphasised that the surface condition might alter the probability of corrosion. The effect on the distribution of attack was of some importance. In particular, if the situation were such that the rate of attack was controlled by some external variable, for example, by the rate of oxygen supplied to the corrosive medium—then some rather strange results might be obtained. If the perfection of the surface were increased, the overall rate of corrosion on that surface would be reduced, but, on the other hand, the rate of corrosion in the few remaining imperfections might be increased. Hence, it was not always a good thing to improve the surface. It might be that, by leaving many imperfections on a surface, the corrosion would be distributed evenly among all of them. The other interesting feature of Dr. Evans's paper was his experimental method of studying the probability of corrosion. In this, he ruled scratches on the metal surface and studied the number of perforations produced in those scratches by the corrosion treatment. There were one or two interesting points about this. The perforations did not occur at the bottom of the scratch, but at the two sides of it. Dr. Evans pointed out that this might well be explained by the fact that when the metal was indented to produce the scratch, some oxide was pressed down into the base of the groove, so that the base of the scratch was covered with oxide. On the other hand, the oxide at the edge of the scratch was fractured and hence, two lines of metal were exposed and the attack might take place along those lines.

The seventh and last paper, by Dr. Chambers and Dr. Pippard, dealt with "The Effect of Method of Preparation on the High-Frequency Surface Resistance of Metals." Here the authors used a physical property to study the condition of the metal surface. They had caused radio-frequency currents to flow in the metal, and it was known that a current of this frequency flowed only in the surface layer of the metal; for electromagnetic reasons it would not flow in the interior. Hence, by adopting this method, high-frequency currents could be used to study the electrical resistance of surface material and, therefore, obtain information concerning the nature of that surface. Unfortunately, the Beilby layer was too thin to be studied in this manner; on the other hand, worked surfaces, which, as pointed out in the paper by Dr. Gay and Dr. Hirsch, were a few microns thick, could be studied in this way. An important fact in all this work was the roughness of the surface. If in the surface there were undulations which were on the scale of the skin depth, i.e., the thickness carried by the current, then this roughness did contribute to the resistance of the skin. Dr. Chambers and Dr. Pippard had compared various surfaces in this way. They had shown that electroplated surfaces have a very high resistance. This seemed to be due to the roughness of the plated surface, to porosity, and also to the high resistivity of the plate metal. Machined surfaces showed a considerable roughness at a depth of the order of a micron, and this could be removed to a small extent by mechanical polishing, and, more completely, by electrolytic polishing. The method became much more sensitive if applied at low temperatures—and by low temperatures were meant temperatures of liquid hydrogen or even liquid helium. The reason for this was that the resistivity due to imperfections appeared much more strongly in comparison with the basic resistivity of the metal at those temperatures.

(*To be continued.*)

UNDER-SEA OIL PIPELINE AT CAPE VERDE ISLANDS.

To save time in the discharge and turn-round of tankers at the bunkering port of St. Vincent, Cape Verde Islands, the Shell Petroleum Company have laid a 16-in. under-sea oil pipeline between a mooring head and the storage installations on shore. The full length of the pipeline, which has a diameter of 16 in., is 4,300 ft. of which 3,300 ft. are under water and the remaining 1,000 ft. are on land. In keeping with the company's practice, the whole length of the pipe was prefabricated by butt-welding successive sections of the lined mild-steel pipe. To aid launching, the pipeline was laid on rollers running on light roller track and it was pulled out to sea by the combined efforts of a tractor and a tug. The pipeline floated when air-filled and therefore could be manœuvred to its required position. It was finally sunk on to the sea bed by withdrawing the sinking plugs and flooding the pipe with seawater, when it submerged steadily at about 20 ft. per minute. Ten concrete blocks, regularly spaced along its length, anchor the pipeline to the sea bed. The value of the pipeline was demonstrated by the first vessel to make use of it, when she discharged 12,814 tons of oil in 30 hours, as compared with the four to five days that had been allowed when discharging into barges. With continued experience, the time taken for the discharge and turn-round of tankers has been further reduced.

Careers on British Railways.—The Railway Executive have published a booklet, *Careers in the Railway Service*, which gives an outline of the opportunities open to young men who enter the service of British Railways. Copies are obtainable from Labour Exchanges.

Reports of Earthquakes.—From time to time, when earthquake reports are received in this country by the Press, inquiries are addressed by telephone to the staff of the Royal Observatory, both at Greenwich and at Herstmonceux Castle, Sussex. The Astronomer Royal asks us to state that the Royal Observatory does not keep any seismological apparatus or records, and hence such calls are fruitless. The official authority on seismological matters is the Kew Observatory, Richmond, Surrey (Telephone: RIChmond 4877).

ELECTRIC TRACTOR FOR RAILWAY SERVICE.

The accompanying illustration shows a battery vehicle, known as an "electric horse," which has been adopted by British Railways and 12 of which are now working in Hull. A total of 100 will be employed in 16 other cities and towns. The frames of these vehicles, which have been constructed by Messrs. Austin Crompton Parkinson Electric Vehicles, Limited, 95, Ladbroke-grove, London, W.11, consist of pressed-steel channel sections with central cross-bracing to form a cradle for the battery. At the rear, the frame is fitted with Scammell coupling ramps, and it is set down at the front to give a low cab floor. The overall length is 13 ft. 2 in. and the overall width and height 5 ft. $10\frac{1}{2}$ in. and 6 ft. 10 in., respectively. The wheel base is 5 ft. $11\frac{1}{2}$ in. and the minimum turning circle is 25 ft. The vehicle is equipped with a 48-cell armoured lead-acid battery of the Young type, which has a capacity of 200 ampere-hours at the five-hour discharge rate. Charging is effected through a 50-ampere socket on the instrument panel, the plug being interlocked with the reverser to prevent starting "on charge."

The battery supplies a 12 h.p. enclosed ventilated series motor, the armature of which runs in ball bearings and is connected to the pressed-steel three-piece $3\frac{3}{8}$ in. by 13 in. road wheels through a single-reduction helical gearbox and a Hardy Spicer propeller shaft with universal joints. Control is effected by a master controller in the cab, above which is an instrument panel. This controller contains the main circuit solenoid contactors, which are fitted with interlocks to ensure the correct sequence of speeds. It also incorporates a solenoid for operating an overload switch in the contactor coil circuit, and a relay which ensures that the controller is returned to the "off" position before re-starting after the overload switch has operated. The master controller is fitted with a sliding cam plate, which closes the magneto-type roller-operated contacts in sequence. It is linked with an accelerator pedal through a spring and an air cylinder, so that the speed of the cam plate is governed and arcing at the contacts is reduced. Five forward speeds and a reverse speed are available, the first four forward speeds being switched in by the accelerator pedal and the fifth by a separate foot switch. The hand-operated reversing switch, which has four positions—"forward," "off," "reverse" and "charge"—is mounted on the instrument panel and is of the drum type, with adjustable tension fingers. A lighting switch and immobilising key switch are also carried on the same panel.

The four-wheel Girling hydraulic brakes are operated by a pedal, and a hand brake operates mechanically on the rear wheels. The trailer brakes are applied automatically through a Scammell coupling when the hand brake is operated. This coupling can be released by a lever in the cab, a safety lock being fitted to prevent accidental release when travelling. The tare weight of the vehicle is 2·2 tons and its payload 2 tons. Tests have shown that, with this load, a speed of 16·5 m.p.h. can be attained on a level road and that, when the battery is fully charged, the range is 27 miles without stops.

Exhibitions of Electrical Equipment.—Exhibitions to demonstrate their Superform fuse board and combination fuse-switch-contactor are being arranged by the English Electric Co., Ltd., at Newcastle, Glasgow, Sheffield and Manchester. The Newcastle exhibition will be held at the Station Hotel on Wednesday and Thursday, December 3 and 4, and the Glasgow exhibition at the Central Hotel on Wednesday and Thursday, January 14 and 15, 1953. Details of the other exhibitions will be announced later.

Television Tubes with Tinted Glass Faces.—Mullard Ltd., Shaftesbury-avenue, London, W.C.2, are now manufacturing television picture tubes with tinted glass faces which enable a picture of good contrast and low glare to be obtained under conditions of normal room lighting. The tinting is carried out during the manufacture of the glass and is therefore an integral part of the tube face. At present, the tubes of this type that are available give a 12-in. round picture or a 14-in. rectangular picture.

ELECTRIC TRACTOR FOR BRITISH RAILWAYS.

THE INSTITUTION OF NAVAL ARCHITECTS' AUTUMN MEETING.

(*Continued from page* 659.)

The last of the five papers delivered at Genoa in the course of the combined meeting of the Institution of Naval Architects and their Italian confrères, the Associazione di Tecnica Navale, was that of Mr. J. Venus and Dr. E. C. B. Corlett on "Fire Protection in Passenger Ships." It bore the subtitle of "Some Implications of the 1948 Conference on Safety of Life at Sea, with Particular Reference to Aluminium Structures," and was illustrated by a film, produced by the Aluminium Development Association, showing the effect of a concentrated conflagration upon a cabin structure of aluminium alloy, carried out under the auspices of the Department of Scientific and Industrial Research, with the co-operation of the Fire Officers' Committee and the Joint Fire Research Organisation at Elstree, Hertfordshire. The test showed that aluminium structures could be protected efficiently against the most serious shipboard fire, and that a normal deck covering afforded a sufficient barrier to the downward passage of heat.

Fire Protection in Passenger Ships.

Fire at sea, the authors premised, was recognised universally as one of the most dangerous hazards in the operation of passenger vessels. The fire risk could not be calculated so easily as other maritime risks, such as those resulting from heavy weather or damage after flooding; because, whatever regulations were made and however rigidly they were enforced, the ultimate safety of the ship would depend upon the efficiency and the discipline of the officers and crew. Even if a ship were constructed entirely of incombustible material, she would always carry great quantities of combustibles in the form of fuel oil, passengers' baggage, and perhaps cargo; thus the fire risk could never be eliminated entirely. Great Britain, while operating the largest passenger fleet of any nation, had escaped large shipboard fires at sea; but the British authorities were conscious of the potential dangers and were moving towards improved standards, though along somewhat different lines to those of France and the United States. But for the outbreak of war in 1939, there might have been an International Conference on the subject in that year; but, in the event, it was postponed until 1948, when the International Conference on Safety of Life at Sea was held in London. That Conference had since been ratified by the requisite number of nations and would come into force in November, 1952.

The tests described in the paper fell into two categories, designated Method I and Method II. In Method I, attention was concentrated on measures for preventing the spread of combustion from its source, while Method II placed the emphasis upon the immediate extinction of the fire. Method I presupposed the provision of bulkhead material which was entirely incombustible and which had a low thermal conductivity. The material most commonly used was a form of asbestos board, which might be entirely unfaced or was faced with very thin wood veneers. The cost of joinery work, in such a case, would be expensive; but that cost might be offset by the cost of providing a sprinkler system, as in Method II. By using Method I and avoiding the cost of a sprinkler system, the use of aluminium as a structural material would involve no disproportionate cost as compared with the traditional methods of construction. In the building of a ship, it was common practice to install the sprinklers as the work proceeded; but it was significant that Great Britain, with its excellent record so far as fires at sea were concerned, did not show up nearly so well when fires in port, or during building or repair, were concerned. This appeared to indicate that efficient manning of a ship was necessary at all times to ensure that the sprinklers were ready for operation and that, when in port or when the ship was building, a pump should always be available to supply the sprinklers when the headers were exhausted.

Discussion.

Mr. H. E. Steel said that the Marine Department of the Ministry of Transport were much indebted to Mr. Venus and Dr. Corlett, and through them to the Aluminium Development Association, for initiating, organising and bearing the cost of the important research described in the paper. Makers of insulating materials also contributed to the available knowledge through the results of approval tests of their products for use in the "A" or "B" classes of fire divisions in steel ships. Some of the materials were tested in combination with light-alloy structures, and the collaboration between the various interests has been noteworthy. The whole range of tests was as much as could be arranged in the interval that had elapsed since the 1948 Convention, and he thought it would be agreed that the range was most comprehensive. With no more recent fire of serious character on a British passenger ship at sea than the Volturno in 1913, the Board of Trade assessed the fire risk at sea in 1931 from two serious fires in port and communicated their conclusions to the shipping industry, which responded immediately. Fires on certain foreign ships confirmed the Board's fears, and what was believed to be the final draft of detail regulations on the subject was ready when war was declared. The similarity between the original recommendations and those of the 1948 Convention was marked.

Probably the most difficult problem set by the Convention related to the fire protection of passenger ships having extensive superstructures constructed of light alloy. It was difficult because there was no experience of a fire on such a ship; that was why a solution had been attempted in the paper. He had asked the surveyors in the Ministry of Transport to discuss with builders the risks of the spread of fire through uninsulated aluminium-alloy casings, and the possibility of the early collapse of funnels, lifeboat launching arrangements, etc., in any ship where light alloys were being used for casings and to support such structures. Justification for that action had been brought to his notice only a few weeks before the meeting, when he was enabled to see a heavily buckled, though intact, steel bulkhead removed from above an engine room which had been on fire in a small ship, and also the aluminium navigating bridge front, situated a tier higher. The bridge had partly melted away round a window in which the glass had obviously been destroyed, thus forming a flue for the flames. Of the two main questions, the first was, what insulation would adequately insulate an A-class division of light alloy, whether a bulkhead or step? The series of test results in the paper was intended to provide answers. Test results suggested that, while asbestos board ½ in. thick might be suitable when there was a 7-in. air gap between it and the deck plating, a thickness of 1 in. would be necessary for an air gap of only 3 in., and *pro rata*. To maintain robustness and integrity when the insulation was subjected to fire, ½ in. seemed to be the minimum acceptable thickness. Thick deck coverings tended to retain heat and to raise the metal temperature. Where the thickness of sheathing was much above that usually fitted in the accommodation of modern ships, the thickness of insulating material should be reconsidered. Owing to convection currents set up in the air gaps of vertical divisions, no variations in thickness of insulation appeared to be justified.

The next question was: would a fire on board ship cause early major collapse of the main aluminium-alloy superstructure, especially the structure supporting the control stations, lifeboat launching arrangements or heavy superstructure, such as funnels, the collapse of which might hasten disaster? Examination of the diagram in the paper illustrating proof stress after a one-hour temperature rise suggested that the arbitrary metal temperature limit of 350 deg. C., imposed by the authors, was too high for aluminium fire divisions—and the more so where the divisions were load-bearing. That will not preclude, as fire divisions, the materials represented by the diagrams in the paper; broadly, however, insulation of double thickness ought to be fitted to protect pillars, bulkhead stiffeners supporting deck girders, and pillar structure supporting lifeboat launching arrangements, control stations, funnels, etc. The appearance of the test cabin after the fire was indeed remarkable for the general absence of distortion. The fire was exceptionally fierce, and his own chief impressions at the test were of the melting away of the aluminium where, in an uninsulated condition, it bounded an aperture which became a flue for the flames, e.g., side scuttles and the lower edge of a doorway lintel; the absence of material deflection in the roof; and the quite local deflection without puncturing of the floor plating between the supporting beams, due to the prolonged glowing of embers which fell upon it. Aluminium side scuttles were not suitable for use below the bulkhead deck.

Notwithstanding the cabin test, he was uneasy lest an aluminium superstructure, subjected to prolonged heating in the neighbourhood of the seat of a fire of standard intensity, might collapse much more readily and extensively than if it were of steel; for, apart from safety considerations, the expense of repairs after a fire would be an important matter to owners. For safety, the undersides of decks and pillar structure, as well as A and B class division, would have to be insulated, and this was accepted. The outcome of discussion was the "cooking test," which had been described. A panel of deck structure, insulated by ½-in. asbestos boards attached by screws under the beams, was stressed to about 4 tons per square inch by a load of 100 lb. per square foot and exposed on its underside to a temperature of nearly 1,000 deg. F. for 5½ hours; afterwards, the temperature was raised through the remainder of the standard curve. Only minor deflection of the beams and some buckling of the plating occurred, and the insulation was neither cracked nor detached. As the loading weights provided an air gap of about 1 in. above the specimen, and the atmospheric conditions in the test-house were reasonably still and warm, the test substantially represented a sheathed deck in passenger accommodation on a ship. He felt that this final test would go a long way to reassure those who entertained fears about the use of aluminium on account of fire.

Commandante Petroni, speaking in Italian, described current insulating practice in recent Italian ships, and suggested that more use might be made of sprayed asbestos.

Dr. Corlett, replying to the discussion, said that the authors of the paper had worked so closely with Mr. Steel in connection with the tests described that there could be no substantial disagreement between them. He agreed with most of the points raised by Mr. Steel. The provision of two dampers in a ventilation system seemed to be a reasonable practice, as was the policy of installing a fire protection system for a group of cabins. Mr. Steel had commented on the diagram illustrating proof stress after one-hour temperature rise, and it was interesting to the aluminium industry also that the properties of the commonly-used modern alloys were so low at temperatures below 300 deg. C. The standards suggested by Mr. Steel, of 300 deg. C. for aluminium divisions bearing no load and 200 deg. C. for loaded aluminium divisions, seemed to be reasonable and entirely fair. Double thickness of insulation for pillars, etc., and for the structures supporting lifeboat stations was also a matter of common sense. Mr. Steel had remarked that, in the present stage of knowledge, it was not desirable to use aluminium side-scuttles below a bulkhead deck. A noticeable difference had been observed between cases where the glass was open and those where the glass was closed. Where the glass was closed, there was no emission of smoke or flame until well after the peak of the fire, and when there was no possibility of deleterious consequences. The side-scuttle which was open emitted smoke or flame 5 in. or 6 in. long, and it was clear that, in important structures, the question of fitting opening side-scuttles must be considered.

Commandante Petroni referred to the sprayed-asbestos type of insulation, which was widely used in Europe. It was the authors' opinion that the need to fit linings in the passenger accommodation, normally of the same thickness as the asbestos composition, made the combination of sprayed asbestos and plywood (and possibly sprinklers in addition) uneconomical.

(*To be continued.*)

The Use of Models in Structural Analysis.—A course of lectures, with practical sessions, on the subject of "Drawing Office Techniques in the Use of Models in Structural Analysis," will be delivered by Mr. J. Wright, B.Sc., in the civil-engineering lecture theatre, Armstrong Building, King's College, Newcastle-upon-Tyne, from Tuesday to Friday, December 2 to 5, inclusive. The lectures will be delivered each day at 6.30 p.m. and the practical sessions will be held on Wednesday, Thursday and Friday at 4 p.m. The fee for the course is 15*s*. Applications for enrolment should be made to the Director of Extra-Mural Studies, 5, Eldon-place, Newcastle-upon-Tyne, 1.

Electricity Supply in Scotland.—A scheme prepared by the North of Scotland Hydro-Electric Board to meet the increasing demand in the Oban area by developing the resources of Loch na Sreinge, Loch Tralaig, the River Oude and tributaries in the Kilmelfort district of Argyllshire has been approved by the Secretary of State for Scotland (the Rt. Hon. J. Stuart). The works will involve the construction of two dams, one of which will raise the level of Loch Tralaig, while the other will form a headpond in the Pass of Melfort. The water will be led through a tunnel and pipe line to a 3-MW station on the right bank of the River Oude above Melfort House. The estimated annual output is 9 million kWh.

POWER GENERATION FROM A HOT SPRING.

(*Concluded from page* 661.)

As the success of this installation depends entirely on the maintenance of as high a vacuum as possible, all potential sources of air leakage have to be reduced to a minimum; barometric legs will therefore be used for the removal of the hot water from the evaporator and the condensate from the condenser. There is no natural fall in the ground level to provide for these barometric legs, so a well will be sunk for this purpose. Two vertical-spindle tail-well pumps are being provided for the removal of the hot water. The larger pump will deal with the normal hot-water flow and the smaller pump will be used for starting and overload conditions.

When starting up the plant, the smaller pump is connected to the auxiliary generator, and the output from this pump is sufficient to keep the level of the water in the tail well low enough to enable the turbine to start up and to run against light load. Immediately the turbine is running at speed, the electrical supply is switched manually to the main turbine alternator, and thenceforward the control of all pumps is automatic. The smaller pump continues to operate and the level in the tail well continues to drop. At a predetermined level the normal pump cuts in and both pumps operate in parallel, rapidly dropping the well level to a point where the smaller pump cuts out, leaving the larger pump to carry the whole load. Should the water in the tail well reach a predetermined low level, another electrode will cause the pump to be cut out until the level has risen about 4½ ft. Under overload conditions, when the tail-well level rises, the smaller pump will again be cut in. When starting up, the pilot set has to provide current for the small tail-well pump, as well as steam for the air pump and for the turbine glands, and it was expected that the small boiler might become rather heavily loaded if it had to supply the whole of the steam requirements. An alternative arrangement has been provided, therefore, so that the steam for the turbine glands is supplied from the exhaust of the pilot engine.

Generally, hot spring water contains gases or salts which are injurious to metals and, therefore, an analysis was made. This showed the hot spring water to be of extremely good quality, containing no acidity and very little hardness. The water, in fact, is suitable as boiler feed and is to be used for the small wood-fired boiler. A small vertical-spindle motor and pump will be installed over the hot-water discharge channel and will deliver through a ball-float valve to the feed tank in the boiler annexe.

The power unit comprises a turbine driving an alternator through reduction gearing of the "stacked" type, all mounted above a condenser of rectangular section, and with the air pump located on the adjacent building wall. The evaporator is to be in a pit at the end of the turbo-generator unit, the level of the evaporator being such that a fall of 1 metre will be obtained from the datum, or natural, overflow level of the hot spring to the inlet on the evaporator. The barometric leg will be located beside the main building and next to the evaporator. The small boiler, with its feed pump and feed tank, together with the pilot engine, will be placed in a lean-to annexe to the main building. The switchgear is to be arranged by the alternator and will be elevated to provide space below for the transformers required to step up the voltage of the supply to the mine. The three circulating pumps for the cold water will be placed in a small building close to the lower reservoir.

The evaporator is shown in Figs. 7 and 8, on page 693; it is of welded steel construction with two groups of stainless-steel nozzles in the lower part of the body. The lower row of nozzles will be used for the normal hot-water flow of 31,750 gallons per hour, and the upper row when starting up and to take any increased flow obtainable by lowering the natural overflow level of the hot spring. The supply to the lower row of nozzles is controlled by hand, but it is expected that the normal flow will be maintained at all loads up to the full load of 220 kW. The supply to the upper row of nozzles is controlled automatically by an Arca valve, actuated by the pressure drop across the governor valve at the turbine. A conical copper baffle is fitted in the body of the evaporator above the nozzles to restrict the height of the spray from the nozzles. To protect the evaporator, and in turn the turbine, against flooding, vacuum breakers are provided on the side of the evaporator, as well as a high-water alarm, with visual and audible indication, supplied by the Drayton Regulator Company. There is also an ordinary water gauge on the evaporator.

The head of the evaporator contains the superheater, for which the heating steam is to be supplied from the discharge from the second-stage ejector jet. "Flashed" steam from the evaporator, before entering the superheater, passes round baffles to reduce its moisture content as far as possible; the baffles drain to the bottom of the evaporator. The superheater is of the floating header type, having brass tubes, with an outside diameter of $\frac{3}{4}$ in., expanded into brass tube plates. The heating steam passes four times across the superheater. The condensate passes to waste, as there is no need to conserve this water for boiler feed purposes. Both the body and the steam ends of the superheater are of welded steel. The piping carrying the hot water to the de-gasser and from the de-gasser to the evaporator, the evaporator itself, and the steam pipe from the evaporator to the turbine are all lagged with asbestos mattresses supplied by the Darlington Engineering Company, Limited, Gateshead.

The power unit comprises the steam turbine shown in Fig. 9, opposite; it runs at 4,500 r.p.m. and drives a dynamo, supplied by Lancashire Dynamo and Crypto, Limited, at 1,500 r.p.m. The reduction gear is supplied by David Brown and Sons, Limited, Huddersfield. Preliminary considerations indicated that the turbine would require three stages approximately equal to the last three stages of a 1,000-kW set; that the inlet system should be 21 in. diameter throughout and that the exhaust would be equivalent to 36 in. diameter. The temperature being low, all the turbine casings have been made in cast iron. It was decided to use three 28-in. diameter impulse stages and to fit manganese-bronze blades, machined from stampings, with the corresponding fixed blading made from rolled brass strip. The inlet system presented some difficulty because of its size compared to that of the turbine itself and, therefore, the standard type of governor valve was discarded in favour of a gate type, as normally used with pass-out turbines. The gate valve is of cast bronze and is operated by a steel pinion engaging with a steel rack, riveted along the edge of the valve; the pinion is driven by the governor gear, using the makers' standard type of governor box for 500/750-kW turbines. The governor box contains a centrifugal governor which operates a piston-type oil-relay valve. This, in turn, operates the power piston. The whole of the governing gear is fully compensating. The nominal speed of the governor can be altered by means of a handwheel and screw which adjusts the tension in the spring attached to the ring lever of the governor. The overspeed emergency governor is of the unbalanced-ring type, in which a compression spring maintains a steel ring in a central position until the centrifugal force of the out-of-balance weight overcomes the spring, when the ring is immediately displaced from the centre to strike a trip lever, so closing the emergency valve.

The emergency valve is a standard butterfly valve, with a diameter of 21 in., fabricated from mild steel and located above the turbine in a section of the inlet pipe. The valve is closed by a falling deadweight and the shock, at the end of its stroke, is absorbed by a hydraulic cylinder. The emergency trip is set at 10 per cent. over normal running speed, namely 4,950 r.p.m.

It will be appreciated that the whole of the system will be at sub-atmospheric pressure and, therefore, the high-pressure and low-pressure glands have had to be designed to exclude air. Carbon rings were selected as being the most effective and the most easily serviced type of gland, the sealing steam being obtained from either the engine exhaust or directly from the boiler. Corliss glands have been used on the operating shafts of both the governor

POWER GENERATION FROM A HOT SPRING.

BELLISS AND MORCOM, LIMITED, BIRMINGHAM.

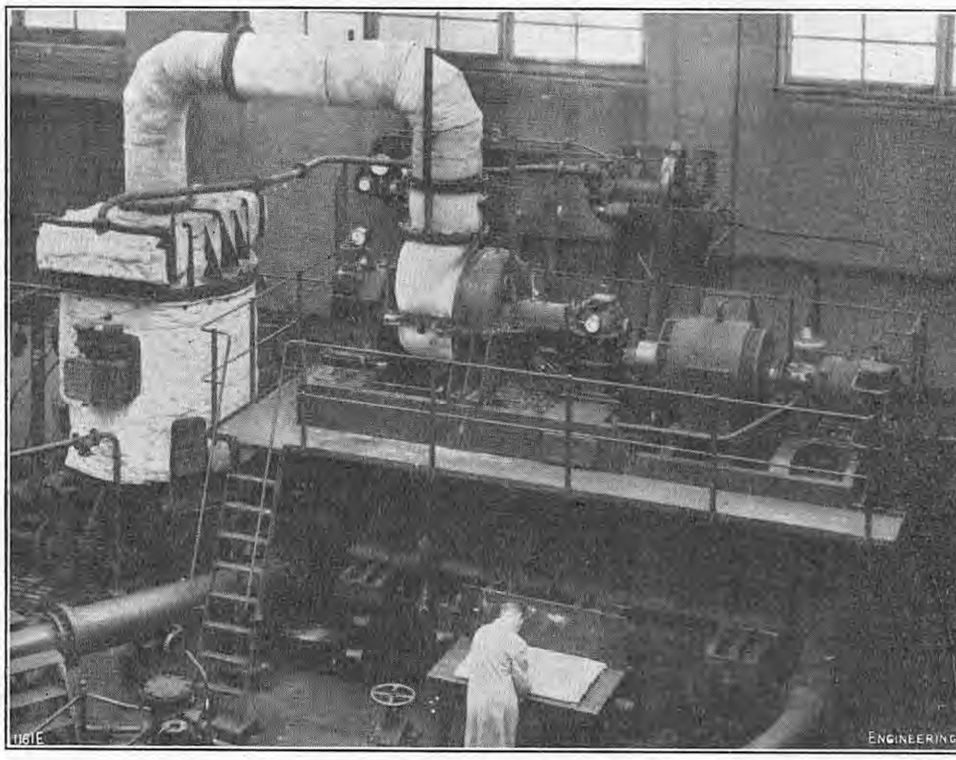


FIG. 6. PLANT UNDER TEST AT MAKERS' WORKS.

valve and the emergency valve, and these are also steam-sealed.

The main oil pump is driven directly from the bottom end of the governor spindle and comprises two helical gearwheels within a casing. The pump supplies oil to the turbine at a pressure of 40 lb. per square inch, and to the gearbox and alternator bearings at a pressure of 8 lb. to 10 lb. per square inch. This oil passes through an oil cooler supplied by H. O. Serck, Limited, Manchester, 15. The oil used in the governor gear is uncooled and is taken directly from the discharge side of the pump.

The turbine is connected to the gearing by means of a flexible coupling, designed by Messrs. Belliss and Morcom, in which the power is transmitted from the turbine shaft to the gearbox pinion by means of a series of flat steel springs. The alternator has only a single outboard bearing, but has a solid coupling at the gearbox end, the gearbox bearings being designed to carry part of the weight of the alternator armature.

A turbine having only a low starting torque, it had been expected that a considerable burst of steam would be necessary to overcome the static friction. In fact, it was found that starting the turbine was quite straightforward if the following procedure was adopted. A moderate vacuum was produced in the main condenser, using steam from the second stage of the ejector pump. With the governor valve wide open and the emergency valve shut, the clearance round the emergency valve was sufficient to creat a vacuum within the evaporator as well as in the condenser. When the hot water was admitted to the evaporator, steam was flash-generated and the evaporator pressure then rose above that existing in the turbine-steam chest. By partly opening the emergency valve manually, the pressure in the evaporator was reduced, so providing the necessary conditions for the continuous generation of steam. The plant was then working continuously. The speed could then be controlled by adjusting the valve opening until the turbine reached full speed, when the governor gear came into action and the emergency valve was set in its fully-open position, ready for operation should too high a speed be attained.

As mentioned previously, the success of this plant depends upon the maintenance of a high vacuum at the turbine exhaust and, therefore, the condenser has been made of unusually large proportions for the size of the unit; so much so, that it was found possible to build the whole of the power unit on top of the condenser. The condenser is a standard Belliss and Morcom "Compact" design, rectangular in section, with the steam entering at the top along the whole length of the central bay, the air and non-condensable gases being drawn upwards on both sides while the condensate drains by gravity down the barometric leg. The cooling water enters by two inlets, and makes three passes through the condenser. The condenser body is of welded steel construction and, as stated above, forms the bedplate of the turbine as well as carrying the operating platform built round the turbine. The condenser tubes are of brass, with an outside diameter of $\frac{3}{4}$ in., and are secured in the brass tube-plates by brass ferrules with asbestos-taped packings; in all, there are 1,121 tubes, each 12 ft. 6 in. long. The internal supporting plates and their securing pins are also of brass. The water boxes and end covers are of cast iron, the covers being hinged for inspection and overhaul.

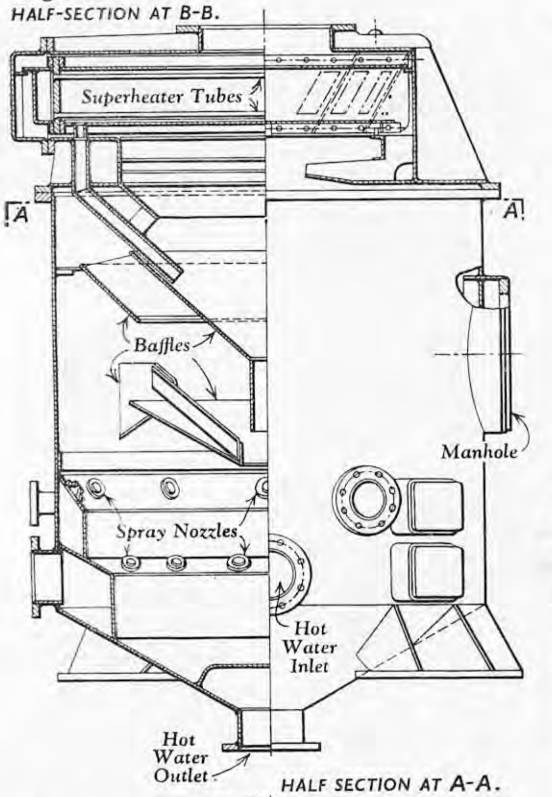
A two-stage steam-jet air pump has been used, with steam nozzles of stainless steel with bronze throats, and with perforated steel strainers above the nozzles. The steam from the first stage is condensed in a small tubular condenser containing $\frac{3}{4}$-in. brass tubes, freely supported at one end and held by ferrules in brass tube-plates at the other. The water for condensing this first-stage steam will be drawn from the cold supply. The body of the heater, together with the discharge chamber for the first-stage steam and the suction chamber to the second-stage ejector, is a fabricated-steel unit. The condensed steam from the first-stage ejector passes through a balance pipe into the main condenser. The second-stage steam is carried to the superheater, where it is condensed at atmospheric pressure, giving up its heat to the steam for the turbine.

The tail-well pumps were supplied by Holden and Brooke, Limited, Manchester, 12, and the motors driving the pumps by Lancashire Dynamo and Crypto, Limited. The automatic control gear is actuated by "No-float" equipment made by Evershed and Vignoles, Limited, London. The larger pump has a rated output of 570 gallons per minute against a 29-ft. head when running at 1,450 r.p.m., and it is to be driven by a motor of 9 b.h.p. This pump is of the vertical-spindle double-suction split-casing type and will be suspended from the floor of the pump house, at a

POWER GENERATION FROM A HOT SPRING.

BELLISS AND MORCOM, LIMITED, BIRMINGHAM.

Fig. 7.
HALF-SECTION AT B-B.



HALF SECTION AT A-A.

Fig. 8.

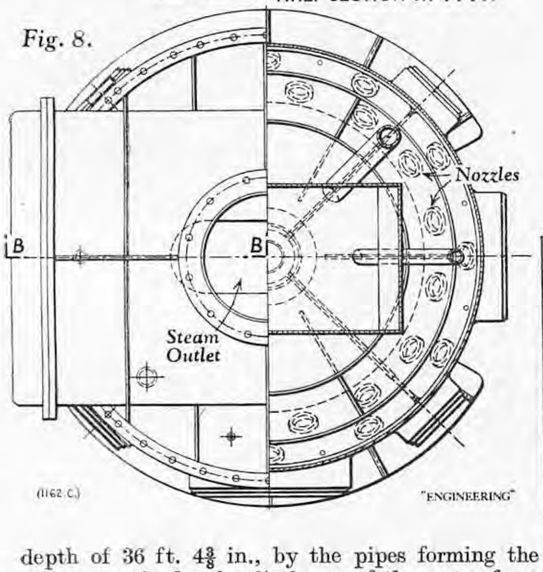
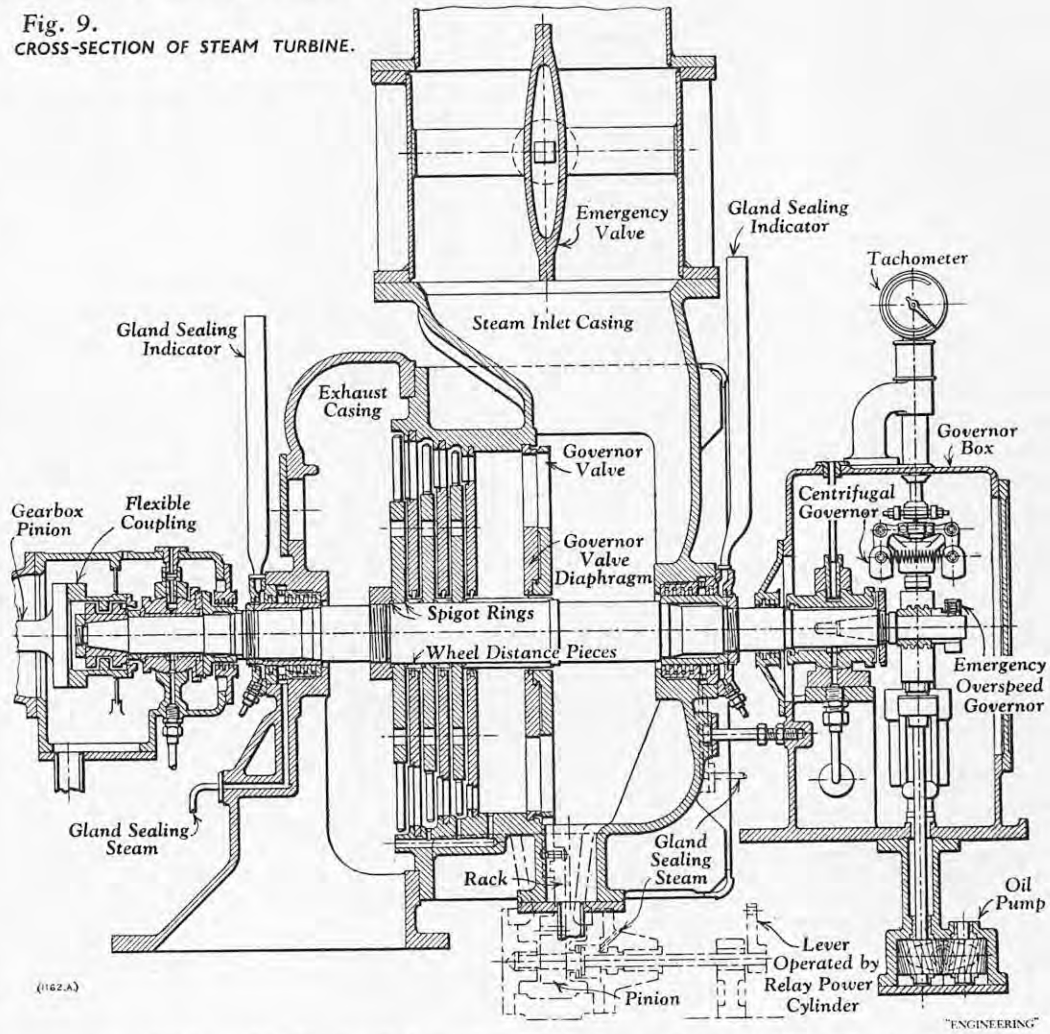


Fig. 9.
CROSS-SECTION OF STEAM TURBINE.



depth of 36 ft. 4⅜ in., by the pipes forming the delivery main for the discharge of the water from the tail well.

The smaller pump has a rated output of 310 gallons per minute against a 22½ ft. head when running at 1,450 r.p.m., and is driven by a motor of 5 brake horse-power. This pump is of the single-inlet end-suction type and is suspended from the pump-house floor at a depth of 35 ft. The delivery pipe in this case will be separate from the supporting pipe.

Both pumps have cast-iron volute casings with renewable neck rings of phosphor bronze and gunmetal impellers. The steady bearings for the spindles are of the "Railko" type, made by Small and Parkes, Limited, Manchester. These intermediate bearings will be pressure-lubricated. The spindles and impellers will be supported by Skefko double-row ball bearings, grease-lubricated, located in the motor stools on the pump-house floor.

The vertical auxiliary boiler, supplied by the Cradley Boiler Company, Limited, Cradley Heath, is suitable for a working pressure of 150 lb. per square inch, and has a normal evaporation of 700 lb. per hour when fired with dry softwood logs. It is also capable of burning coal or refuse. The boiler has eight cross tubes, electrically welded into the firebox.

The pilot set is to be a single-crank compound steam engine, driving a 9-kW 220-volt three-phase 50-cycle alternator at 750 r.p.m. The steam supply from the auxiliary boiler will be at 145 lb. per square inch (gauge). This single-crank tandem engine is the smallest compound engine made by Messrs. Belliss and Morcom and was chosen for its economy of steam consumption, so as to keep the size of the wood-fired boiler as small as possible. The engine is double-acting and all working parts are force-lubricated, including the spring-loaded governor, which is carried on the end of the crank-shaft and operates a double-beat throttle valve on the high-pressure cylinder inlet.

The hot and cold water supplies are measured by Venturi meters supplied by Electroflo Meters Company, Limited, who are also supplying a remote temperature recorder with six points, covering the most important temperatures. A level indicator by Elliott Brothers, Limited, will be installed in the tail-well and coupled to the alarm system.

Testing the combined evaporator, turbine and condensing plant presented a problem in ensuring that the conditions obtaining on site should be produced with reasonable accuracy. The plant, on trial, is shown in Fig. 6, opposite. A continuous supply of hot water at the required temperature had to be provided to simulate the flow from the hot spring, together with a supply of cold water equivalent to that available at site. The hot water was produced by blowing live steam into a large tank of water, the level of the tank being maintained at the same height, relative to the evaporator, as the natural overflow of the hot spring. Cold circulating water was obtained from the testing-house reservoir, but special arrangements had to be made to recirculate part of the cold water passing through the condenser so as to reproduce the heat transfer conditions that will obtain on site. It was not feasible to provide a tail-well at the works, so the hot water from the evaporator was pumped out and returned to the tank by means of a large-capacity pump, provided with special vapour pipes at the inlets of the impeller. The condensate from main condenser was also removed by a pump and discharged to a weigh-tank. Despite some initial troubles, the plant proved successful in operation, and the designed performance was attained.

Dumfries Goods Depot.—British Railways are introducing a scheme of modernisation in the goods depot at Dumfries to accelerate the handling of traffic. The scheme includes structural alterations and the provision of electrical elevating platform trucks and stillages. Work will begin this month and should take about nine months to complete.

100-MVA 132/33KV Transformer.—One of the largest power transformers to be installed in this country was recently dispatched from the Hollinwood works of Ferranti, Ltd., to the Low-road substation in Leeds of the Yorkshire Electricity Board. The unit has been designed for a three-phase output of 100 MVA at 132/33 kV, and is star/delta connected. The high-tension winding is provided with on-load tap changing gear of the continuously-rated reactor type. Cooling is effected by two banks of air-blast cooled radiators with forced oil circulation. On completion in the works the transformer was subjected to impulse test voltages of 550 kV and 200 kV, and to over-potential test voltages of 372 kV and 93 kV on the high and low voltage sides, respectively.

Appointments Services of the Ministry of Labour.—The number of vacancies filled through the agency of the Technical and Scientific Register of the Ministry of Labour, during the five weeks August 12 to September 15, was 215, which is an average of 43 per week. This figure, however, should be considered in relation to the total number of persons enrolled on the Register—5,821 on September 15. The Ministry also have another register—the Appointments Register—which deals with persons having professional administrative, managerial or senior executive experience or qualifications, and those having technical qualifications not appropriate to the Technical and Scientific Register. On September 15, the number of persons enrolled on this register was 16,120; the number of vacancies filled during the preceding five weeks was 304, equivalent to about 61 per week.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

Industrial Productivity.—The various Anglo-American productivity teams brought back from the United States a great deal of useful information, but when it was analysed it was found to consist of nothing but the logical application of principles of sound common sense, said Sir Andrew McCance, F.R.S., deputy chairman and joint managing director of Colvilles Ltd., when proposing the toast of "The Institution of Civil Engineers" at the annual dinner of the Glasgow and West of Scotland Association, in Glasgow, on November 20. There was nothing he could see in the information which was not well within the capabilities of men in this country to have thought out for themselves. If men were prepared to put their backs into their work, this country could once again occupy its old position among the industrial nations of the world. Greater reliance must be placed on the scientific and technical men. "We cannot expect much help from our politicians," he added, "and I do not think we can expect much help from our workmen. All we can hope for is that they will not place too many hindrances on our progress."

Propane for Lighting Buoys.—On November 18, Greenock Chamber of Commerce re-appointed Mr. John Drummond and Mr. James Ferrier to be their representatives on the Clyde Lighthouses Trust. Mr. Drummond, addressing the members, said that the Trustees had continued their experiments with propane gas and had now overcome certain technical difficulties. They had in operation on the Clyde, for testing, a buoy which was itself the container for the propane gas. Initial reports showed that this installation gave a better and clearer light than oil gas.

Future of Prestwick Airport.—Prestwick Airport had a great future, said Mr. A. T. Lennox-Boyd, Minister of Transport and Civil Aviation, speaking at the 12th anniversary dinner held at the airport on November 14 to mark the inauguration of transatlantic air services to Scotland. The Government hoped that it would continue to play an important part in the development of British aviation. In enlarging Gatwick Airport, the Government had not by any means departed from their intention to make Prestwick the second international airport in Great Britain.

The Late Mr. W. McLean.—The death occurred on November 14 of Mr. William McLean, Glasgow, who retired in 1944 from the post of shipyard manager of the Fairfield Shipbuilding and Engineering Co., Ltd., Govan, after 43 years of service with the firm. Mr. McLean was one of 80 persons on board the submarine K 13 when she sank in the Gareloch in 1917, during her trials, with the loss of 31 lives.

CLEVELAND AND THE NORTHERN COUNTIES.

Proposed Stella to Carlisle Electric Transmission Line.—Northumberland County Council are not to take any further action regarding the proposed route of a 275-kW overhead power-transmission line from Stella, Blaydon-on-Tyne, to Carlisle, a distance of about 50 miles. Following a public inquiry, the Ministry of Fuel and Power generally approved the route selected by the British Electricity Authority. The National Farmers' Union, however, proposed that the line should be erected in a more southerly direction, to avoid good agricultural land. The Ministry stated that this new route would not satisfy the requirements.

New Cleveland Open-Hearth Steel Plant.—The Ministry of Works have issued a licence to Dorman, Long & Co. Ltd., Middlesbrough, for the construction, at a cost of 3,250,000*l*., of an open-hearth plant on the site of the Cleveland Iron and Steel Works, Lackenby. The plant is to be erected by Messrs. Dorman, Long.

Engineering Firms and Wage Award.—The Marshall Richards Machine Tool Co., Ltd., Crook, Co. Durham, recently addressed letters to about 300 firms who supply components to the company, urging them not to increase their selling prices as a result of the recent engineering wage award of 7*s*. 4*d*. a week. Replies received by the firm said that they were in sympathy with Marshall Richards' policy and would try to fall in line wtih the request. Mr. R. T. V. Hay, a director, said that Messrs. Marshall Richards had decided themselves to bear the full cost of the engineering wage increase.

Institution of Electrical Engineers.—At the annual dinner of the Tees-side Sub-centre of the Institution of Electrical Engineers, the opinion was expressed that more electricity was used on Tees-side in connection with industry than in any other area. Mr. T. W. Hayhow, managing director of the Stockton Shipping and Salvage Co., who proposed "Tees-side Industries," said that the Furness shipbuilding yard, Haverton Hill-on-Tees, was probably the most electrically-minded shipbuilding concern. Mr. R. Mather, chairman and managing director of the Skinningrove Iron Co., Ltd., proposing the "Institution," said that his company had been the first to build a heavy rolling mill with an electric drive, about 40 years ago, when many similar mills were still being built with steam drives. Mr. W. G. Thompson, past-President of the South Midland Centre of the Institution, said the organisation's membership would have to grow enormously if it were to face the change coming in Britain as a result of developments in the iron and steel industry and the electricity industries.

River Tees Traffic.—Mr. Stephen Furness, vice-chairman of the Tees Conservancy Commission, told members of that authority at the annual meeting, held at Middlesbrough, that revenue received from ships and goods entering the Tees ports during the past year constituted a new record. Imports, during the year ended October 31 last, totalled 3,643,634 tons, also a record. Although exports from the Tees showed an increase of over 44,000 tons on those of last year and amounted to 1,490,000 tons, they were equal only to about 50 per cent. of the exports recorded as far back as 1907. Alderman B. O. Davies was re-elected chairman of the Commission and Mr. Furness vice-chairman.

Long-Service Conveyor Belt.—After carrying 4,000,000 tons of ore between primary and secondary crushers at the works of Dorman, Long & Co., Ltd., Middlesbrough, a 54-in. 10-ply conveyor belt, made by the British Tyre and Rubber Co., Ltd., London, S.W.1, has recently been taken out of service.

LANCASHIRE AND SOUTH YORKSHIRE.

Record Coal Production.—Doncaster district collieries have been outstanding contributors to the recent high production of coal in Yorkshire, which, for the eighth time, has surpassed all earlier records achieved since the nationalisation of mines. Bentley Colliery, on November 21, sent to the surface their 1,000,000th ton of coal for the third year, an achievement a fortnight earlier than last year. Brodsworth Colliery was the first of the Doncaster district pits to raise 1,000,000 tons this year.

The Engineering Outlook.—The decision of John Fowler & Co. (Leeds), Ltd., to discharge more than 200 employees at the end of November has raised the question of engineering prospects in Yorkshire. Some firms are still optimistic and regard as temporary the decline in the demand for engineering products. There are export difficulties because some countries have used up their allocation of sterling for the time being, but this condition is not expected to last long.

Centenary of Leeds Corporation Water Works.—The centenary of the purchase by the municipality of the undertaking of the former Leeds Waterworks Company was celebrated in Leeds on November 17 by a dinner at which the principal guest was Sir Geoffrey Hutchinson, Q.C., M.P., chairman of the Water Companies Association and a past-President of the British Waterworks Association. Sir Geoffrey, in his speech, deprecated any idea of nationalising water supply, maintaining that it could not be administered with full efficiency on other than a local basis. Some minor changes in the methods of control were admitted to be desirable, and the Water Act of 1945 was intended to facilitate them; but successive Governments had hesitated to bring the provisions of the Act into operation. He hoped that its application would not be delayed much longer.

The Late Mr. Samuel Martin.—We have learned with regret of the death, on November 15, of Mr. Samuel Martin, A.M.I.Mech.E., chief draughtsman and drawing-office manager since 1945 of Messrs. Mirrlees, Bickerton and Day, Limited, Hazel Grove, Stockport. Mr. Martin, who was a native of Broughty Ferry, received his technical education at Dundee technical college and had been with Messrs. Mirrlees, Bickerton and Day for more than 40 years.

THE MIDLANDS.

Portable Space-Heating Equipment.—The Aldersley Engineering Co., Ltd., Tettenhall, Wolverhampton, have constructed a portable space-heating plant for a circus which is now touring the Midlands. The heater consists of an oil-fired heat exchanger, through which air is drawn by an electric fan. The heated air passes into perforated tubes inside the circus tent, and is distributed into the tent at a rate of 2,000 cub. ft. per minute. The installation, which can be dismanlted easily for transport, is based on the firm's grain-drying plant.

Fuel Economy Courses.—A report prepared by Mr. A. N. Dodson, regional controller of the Ministry of Fuel and Power, and presented to the Midland Regional Board for Industry in Birmingham on November 18, shows that the response to the Ministry's fuel economy courses in the Midlands has been poor. Considerable publicity has been given to these courses, which are for instructing boiler-house attendants in modern operational technique. On the whole, however, industry in the area has shown little interest, in spite of the fact that investigations in individual boiler plants have shown extremely good results, and have enabled subtsantial economies to be made. Courses have been held in seven centres, and two more are due to start at Coventry in the near future.

Stourport "B" Power Station.—The first half of Stourport "B" power station of the British Electricity Authority having been in service for rather more than two years, some details of the experience gained in operating the station have been published in the Midlands Electricity Board's magazine. Stourport "B" power station contains the first of the British Electricity Authority's generating sets to operate under advanced steam conditions. The boiler, which has a rating of 525,000 lb. of steam per hour, works at 1,275 lb. per square inch, the steam being superheated to 975 deg. F. The turbo-alternator is hydrogen-cooled, and has an output of 60,000 kW. Some troubles were experienced at first, but the plant has now operated with complete satisfaction for over 8,000 hours. A second set, working at a somewhat higher steam pressure, is being installed.

Old Mine Workings.—The working of shallow coal seams by opencast methods at Monk's Park Wood, near Atherstone, has uncovered several old underground workings of unknown date. It is known that coal was worked on the site in the early part of the Seventeenth Century. It has been found that, in parts of the area being worked, as much as 60 per cent. of the coal has been extracted already.

Glasgow Trolley 'Bus for Walsall.—Walsall municipal transport department are to try a Glasgow single-deck trolley 'bus early in the new year on one of the town's busiest routes. The transport department's existing trolley 'buses are all double-decked, and the trial vehicle is of a type not at present used in the town. It has a separate exit, which enables the conductor to remain in full control on the entrance platform at all times.

Mechanisation of Small Farms.—A booklet has been published by the West Midlands Agricultural Advisory Service, dealing with the mechanisation of small farms. It examines the economics of various kinds of farm machinery, and goes into the question of how much machinery a small farm can use to advantage, and of what type.

SOUTH-WEST ENGLAND AND SOUTH WALES.

Developments at Welsh Collieries.—Glyncorrwg Colliery, at the head of an isolated valley, six miles north of Maesteg, is to be modernised, according to an announcement made by the South Western Divisional Coal Board on November 20. The cost will be in the region of 2,000,000*l*. It is planned to tap reserves of coal estimated at 41,000,000 tons, although the area of primary development will apply to resources of 28,000,000 tons. The saleable output will reach 1,480 tons a day, from a man-power of 1,125. At present, just under 800 men are employed at the colliery, which has an output of about 4,000 tons a week. Nantgarw Colliery, the first and largest of the Coal Board's re-organisation plans for South Wales, is making steady progress towards full production. Already the output has increased to well over 1,000 tons a week. By the beginning of next summer, Nantgarw will be producing about 1,200 to 1,500 tons a day.

Brecknock Water Supply.—A Cardiff firm of civil-engineering contractors have secured a contract worth 459,000*l*. from the Brecknock Rural Council for the first portion of the regional water-supply scheme. The contract involves the laying of about 75 miles of spun-iron water main, varying in diameter from 3 in. to 9 in.; the construction of eight reinforced-concrete reservoirs capable of holding from 20,000 to 100,000 gallons; and the construction of a small pumping station, treatment works, and various incidental works. Work is to start before the end of the year.

NOTICES OF MEETINGS.

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

Royal Society.—Monday, December 1, 2.30 p.m., Burlington House, Piccadilly, W.1. Anniversary Meeting.

Society of Engineers.—Monday, December 1, 5.30 p.m., Geological Society's Apartments, Burlington House, Piccadilly, W.1. "The Fatigue of Metals: Facts and Theories Reviewed," by Mr. B. R. Byrne.

Institution of Structural Engineers.—*Wales and Monmouthshire Branch:* Monday, December 1, 6.30 p.m., South Wales Institute of Engineers, Park-place, Cardiff. Film Evening. Wednesday, December 3, 6.30 p.m., Mackworth Hotel, Swansea. Film Evening. *Northern Counties Branch:* Tuesday, December 2, 6.30 p.m., Cleveland Scientific and Technical Institution, Middlesbrough; and Wednesday, December 3, 6.30 p.m., Neville Hall, Newcastle-upon-Tyne. "Relaxation Methods," by Mr. D. M. Brotton. *Western Counties Branch:* Friday, December 5, 6 p.m., The University, Bristol. "Design and Erection of Television Masts," by Mr. P. J. Ward.

Institution of Electrical Engineers.—*Merseyside and North Wales Centre:* Monday, December 1, 6.30 p.m., Royal Institution, Colquitt-street, Liverpool. Discussion on "The Impact of Television on Sound Broadcasting," opened by Mr. G. Parr. *South Midland Centre:* Monday, December 1, 6 p.m., James Watt Memorial Institute, Birmingham. "Colour Television: Some Subjective and Objective Aspects of Colour Rendering," by Mr. G. T. Winch. *District Meeting:* Monday, December 1, 7.30 p.m., Royal Hotel, Norwich. "275-kV Developments on the British Grid System," by Mr. D. P. Sayers, Dr. J. S. Forrest and Mr. F. J. Lane. *Measurements Section:* Tuesday, December 2, 5.30 p.m., Victoria-embankment, W.C.2. Discussion on "Recording Instruments," opened by Mr. W. Bamford. *North-Western Centre:* Tuesday, December 2, 6.15 p.m., Engineers' Club, Manchester. "Electronic Telephone Exchanges," by Mr. T. H. Flowers. *North Midland Centre:* Tuesday, December 2, 6.30 p.m., Huddersfield Training College, Huddersfield. Discussion on "The Technique of Teaching," opened by Mr. A. Machennan. *London Students' Section:* Tuesday, December 2, 7 p.m., Public Library, Chelmsford Open Discussion Evening. *Radio Section:* Wednesday, December 3, 5.30 p.m., Victoria-embankment, W.C.2. "A Survey of Present Knowledge of Thermionic Emitters," by Mr. D. A. Wright. *Institution:* Thursday, December 4, 5.30 p.m., Victoria-embankment, W.C.2. "Economic Aspects of Overhead Equipment for Direct-Current Railway Electrification," by Mr. O. J. Crompton and Mr. G. A. Wallace. *East Midland Centre:* Friday, December 5, 6.30 p.m., College of Technology, Leicester. "Diesel-Electric Locomotives for Industrial Haulage," by Mr. F. D. Lester.

Institute of Road Transport Engineers.—*Scottish Centre:* Monday, December 1, 7.30 p.m., 39, Elmbank-crescent, Glasgow. "The Selection and Characteristics of a Marine Engine," by Mr. H. Brady. *Eastern Centre:* Tuesday, December 2, 7 p.m., Swan Hotel, Bedford. "Specialised Vehicles for Road Transport," by Mr. L. D. Watts.

Institute of British Foundrymen.—*Sheffield Branch:* Monday, December 1, 7.30 p.m., Sheffield College of Commerce and Technology, Pond-street, Sheffield, 1. "Manufacture of Foundry Pig Iron," by Mr. J. T. Gilmore. *Burnley Section:* Tuesday, December 2, 7.30 p.m., Technical College, Accrington. "Sand Mechanisation of a Small Jobbing Foundry," by Mr. W. Connan. *London Branch:* Thursday, December 4, 7 p.m., 4, Grosvenor-gardens, Westminster, S.W.1. "Mould Reaction," by Mr. R. W. Ruddle. *West Wales Section:* Friday, December 5, 7 p.m., Technical College, Llanelly. "Loam Moulding as Applied to the Production of Pumps and Impellers," by Mr. E. Clipson. *East Midlands Branch:* Saturday, December 6, 6 p.m., College of Technology, Leicester. "Flow of Metals," by Mr. F. Hudson. *Wales and Monmouth Branch:* Saturday, December 6, 6 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Loam Moulding as Applied to the Production of Pumps and Impellers," by Mr. E. Clipson. *West Riding of Yorkshire Branch:* Saturday, December 6, 6.30 p.m., Technical College, Bradford. Report on "Flow of Metals," presented by Mr. G. W. Nicholls.

Association of Supervising Electrical Engineers. —*North-East London Branch:* Monday, December 1, 8 p.m., Angel Hotel, Ilford. "General Installations," by Mr. H. W. Quelch. *Nottingham Branch:* Tuesday, December 2, 7.30 p.m., East Midland Electricity Board's Offices, Smithy-row, Nottingham. "Power Factor Correction." by Mr. G. Knights.

Institute of Marine Engineers.—Tuesday, December 2, 4 p.m., Queen Mary College, Mile End-road, E.1. "Construction of Oil Tankers," by Mr. H. Armstrong.

Institution of Civil Engineers.—*Structural and Building Engineering Division:* Tuesday, December 2, 5.30 p.m., Great George-street, S.W.1. "Design and Construction of Hangars at London Airport, with Particular Reference to Prestressed Concrete," by Mr. D. H. New.

Institute of Metals.—*South Wales Section:* Tuesday, December 2, 6.30 p.m., University College, Swansea. "Synthetic Resin Adhesives for Metals," by Mr. R. A. Johnson.

Institution of Mechanical Engineers.—*London Graduates' Section:* Tuesday, December 2, 6.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Power Requirements of Machines," by Mr. S. Dean. *Coventry Automobile Division Centre:* Tuesday, December 2, 7.15 p.m., Craven Arms Hotel, High-street, Coventry. "The Changing Practice of Automobile Engineering," by Mr. Maurice Platt. *North-Western Branch:* Thursday, December 4, 6.45 p.m., Engineers' Club, Manchester. (i) "Control and Recovery of Dust and Fume in Industry," by Mr. R. Ashman; and (ii) "Filter Efficiency and Standardisation of Test Dust," by Dr. H. Heywood. *Institution:* Friday, December 5, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. Meeting with *Applied Mechanics* and *Industrial Administration and Engineering Production Groups.* (i) "Redrawing of Cylindrical Shells," by Dr. S. Y. Chung and Professor H. W. Swift; and (ii) "The Yielding of Strip Between Smooth Dies," by Mr. A. B. Watts and Professor Hugh Ford.

Institution of Works Managers.—*Leicester Branch:* Tuesday, December 2, 7 p.m., The Saracen's Head, Loughborough. "Research and Management in the Chemical Industry," by Dr. G. M. Dyson.

Incorporated Plant Engineers.—*London Branch:* Tuesday, December 2, 7 p.m., Royal Society of Arts, John Adam-street, W.C.2. "Steam versus High-Pressure Hot-Water Installations," by Mr. B. Pheasant. *South Wales Branch:* Tuesday, December 2, 7.15 p.m., South Wales Institute of Engineers, Park-place, Cardiff. Discussion on "Mechanical-Handling Problems." *Southampton Branch:* Wednesday, December 3, 7.30 p.m., Polygon Hotel, Southampton. "High-Speed Diesel Engines in Mobile Plant," by Mr. A. V. Driver. *Peterborough Branch:* Thursday, December 4, 7.30 p.m., Eastern Gas Board's Offices, Church-street, Peterborough. "Modern Dairy Plant," by Mr. C. H. Macquire.

Institution of Engineering Inspection.—*South-Western Branch:* Tuesday, December 2, 7.30 p.m., Grand Hotel, Bristol. "Testing Metals," by Mr. A. D. Mallon. *London Branch:* Thursday, December 4, 6 p.m., Royal Society of Arts, John Adam-street, W.C.2. "The Gas Turbine," by Mr. A. W. Pope.

Royal Sanitary Institute.—Wednesday, December 3, 2.30 p.m., 90, Buckingham Palace-road, S.W.1. "Swimming-Bath Water Treatment," by Dr. S. G. Burgess, Mr. D. Burns and Mr. C. W. Tidy.

Royal United Service Institution.—Wednesday, December 3, 3 p.m., Whitehall, S.W.1. "The Air Battle," by Air Chief Marshal Sir Robert Saundby.

Institution of Heating and Ventilating Engineers.—Wednesday, December 3, 6 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "School Heating Research," by Dr. J. C. Weston.

Illuminating Engineering Society.—*Newcastle Centre:* Wednesday, December 3, 6.15 p.m., Minor Durrant Hall, Newcastle-upon-Tyne, 1. "Brightness Engineering," by Mr. W. Robinson.

Institute of Fuel.—*Midland Section:* Wednesday, December 3, 6.30 p.m., Grand Hotel, Birmingham. Brains Trust Meeting.

Junior Institution of Engineers.—*Midland Section:* Wednesday, December 3, 7 p.m., James Watt Memorial Institute, Birmingham. "Iron Making in the Black Country," by Mr. W. K. V. Gale. *Institution:* Friday, December 5, 7 p.m., Townsend House, Greycoat-place, S.W.1. Film Evening.

Institution of Production Engineers.—*Nottingham Section:* Wednesday, December 3, 7 p.m., Victoria Station Hotel, Nottingham. "High-Speed Photography," by Miss M. D. Gauntlett. *Reading Section:* Thursday, December 4, 7.15 p.m., Great Western Hotel, Reading. "Future Prospects of the Production Engineer," by Mr. W. C. Puckey.

Engineers' Guild.—*Metropolitan Branch:* Thursday, December 4, 6 p.m., Caxton Hall, Westminster, S.W.1. Film Evening.

British Institution of Radio Engineers.—*Scottish Section:* Thursday, December 4, 7 p.m., University, Edinburgh. "London to Kirk o' Shotts Television System," by Mr. J. H. H. Merriman.

Institution of Water Engineers.—Friday, December 5, 10 a.m., Institution of Civil Engineers, Great George-street, S.W.1. (i) "Prestressed-Concrete Dams and Tanks," by Professor R. H. Evans; (ii) "Seepage and Stability Problems," by Mr. K. L. Nash; (iii) "Harrogate Dam Failure," by Mr. D. G. Davies; and (iv) "Pressure-Surge in Pumping Systems," by Mr. H. R. Lupton.

PERSONAL.

His Royal Highness the Duke of Edinburgh has accepted honorary life membership of the Institution of Gas Engineers, and honorary membership of the Institution of Mining and Metallurgy.

Sir Geoffrey de Havilland, C.B.E., A.F.C., F.R.Ae.S., the founder of the de Havilland Aircraft Co. Ltd., Hatfield, Hertfordshire, and technical director of the company since its formation in 1920, has been awarded the Guggenheim Medal for 1952. The Medal will be presented to Sir Geoffrey during the annual meeting of the American Society of Mechanical Engineers, to be held in New York from November 30 to December 5.

Mr. J. M. Ormston, C.B.E., M.I.N.A., who retired from the positions of director and general manager of the Walker-on-Tyne Naval Shipbuilding Yard of Vickers-Armstrongs Ltd. on October 1, 1950, has been appointed a director of S. P. Austin and Son, Ltd., Sunderland.

Lt.-Colonel H. Riggall, D.L., J.P., managing director and deputy chairman of Ruston and Hornsby Ltd., Lincoln, has been appointed a Governor of Loughborough College of Technology, Loughborough, Leicestershire.

Mr. G. D. D. Greig, assistant (maintenance) to the chief officer engineering (maintenance), Railway Executive, has been appointed district engineer, Inverness.

Mr. L. W. H. Savage, B.Sc., M.Eng.(Sheffield), A.M.I.C.E., is to be divisional road engineer for the North Midland Division, in succession to Mr. E. O. Blunden, B.A., B.A.I., M.I.C.E., who is retiring on December 31. Mr. J. Edgar Jones, M.Sc.(Eng.), M.I.C.E., is to be divisional road engineer for the Midland Division, in succession to Mr. J. E. Cardell, A.M.I.C.E., A.M.I.Mun.E., A.M.T.P.I., when he retires in May, 1953.

Mr. W. Owen, M.I.Mech.E., has been made assistant chief engineer to Saunders-Roe (Anglesey) Ltd., coach division, Beaumaris, Anglesey, N. Wales.

Mr. John MacLean has been re-elected chairman of the Clyde Navigation Trust. Mr. I. C. Macfarlane has also been re-elected, to the position of deputy chairman.

Mr. James Rowbotham, A.M.I.C.E., A.M.I.Mun.E., A.M.R.San.I., of Levenshulme, Manchester, has been appointed to the Colonial Engineering Service in Tanganyika.

Mr. Daniel Longden, M.R.San.I., M.I.San.E., consulting sanitary engineer, 2, Promenade-chambers, Edgware, Middlesex, has taken as partner Mr. R. F. Earley, B.Sc., A.M.I.C.E., A.M.I.Mun.E., F.G.S., who until recently was assistant chief engineer to the Stevenage Development Corporation. In future, the firm will be known as Longden and Earley, consulting engineers.

Mr. J. Walsh, who has been with Prior Stokers Ltd., Prior Works, 1-3, Brandon-road, York Way, London, N.7, for some years, has been appointed the firm's technical representative for the North-East area. He will be responsible for the greater part of the territory for which Thoburn, McLaren, Ltd., were previously the firm's agents.

Mr. H. G. Carter, A.C.A., secretary of Lancashire Dynamo Holdings Ltd., has been appointed to the board of directors.

Mr. F. A. Martin has succeeded Mr. W. J. Colton as President of the Sheffield and district branch of the Institute of British Foundrymen.

Mr. A. Robert Jenkins, J.P., A.I.Mech.E., President of the Institute of Welding, has accepted an invitation to serve on the Comité de Patronage of the Third International Congress on Electro-Heat, to be held in Paris from May 18 to 23, 1953.

Mr. A. S. Walker, A.M.I.Mech.E., has been appointed lecturer, mechanical engineering department, Woolwich Polytechnic, London, S.E.18.

Messrs. Herbert Lapworth Partners, 25, Victoria-street, London, S.W.1, announce that they have now taken into partnership Mr. P. B. Mitchell, B.Sc., A.M.I.C.E.

The Telegraph Construction and Maintenance Co. Ltd., Telcon Works, Greenwich, London, S.E.10, announce that a branch office of the firm will be opened on December 1, at 43, Fountain-street, Manchester, 2. (Telephone: Central 0758.) The branch will be under the charge of Mr. J. Taylor.

Roles and Parker Ltd., have moved their office to Rapier House, Turnmill-street, London, E.C.1. (Telephone: CLErkenwell 0545.)

Robert Hudson, Ltd., are moving to 47, Victoria-street, London, S.W.1, as from December 1. (Telephone: ABBey 7127; telegraphic address: "Raletrux Sowest.")

1,000-H.P. DIESEL-ELECTRIC LOCOMOTIVE FOR CEYLON.

(*For Description, see Page* 700.)

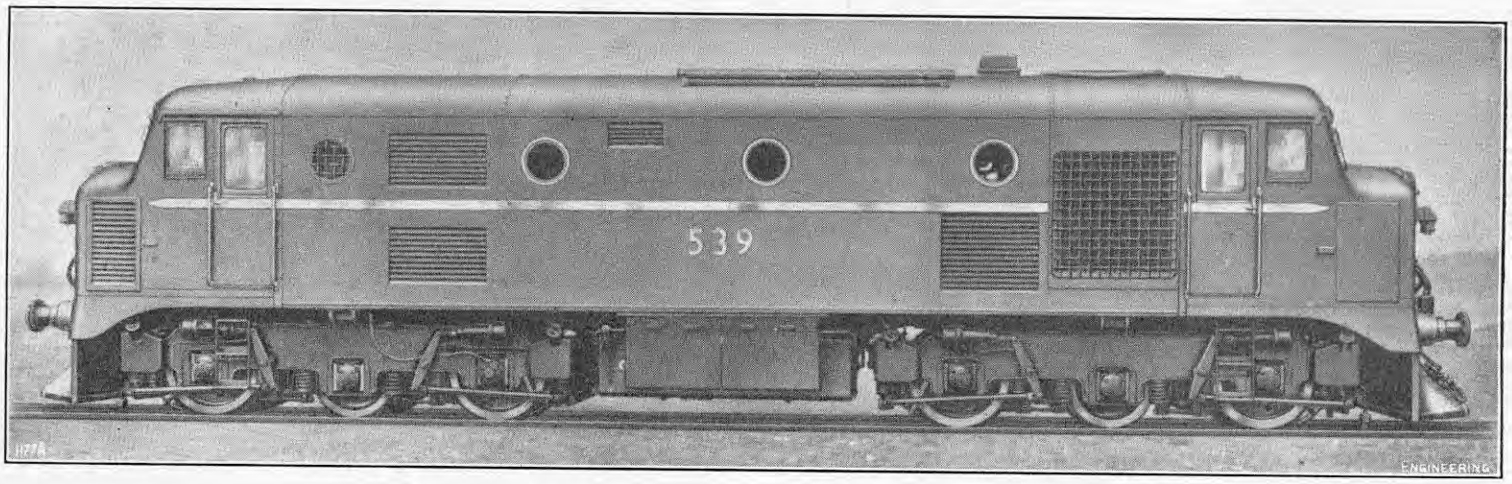


Fig. 1. General View of Locomotive.

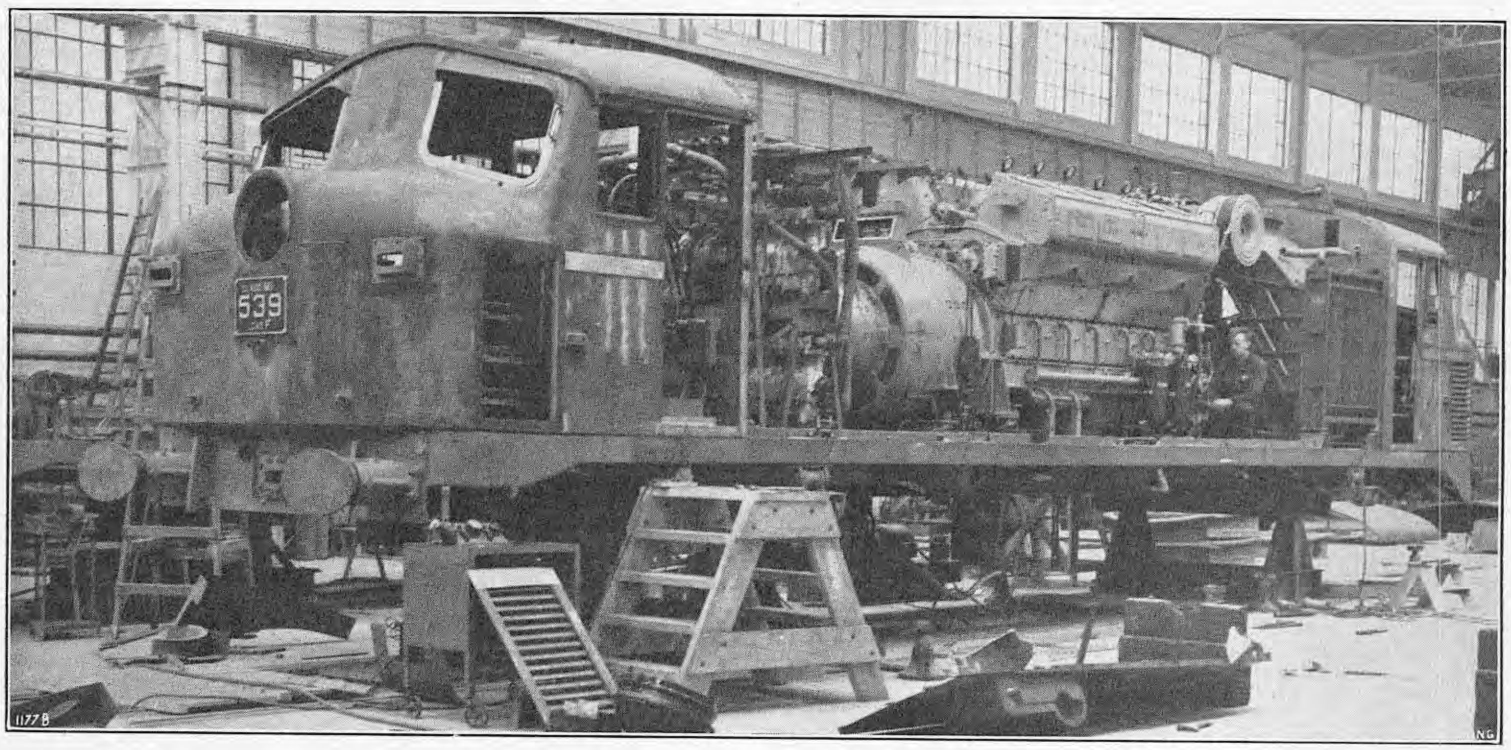


Fig. 2. Power Unit being Erected.

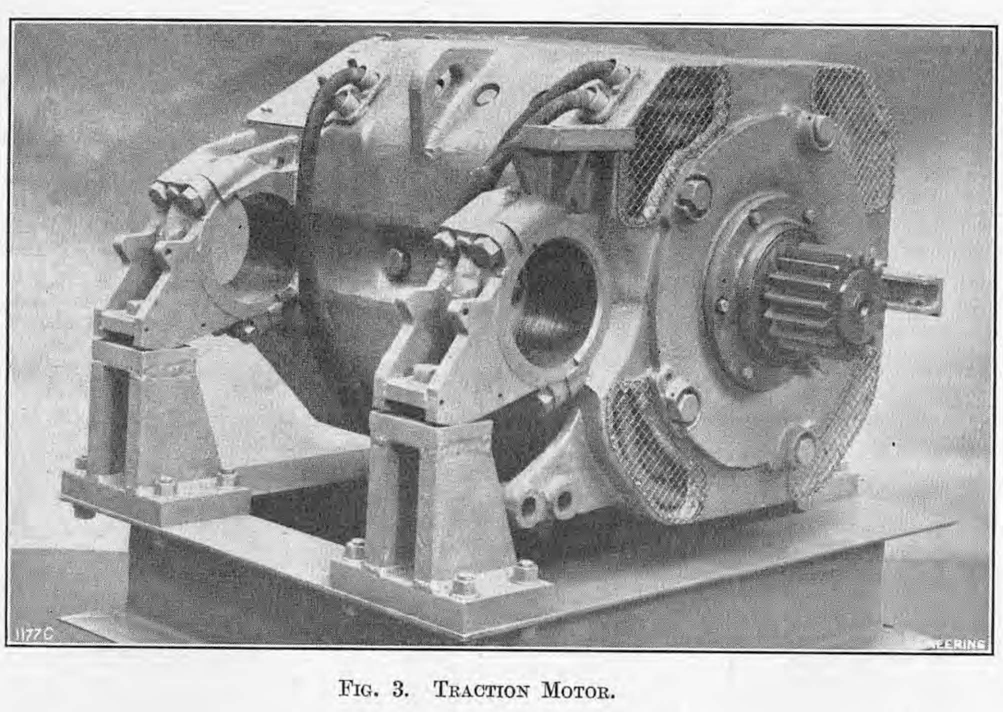


Fig. 3. Traction Motor.

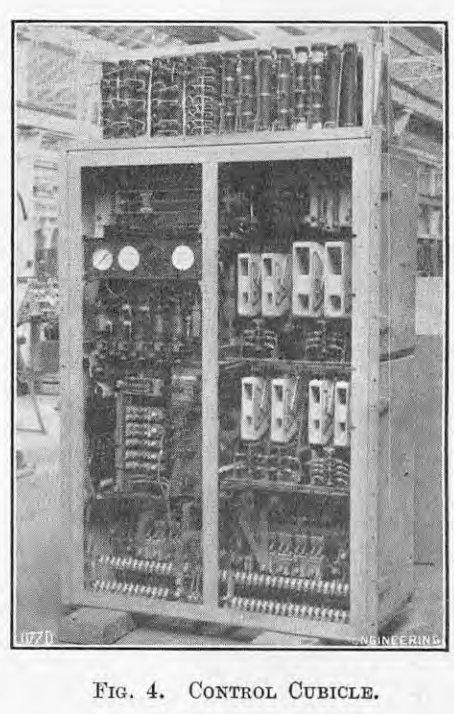


Fig. 4. Control Cubicle.

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ENGINEERING

FRIDAY, NOVEMBER 28, 1952.

VOL. 174. No. 4531.

THE FUTURE OF WOOLWICH ARSENAL.

THE analogy of the cowboy's gun ("You don't need it often, but when you do, you need it badly") applies more or less to all arsenals, naval dockyards and munitions factories. Least, perhaps, to the dockyards, because ships must be docked and refitted at fairly regular intervals, and those intervals are probably more regular in peace than in war; most, probably, to explosives and ammunition factories, in which the war-time load may be scores or even hundreds of times as great as the peace-time demand. It is possible, too, that the specialisation which has characterised the design and purpose of the newer ordnance factories has intensified the contrast between the war-time and peace-time loads to a degree not commonly experienced by Woolwich Arsenal, so long regarded by the nation at large as the archetype of them all. Not for the first time, the fate of the Arsenal appears to be in the balance, and what the future may have in store for Woolwich would seem to depend on how much notice the Government take of the recommendations of the Select Committee on Estimates, contained in their report* on "The Royal Ordnance Factories," recently made public.

Woolwich has been a centre of Government industry since the time of Henry VIII, and possibly even longer, but its real importance as an arsenal began to develop towards the close of the Seventeenth Century. The national gun foundry was established there in 1716, but its scale of operations was comparatively modest until the Napoleonic wars and even then its importance derived chiefly from the Royal dockyard, which was the principal naval yard until the introduction of iron shipbuilding. The dockyard was closed in 1870, but ten years previously the Arsenal had undergone extensive modernisation, so that the main industrial activities of the town had become centred on the needs of the Army rather than those of the Navy. By the eighties of the last century, the Arsenal had grown to an area of rather more than 330 acres and employed some 10,000 men. It consisted at that time of four main departments, namely, the gun factory, which formerly supplied the Navy as well as the Army; the carriage department, which was responsible for the Army's transport vehicles; the so-called laboratory, which produced ammunition; and the stores department. In course of time, a considerable additional area was taken in for use as proving grounds, until in 1930 the establishment covered some 1,300 acres. At the present time, according to the Select Committee's report, it contains 2,161 acres and has a river frontage of about three miles. Of the total area, 1,312 acres are occupied by the factories, the remaining acres being used by the Ministry of Supply for storage or sublet to other departments. The number of employees in the Arsenal proper is now "just over 9,000"—fewer than seven persons per acre.

During both the World Wars, the obviously vulnerable position of the Arsenal led to the transfer elsewhere of a good deal of the work formerly concentrated there; and the wisdom of this move was demonstrated during the recent war, when the establishment suffered considerable damage by enemy action. More than once, proposals had been made to close it entirely, but political pressure led to the postponement of these schemes in favour of various projects, such as the construction of railway vehicles, for its maintenance as an industrial unit. As such, it was hardly in a position to compete on even terms with private industry. The Select Committee comment that "the wide dispersal of the activities of the factories . . . inevitably makes difficult the task of efficient management and control," even of the Arsenal's proper work; and they add the rather serious charge that "it seems likely that the true costs of production at Woolwich are never recorded" by reason of the manner in which its accounts are presented, and the omission from them of any figure representing the value of the land, or the rent or interest upon it.

The report of the Select Committee is based mainly upon the evidence collected by a sub-committee from a considerable number of officials, trade-union representatives and others, which ranged over a very wide field. Much of it was obtained in the course of visits to various Royal Ordnance Factories, where they formed the impression that "in general, the quality of the management is high." They recognised that the performance levels attained in factories that were working, of necessity, far below their optimum planned output could not be judged by the same standards as would be applied to an ordinary industrial undertaking with a full order-book; but, even so, we rather doubt whether they realised how much had been done in the past to improve the efficiency of operation at Woolwich, in spite of the great handicaps imposed by piecemeal development and comparatively frequent changes of policy and product. In 1930, the late Mr. Francis Carnegie, then chief mechanical engineer at Woolwich, presented a paper to the Institution of Mechanical Engineers on the work that he had done in rationalising the supply of steam in the Arsenal. When he commenced that

* *Twelfth Report from the Select Committee on Estimates, Session* 1951-52. H.M. Stationery Office, York House, Kingsway, London, W.C.2. [Price 9*s.* net.]

considerable undertaking, he found that there were 47 separate boiler-houses on the premises, containing 228 boilers with a total capacity of about 920,000 lb. of steam per hour. The steam was used at pressures from 10 lb. to 200 lb. per square inch, and the peak load was about 605,000 lb. per hour.

When his process of rationalisation was completed, he had closed 36 boiler-houses and was operating the plant with only 61 boilers, with a maximum aggregate capacity of 441,000 lb. of steam per hour and an approximate maximum load, under peace-time conditions, of slightly over 276,000 lb. per hour; a truly remarkable achievement, but one that was no more than typical of the high level of competence possessed by the technical officers responsible for operating and maintaining the engineering equipment of the Royal Arsenal. They cannot be held to blame for its extraordinary complexity, due in part to the vicissitudes which have affected its growth and in part to its unique character. As was stated by one of the witnesses (Mr. F. E. Glasson, secretary of the Combined Shop Stewards' Committee) in his evidence: "Woolwich is different from the other Ordnance Factories. We are not a single-purpose factory. When you visit the others you will find that they are gun factories, tank factories or explosives establishments. With the exception of the small arms themselves, rifles and Bren guns, we do the whole lot—guns, carriages, mountings, tanks, shells, cartridges, bullets and filling. No other factory does all that." When it is borne in mind that the Arsenal is also a principal centre for much miscellaneous experimental work, frequently urgent, it is obvious that its efficiency of production must be difficult to evaluate.

When all this has been said and admitted, however, the fact remains that the Arsenal has been for years the Cinderella of the Royal Ordnance Factories and is now suffering from the inevitable consequences. Of its 4,500 machine tools, according to the evidence of the Chief Superintendent, Mr. A. T. Barnard, O.B.E., 2,600 are more than ten years old and 850 are between 20 and 60 years old. A survey embracing "a number of shops" (an unspecified number) showed that only 10 per cent. of the machines in those shops could be classed as being in "very good condition." A further 17 per cent. were "usable," 50 per cent. were in need of replacement or major overhaul, and 23 per cent. were only fit for scrap.

The Committee's conclusion was that "the Royal Arsenal at Woolwich presents an urgent and pressing problem to the Royal Ordnance Factory Board" because of "the apparent shortage of work, the uneconomic methods of production, the wastage of land and buildings, the obsolescence of the plant, the difficulties of management and the general running down of the Arsenal." Not unnaturally, they formed the opinion that it was "regarded by the Ministry [of Supply] as something of a white elephant"; but, they suggested, it might be possible to find "some specialised use" for it—for example, as a factory for the manufacture and overhaul of plant and machine tools for all the Royal Ordnance Factories. Evidence was given that difficulty had been experienced in persuading private firms to make some of the specialised plant that the Arsenal had needed from time to time. The Directors of the various groups of Factories admitted the advantages in keeping the Arsenal in production as a potential war reserve, and in keeping the skilled personnel employed, while pointing out their lack of experience in making machine tools. In the end, the Select Committee made the recommendation that "the question of the use of the Arsenal and its fuller integration with the whole organisation of the Royal Ordnance Factories should be given immediate consideration by the Board . . . and that a decision should be reached at the earliest possible moment"; where, for the present, the matter rests.

TIMBER RESEARCH.

The introductory remarks in the latest report* of the Forest Products Research Board refer to two matters which are of interest outside the particular field of work with which the Board are concerned. These are that the time and staff available for basic investigations have been severely limited by advisory work for industry, and by the evaluation and testing of new Colonial timbers. As there has been so much criticism, much of it uninstructed, about the neglect of the results of scientific research by industrial firms, it can only be a matter of satisfaction that so much of the interest of the Forest Products Laboratory is being directed to the industrial application of the scientific data which it has established. More than once it has been said that the mass of scientific knowledge now available is so great that the chief need of the country is that it should be applied. It has even been suggested that a halt might be called to fundamental research until industry has digested the data now established. Apparently a condition approaching it is being forced on the Laboratory.

The necessity for work on Colonial timbers arises from the considerable importation of these materials, largely caused by deficiencies in the supply of types which have been generally available in the past. It is also due to the efforts being made to develop the Colonial territories, which, with the closing or restriction of some traditional markets, may come to play a major part in the future trade of the country. In as far as the natural resources of these territories can be exploited, good will come to many industries other than those concerned with timber. There is no *a priori* reason to suppose that the traditional timbers used in building, furniture-making and for other purposes were employed because no others were suitable. They were utilised because they were in good supply and easily available, but as, in the changing pattern of the trade of the world, these conditions no longer apply, it is fortunate that others can be obtained.

In this introductory section of the report, Sir Edward Salisbury, the chairman of the Board, refers to the testing of new Colonial species as "the major project." A study of the main part of the report, however, contributed by Dr. F. Y. Henderson, the Director of Research, appears to show that, so far, use of these new materials has been confined to furniture-making. This particular industry cannot be said to be within the engineering field, although the machinery which it uses certainly is, and the section dealing with woodworking refers to investigations on chip formation, sawing, nailing and boring. Work on nailing was naturally concerned with the reaction of various types of timber to this operation rather than to any equipment employed. The results obtained indicate that the tendency of timbers to split is proportional to their hardness: cleavage ratio. No results are quoted on boring and the work done appears to be in connection with the design of equipment. A drill-point tester has been designed for the accurate measurement of the angles and dimensions of boring bits, and improvements have been made in the special boring machine which has a spindle-speed range of from 950 to 6,000 r.p.m.

In connection with chip formation, it is pointed out that the behaviour of wood in cutting is far more variable than that of metal, owing to the cellular structure. In metal cutting, the chip is formed by a shearing process and, although it is subjected to high crushing stress, its volume remains essentially unchanged. Wood, being composed of hollow fibres and other types of cell, which close up when under compression, decreases considerably in volume. The direction of cutting relative to the grain, the moisture content, and local variations in density affect the reaction of the wood. The sharpness of the cutting edge, the cutting angle and rate of cutting also have considerable effect on the result and these considerations, coupled with the effect of the nature of the material, make the whole problem one of considerable complexity. A technique has been developed for observing chip formation at magnifications up to 240. Useful preliminary work has been done and investigations are being continued. The work on sawing has been mainly concerned with tooth form. A matter of possible interest and value to some who are not normally concerned with wood technology relates to the trimming of battery separators which were in a moist woolly condition. They could not be dealt with by any form of toothed saw, but a high-speed rotary cutting disc proved to be satisfactory.

The whole section of the report which deals with wood preservation is of engineering interest. In some applications, timber is employed without preliminary treatment, and investigations have indicated that while the service life of perishable timbers, such as beech or pine sapwood, does not vary much with size, with durable timbers, such as oak or teak, the life increases. Transmission poles and railways sleepers are referred to in this section of the report. There has been an undesirable number of failures of creosoted transmission poles which has been found to be due to unsatisfactory creosoting. A new British Standard Specification has now been issued, which puts more stress on preservation, and it is hoped that this will reduce the number of failures. In connection with railway sleepers, it is reported that trials have shown home-grown Scots pine and Douglas fir to be just as satisfactory as Baltic redwood, which has been the standard timber used in the past. Some Douglas fir sleepers were found to be in better condition than any other sleepers after 16 years in service. This is thought to have been due to the character of the home-grown wood, which contains large sound knots. These appear to hold the wood together and to reduce the tendency to split.

In the mycology section of the report, it is stated that the decay of timber in small boats had been the subject of many inquiries. One writer estimated that over $1\frac{1}{2}l.$ million is spent annually on the repair of yachts and an additional 1*l.* million on fishing craft and open boats. It is stated that much of the decay results from faulty design, which permits the penetration of rain-water, and also to the absence of provision for adequate ventilation. The trouble appears to have been accentuated since teak has not been so readily available, less durable timber being used in its place. The remedy is an increased use of wood preservatives, and correspondence with naval architects and yacht designers has resulted in a decision to hold a joint conference in order to make the information at present available more widely known.

Two novel methods of seasoning timber have been tested but the results have not been encouraging. The first is a method of seasoning in superheated steam, which has been advocated by some firms in Germany. Steam at atmospheric pressure, but at temperatures above the boiling point of water, is used. Fans ensure a rapid movement of the superheated steam through the pile of timber. In tests with beech, the shrinkage of the wood was high with considerable surface splitting. More promising results were obtained with some African woods, such as mahogany, but the shrinkage and casehardening were usually greater than that brought about by normal kiln drying. The second novel procedure was drying by boiling in oil. Tests showed that oak and beech can be dried very rapidly in this way, but the oak was so badly split as to be virtually useless. Though the beech did not suffer so seriously, the conclusion reached was that the method did not merit serious consideration.

* *Report of the Forest Products Research Board, with the Report of the Director of Forest Products Research for the Year* 1951. H.M. Stationery Office. [Price 3s. net.]

NOTES.

The Volta River Aluminium Scheme.

A White Paper (Cmd. 8702; price, 9*d.* net) has been issued by H.M. Stationery Office, which gives particulars of a scheme to develop aluminium production on a large scale in the Gold Coast, West Africa, where there are available great resources of bauxite, and of water power for the generation of electricity. The scheme has been prepared jointly by the United Kingdom Government, the Gold Coast Government, and the Canadian and United Kingdom producers of aluminium, and is estimated to enable a production of 210,000 tons a year of aluminium to be achieved. The initial capital expenditure would amount to 100*l.* millions, rising eventually to 144*l.* millions. The main proposals are for the construction of a dam and power station at Ajena, about 70 miles from the mouth of the Volta River; the erection of an aluminium smelter near Kpong, 12 miles from Ajena; and various public works, including port facilities, roads and railways, housing, etc. The dam would form a reservoir 2,000 square miles in area, and the power station would have an ultimate capacity of 564,000 kW; and the smelter would have an initial capacity of 80,000 tons a year, rising to 210,000 tons in about 20 years. It is proposed to set up a Preparatory Commission to examine the problems, with instructions to report as soon as possible.

The Institution of Mechanical Engineers.

A review of "Recent Developments in the Machinability of Steel," especially of work carried out at the B.S.A. Group's machinability research laboratories, was given in a paper of that title by Mr. K. J. B. Wolfe, M.Sc., A.M.I.Mech.E., at a meeting of the Institution of Mechanical Engineers on Friday, November 21. Much of the information he presented was in the nature of a progress report, with suggestions as to future research, but there was also some information of immediate significance in the machine shop. Referring to the fact that surface austenite is produced on high-speed steel tools by harsh grinding, and that this austenite has a deleterious effect on the tools' cutting power, Mr. Wolfe said that three treatments had been developed to overcome this trouble; they were the B.S.A. "Golden Arrow," "Goldray" and "Blue Arrow" treatments. The first two not only dispersed the austenite, but also induced in the surface of the tool certain materials, not metallic oxides, which had excellent lubricating properties under conditions that involved boundary lubrication. These treatments reduced the tendency of the swarf to weld on to the tool. The Blue Arrow treatment gave, in addition, a high resistance to abrasion. In reviewing recent developments, Mr. Wolfe distinguished between "true machinability" and "cutability." The former was a property of the material being machined and was defined as that complex property which controlled the facility with which it could be cut to the size, shape, and surface finish required commercially; cutability was that property of the tool material which controlled the facility with which it could act as a cutting tool in a commercial machining operation. In considering true machinability it was important to include, in addition to the normal hardness concept (which was resistance to penetration), the strain or work hardening capacity. Some tests carried out had suggested that true machinability was improved by having fewer and finer manganese segregates, and that molybdenum could have a beneficial effect in this connection. Work on the effect of the size of lead globules on true machinability—which had already shown that there was an optimum size—was being continued. Mr. Wolfe also dealt with the effect of intermittent cutting and, in his survey of future development, with the possibility of ensuring that the production of a free-machining steel did not lower its physical properties. He spoke also of the casting of milling cutters, the use of ceramics as cutting tools, the "hot-spot" machining method (in which intense local heat was induced in the material just ahead of the cutting tool), and the electrolytic/electro-erosion cutting of metals. An article on the latter subject was published on page 121 of our issue of July 25, 1952.

Improved Prospects in Steel Industry.

There is now little doubt that the 1952 production of steel ingots and castings in the United Kingdom will total more than 16 million tons, compared with 15,640,000 tons in 1951. Moreover, providing there are no unexpected difficulties over raw materials, the output of steel next year should beat the 1950 record production of $16\frac{1}{4}$ million tons by a substantial margin. It is shown in the current issue of the *Bulletin for Industry*, a monthly review of the economic situation prepared by the Information Division of H.M. Treasury, that the main factor in the rapid rise in the output of steel has been an expansion in pig-iron production. This is offsetting the decline in the supplies of imported scrap which has been one of the industry's most important raw materials in recent years. During the first 10 months of the present year, the average weekly output of pig-iron was 202,000 tons, compared with 184,000 tons in the corresponding period of 1951 representing an increase of 9·1 per cent. During the past 18 months, seven new blast furnaces have been blown in, and another three are to come into blast shortly. On average, these furnaces, which formed part of the 1946 development plan of the industry, have taken about three and a half years to build. A shortage of blast-furnace coke, mainly in the first quarter of 1952, hampered pig-iron production in the early part of this year; but the position has now improved sufficiently to allow some rebuilding of coke stocks at the blast furnaces and coke ovens, and the outlook is definitely better than it was early in this year.

The Iron and Steel Institute.

The autumn general meeting of the Iron and Steel Institute opened in London on the morning of November 26 and was brought to a conclusion yesterday. Captain H. Leighton Davies, C.B.E., the President, took the chair at 10 a.m. on the first day. In the course of the preliminary business meeting it was announced that, at the request of the Minister of Supply, a meeting to discuss the question of "Boron in Steel" would be held on February 18, 1953. The annual general meeting of the Institute is to be held on April 29 and 30, 1953, with the annual dinner taking place at the end of the first day of the meeting. Jernkontoret, Stockholm, have invited the Institute to visit Sweden in 1953 but, owing to the intervention of the Coronation, it has been arranged for the meeting to take place in 1954, when it will probably be held during the second or third week of June. Next year, it is proposed to hold a short week-end meeting in Holland towards the end of September. This meeting is in response to an invitation issued by the Royal Dutch Steelworks, Ijmuiden. Changes in the membership of the Council, which have taken place since the annual meeting in April, 1952 were announced by the secretary. These indicate that Mr. C. R. Wheeler, C.B.E., has been elected a vice-president and that Mr. B. Chetwynd Talbot has become a member of Council. Three vice-presidents, namely, Mr. G. Steel, the Hon. R. G. Lyttelton, and Mr. I. F. L. Elliot and five members of Council, Mr. D. F. Campbell, Mr. G. H. Johnson, Mr. D. A. Oliver, Dr. C. Sykes, F.R.S., and Mr. W. Barr, are due to retire at the next annual general meeting, but are eligible for re-election. The new Presidents of several local societies affiliated to the Institute have been elected honorary members of the Council during their period of office. They are Mr. F. Kennedy of the Cleveland Institution of Engineers, Mr. W. D. Jenkins of the Ebbw Vale Metallurgical Society, Dr. N. J. Petch of the Leeds Metallurgical Society, Mr. W. L. James of the Lincolnshire Iron and Steel Institute, Mr. R. S. Brown of the Liverpool Metallurgical Society, Mr. T. G. Grey-Davies (chairman) of the Newport and District Metallurgical Society, and Mr. H. N. Bowen of the Swansea and District Metallurgical Society. Dr. C. J. Smithells, M.C., President of the Institute of Metals has been made an honorary member of Council and Mr. R. S. Brown and Dr. L. B. Pfeil, F.R.S., are the new representatives of the Institution of Metallurgists, in place of Mr. W. E. Bardgett and Mr. W. W. Stevenson. Captain Leighton Davies announced that Mr. James Mitchell, C.B.E., of Stewarts & Lloyds Ltd., Corby Steelworks, had been elected President and would take office at the 1953 annual general meeting. Mr. W. Barr has been nominated to succeed Mr. Mitchell as honorary treasurer.

The New Royal Yacht.

Some particulars have been issued by the Admiralty of the new Royal yacht, now under construction by John Brown and Company, Limited, at their shipyard at Clydebank. The keel was laid in June of this year and it is expected that the vessel will be launched by Her Majesty in April, 1953. Though designed by the Admiralty, the vessel is being built according to merchant-ship practice and in accordance with the rules of Lloyd's Register of Shipping. She will have a length overall of 413 ft. and, on the water-line, of 380 ft., with a maximum beam of 55 ft. and a moulded depth of 32 ft. 6 in. The loaded displacement will be about 4,000 tons, and the maximum draught will not exceed 16 ft. Single-reduction geared steam turbines will be fitted, driving twin screws and taking steam from two boilers, and will give the vessel a cruising speed of 21 knots. She will have a raked stem, what is described as "a modified cruiser stern," two funnels and three masts, and will be fitted with a stabiliser. The structure above water will be riveted throughout. The Royal and State apartments, which will be air-conditioned, will be aft, and the accommodation for both officers and crew forward. The State apartments are to be on the upper deck abaft the mainmast, and the Royal apartments on the shelter deck. The vessel is designed to be convertible into a hospital ship in time of war with the minimum of structural alteration, and will be equipped for service in both cold and tropical waters. The shelter deck is being made strong enough, at the after end, for a helicopter to land on it.

Power Alcohol from Vegetable Waste.

A subject akin to the utilisation of solar energy, a report on which has recently been published in this country (see pages 607, 645 and 679) was discussed at a conference held at Lucknow, Northern India, from October 23 to November 6, and convened by the United Nations Economic Commission for Asia and the Far East, and the United Nations Technical Assistance Administration. The conference considered 30 papers on the blending of alcohol, made from domestic agricultural waste material, with ordinary petrol as used in motor-cars. The production of motor fuel by this method was recommended as a way of saving foreign currency in Asian countries where indigenous oil was scarce. It was considered that waste products, particularly from Asian sugar factories, could be used on a greater scale than hitherto and that, as part of long-term agricultural planning, more land could profitably be cultivated for growing "alcohol crops," especially tapioca. Of the various raw materials considered, molasses appeared to be the most important because of its content of fermentable sugar and its low cost. To conserve coal resources, the production was recommended of charcoal briquettes from farm waste, such as straw shells and corn cobs, and from the by-products of the lumber industry. There was already considerable experience of the production of power alcohol—the annual production in India was about 6 to 7 million Imperial gallons—but there were not sufficient alcohol factories, raw materials, or up-to-date knowledge. It was necessary to adjust motor-cars to run on petrol-alcohol mixtures; the petrol had to be cleaned, sparking plugs adjusted, the ignition advanced, fuel-pump diaphragms resistant to the mixture had to be fitted, and it was necessary to use a metal float in the carburettor instead of a cork float impregnated with shellac. If these adjustments were carried out, a 20 per cent. petrol-alcohol mixture was regarded as at least equal in engine performance to pure petrol. Alcohol had a lower calorific value than petrol, but when the two were mixed the octane number was raised and carbon deposits were reduced.

LETTERS TO THE EDITOR.

FULL EMPLOYMENT.

To the Editor of Engineering.

Sir,—Mr. C. H. Smith, in his comments which you printed on page 604, *ante*, has missed the point of my letter. I did not suggest that employers, as a class, desire unemployment. What I did say was that the majority of industrial managements still seem to regard hourly-paid labour as the most readily variable of their prime costs. It is this attitude—the assumption that, whereas capital commitments must be planned years ahead and even raw material contracts may have to run for as long as a year or 18 months, one week is adequate notice for terminating employment—which, in my view, will not be tolerated in the long run by politically emancipated workpeople.

I am quite willing to accept his analogy of the over-loaded 'bus which has to get rid of some of its passengers before it can surmount a hill. Is it not reasonable to suppose, however, that, after repeated experiences of this sort, the passengers might come to doubt the competence of the people running the service, and to reflect on the fact that, whereas they, who had no say in planning the route, always did the walking, the driver and conductor always remained on board ?

In plain language, my argument is that if Mr. Smith, and employers who share his views, are content to see the rest of British industry swallowed up by monopolistic national corporations, all they have to do is to go on treating labour as the short-term shock-absorber for fluctuations in business activity. If, on the other hand, they are not content with this prospect, then it is they, not I, who are emulating King Canute by ignoring the outstanding "practical fact" of our century—namely, universal suffrage.

Yours faithfully,
Bjorn Guy.

18, Gardnor Mansions,
Church-row,
London, N.W.3.
November 18, 1952.

LABORATORY REPRODUCTION OF THE FIELD DENSITY OF SAND.

To the Editor of Engineering.

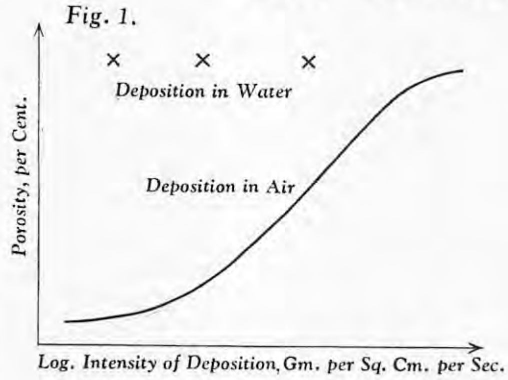
Sir,—May I be allowed some space in your journal to say a few words about the laboratory reproduction of field density of sand ? The problem is of considerable importance to soil mechanicians and as it is not yet standardised it is sometimes slightly inaccurately described in various soil mechanics literature. For example, G. P. Tchebotarioff, in his recent book *Soil Mechanics: Foundations and Structures* (McGraw-Hill Book Co. Inc., 1951), on page 58 makes the following statement: "The determination of both $e_{max.}$ and $e_{min.}$ can be made in a laboratory, but the reproduction of e, that is, of the actual natural state of a deposit, is not possible in a laboratory."

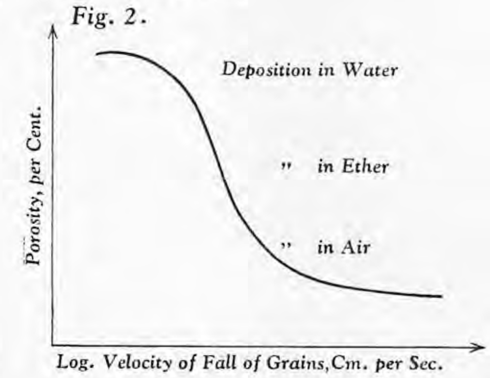
These three values ($e_{max.}$ = voids ratio of the sand in the loosest possible state ; e = voids ratio of the sand in the actual state in nature ; and $e_{min.}$ = voids ratio of the sand in the densest possible state) are used in soil mechanics for determining the relative density of the deposit found in the field :

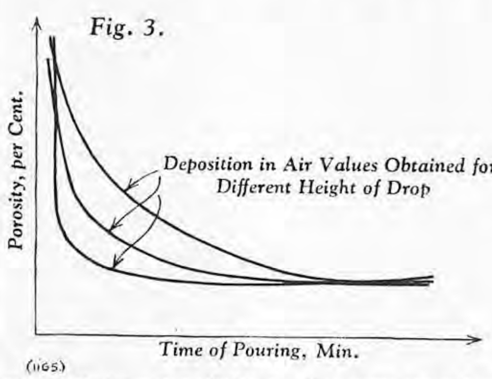
$$D_R = \frac{e_{max.} - e}{e_{max.} - e_{min.}}.$$

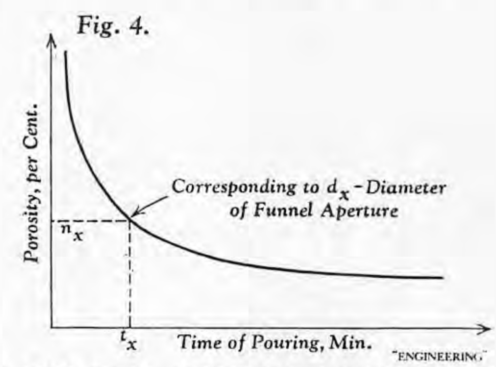
Remembering that the porosity, n, of a deposit, $= \frac{e}{1+e} \times 100$, is governed by two factors controlling the deposition, namely, the intensity of deposition, Q gm. per square centimetre per second, and the velocity of fall of the grains, V cm. per second, giving the relationships shown in Figs. 1 and 2. We can easily find for each sand the relationship represented in Fig. 3, where the time of pouring of the same amount of sand into a container (rate of deposition) is plotted against the porosity obtained. Thus, the reproduction of the voids ratio, e, of a sand as found in the field is possible in a laboratory.

THE DENSITY OF SAND.









The technique is as follows. The same weight of sample of sand is poured through a series of funnels, having various diameters of apertures, from the same height into a container, and for each test the time of pouring and resulting porosity or voids ratio are measured. The results are plotted as in Fig. 4. By interpolation the time t_x required for setting the sample at the required porosity n_x is found and the aperture of the funnel adjusted. The funnel is then used for setting the sample at n_x, i.e., in a shear box or triaxial compression-test machine or a permeameter. The technique and the theory are explained in more detail in "Notes on Deposition of Sands" (*Research*, November, 1950).

It may be pointed out that in $e_{max.}$ cases a 1,000-c.c. measuring cylinder (2 in. in diameter) should not be used (Tchebotarioff, page 58), but a 2,000-c.c. cylinder of 3-in. diameter. It was found that diameters smaller than 3 in. affect the obtained porosity of sands, increasing it by the action of the so-called "wall friction." Moreover, the loosest possible state of sand will be obtained by depositing it in water with no air entrapped. The procedure, developed in this country, in which sand is allowed to drop freely from a funnel, filled up with distilled water and thoroughly mixed with it until all air is washed out, into a 2,000-c.c. glass cylinder filled with distilled water, creates no danger of swelling and gives higher values than any deposition of dry sand in air—higher, for example, than that described by Tchebotarioff (page 58).

Yours faithfully,
J. Kolbuszewski,
Lecturer in Soil Mechanics.

Department of Civil Engineering,
The University,
Edgbaston,
Birmingham, 15.
November 5, 1952.

Electricity Supply in France.—During 1951 38,282 million kilowatt-hours of electricity were produced in France, of which 21,144 million kilowatt-hours were generated by water power and 17,138 million kilowatt-hours in thermal stations. The corresponding figure in 1950 was 33,141 million kilowatt-hours, of which 16,188 million kilowatt-hours were produced by water power and 16,953 million kilowatt-hours in thermal stations. The capacity of the plant installed in water-power stations was 5,843 MW, of which 4,777 MW were operated by Electricité de France and in thermal stations 6,784 MW, of which 3,958 MW were owned by the same body. The amount exported rose from 398 million to 641 million kilowatt-hours; while that imported fell from 647 million to 638 million kilowatt-hours, compared with 1950.

1,000-H.P. DIESEL-ELECTRIC LOCOMOTIVES FOR THE CEYLON GOVERNMENT RAILWAY.

The Ceylon Government Railway consists of 809 miles of 5 ft. 6 in. gauge track and another 87 miles of 2 ft. 6 in. gauge track. A considerable proportion of this mileage follows the coast both northwards and southwards from Colombo, but a line crosses the island from the latter place to Trincomalee, with branches to Batticaloa, Kandy and Matale and Badulla. The Badulla branch rises to a height of 6,200 ft. on a ruling gradient of 1 in 44, and comprises curves with radii as small as 5 chains. A heavy suburban traffic is carried within a radius of 25 miles from Colombo ; and the rolling stock comprises not only steam locomotives and railcars, but Diesel-electric train units and shunting engines. This stock will, however, shortly be augmented by 25 main-line Diesel-electric locomotives which are now being constructed by Messrs. Brush Bagnall Traction, Limited, Loughborough.

A photograph of one of these locomotives, which was formally accepted by the High Commissioner of Ceylon at Loughborough on Thursday, November 20, is reproduced in Fig. 1, on page 696. It is of the A-1-A—A-1-A type, with a length of 50 ft. 9 in. over the buffers and a bogie wheelbase of 10 ft. 6 in. Its maximum height is 13 ft. 3½ in. and its maximum width 10 ft. 3⅞ in. The underframe is made up of four main steel members of I-section, which were reduced in depth over the bogies by flame cutting and welding along the neutral axis, in order to provide clearance for the bogies. The two outer main members are welded to the centre cross-members of the bogies, but the inner longitudinals continue and are welded to the fabricated drag box. Cross-members, which are riveted to the main longitudinal members, carry sole bars of channel section and the underframe as a whole is covered by a continuous deck of steel plate. The bogies consist of welded box-type side frames which are joined by a fabricated-steel transom in the centre and by two channels which act as headstocks. The centre bolsters of the bogies, which carry the weight of the locomotive, rest on eight nests of springs. These springs are carried on two planks, which are, in turn, suspended from the side frames by swing links. The leaf springs for the axles are borne internally in the side frames with the coil springs below. The axles run in roller bearings, the boxes of which are fitted in manganese-steel horn guides. The superstructure is of No. 14 gauge steel sheet, which is welded to the framework. There is a driving cab at each end, which, as will be seen from Fig. 1, is mounted behind a short streamlined end compartment. This compartment contains an electrically-driven Sturtevant blower for cooling the traction motors and has an output of 2,940 cub. ft. per minute. These compressors are driven by 5-h.p. 110-volt Brush motors. In both cabs the driver's controls are on the left-hand side with an assistant driver's position on the right. A complete set of instruments is mounted below the two windows, where they are visible to both men, and these windows are provided with pneumatically-operated wipers. Immediately behind one cab is the main radiator ducting, which carries the fan motor and runner. Air is drawn in through panels which are mounted vertically on the sides of the locomotives and, after passing through the ducting, is discharged upwards through a grille in the roof. The radiators are of the Serck type. Behind this ducting is the Diesel engine, access to which is obtainable from gangways on each side of the superstructure, sufficient room being available for the withdrawal of the pistons and connecting rods. The engine and generator compartments are separated by partitions with doors. The main fuel tank and batteries are slung beneath the locomotive between the bogies, but there is a separate fuel service tank on the roof. Owing to the weather conditions in Ceylon, which include tropical rain and salt-laden atmosphere, all the ventilating and air inlet louvres are waterproof and considerable use has been made of anti-corrosive constructional materials. The main control cubicle is mounted in the generator compartment and is dustproof.

The locomotive is powered by a Mirrlees, Bickerton and Day V-type 12-cylinder four-stroke engine, which is fitted with two Napier superchargers and has an output of 1,254 brake horsepower at 850 r.p.m. under normal temperature and altitude conditions. It is shown being erected in Fig. 2, page 696. In Ceylon, however, the engine will develop 1,000 h.p. at this speed owing to the climatic conditions. The main generator, which was constructed by the Brush Electrical Engineering Company, Limited, Loughborough, and has a continuous output of 652 kW at 630/750 volts, is directly connected to the engine. An auxiliary generator, with an output of 35 kW at 110 volts, is also coupled to the same shaft. The main generator supplies power to four motors, each having a continuous rating of 196 h.p. at 315 volts, which are hung on the outer axles of the two bogies. These axles are fitted with tubes for the axle suspension of the traction motors, the noses of which are suspended by a flexible link from the centre transom. The armature and suspension bearings are both of the roller type and the drive is through single-reduction gearing with a ratio of 82 to 16. These motors, one of which is illustrated in Fig. 3, page 696, can be connected in series-parallel or parallel, the change from one to the other arrangement being made automatically. A single handle on the master controller in the cab enables the driver to select the "engine starting," "forward" and "reverse" positions, as well as all the running notches. Control is effected by varying the speed of the engine and the excitation of the main generator. The control cubicle for this purpose is illustrated in Fig. 4, page 696. The engine is started from a 48-cell lead-acid battery with a capacity of 192 ampere-hours at the five-hour discharge rate. This battery, which was manufactured by the D.P. Battery Company, Limited, Bakewell, Derbyshire, can also be used as a source of auxiliary power when the main engine is not running. Current for exciting the main generator, for driving the auxiliaries, for operating the control equipment, and for battery charging, is supplied from the auxiliary generator. Two locomotives can be coupled together electrically as well as mechanically and controlled by one driver.

The locomotive is fitted with twin reciprocating exhausters, made by the Westinghouse Brake and Signal Company, Limited, York-road, London, N.1, for the purpose of operating the train brakes. The locomotive itself is braked by Westinghouse brakes, air being supplied by an electrically-driven compressor. There is also a hand brake in each cab.

THE FUTURE OF PLASTICS IN ENGINEERING.*

By J. E. Gordon, B.Sc.

Present-day engineers have built for themselves an age of "Meccano." They think in terms of fabricating all kinds of structures from sheets, angles, etc. This leads to a very inconvenient division of labour, for it is the duty of the metallurgists to produce these sheets and angles, after which they hand them over to the engineer who builds whatever he can from the "Meccano" parts available. Though many engineers would deny it, this way of thinking is deeply ingrained in the engineering outlook and it is going to take a great deal of hard work to get rid of it. Of course, for many purposes the "Meccano system" is very convenient, but I would suggest that a limit of development along those lines is almost in sight.

During the war, when I was serving on a committee to encourage the use of plastics in aircraft structures, we circularised the leading aircraft designers and asked them what properties they would like to have in a plastic for aircraft construction. Without exception the replies indicated that they would like a material very like Duralumin, but rather better, if possible, which could be used in the same way. I do not think that it is technically possible to produce a "plastic metal," and even if it were, it is difficult to see any object in doing so. It is, perhaps the combination of the two factors—high efficiency and cheapness—which is, I hope, going to enable some real advances to be made in engineering. Because, with this "Meccano system," it is convenient to make rectangular objects, the engineer perhaps assumes that rectangular shapes are those which it is desirable to make.

There is another aspect of the problem. It suits our present system of dividing labour and responsibilities for one man to design the structure and for others to add the wiring, plumbing and the internal and external finishes more or less as afterthoughts. In plastics, of course, we have the possibility of combining all these into one integrated structure, with great improvements in cost and efficiency. However, the amount of human co-ordination required is certainly frightening. This question of the efficiency of shape and function is a very real one. Engineers tend to compare materials by simple mechanical properties such as tensile strength, and in a "Meccano" structure this is generally fair and correct. In some aircraft structures, however, we tend to find that it is not at all an adequate criterion. Comparing, say, Duralumin and Durestos simply as materials, you must come to the conclusion that Durestos is only about half as efficient as Duralumin. On the other hand, since, by being cunning you can make structures from Durestos which are about as efficient as Duralumin structures, it follows that the efficiency of shape in the plastic structure must be something like twice as high as that of the "Meccano" component.

To both the layman and the engineer the whole idea of plastics has somehow become associated with lightly-stressed and relatively trivial uses. The prospect of putting really large loads upon apparently fragile plastic structures is felt to be wrong. Even when one has worked on the subject for quite a long time and is familiar with the calculations and the stresses involved, one feels "It cannot possibly take such loads." Of course, there are many failures, but generally these devices do take the loads expected of them. We have to demonstrate that this subjective feeling is wrong, both to ourselves and to others. Nevertheless, the mechanical properties of plastics are important. Though for many purposes we have quite adequate strength and stiffness already, there are quite a number of applications where we should like better materials. For a long time to come we shall have to depend on reinforced plastics for high-strength applications. Considering reinforcing fibres, we should do well to banish cellulose as far as possible, at least until its moisture response can be much better controlled.

At present we have only glass and asbestos as relatively inert and strong reinforcements. There may be other fibres which exist or can be made. Both silica glass and crocidolite asbestos seem to promise the possibility of much higher strengths.

Stiffness is just as important as strength in many structures, and it has long been one of the principal defects of plastics that their stiffness compared with that of metals is too low. Fairly recently it has been found possible in the laboratory and on a small scale to make reinforced materials with a marked improvement in stiffness. Unfortunately, it has not so far been possible to combine the increased stiffness with the increased strength. However, I am quite hopeful that we shall be able to do so before long. If we succeed in making a really strong and stiff material, then it will produce at least one serious difficulty in its use. It is of no value having a more efficient material unless you can use less of it. This means that the various thicknesses will be greatly reduced and we shall encounter buckling troubles. There are, perhaps, two ways of avoiding this difficulty. The first is to introduce some kind of light-weight stabilising material. There are a number of these, the most attractive seems to be the kind which can be poured into a cavity and will foam and set *in situ*. At present there is only one material of this kind, i.e. the Sebalkyd class of resin. It is still rather expensive, but its worst defect is that, at the moment of pouring, it is extremely poisonous and must be handled with great care. We should very much like to have a cheaper and a harmless material. Whether such a structure consists of a single closed shell filled completely with foam or whether it consists of a "sandwich" in the ordinary sense, will depend on the circumstances of the design.

In many cases, however, it would be preferable to approach the problem in a different way, that is, by reducing the specific gravity of the material. It may be that one reason why wood is so widely used, even to-day, is that its specific gravity is practically ideal. A timber of twice the present density would be rather an impracticable material, yet the densities of most plastics are about twice that of most timbers. It would help the design of aircraft structures, at least, if we had a plastic with a specific gravity of about 0·5 while keeping the present specific strength and stiffness properties. The reduction in density would probably have to be achieved by incorporating air voids, as in wood; then, no doubt, we should get something like the toughness and the warm "feel" of wood.

So far, I have speculated about plastic structures as being made wholly of plastics, but I do not think there is any reason why we should not employ metals in the same way as plastics and in conjunction with them. As a simple example, one might have a pressed shell of thin sheet metal filled with a foamed plastic. Some of the more complicated examples also look promising. It is possible, for instance, to obtain good adhesion between steel and the Durestos class of materials if the two are moulded together. The coefficients of thermal expansion are similar and the phenolic resin appears to inhibit corrosion in the steel. In this way, one can make Durestos shell structures with steel inserts in the more highly stressed places; the steel sheet need only be cut roughly to shape and the Durestos provides protection and a smooth finish, besides helping to stabilise the steel under compression. In this way, we may have some of the best of both worlds, having, to some extent, the strength, stiffness and low material cost of the steel combined with manufacturing cheapness and good finish of the plastic. Metals are really excellent as materials: they are cheap, strong, stiff and tough. The difficulties arise in shaping them and to some extent in stabilising thin shells (hence corrugated iron). Going a little farther in the direction of metal construction, I should not be surprised to see a wide use for the process which has recently been developed at the Royal Aircraft Establishment whereby shaped objects are assembled from simple stepped plates of metal. The steps are then filled in with a suitable resin which can easily be finished to the required form. Another need is a really cheap and satisfactory finish for the low-pressure laminates. Perhaps the "transfer finish" system (whereby

* Fourth annual lecture of the Plastics Institute, delivered on November 13, 1952. Abridged.

the finish is sprayed on the mould and transfers itself to the moulding) may be an answer.

All these requirements are very desirable, but I think that existing processes, imperfect as they are, would be technically quite satisfactory for a wide range of applications. One has to ask "Why do plastics seem to be catching on so slowly in engineering?" The answer is perhaps partly a question of conservatism, a reluctance to break out of the cage, and partly that many designers do not realise how much can now be done by the various new processes and their imaginations have not been caught by the armoury of new devices at their disposal; yet I think the main reasons are economic. The manufacturer is frightened by the high costs of the raw materials combined with the undoubted technical difficulties. The economic question is very complex and must depend on the type of product. Let us examine a few concrete examples and hazard some actual costs.

Application to Aircraft.

There are some parts of aircraft, such as "radomes," where plastics are essential for technical reasons, and there are others, such as internal equipment, where plastics have proved cheaper and lighter than metals, but with the main structure of the aircraft the position is different. If we consider the airframe of a transport machine, the all-important consideration is weight. A pound of weight saved on the airframe is a pound of extra pay-load throughout the life of the machine, and that is worth a great deal of money. With existing materials it is difficult to promise any considerable saving of weight over a metal airframe; relatively small improvements in materials, however, might put the question in quite a different light. If that were so, the cost of the material would be a secondary consideration. The design and manufacture of a transport aircraft, however, is an enormously difficult and expensive project and it is unlikely to be undertaken in plastics until there is ample successful experience with small light aircraft. Leaving aside military aeroplanes, this experience is most likely to be gained on the light "private owner" type of machine. I believe that the cost of building conventional airframes is in the region of 50*s*. per lb. of finished weight, the cost of Duralumin is about 3*s*. per lb., the difference being mainly cost of fabrication. Since the weight of the airframe of a two-seater aircraft will not be less than about 600 lb., one is faced with an expenditure of about 1,500*l*. before providing an engine and instruments.

If the cost is to be reduced sufficiently to justify quantity production the total price must be cut substantially. Most of this reduction must be at the expense of the airframe because the engine and instruments probably cannot be very greatly cheapened. To make the venture attractive, therefore, the target to be aimed at seems to be a structure cost between 10*s*. and 15*s*. per lb. This might reduce the airframe cost to 300*l*. or 400*l*., and take 1,000*l*., or so, off the cost of the aircraft.

This probably requires a material cost of, say, 5*s*. to 7*s*. per lb. at the most, and there are structural plastics available at these prices which are technically suitable. A difficulty arises out of the low wing loadings which are necessary. These lead to low structure loadings and thus to thin panels of material which need to be stabilised, probably by a foamed material. If this is to be of the foamed *in situ* type, it will cost about 15*s*. per lb. Such a project might, therefore, be regarded as just about marginal at present; a relatively small reduction in cost might make it economically attractive. Technically, I do not think there are any insuperable difficulties, and there are some considerable advantages. For some time aerodynamicists have had available wing sections of much lower drag, if only smooth surfaces could be attained; if we can get these smooth surfaces with plastics we shall see a much better performance. Again, a considerable part of the cost of running an aircraft arises because the law rightly requires that the complex structure shall be pulled to pieces and examined at fairly frequent intervals in the interests of safety. In a plastic aircraft this should not be so necessary as there will be very little to examine; moreover, fatigue is unlikely to be a serious trouble.

(*To be continued.*)

GEOLOGICAL RESEARCH AND ITS PRACTICAL APPLICATION.*

By Dr. J. E. Richey, M.C., F.R.S.

In the English-speaking world alone, very many geologists are at work at the present time in the field and laboratory, exploring the mineral constitution of the earth. Many are engaged in mapping new territories and carrying out fundamental research on stratigraphical, structural, and other problems of varying complexity. Many are concerned with economic inquiries, applying the normal methods of geological investigation to the elucidation of practical issues, aided by new techniques which have been developed for specific purposes. I should like to remind you of the varied content of the phrase "economic geology." We have only to think of its many divisions and subdivisions, its numerous applications in the coalfields, in the search for oil, in metalliferous mining, in agriculture, forestry, water-supply, and in civil engineering undertakings, with all their multifarious ramifications, to realise how important a share geology is taking, directly and indirectly, in the control and development of world affairs.

The practical importance of a knowledge of the geology of a country has long been recognised. For example, in the British Isles, as early as 1813, John Macculloch was appointed to carry out a geological survey in Scotland in connection with the work of the trigonometrical survey. In 1832 a similar appointment was made in Ireland in the person of Captain (later General) J. E. Portlock, R.E., who, in 1843, presented his notable report on the geology of the county of Londonderry and parts of Tyrone and Fermanagh. In the preface, Portlock states that the object in view was to combine with scientific investigation much practical information. This dual purpose, widened to include investigations into mineral resources, has been the guiding principle in shaping the policies of national geological surveys at home and abroad, although on occasions the need for carrying out special economic inquiries has taken precedence over comprehensive mapping. A point which should be specially emphasised is that economic or applied geology is not a separate subject from geology. It is simply geology applied to objectives containing an economic purpose.

Coalfield Geology.

Among the wealth of scientific achievement which has come from the study of coal, it is difficult to single out a subject in illustration of the main patterns of evidence involved, but perhaps the discovery and exploitation of the concealed coalfield of Kent may be selected. In the words of the late Professor Boyd Dawkins, spoken in 1906, its discovery is "the story of a scientific idea, originated many years ago, taking root in the minds of geologists, developed into theory, and ultimately verified by facts."

In 1821, William Buckland and William Daniel Conybeare drew attention to the similarity of the structure of the coalfields of Bristol and Somerset, on the one hand, and northern France and Belgium, on the other. In 1846, De la Bêche stated that there might be coal measures beneath the intervening Jurassic rocks of the south of England, and, in the same year, a bore for water in the Pas de Calais district proved coal measures on the other side of the Channel. In 1856, R. A. C. Godwin-Austen gave more precision to these early ideas. He visualised a far-extending belt of uplift that had involved the coal measures and older rocks, stretching from the south-west of England to northern France and Belgium. Southwards against the uplifted belt, after the removal of the tops of anticlines by post-coal measures denudation, he suggested that the cover of younger strata would have overlapped and, at the same time, become thinner than farther north. So the cover, overlying coal measures preserved in troughs, might be sufficiently thin in the south-east of England for the underlying coals to be reached by boring and exploited.

* Presidential address to Section C of the British Association, delivered at Belfast on September 8, 1952. Abridged.

The idea became accepted by many geologists, and the experimental stage of putting the matter to the test by boring was begun in 1872, near Battle, north of Hastings in Sussex. The bore, however, showed that in this area the upper oolites of the Jurassic by themselves were much thicker than anticipated, and the bore did not extend below the Oxford Clay. But the idea persisted, though as now known it was incorrect as regards the direction in which the thinning of the Mesozoic cover takes place; and in the mind of Boyd Dawkins, in collaboration with the engineer, Brady, it led to the drilling of a bore, starting in the chalk close to Shakespeare Cliff, near Dover, in 1886-90. The bore reached coal measures at a depth of only 1,100 ft. and proved a number of seams of coal. Many more deep bores were subsequently drilled in Kent, and exploitation at several collieries followed the experimental stage. As H. G. Dines and others have recently shown, coal measures are now known to occur within an area of about 100 square miles bounded by Dover, Canterbury and Ramsgate in east Kent, in a structural basin the axis of which extends west-north-west through a point a few miles north of Dover.

Exploitation has been accompanied by much geological research, and classification by means of widely applicable methods of comparison has proved useful in Kent, as in so many other coalfields in Britain and elsewhere. In this study, H. Bolton, working with the animal remains, and Newall Arber with the plants, applied stratigraphical knowledge gained elsewhere to determine the position of the Kentish coal measures in the general sequence. The two seams of coal mainly worked at present are situated in the upper coal measures, the lower seam towards their base.

The less spectacular, though on occasions highly profitable, method of detailed comparison of lithological sequences should also find a brief mention here. The life of a coalfield depends largely upon the number and lateral extent of its workable coal seams. The correct recognition of the various coals in a local succession thus becomes a matter of vital importance in ground so much broken by faults as many of the British and Continental coalfields are. It would be invidious, perhaps, to select as an illustration one of the many cases where Survey geologists and mining engineers have corrected a wrong designation of a seam and have brought welcome extensions of life to particular coalfields. The value of their work emphasises the need for a continuing study while coal remains an essential asset for Britain's economic prosperity.

The Search for Oil.

Much has happened since 1859, when the first oil-reservoir to be discovered was pierced in Pennsylvania by "Colonel" Drake's drill at a depth of 69 ft. Scientific methods of locating possible reservoirs have been developed with such precision that nowadays deeper and deeper sources of oil are being sought and exploited. In the United States alone, in 1945, no fewer than 65 wells were drilled to depths greater than 12,000 ft. In the early search for oil, geology was hardly used at all, but the phenomenal developments of the past 50 years have resulted very largely from geological and geophysical investigations. At the present time, in the United States, the chances of locating an oil-reservoir by the "wild cat" drilling that was almost exclusively practised up to the close of last century have been estimated as only 5 in 100, as compared with the chances of 23 in 100 for cases in which geological and geophysical methods have been employed.

The geologist and geophysicist are concerned mainly with the determination of structure, and geometrical patterns of evidence are of chief value in the discovery of suitable "traps" for oil. The anticlinal theory of the early days became well substantiated with the inception of organised field research by geologists, and geological mapping increased in importance from 1897 until 1923, when, in the United States, the first oil-location based upon a geophysical (gravity) survey was drilled. To illustrate an idea which has proved highly profitable, I propose to take an example from the other world-pole of oil production, situated around the Persian Gulf.

LIFTING BARRIERS FOR LEVEL CROSSING.

Early Tertiary (Eocene) beds form the surface rocks of Bahrein Island, 30 miles long by some 10 miles in width, in the south-eastern part of the Persian Gulf. The rocks were examined in 1908 by G. E. Pilgrim of the Geological Survey of India, who showed that the strata occurred in the form of a slightly elongated dome. He noted associated deposits of asphalt and speculated on the probability of oil occurring at depth. His idea was not put to the test till much later. The delay, no doubt, is attributable to the fact that the Bahrein rocks lie at a lower stratigraphical level than the oil-producing beds—the Asmari limestone—of the adjoining great Persian field. It was not until 1932 that the Standard Oil Company of California discovered, by drilling, the first oil-pool at Bahrein in cretaceous limestone. Since then production has gone on apace, and reserves in this small insular area have been estimated to be nearly one-half of 1 per cent. of the total known world resources of petroleum. An interesting feature of the production side is that the pressure in the oil below ground is maintained by injecting into the oil-reservoirs high-pressure gas obtained from a level in the cretaceous limestone deeper than the oil-horizons concerned.

It may be of interest to refer to another aspect, namely, the importance of voids in reservoir rocks, and the chances which have proved successful of finding oil in dense strata owing to the local occurrence of fissures and fractures. The recent discovery of oil in northern Venezuela in dense cretaceous limestone, below previously exploited porous tertiary strata, provides an example of the role of fracturing associated with folding. Another case is the Balkassar field in the Punjab. The search for fissured zones at depth should prove to be a fruitful, if difficult, subject for future investigations, and in their prosecution geological and geophysical research may pay high dividends.

Appreciation of the conditions under which the initial migration of oil takes place from the source rocks to the porous or fissured reservoir rocks is also vital. The matter was discussed at the Geological Congress in London in 1948 by L. G. Weekes, and emphasis was laid upon the importance of unconformity and overlap, in other words, the positions of ancient shore-lines with off-shore dip of beds, for these are guides to the present-day geographical locations where oil may be expected to occur. In resolving such problems of palæogeography, every available branch of geological science must be brought into action, and the future holds, no doubt, as high a place for geology in the search for oil as the history of the past 50 years testifies.

(*To be continued.*)

ILLUMINATED LIFTING BARRIERS FOR RAILWAY LEVEL CROSSING.

The accompanying illustration shows the illuminated lifting barriers which have been experimentally installed by British Railways (North Eastern Region) at Warthill, Yorkshire, where the public road crosses the main line from York to Hull. These barriers, which are each 30 ft. long, replace four 15-ft. gates, thus reducing the number of connections, and, it is hoped, cutting down the maintenance costs. Each barrier consists of a steel tube, 12 in. in diameter at one end, and tapering to 5 in. at the other, pivoted on plummer blocks lined with phosphor bronze, which are carried on welded steel pedestals so that the centre line of the barrier is about 4 ft. above road level. The larger end of each tube contains 1,500 lb. of balancing weights. A curtain of light-alloy rods is suspended from each barrier. These rods are pivoted at their tops and linked together at their lower ends so that when the barrier is down the gap between it and the road is closed. As the barrier is raised, however, the curtain folds inwards, so that the passage of the road traffic is not obstructed. The barriers are operated through rack and pinion gearing from the signal box and are locked in the horizontal position by a catch, so that they can be secured before the railway signals can be cleared.

As will also be seen, a "Stop" board, 3 ft. in diameter and carrying 9-in. letters, has been erected on each side of the crossing. These boards can be rotated by operating a lever in the signal box, so that they face the road when the barriers are about to be lowered and are turned through 90 deg., so that they show their edges, after the barriers have been raised. Twin electric lamps are mounted on these boards, one of which flashes when the barriers are about to be lowered, exhibits a steady light to the road traffic when they are down, and is extinguished when they are raised. When the "Stop" board is moved to face the road traffic a second warning lamp at the centre of each barrier is illuminated. Floodlights, which illuminate the "Stop" boards during the hours of darkness, are also switched on. The reflectors employed on these floodlights were supplied by Benjamin Electric, Limited, Tottenham, London, N.17, and have a cut-off of 20 deg., thus preventing interference with the railway signals. The reflectors are 18 in. in diameter and are finished with crystal vitreous enamel.

FORTHCOMING EXHIBITIONS AND CONFERENCES.

This list appears in the last issue of each month. Organisers are invited to send to the Editor particulars of forthcoming events.

20th National Exposition of Power and Mechanical Engineering.—Monday, December 1, to Saturday, December 6, at the Grand Central Palace, New York. Organised by the American Society of Mechanical Engineers, 29, West 39th-street, New York 18.

Conference on Prevention and Suppression of Dust in Mining, Tunnelling and Quarrying.—Monday, December 1, to Wednesday, December 17, at Geneva. Arranged by the Industrial Safety Division, International Labour Organisation, Geneva, Switzerland.

Symposium on Light-Metal Heavy Forgings and Extrusions for Modern Aircraft.—Tuesday, December 2, at New York. Organised by the American Society of Automotive Engineers. For further information, apply to the secretary of the Society, 29, West 39th-street, New York 18, U.S.A.

Smithfield Show and Agricultural Machinery Exhibition.—Monday, December 8, to Friday, December 12, at Earl's Court, London, S.W.5. Details obtainable from the Smithfield Show Joint Committee, 148, Piccadilly, London, W.1. (Telephone: GROsvenor 4040.)

Ramsay Centenary Exhibition.—Open until Saturday, January 3, 1953, at the Science Museum. Arranged, in collaboration with University College, London, by the Science Museum, South Kensington, London, S.W.7. (Telephone: KENsington 6371.) See also page 475, *ante*.

Netherlands Packaging Fair.—Thursday, January 8, to Friday, January 16, 1953, at Amsterdam. Apply to N.V. Het Raedhuys, Tesselschadestraat 5, Amsterdam, Holland.

43rd National Motor Boat Show.—Friday, January 9, to Saturday, January 17, 1953, at Grand Central Palace, New York. Details obtainable from W. H. Pearsall, H. A. Bruno and Associates, 30, Rockefeller Plaza, New York 20, U.S.A.

8th Annual Farm Equipment Show.—Tuesday, January 20, to Friday, January 23, 1953, at Canadian National Exhibition Grounds, Toronto. Further information obtainable from Ontario Retail Farm Equipment Dealers' Association, 81, King-street East, Toronto.

Packaging Exhibition.—Tuesday, January 20, to Friday, January 30, 1953, at Olympia, London, W.14. Held in collaboration with the Institute of Packaging. Organised by Provincial Exhibitions, Ltd., City Hall, Deansgate, Manchester. (Telephone: Deansgate 6363.) Apply as above, or to London office, 167, Oakhill-road, Putney, London, S.W.15. (Telephone: VANdyke 5635.)

Fifth Annual Pakistan Science Conference.—Monday, February 16, to Saturday, February 21, 1953, at Lahore. Applications to be made to Dr. Bashir Ahmad, Pakistan Association for the Advancement of Science, The Mall, Lahore, Pakistan.

Frankfurt International Spring Fair.—Sunday, February 22, to Thursday, February 26, 1953, at Frankfurt. *Agents:* Lep Transport Ltd., Sunlight Wharf, Upper Thames-street, London, E.C.4. (Telephone: CENtral 5050.)

Radio and Television Exhibition.—Friday, February 27, to Sunday, March 8, 1953, at Düsseldorf. *Agents:* John E. Buck and Co., 47, Brewer-street, London, W.1. (Telephone: GERrard 7576.)

Indian Railways Centenary Exhibition.—Saturday, February 28, to Thursday, April 16, 1953, at Purana Quila, India. Additional particulars obtainable from the joint director, Indian Railways Centenary Exhibition, Ministry of Railways, New Delhi.

Hanover Fair.—*Light Industries Fair:* Sunday, March 1, to Thursday, March 5, 1953, at Hanover. *Heavy Industries Fair:* Sunday, April 26, to Tuesday, May 5, 1953, at Hanover. *Agents:* Schenkers, Ltd., 27, Chancery-lane, London, W.C.2. (Telephone: HOLborn 5595.)

33rd International Spring Fair.—Sunday, March 15, to Sunday, March 22, 1953, at Vienna. Apply to the British-Austrian Chamber of Commerce, 29, Dorset-square, London, N.W.1. (Telephone: PADdington 7646.)

Royal Netherlands Industries Spring Fair.—Tuesday, March 17, to Thursday, March 26, 1953, at Utrecht, Holland. *Agent:* Mr. W. Friedhoff, 10, Gloucester-place, London, W.1. (Telephone: WELbeck 9971.)

Frankfurt International Motor Show.—Thursday, March 19, to Sunday, March 29, 1953, at Frankfurt-am-Main. Organised by the Versand der Deutschen Automobilindustrie, Westendstrasse, Frankfurt-am-Main.

FACTORY EQUIPMENT EXHIBITION.—Monday, March 23, to Friday, March 27, 1953, at the New Horticultural Hall, Greycoat and Elverton Streets, Westminster, London, S.W.1. Further particulars obtainable from Mr. J. E. Holdsworth, Exhibition Offices, 117, Kingsway, London, W.C.2. (Telephone: HOLborn 1414.)

SECOND NATIONAL ELECTRICAL ENGINEERS' EXHIBITION.—Wednesday, March 25, to Saturday, March 28, 1953, at Earl's Court, London, S.W.5. Organised by the Association of Supervising Electrical Engineers. Apply to Mr. P. A. Thorogood, 35, Gibbs-green, Edgware, Middlesex. (Telephone: MILl Hill 3528.)

RADIO COMPONENTS SHOW.—Tuesday, April 14, to Thursday, April 16, 1953, at Grosvenor House, Park-lane, London, W.1. Organised by the Radio and Electronic Component Manufacturers' Federation, 22, Surrey-street, Strand, London, W.C.2. (Telephone: TEMple Bar 6740.)

FIFTH EMPIRE MINING AND METALLURGICAL CONGRESS.—To be opened on Tuesday, April 21, 1953, at Melbourne. Closing date in May not yet fixed. Sessions will be held at centres in Australia and New Zealand. Apply to Miss B. E. Jacka, Australian Institute of Mining and Metallurgy, 399, Little Collins-street, Melbourne, C.I.

BRITISH INDUSTRIES FAIR.—Monday, April 27, to Friday, May 8, 1953, at Earl's Court, London, S.W.5, and Olympia, London, W.14; and Castle Bromwich, Birmingham. Particulars obtainable from the director, British Industries Fair, Board of Trade, Lacon House, Theobald's-road, London, W.C.1. (Telephone: CHAncery 4411); or the general manager, British Industries Fair, 95, New-street, Birmingham, 2. (Telephone: Midland 5021).

ROYAL SANITARY INSTITUTE HEALTH CONGRESS.—Tuesday, April 28, to Friday, May 1, 1953, at Hastings. Particulars obtainable from the secretary, Royal Sanitary Institute, 90, Buckingham Palace-road, London, S.W.1. (Telephone: SLOane 5134.)

ROYAL ULSTER AGRICULTURAL SHOW.—Wednesday, May 27, to Saturday, May 30, 1953, at Balmoral Show-grounds, Belfast. Organised by the Royal Ulster Agricultural Society, The King's Hall, Balmoral, Belfast.

BATH AND WEST AGRICULTURAL SHOW.—Wednesday, June 3, to Saturday, June 6, 1953, at Bath. Organised by the Bath and West and Southern Counties Society, 3, Pierrepont-street, Bath. (Telephone: Bath 3010.)

BRITISH PLASTICS EXHIBITION.—Wednesday, June 3, to Saturday, June 13, 1953, at Olympia, London, W.14. Organised by *British Plastics*, Dorset House, Stamford-street, London, S.E.1. (Telephone: WATerloo 3333.)

THREE COUNTIES AGRICULTURAL SHOW.—Tuesday, June 9, to Thursday, June 11, 1953, at The Racecourse, Hereford. For further particulars, apply to the Three Counties Agricultural Society, Berrington House, 2, St. Nicholas-street, Hereford. (Telephone: Hereford 3969.)

BUSINESS EFFICIENCY EXHIBITION.—Tuesday, June 16, to Friday, June 26, 1953, at Olympia, London, W.14. Organised by the Office Appliance and Business Equipment Trades Association, 11-13, Dowgate-hill, Cannon-street, London, E.C.4. (Telephone: CENtral 7771-2.)

SAFETY AND FACTORY EFFICIENCY EXHIBITION.—Friday, June 19, to Friday, June 26, 1953, at Bingley Hall, Birmingham. Sponsored by the Birmingham Industrial Safety Group, 15, Old Town Close, Birmingham, 30. Further particulars obtainable from the exhibition secretary, Mr. A. G. Cogswell, Dunlop Rubber Co., Ltd., Fort Dunlop, Birmingham, 24. (Telephone: Erdington 2121.)

SECOND BRITISH INSTRUMENT INDUSTRIES' EXHIBITION.—Tuesday, June 30, to Saturday, July 11, 1953, at Olympia, London, W.14. Apply to F. W. Bridges & Sons, Ltd., Grand Buildings, Trafalgar-square, London, W.C.2. (Telephone: WHItehall 0568.)

ROYAL AGRICULTURAL SHOW.—Tuesday, July 7, to Friday, July 10, 1953, at Stanley Park, Blackpool. Organised by the Royal Agricultural Society of England, 16, Bedford-square, London, W.C.1. (Telephone: MUSeum 5905.)

SEVENTH INTERNATIONAL CONGRESS OF RADIOLOGY.—Sunday, July 19, to Saturday, July 25, 1953, at Copenhagen. Further particulars obtainable from the secretary-general, Professor Flemming Nørgaard, Kommunehospitalet, Copenhagen, Denmark.

THIRD INTERNATIONAL CONFERENCE ON SOIL MECHANICS AND FOUNDATION ENGINEERING.—Sunday, August 16, to Tuesday, August 25, 1953, at Zürich and Lausanne. Apply to the secretary, Société Internationale de Mécanique des Sols et des Travaux de Fondations, Gloriastrasse 37, Zürich 44.

19TH ENGINEERING, MARINE AND WELDING EXHIBITION AND CHEMICAL PLANT EXHIBITION.—Thursday, September 3, to Thursday, September 17, 1953, at Olympia, London, W.14. Apply to F. W. Bridges & Sons, Ltd., Grand Buildings, Trafalgar-square, London, W.C.2. (Telephone: WHItehall 0568.)

LABOUR NOTES.

INTERESTING comments on the attitude of work-people to cost-of-living figures are contained in the November issue of *Man and Metal*, the official journal of the Iron and Steel Trades Confederation. The writer points out that the interim index of retail prices, which measures changes in the cost of living, dropped by one point in August and by another point in September, and that there were some people who, instead of accepting this as evidence of a genuine decline in the cost of living during those months, were questioning the reliability of the index. While it was not suggested, the writer states, that the index was infallible, the recent fall by two points provided no valid reason to doubt its reliability, and anyone doing so must be lacking in a sense of proportion.

In examining the position in relation to the recent decline of the index, there were several points to be borne in mind, the first of which was that, round about August and September each year, there tended to be seasonal falls in the prices of fruit and vegetables. It was true that these declines in price were only temporary, but it was quite right that such reductions should be reflected in the index at the time that the falls took place, in exactly the same way as increases in prices would be shown. Further, the index figures were taken to the nearest whole number, and, although in August the actual figure was 136·7 (taken as 137), the fall in September was just sufficient to bring the figure to below the half-way level of 136·5, and, consequently, it was then taken as 136. This was just as the event happened. The process could quite as easily operate in the other direction.

During the two months in question, there was no general advance in the prices of other commodities, such as might have offset, in the final index figure, reductions in the prices of fruit and vegetables. The two or three hundred items included in the index covered a very wide field, and the localities from which the prices of these items were collected embraced an area extending from one end of the country to the other. It could not be said, therefore, that the index was too limited in its scope. Between September, 1951, and July, 1952, the writer concludes, the rise in the cost of living was reflected in the index to the extent of 10 points, in spite of the fact that some items in the wide range of commodities included in the index unquestionably fell in price during the period.

The need to halt the decline in productivity which had arisen in some industries during recent months was referred to by Mr. Harold Watkinson, the Parliamentary Secretary to the Ministry of Labour and National Service, in an address to the Slough Chamber of Commerce on Monday last. He said that the Government would do everything in its power to free channels of manufacture and trade, so that the country might not only balance its financial affairs, but build up a surplus. Provided trading conditions did not swing further against us, there was no reason why the enterprise, energy and determination of British industry, supported by the skill of its technicians, should not re-establish the country's position among the world's leading industrial nations.

Declines in productivity during the past few months had not been catastrophic, Mr. Watkinson stated, but they were certainly proof that what Britain was going to lack during the coming months would not be raw materials but orders. The Government regarded the drop in productivity as serious and as something that had to be altered without delay. The main task confronting industry at the present time was to reverse the downward trend of production and exports, and, in this effort, the Government would give all the assistance it could. It was fully realised by the Government that a policy of reducing trade could not benefit this country other than as a very short-term policy. To attract buyers from overseas, British exporters must be in a position to offer them the kind of commodities they want, of the quality they demand, at the price they were able to pay and with the certainty of quick delivery. To keep down the cost of living in Britain, without reducing wages, prices must be kept as low as possible. One certain way to achieve that aim was by increased productivity.

Unions representing draughtsmen, clerical employees and scientific staffs in the engineering and cognate industries presented claims for increases in pay to the Engineering and Allied Employers' National Federation at a joint meeting of representatives held in London on Tuesday last. The new demands have arisen as a result of the recent agreement in the engineering industry under which adult male manual employees were given an additional 7*s*. 4*d*. a week, and apprentices and other juvenile employees obtained lesser amounts.

Increases of 10*s*. a week for members aged 21, and proportionate advances for older men up to the age of 25, were asked for by the Association of Shipbuilding and Engineering Draughtsmen. Minimum rates of pay at the present time, for draughtsmen aged 21, are 6*l*. 14*s*. in the provinces and 6*l*. 19*s*. in London. The Clerical and Administrative Workers' Union and the Association of Scientific Workers requested "substantial" increases, without mentioning definite amounts. Clerical employees, both in London and the provinces, at present receive a basic wage of 5*l*. 19*s*. 6*d*. at the age of 21. The minimum rates for members of scientific staffs are 6*l*. 14*s*. in the provinces and 6*l*. 19*s*. in London at the age of 21; rising to 8*l*. 4*s*. and 8*l*. 9*s*., respectively, at the age of 25.

Adult male manual employees in the shipbuilding and engineering industries, working at the Royal Dockyards, have been awarded a wage increase of 7*s*. 4*d*. a week. An announcement issued on Tuesday last stated that this increase, which had been granted owing to the corresponding advance in wages in civilian engineering and shipbuilding establishments, would take effect as from November 10 last. As a result of this addition, the wages of the lowest-paid labourers at the Dockyards would be increased to a minimum of 6*l*. 1*s*. 4*d*. a week.

An unofficial strike of some 2,300 men at the Betteshanger Colliery, near Deal, commenced last Monday, when the afternoon shift refused to descend the mine. The miners expressed their strong dissatisfaction with the working conditions in one of the pit's underground sections. Ventilation difficulties were given as the main cause of the dispute. It was stated that it became very hot at the coalface in certain parts of the mine and the men asked for increases in the rates of pay for work done in those sections, but the management were not prepared to grant the additional remuneration. Members of the men's committee were reported to have expressed the view that conditions in the areas under notice were suitable for working. The miners, however, alleged that the conditions under which they worked were not the same as those prevailing at the time of the committee's visit. It was stated by the South-Eastern Division of the National Coal Board that the strikers had ignored the existing conciliation machinery.

Yorkshire winding enginemen's wage dispute took a more serious turn at the end of last week. At a special meeting at Barnsley on Sunday last a report was presented of the efforts made by union officials to secure the maximum rates of pay for colliery enginemen in the North-Eastern Division of the Coal Board. In view of the lack of success which had attended these representations, the delegates, from almost every pit in the Division, decided to tender seven days' notice to the Board to terminate their contracts as from December 13. The men have asked for payment at the maximum rate of 29*s*. 11*d*. a shift which, they claim, is paid in other Divisions. The present rate in Yorkshire is 3*s*. less. Some 700 enginemen employed at 117 Yorkshire collieries are affected.

OIL JETTY FOR SHELL HAVEN REFINERY

Fig. 1. General View of Jetty and Approach.

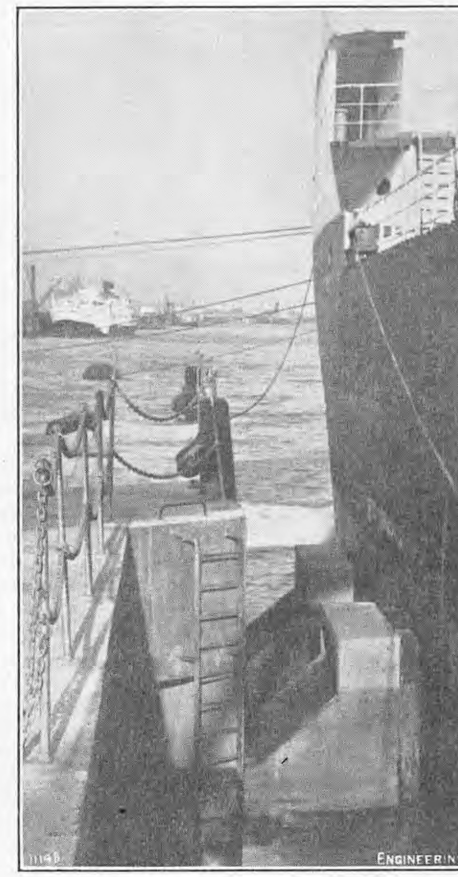


Fig. 3. Concrete Fender.

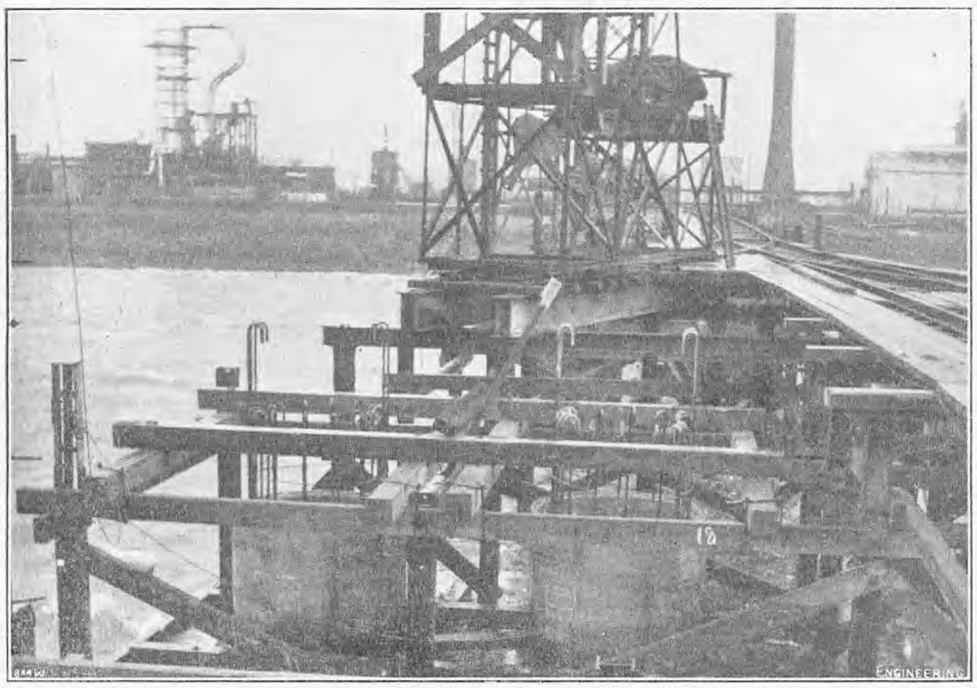


Fig. 2. Approach under Construction.

JETTY FOR SHELL HAVEN OIL REFINERY.

The new oil jetty for use in connection with the Shell Haven oil refinery, Essex, to which brief reference was made on page 736 of our 173rd volume (1952), has now been completed and is being used to berth the largest types of oil tankers. This jetty, which is believed to be the largest in the Thames estuary, was built by John Mowlem and Company, Limited, London, to the order of London and Thames Haven Oil Wharves, Limited, whose premises adjoin the new refinery and who, under arrangement with the "Shell" Petroleum Refining and Marketing Company, Limited, are providing jetty facilities and much of the tank storage capacity required for incoming crude oil and outgoing refined products. The new jetty, which can accommodate tankers of up to 40,000 tons deadweight, is unique in that it incorporates prestressed, pre-cast concrete beams in its construction and is the first to be provided with a new form of fender.

In plan view, the new jetty is in the form of the letter L, the approach being 414 ft. long and 23 ft. wide and the head 240 ft. long by 40 ft. wide. Both the approach and head are supported on concrete cylinders, 8 ft. 3 in. in diameter, consisting of pre-cast hollow sections each 8 ft. long. The sections are connected by spigot joints and the lower edge of each bottom section is provided with a steel cutting edge for penetrating the river bed. The cylinders were sunk into the river bed to a depth of approximately 34 ft. by means of superimposed weights, about 120 tons being placed on each cylinder, and then filled with concrete suitably reinforced, some 4,000 tons of concrete being used for this purpose. The cylinders were used throughout except at the shore end of the approach, where it rests on the sea wall, two bored piles being used at this point. The approach is shown in course of construction in Fig. 2, above.

There are five 77-ft. clear spans in the approach, each span resting at the ends on a single cylinder, except for the two outermost spans, which rest on two cylinders. Each span consists of two pre-cast, prestressed concrete I-section beams. The beams were made in three lengths on the shore and after they had been placed in position and supported by suitable staging, the prestressing cables were manipulated through each section and the whole beam was subsequently prestressed to form a continuous member. The jetty head is supported on three dolphins each consisting of six cylinders of the type just described and approximately 70 ft. long; these are located three on the out-river side and three on the inshore side. Each pair of cylinders is connected by a cast *in situ* prestressed-concrete beam of box form 9 ft. in width, 8 ft. 6 in. deep and 40 ft. long. The dolphins are spanned by five pre-cast, prestressed concrete beams of I-section which, unlike the approach beams, are cast in one length. The decking throughout consists of pre-cast concrete slabs, those on the approach being 23 ft. long, 2 ft. wide and 5 in. thick, and those on the head 9 ft. long by 2 ft. wide by 4 in. thick.

Bean-type bollards are provided on the jetty head for mooring purposes, there being six bollards at the front and five at the back. Mooring posts have been constructed up-river and down-river from the jetty and ground moorings, consisting of mooring screws to which bridle and pendant chains are attached, are provided to take the head and stern ropes of the vessels. Samson posts with double derricks and electric winches are installed on the jetty head for dealing with the suction hoses; the pipe lines from the headers on the jetty are capable of discharging tankers at up to 2,000 tons per hour. Both the approach and head are provided with fluorescent safety lighting; this was supplied by the British Thomson-Houston Company, Limited, and is of sufficient intensity to enable all craft to be berthed and unberthed at night. The handrail stanchions of the approach perform a dual function, being designed to act as supports for the water and steam pipes serving the jetty.

The fenders, which are of the horizontal suspended type patented by Professor A. L. L. Baker, were designed by L. G. Mouchel and Partners in conjunction with Mr. T. C. Rolland and Messrs. Port and Harbour Fenders, Ltd., and are understood to be the first of their kind to be installed on any jetty. There are six fenders in all, each being suspended from the underside of the jetty deck by four $2\frac{1}{2}$-in. diameter chains. They are prestressed by eight cables and protrude 6 ft. at the front of the jetty and 2 ft. at the back. One of the fenders can be seen in Fig. 3, which shows a vessel alongside the jetty head. Each fender is made from concrete and is 48 ft. long, 7 ft. 6 in. wide and 14 ft. high, and by swinging on the chains is capable of absorbing, by an inward and upward movement, an energy of 90 ft-tons when immersed.

Development of Guided Weapon Equipment.—The research department of the General Electric Co., Ltd., Kingsway, London, W.C.2, proposes to set up a unit at the Long Range Weapons Establishment, Salisbury, near Adelaide, South Australia, for trials and further development of guided-weapon equipment, on which they are working at present in the United Kingdom.

SERVO MECHANISMS FOR SHIPS.*

By Lieut.-Cdr. J. R. D. Walker, R.N.V.R.

In his paper, Mr. F. W. Meredith has described, if not defined, closed-loop servo mechanisms, and this is the class to which I shall refer by the unqualified term "servo mechanism." The essential features of such a system are that it is "error-actuated" and "power amplifying." In the middle of the Nineteenth Century, before the modern name of servo mechanism had been coined, the principle was applied to steering gear of steamships. Indeed, this mechanism was probably the first serious use of the servo principle. By the middle of the Twentieth Century the necessity to place an anti-aircraft shell at the proper place in the sky at the proper instant so that an enemy aircraft, after flying perhaps two miles, would arrive to meet it at the same instant, had mothered many inventions. Nearly all of these inventions required quick and accurate motions of guns, sights and calculating apparatus, and led to very rapid development of servo mechanisms ranging from $\frac{1}{100}$th of a horse-power to several hundreds. The requirements on board ship were even more exacting than on land, because to compensate the ship's motion called for very considerably greater powers and precision. This development called for new techniques of testing and has provided one of the foundations on which the latest guided weapons have been built up. I do not propose, however, to say much about the warship problems, partly because the unhappy state of the world to-day imposes security restrictions on the most interesting parts and partly because the subject is large enough to occupy more than the time available.

The original steam steering-engine gradually developed into the more elaborate electric and hydraulic mechanisms which are used to steer modern ships, great and small. It is quite out of the question to describe all of the systems, but, fortunately, the principles at least are common to all and it will suffice to describe a typical system in some detail.

Steering Gears.—The earliest servo mechanism I have so far discovered was built in 1867 by George Forrester and Company, of Liverpool, to steer the Great Eastern. Mr. J. MacFarlane Gray's patent for this system may perhaps be the first for any servo mechanism. Fig. 1, herewith, reproduced from Engineering, vol. 3, page 580 (1867), shows the principle. Steam to the engine is controlled by a reverse-and-throttle valve *k*. The valve is moved, through a system of levers, by a screwed sliding shaft geared to the steering wheel. A nut on the shaft is turned by the steering engine so that the endwise displacement of the sliding shaft is proportional to the "misalignment" of wheel and rudder. If the wheel were moved it would open the valve and the engine would turn until the valve was fully closed again; the rudder would then have been moved an amount proportional to the movement of the steering wheel. You will notice that the engine was actuated by the "error" between the position of the rudder and the position of the wheel. The engine, of perhaps two or three horse-power, amplified the one-man power of the helmsman.

At this point we may conveniently digress. You will notice another very common (though not essential) characteristic of servo mechanisms. In ships with hand steering, a strong sea might, on striking the rudder, jar the wheel from the grasp of the helmsman; in the ordinary way, the force on the rudder would react on the helmsman. With the steam steering, the helmsman could no longer feel the effect of a sea striking the rudder or even the steady thrust while the rudder was over one way. The servo mechanism had acted as a buffer between the load and order mechanisms. This is a property of servo mechanisms and can sometimes be a mixed blessing. Anyone who has sailed a small yacht will know how much he depends upon the "feel" of the tiller to judge the behaviour of the vessel. The helmsman with a servo-operated rudder has lost this advantage and cannot so

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

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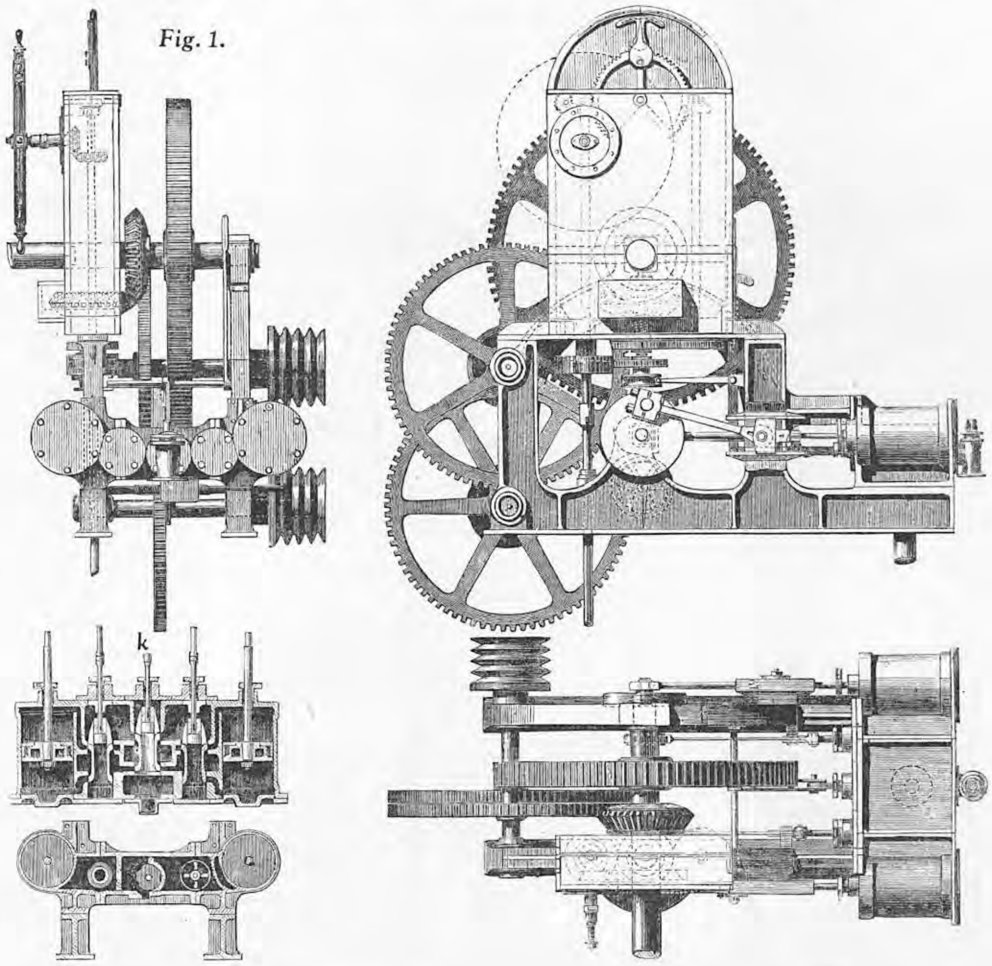
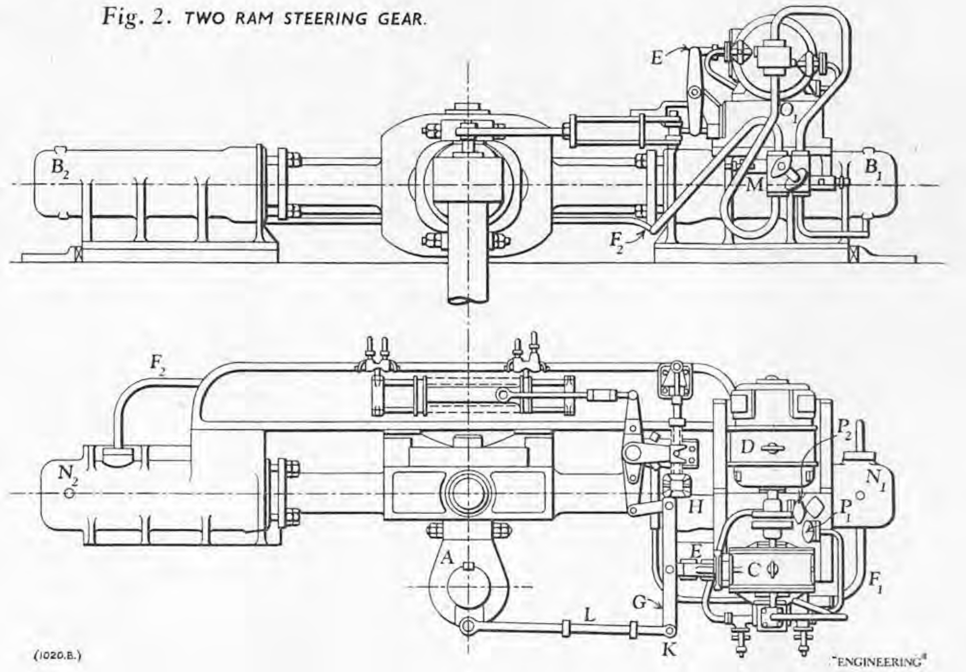


Fig. 1.

Fig. 2. TWO RAM STEERING GEAR.



readily even tell where the rudder is. Partly to replace the "feel" which the helmsman has lost, ships are now almost invariably fitted with a rudder indicator to repeat back to the wheelhouse the position of the rudder. Much thought has been given to restoring the feel of an aeroplane pilot's ailerons, rudder and elevator, because pilots have been trained to fly by feel.

It is convenient, while we have a simple system in mind, to digress farther. The conception of "error actuation" has led quite naturally to an unfortunate mistake in the convention adopted for the sign (plus or minus) of the "error." It has been repeated in text-books the world over, not least in America and in this country. The mathematician, engineer and scientist hold that Truth = Observation − Error, or that Quantity = Reading − Error. In a servo mechanism the "error" was conceived as the thing which actually controlled the mechanism and "error" was usually generated in some form of differential equipment operated by the output of the mechanism. Consequently, error came to be regarded as the difference between the output and the input and the equation became Output − Input = Error, or, transposing, Input = Output + Error. This unfortunate mistake was made quite spontaneously by different workers the world over, but it has led to considerable confusion in the ordinary engineer's mind. I am glad to say that at least one authority (the Interdepartmental Technical Committee on Servomechanisms, of the Ministry of Supply) have decided to try to secure the adoption of the time-honoured mathematical convention. The number of text-books which have been written

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Fig. 3. CONNECTIONS FOR PUSH-PULL STEERING GEAR.

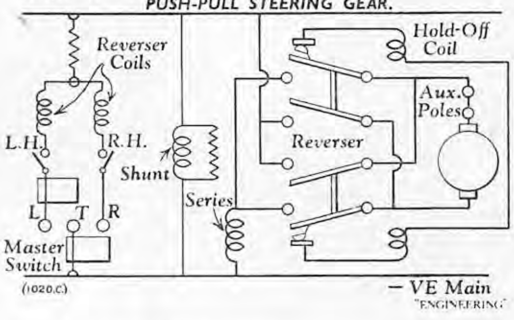


Fig. 4. CONNECTIONS FOR WARD-LEONARD STEERING GEAR.

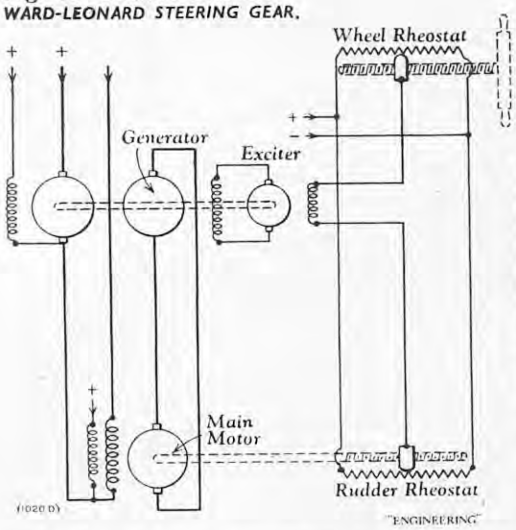


Fig. 5. CYCLE OF OPERATION OF BROWN AUTOMATIC HELMSMAN.

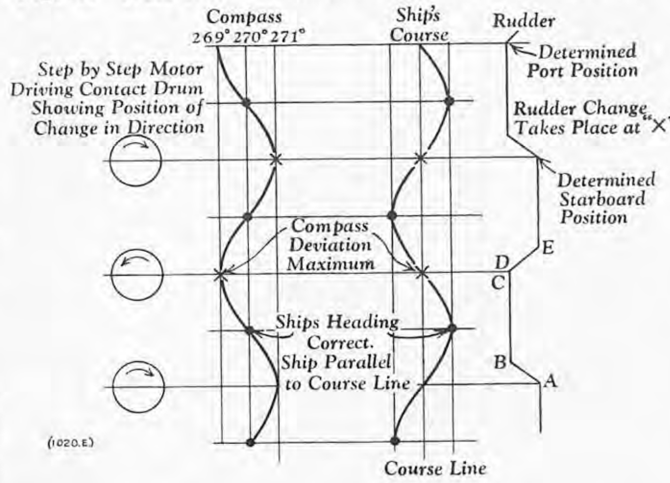
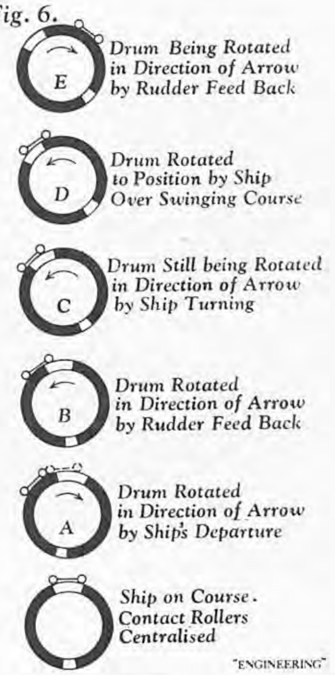


Fig. 6.



with the mistaken convention is already considerable, but there is no doubt that, the longer the mistaken convention is followed, the more harm will be done and the more difficult it will be eventually to put matters right. Certainly, the work involved in correcting matters at this date will be negligible in comparison with the time that will be wasted in developing an independent system of mathematics for servo theory.

Fig. 2, opposite, shows a typical modern electro-hydraulic steering gear, as supplied by John Hastie and Company, Limited, Greenock. The duty of the old-fashioned rod gearing, connected between the steering wheel on the bridge and the steering engine, is now performed by a hydraulic "telemotor." This is simply an arrangement by which oil is pumped from the steering wheel into one or other of the hydraulic rams situated near the steering engine, so that the motion of the wheel is produced conveniently as a displacement of a floating link at the steering engine. Fig. 2 illustrates a two-ram gear. In the figure, A is the tiller fixed to the rudderstock; B_1 and B_2 are hydraulic cylinders and rams operating the tiller by means of a swivel block carried in the fork of the rams; C is a Hele-Shaw pump, driven continuously by the electric motor D; and E is a spindle controlling the operation of the pump. This is so arranged that in the mid-position no oil is discharged, although the pump is running. F_1 and F_2 are oil pipes leading to the cylinders B_1 and B_2, respectively. If spindle E is pulled out from the pump, oil is drawn from pipe F_1 and cylinder B_1 and is discharged through the pipe F_2 to the cylinder B_2. If the spindle E is pushed in, oil is drawn from the pipe F_2 and the cylinder B_2 and is discharged through the pipe F_1 to the cylinder B_2. G is a floating lever connected, approximately at its middle point, to vertical levers which operate the control spindle E of the pump. H is the connection to the telemotor at one end of the floating lever G. K is the connection at the other end of the floating lever G to the tiller through the spring link L. The object of the spring link is to prevent damage to the control mechanism. When H is moved by the telemotor or by hand control, it moves the floating lever G and the spindle E. The pump at once draws oil from one cylinder and discharges it to the other, thus moving the tiller. As the tiller moves, it moves the point K of the floating lever G through the medium of the spring link L, and in doing so, returns the spindle E to mid-position, at which point the pump ceases to discharge oil, the rudder movement stops, and the rudder is held until H is again moved. M is a hand-operated by-pass valve, combined with spring-loaded double shock valves. The shock valves are set at a pressure which will allow the rudder to give way when it is subjected to a severe shock from a heavy sea or other cause. In giving way, the rudder moves the pump spindle E by means of the spring link L. In doing this, it puts the pump on stroke, so that, when the excessive pressure has been relieved, the rudder returns automatically to its former position. N_1 and N_2 are air cocks on the hydraulic cylinders, and O_1 is a replenishing tank containing the non-return suction valves P_1 and P_2, which are connected to the pump by piping. These valves automatically make up any leakage in the system.

Electrical steering was a much later development. The m.s. Mississippi was fitted with the first Ward-Leonard steering gear in 1913. This comprised a potentiometer on the bridge and another potentiometer on the rudder, connected in parallel and fed from the 220-volt direct-current mains. The sliders were connected, respectively, to the terminals of the field coils of a Ward-Leonard generator which supplied a motor geared to the rudder.

Developed from this was a contactor steering gear in which potentiometers were fitted to the wheel and the rudder as before, but this time the sliders energised a very small servo-motor field, the armature of which carried constant current. This servo motor was geared to a reversing-drum controller which controlled the supply to a compound motor, geared to the rudder. This was fitted in January, 1917, to the Lobos. A diagram of connections is shown in Fig. 3, herewith.

Following this, the Ward-Leonard system was improved and, this time, instead of using the null voltage from the sliders of the wheel and rudder potentiometers to drive the Ward-Leonard directly, they supplied the field coils of an exciter which, in turn, supplied the Ward-Leonard generator—in other words, the original steering gear was improved by the addition of one stage of electro-dynamic amplification. Fig. 4, herewith, shows the connections for the Ward-Leonard system steering gear, but to bring it up to date it should have an additional winding on the exciter field, with its terminals connected to the generator brushes. The potentiometer for the wheel and the rudder consists of studs arranged in a circle, and between each stud is connected a suitably low-value resistance. This form of construction stands up to the continuous movement which is required from the controls. As was to be expected, the increased sensitivity and the additional time constant in the loop gave rise to instability; this was eliminated by providing an extra coil on the exciter, which was fed from the motor armature terminals. This improved gear was fitted to the White Star liners Doric and Pittsburgh in 1925 and is the earliest deliberate use of velocity feedback of which I am aware.

Automatic Helmsmen.—The United Kingdom manufactures two automatic steersmen, either of which will steer a ship more accurately than the human steersman. The engineering of each is, of course, quite different, but perhaps even more interesting is that one, the Brown, is designed as a "bang-bang" servo, while the other, the Sperry, is essentially a continuous servo system. The contrast is of sufficient interest for both systems to be considered in some detail.

Both makers manufacture a number of variations to suit the particular steering gear with which a ship may be fitted, and each type is designed to follow a gyro compass. The gyro compass itself, if it is to be accurate, must be arranged so as to have extremely little friction in its gimbal bearings, so it is usual for some kind of hunter or follow-up motor to be employed to drive the gimbal ring in its bearings, thus relieving the gyro itself of all except the very light load required to operate the follow-up mechanism. The Brown gyro compass uses an air jet to switch the follow-up motor, while the Sperry uses electric contacts to perform the same function. The Brown equipment now uses a thermionic amplifier to reduce the wear and tear of the electric contacts operated by the air vane.

The Brown pilot is arranged so that the rudder always lies in a predetermined position to port or to starboard. The rudder angles are chosen to suit the ship and the prevailing weather, and are normally set so as to give the least motion of the steering gear consistent with a reasonably steady course. When a ship is rolling or pitching the angular movement of the compass gimbals causes geometric errors, so that the lubber's line appears to move to and fro. Clearly it is not desirable that, every time the ship rolls, the rudder should be reversed, so a dead motion is provided which will allow the ship (or the lubber's line) to yaw a certain amount before the rudder is applied. The Brown helmsman uses electrical contacts to control the rotation of an electric motor which is geared either to the ship's steering wheel or replaces the ship's telemotor system. The action of the Brown automatic helmsman is shown in Figs. 5 and 6, herewith, and the wiring diagram in Fig. 7, on page 708. Such a system will hunt continuously, but the determined rudder angle being fairly small, this is acceptable. The system may be made much more stable by means of a feedback from the actual rudder position, which is combined with the deviation from true course to operate the contact drum. This feedback has the effect of advancing the instant of release of the rudder as the ship swings towards its course and of hastening the instant of application as the ship yaws away from its course; it thus acts as a

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Fig. 7.

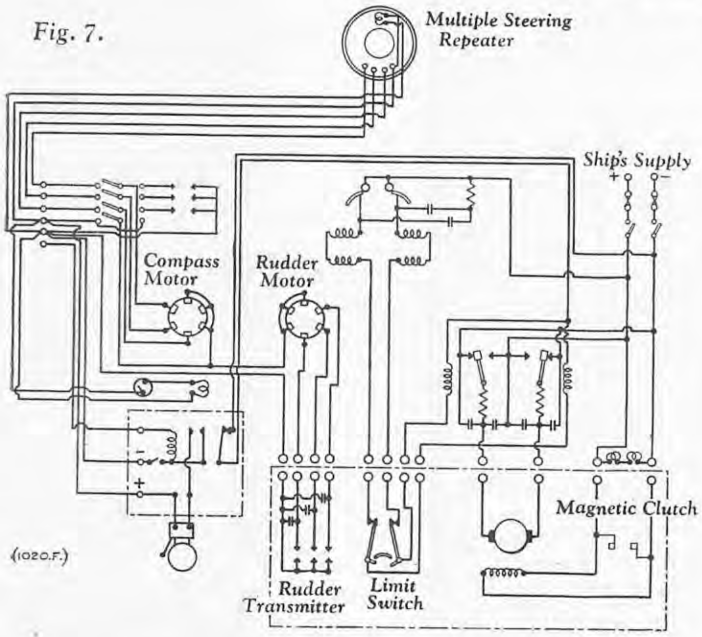


Fig. 9. SCHEMATIC OF CONTROL SYSTEM.

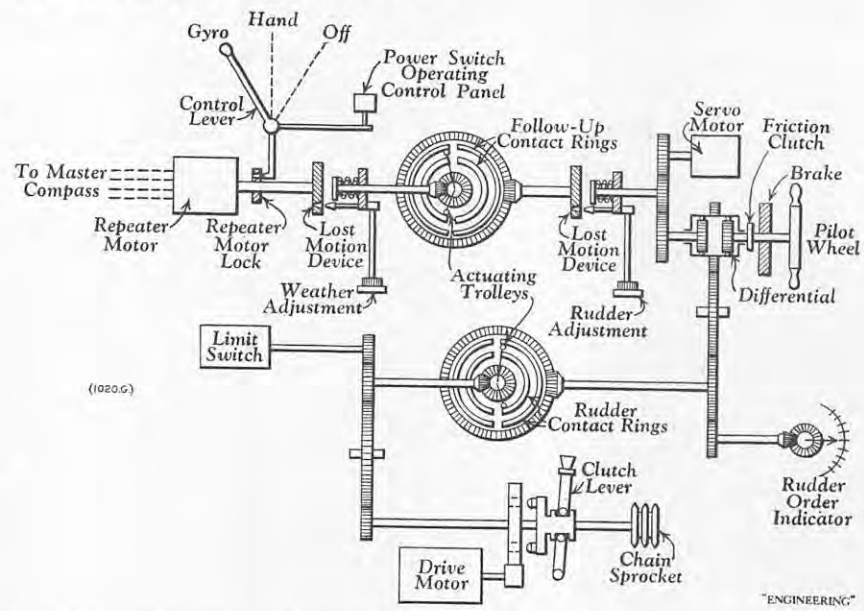
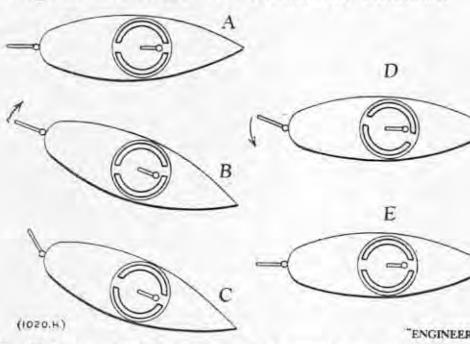


Fig. 8. PRINCIPLES OF OPERATION DIAGRAM.



A Ship on straight course with rudder amidships.
B The ship has departed from a straight course, causing the roller to make contact with one segment of the contact ring thereby turning the steering wheel.
C The steering wheel has moved, corrective rudder action has been applied, the contact ring has followed the roller, thus stopping the steering wheel.
D The ship has returned to the set course, this moving the roller and moving the steering wheel in the reverse direction.
E The rudder has moved to the amidships position, bringing the roller to the neutral position again and stopping the steering wheel.

human helmsman should when he "meets" the swing of the ship. With the feedback added there are now two reset loops or means by which the contacts may be brought central, and it becomes possible for the contact to become central with the rudder offset at some angle less than the predetermined limits. Any further yaw of the ship will be balanced by small changes in the rudder position. In this manner, therefore, when the yaw is small, the servo will behave as a continuous type, similar to the Sperry, but with larger yaws, where the rudder reaches its preset limits, it will function as an on-off or "bang-bang" servo.

The movement of the rudder in the Sperry system is limited only by the limits of the steering gear. The behaviour of the rudder is illustrated in Fig. 8, and a schematic diagram of the control system in Fig. 9. Course records obtained with the trawler Andanes, in a gale, show that the gyro pilot steered the vessel within very much closer limits than a quartermaster could have done. The strength of the wind during much of the trip was force 7 and the gyro pilot steered the vessel within 7 deg. of the course set, whereas the human helmsman deviated as much as 27 deg. It is, in fact, quite an achievement to steer a small vessel of 724 gross tons so accurately in bad weather.

Ship Stabilisers.—The ship stabiliser is a very spectacular application of servo-engineering principles in another field. Several systems of ship stabilisers have been tried in the past. Some depended on damping (bilge keels are invariably fitted for this purpose); and in another example stabilisation was effected by the transfer by gravity of water ballast from one side of the ship to the other, through a throttle where the energy was dissipated. Many have attempted to hold the vessel upright. The roll of a ship, however, is an oscillatory motion, which normally takes several cycles to build up to its greatest value. Only a comparatively small force is required to set a ship rolling, provided it is applied regularly. In practice, the waves of the sea provide the force to excite the rolling and the ship responds until the damping caused by friction absorbs the energy supplied by the waves. In the same way that a small force applied at the right moment will cause rolling, so a small force applied at the right moment will cause a roll, once established, to die away or, if applied in time, even prevent it from building up. I propose to describe in some detail the action of the Denny-Brown stabiliser which was applied to some warships during the recent war and is now being applied to ships of all sizes. First, however, I would emphasise the very important differences between the active stabilisers and the passive kind, such as bilge keels. The damping force generated in the bilge keel is more or less proportional to the rate of roll, so cannot be effective for slow or small rolls. The active kind, however, can, if necessary, be equally effective against small rolls or large. During the war, Denny-Brown stabilisers were fitted to various small vessels to assist gunnery and to gain experience; for example, H.M. destroyer Wolfhound and many "Hunt" class destroyers and sloops. The Denny-Brown uses fins or hydrofoils which are acted on by the water moving past the ship when it is under way. These fins project from the side of the ship and are used in much the same way as ailerons are used to keep an aeroplane level. The fins are worked together so that if, say, the port fin is deflected upwards the starboard fin is simultaneously turned downwards.*

In order to get the greatest turning moment from the force on the fins, it is desirable that they shall be placed as far apart as possible, and this requires that they should be somewhere near the centre part of the ship. They must be submerged below the surface even when the ship makes an extreme roll. These considerations determine the best position to be about the turn of the bilge, not too far forward or aft. Unfortunately, fins in this position would prevent the ship from coming alongside a wharf, so they must be retractable. This leads to more complicated machinery for operating them and a fairly large flooded space inside the ship's hull into which the fins may be retracted; this is undoubtedly the least attractive feature of this form of stabiliser. The fins are balanced round their axes of rotation, so that the torque required to move them is not large. An ingenious linkage automatically moves the flap in the right direction.

While the rudder of a ship need not move particularly fast, say, 30 seconds to move the rudder through 70 deg., the motion of the fins must take place much more quickly because the ship will roll from port to starboard in 5 seconds or less. In some cases, the fins are designed to reverse fully in less than a second and during this time will have moved through 35 deg. to 40 deg. The fins are operated by hydraulic rams supplied from a variable-delivery pump. The supply of oil from the pump is controlled by a hydraulic valve. If the ship is proceeding on an even keel with fins extended, there is neither list nor angular velocity; in this condition, the gyros are inoperative and the fins remain in their neutral position. If the ship takes a list, the "vertical-keeping" gyro comes into action and angles the fins to correct the list. Should sea conditions cause the ship to roll, the "velocity" gyro plays the major part in the control, and until the angular velocity exceeds 2 deg. per second the fins are set proportionately to an angle to resist movement from the vertical. At the end of each roll, as the angular velocity approaches zero, the fins resume their neutral position, and thereafter reverse their attitude at the initiation of the return swing. As is well known, however, following seas often cause rolling which is not regular and, on occasion, the ship may roll to one side, pause momentarily, and then complete her roll in the same direction. It is in such conditions that a control consisting of two gyros is required, when they combine their reactions to ensure that, at every phase of the rolling motion, the righting effect produced by the fins is continuously proportional and opposed to the upsetting effect of the sea. By reversing the control, a roll may be built up in calm weather and then allowed to die down or may be rapidly damped out by switching over to normal stabilised gyro control. A simple and convenient method of testing the stabiliser is therefore always available.

* As the Denny-Brown stabiliser has been illustrated and described in ENGINEERING on previous occasions, a considerable part of this section of the paper has been omitted. See "The Stabilisation of Ships by Activated Fins," by J. F. Allan, B.Sc., vol. 160, pages 318, 338 and 361; also vol. 159, page 434 (1945). See also "Denny-Brown Stabiliser for P. & O. Liner Chusan," vol. 170, page 557 (1950).—Ed. E.

Freight-Carrying by British Overseas Airways Corporation.—During the period May 1 to October 31, British Overseas Airways Corporation transported 550 short tons of freight across the North Atlantic, compared with 517 short tons in the corresponding period last year. Most of the freight is carried in cargo compartments on the lower decks of the Corporation's Stratocruiser aircraft.

THE INSTITUTION OF CIVIL ENGINEERS: PRESIDENTIAL ADDRESS.*

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

(*Concluded from page* 676.)

The Thames and Lee Supplies.

The catchment area of the Thames above Teddington Weir is 3,812 square miles and, over this, the standard average rainfall is 28·21 in. Chalk and other limestones, sandstones, and clay are the principal geological formations in the valley, and, since about two-thirds of this area is permeable or semi-permeable, and, in addition, there are extensive deposits of gravel, the flow is well maintained even during long periods of low rainfall. The standard average natural flow at Teddington Weir is 1,357 million gallons per day for the year, and for the month of lowest flow (September) it is 528 million gallons per day. In the summers of drought years, however, the average daily natural flow during a month is often about half this amount, the lowest recorded being 205 million gallons per day in July, 1921.

Records of the natural flow of the Thames at Teddington exist from 1883 and from these a good indication of the quantities of water likely to be available in dry years can be obtained. Owing to the lag between the incidence of rainfall and the emergence of the water from the springs, storage calculations are based on river flow records, which in drought years follow a fairly regular elongated U-shaped pattern. The drought years have been 1899, 1921, 1934, 1944, and 1949, and, if calculations are made to ascertain the amount of storage required to maintain the present supply, it is found that 1921 was the most severe drought. Denoting this by unity, the relative severity of the series is:—

1921	1·00
1934	0·99
1944	0·91
1949	0·69
1899	0·69

In their early days, the Board estimated their storage requirements on the 1899 flows. The information furnished by the later gaugings shows that considerably lower flows may be expected in drought years and it has now been decided to adopt the flows of 1944 as a standard, leaving the supply in the still more severe droughts of the 1921 and 1934 types to be taken care of by the reduction of the statutory flow. On this basis, the maximum economic yield of the Thames during a drought similar to 1943-44 would be about 345 million gallons per day, for which a gross reservoir capacity of some 52,500 million gallons would be needed. Any attempt to augment the supply by still further increasing the storage would result in the provision of reservoir accommodation which, during a repetition of this particular type of drought, could not be refilled during the winter.

While there is still ample water available from the Thames to increase the supply, provided that sites for additional reservoirs can be found, the Lee, from which the Board have the right to abstract practically the whole flow, is overdrawn. The river is gauged at Feilde's Weir, Hoddesdon, and, owing to excessive pumping of underground water in its valley, its dry-weather flows are diminishing. While the standard average daily natural flow for the year is 110 million gallons, monthly average flows of only 16 million gallons per day have been recorded for two successive months. Besides this, the winter flows are often so low that they will not provide sufficient water to refill the reservoirs. In addition, the quality of the water is deteriorating, and altogether this river is a troublesome and unsatisfactory source. To safeguard and to improve the supply to East London the Board have recently sanctioned the construction of a 75-in. main, 24 miles in length, from Hampton to Chingford, for the conveyance of raw Thames water to the Lee Valley. Owing to the difficulty of finding a path for a main of such a size in the streets of London, it is to be laid in a tunnel driven through the London clay.* At present, the yield of the Lee and its reservoirs in a drought year is about 44 million gallons per day and it is probable that this will decrease.

Supply from Underground Sources.

The underground supply is obtained by pumping from 53 wells and boreholes sunk in the chalk and two each in the upper and lower greensands. These are capable of yielding about 65 m.g.d. and, despite the overpumping in many parts of the Board's area, it should be possible to maintain this quantity or even to increase it slightly, especially since the area is now scheduled under Section 14 of the Water Act. Nearly all the wells are in the Board's Kent Area or the Lee Valley. On account of the extension of housing development into rural areas, with the consequent pipe drainage or cesspools, constant vigilance is necessary to detect and counteract any pollution which may find its way through the fissures of the chalk to the water drawn from the wells. Further, there is now some risk of estuarine water being drawn into the chalk adjacent to the lower reaches of the river, owing to the lowering by pumping of the underground water table

Consumption of Water.

Neglecting bulk supplies, the average daily supply in 1951-52 for domestic purposes was 212 million gallons, and the metered or trade supply was 104 million gallons. The total consumption since the Board came into being has been increasing, but the remarkable fact is that, of the total increase of 73 m.g.d. since 1911 (the first year for which the records of metered supplies are available), the domestic consumption has risen by only 25 m.g.d., or 13 per cent., while the increase in the metered or trade supply has been 48 m.g.d., or 86 per cent. This is not easy to explain in view of the large number of houses built since the end of the first World War, but it has to be remembered that the figure for domestic consumption includes practically all the leakage and waste, and any reduction in these lessens the apparent domestic demand. The peculiarity of these figures may not be unconnected with the substitution of Venturi meters, to measure the output, for the method of calculation by engine counters; while, since and during the war, the scarcity and high cost of fuel have restricted the use of hot water.

Future demands are influenced by the population, the quantities of water required for domestic purposes, the needs of industry, and by bulk supplies. In 1899, Lord Llandaff's Commission estimated that the population of "Water London" (620 sq. miles) might slightly exceed 12,000,000 persons by 1941. Very fortunately, this estimate has not been realised and the population in the Board's area of supply (540 sq. miles) at the 1951 census was 6,500,000 persons, as against 6,400,000 in 1904, having fallen from the peak figure of 7,000,000 in 1931. The economic and strategic problem created by the drift of the industrial population to London was recognised by the Barlow Commission in 1940, and it is significant that the London County Council are planning for an ultimate population of 3,250,000 in that area as against an estimated population of just over 4,000,000 in 1939, though presumably a large proportion of the 750,000 will still be housed in the Board's area. The consumption per head per day for all purposes is now about 49 gallons, being divided into 33 gallons for domestic purposes and 16 gallons for trade, supplied by meter. The two Royal Commissions considered that 35 gallons per head per day for all purposes would be ample, so that, while they over-estimated the population, they under-estimated the *per capita* demand.

While it is not easy to predict either the future population or the demand per head per day, the estimation of the combination is even more hazardous and so Sir Jonathan Davidson, when he was chief engineer, analysed mathematically the trend of supply between 1904 and 1938, and projected it on to 1957. On the assumption that this followed a straight-line law, he found that the increase in the consumption was at the rate of 2·32 m.g.d. per annum, and a recent calculation based on the period 1904 to 1952 showed but little departure from this figure. At the moment, the consumption is slightly below the line of trend, but if no disturbing factors intervene and this trend still holds good, a total demand of about 370 m.g.d. might be expected in 1970 if this should be a normal year, rising perhaps to 390 m.g.d. if that summer were excessively hot and dry.

The Board's Resources.

With the existing Thames storage of 17,700 million gallons, an average daily Thames-derived supply of about 175 million gallons could be afforded during a drought like 1944, so that there is now a deficiency of some 37 m.g.d. to be made up by reducing the statutory flow. The Board have powers to build three reservoirs, at Walton, Wraysbury, and Datchet, which together would provide some 13,000 million gallons of storage, but, on account of the economic situation, their construction is at present in abeyance. However, when these reservoirs are in existence, the reliable Thames-derived supply will be 240 m.g.d. This, with 110 m.g.d. from the other sources, will provide a total of 350 m.g.d., which will be the limit of the Board's resources until further storage is provided. Thus, were the demand to reach 390 m.g.d. after the construction of the three reservoirs, the deficiency would be about the same as it now is, that is, 40 m.g.d., and this again would have to be made up by the reduction of the statutory flow, the reduction, of course, being greater if the drought should happen to be of the 1921 or 1934 pattern.

Broadly speaking, the supply of each additional million gallons per day requires the provision of 200 million gallons of storage, so that, on the foregoing estimates, not only should the three reservoirs be in commission before 1970, but some 8,000 million gallons of additional storage would be needed to enable the Board to comply with their statutory requirements. It is fully appreciated that these estimates of consumption may not be realised, but the figure quoted indicate that, unless the increasing demand for water is slowed down or halted—and there does not appear to be any sign of either taking place—further reservoirs will be required. The provision of such reservoirs, involving as it does the selection of geologically and geographically suitable sites, with the minimum disturbance of development and agriculture, is the most difficult and costly problem with which the Board are faced, and failure to find a solution may entail the much greater expense of obtaining a supply from Wales. Whatever view is held of the adequacy or otherwise of the statutory flow of 170 m.g.d. over Teddington Weir, it provides a valuable reserve when the programme of reservoir construction is in arrears—as it is now, due to the two wars and their aftermath—but in common with most reserves, it is not inexhaustible. The only safe method of increasing the supply from the Thames up to the economical limit is by the construction of more reservoirs.

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

* P. A. Scott, "A 75-inch-diameter Water Main in Tunnel: A New Method of Tunnelling in London Clay." *Proc. I.C.E.*, Part I, vol. 1, page 302 (1952).

Armstrong Siddeley Double Mamba Engine with Increased Power.—Some information on the Double Mamba ASMD3 propeller-turbine engine, to be fitted in Fairey Gannet anti-submarine aircraft for the Royal Navy, has been released. The ASMD3, which is manufactured by Armstrong Siddeley Motors Ltd., Coventry, consists of two side-by-side Mamba ASMA5 engines, driving contra-rotating co-axial propellers. Each half of the unit can be started, run, or stopped independently. The static sea-level power of the ASMD3 is 2,920 shaft horse-power, plus 535 lb. jet thrust, giving 3,125 equivalent horse-power for take-off. The corresponding specific fuel consumption is 0·7 lb. per equivalent horse-power per hour. The power unit is 102 in. long, 52·8 in. wide and 45·25 in. in height, with a dry weight of 2,100 lb. (plus 2½ per cent. tolerance). The earlier mark of engine, the Double Mamba ASMD1, develops 2,950 equivalent horse-power under sea-level static conditions for the same dry weight, and has a higher specific fuel consumption. The Armstrong Siddeley Double Mamba engines can operate satisfactorily on Diesel fuel.

ELECTRIC POWER PLANT IN BEET-SUGAR FACTORY.

THE extraction of sugar from beet is now largely a mechanised process, the roots being taken straight from the fields into the factory where they are first cleaned, weighed, sliced or shredded and then passed to the diffusing plant. After diffusion, the juice is pumped through defecation, filtration and concentration stations to centrifuges, where the molasses are extracted and the sugar discharged for conveyance to the refineries. These processes are obviously largely seasonal and for about 16 weeks the plant, which since the establishment of the industry in East Anglia has been generally driven electrically, is operated continuously at maximum capacity.

These points may be illustrated by referring to the factory of the British Sugar Corporation at Bury St. Edmunds. This is the largest of that organisation's 18 factories and can handle 4,500 tons of beet in a 24-hour shift, this being equivalent to the production of about 800 tons of sugar. When this factory was opened in 1923, the power plant consisted of a number of Crompton turbo-alternators generating three-phase current at 220 volts. The growth of the electrical demand and additional extensions, which raised the total load to 5,500 kVA, however, led recently to the preparation of a scheme whereby generation is carried out at 3·3 kV and power is supplied to the existing 220-volt system through substations.

The new generating plant installed for this purpose consists of two turbines manufactured by Messrs. W. H. Allen, Sons and Company, Limited, Bedford, which are illustrated in Fig. 1. These machines are supplied with steam at 285 lb. per square inch and exhaust into a process-steam range at a pressure of 31 lb. per square inch. About 44·25 tons of steam per hour are available in this way from the turbines and this quantity is supplemented by a further 17·5 tons per hour from various sources. The turbines are coupled to 2,800-kVA alternators, which generate at 3·3 kV and are connected to truck-type switchgear of the horizontal isolation and draw-out pattern. This switchgear which is illustrated in Fig. 2, was manufactured by Messrs. Crompton Parkinson, Limited, Aldwych, London, W.C.2, and has a rupturing capacity of 75 MVA. In addition, there is a 'bus section circuit-breaker which enables power to be obtained from the Eastern Electricity Board for starting the station auxiliaries and for supplying a restricted load during the off-season. Interconnectors enable certain small motors and lighting to be used during this time without energising the 3·3-kV network.

Power from the main switchboard is supplied through circuit-breakers to seven main substations, four of which have a capacity of 1,000 kVA and three of 600 kVA, and is stepped down to 220 volts for local distribution through trunking, provided with hinged front panels on which instruments are fitted. The total demand on these transformers is reduced by a 375-kVA 220-volt synchronous condenser which is installed in one of the more heavily loaded substations and formed part of the original installation. The lighting circuits are separate from the power circuits and are controlled from a single multi-circuit board in the power house. In the design of the plant great attention has been paid to simplicity of operation in view of the importance of continuity of supply during the manufacturing process.

ELECTRIC POWER PLANT IN BEET-SUGAR FACTORY.

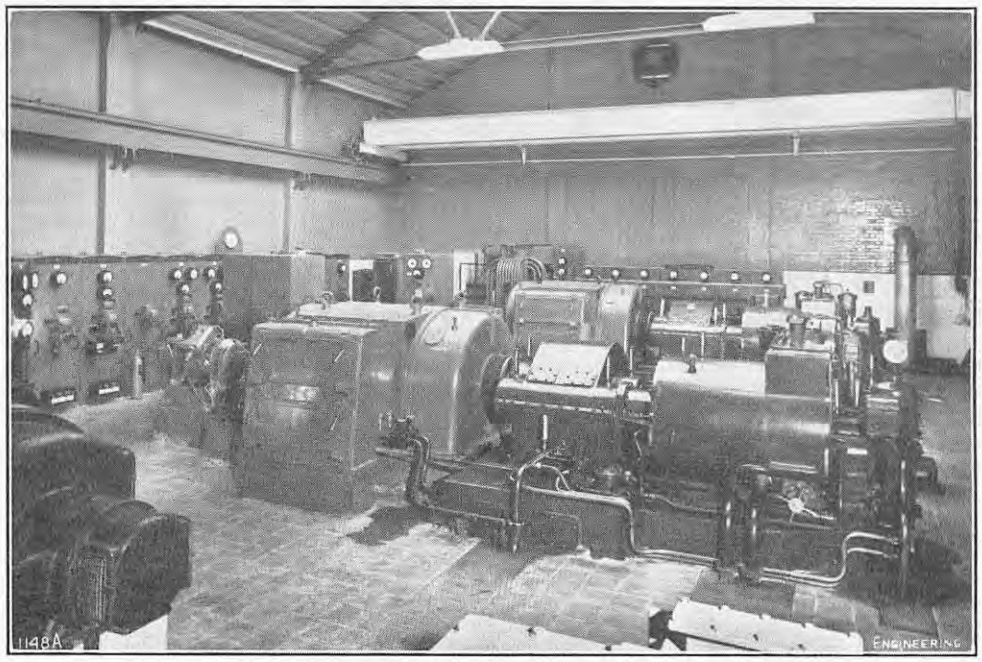


FIG. 1. TURBINE ROOM.

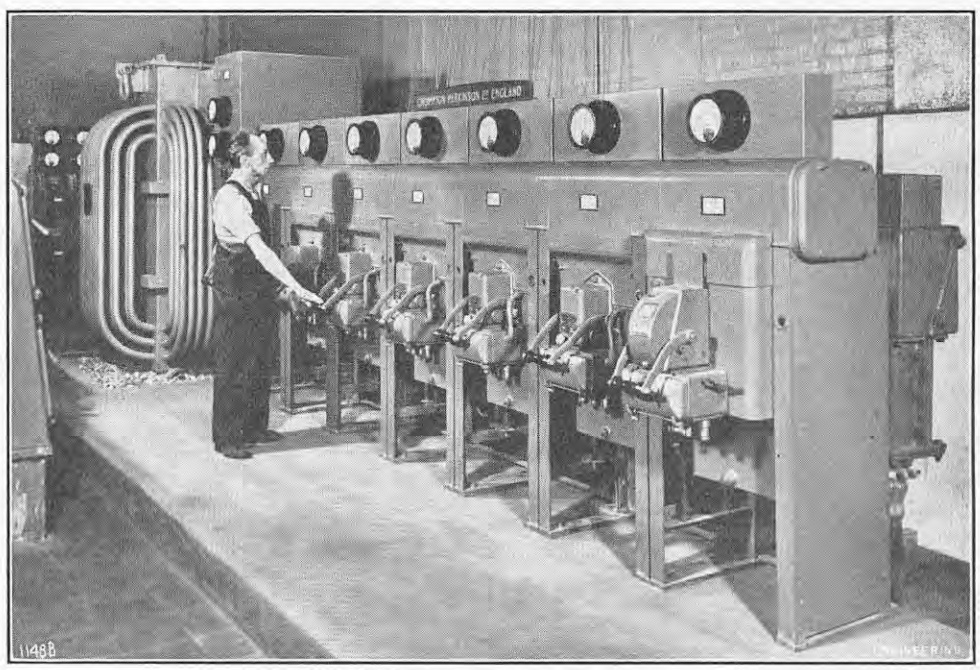


FIG. 2. SUBSTATION, WITH 220-VOLT SWITCHGEAR.

LAUNCHES AND TRIAL TRIPS.

S.S. "ROMERAL."—Single-screw ore-carrying vessel, built and engined by William Gray & Co., Ltd., West Hartlepool, for the Compañia Sud-Americana de Vapores, Valparaiso, Chile. Second vessel of two. Main dimensions: 415 ft. between perpendiculars by 57 ft. 6 in. by 34 ft. to upper deck; deadweight capacity, 9,465 tons on a draught of 25 ft. 9¾ in. Triple-expansion steam engine and two forced-draught oil-fired boilers, developing 1,835 i.h.p. at 69·5 r.p.m., constructed at the builders' Central Marine Engine Works. Service speed, 10¾ knots. Launch, October 3.

M.S. "DRYBURGH."—Single-screw cargo vessel, with accommodation for twelve passengers, built by the Grangemouth Dockyard Co., Ltd., Grangemouth, for Geo. Gibson & Co., Ltd., Leith, and James Rankine and Son, Ltd., Leith. Main dimensions: 245 ft. between perpendiculars by 38 ft. by 22 ft. 2 in. to shelter deck; deadweight capacity, about 1,380 tons on a draught of 14 ft. 6 in. Eight-cylinder marine oil engine, developing 1,520 b.h.p. at 300 r.p.m., constructed by British Polar Engines, Ltd., Glasgow. Loaded speed, 13½ knots. Trial trip, October 6.

M.S. "GRETAFIELD.—Single-screw oil tanker, built by the Furness Shipbuilding Co., Ltd., Haverton Hill, County Durham, for the Northern Petroleum Tank Steamship Co., Ltd., Newcastle-upon-Tyne. Second vessel of an order for two. Main dimensions: 521 ft. overall by 67 ft. 6 in. by 36 ft. 5 in.; deadweight capacity, about 16,500 tons on a draught of 29 ft. 1⅛ in.; oil-tank capacity, about 15,600 tons. Hawthorn-Doxford five-cylinder single-acting two-stroke reversible oil engine, developing 5,500 b.h.p. at 112 r.p.m. in service, constructed by R. and W. Hawthorn, Leslie & Co., Ltd., Newcastle-upon-Tyne. Speed, 14 knots. Trial trip, October 6.

M.S. "STYLEHURST."—Single-screw cargo vessel, built and engined by Swan, Hunter, and Wigham Richardson, Ltd., Newcastle-upon-Tyne, for the Grenehurst Shipping Co., Ltd., London, E.C.3. Main dimensions: 435 ft. between perpendiculars by 60 ft. by 39 ft. to shelter deck; deadweight capacity, 10,000 tons on a draught of 26 ft. 5 in.; gross tonnage 5,750. Swan Hunter-Doxford four-cylinder opposed-piston heavy-oil engine, developing 4,400 b.h.p. at 115 r.p.m. and a speed of 13⅜ knots in service. Trial speed, 15 knots. Trial trip, October 7.

M.S. "GOSPORT."—Single-screw collier, built by S. P. Austin & Son, Ltd., Sunderland, for Stephenson Clarke, Ltd., London, E.C.3. First vessel of an order for two. Main dimensions: 249 ft. by 38 ft. 9 in. by 18 ft. 4½ in.; deadweight capacity, about 2,400 tons on a mean summer draught of 17 ft. Clark-Sulzer eight-cylinder vertical two-stroke single-acting trunk-piston reversible oil engine, developing 1,150 b.h.p. at 225 r.p.m., constructed by George Clark (1938) Ltd., Sunderland. Speed on trial, 11½ knots. Trial trip, October 15.

M.S. "DAGLAND."—Single-screw oil tanker, built by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend-on-Tyne, for Aktieselskabet Ocean (Managers: John P. Pedersen & Son), Oslo, Norway. Main dimensions: 500 ft. between perpendiculars by 65 ft. 6 in. by 37 ft. 6 in.; deadweight capacity, about 15,560 tons on a draught of 29 ft. 2 in.; gross tonnage, 10,226; oil-tank capacity, 712,430 cub. ft. Wallsend-Doxford five-cylinder two-stroke opposed-piston Diesel engine, developing 5,100 b.h.p. at 105 r.p.m. in service, constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne. Service speed, 13 knots. Trial trip, November 4.

THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND: PRESIDENTIAL ADDRESS.*

By Sir William Wallace, C.B.E., F.R.S.E.

My firm, Brown Brothers and Company, have been interested in hydraulic equipment for about 80 years. The founder's usual label on the cheerful ship trials of the past was "Hydraulic Brown," and his first large contract was for cargo-working cranes for Hamburg. It was after the successful completion of that contract that he wandered into the realm of auxiliary machinery for ships and brought a new outlook on problems associated with this equipment. The natural sequel to the Hamburg contract was the use of hydraulic equipment for cargo-working in ships. William Denny and Brothers, Dumbarton, and the British India Steam Navigation Company provided his first opportunity, and large numbers of ships were similarly fitted. The last hydraulic cargo-working equipment supplied was to large P. & O. liners, each equipped with 16 cranes, in 1925. I saw these cranes in operation in London, hoisting the load at average speeds of 600 ft. per minute, lowering the load at 1,200 ft. per minute, and lowering the light hook at 300 ft. per minute. I do not think there is a faster cargo-working gear in any ship at the present day.

One of the disadvantages of the constant-pressure hydraulic system is that the consumption of power when lifting, say, the light hook of a hydraulic crane is equal to the power taken from the accumulator when lifting the maximum load. Some of the cranes in these ships lifted maximum loads of five tons. To save power when on lighter loads a small ram was telescoped inside the main ram; on loads of up to 2 tons, the small ram took over the duty. However, with the advent of silent electric winches, cargo-working gear operated by them showed advantages over hydraulics, and with a few exceptions hydraulic cargo-working equipment has been dropped from marine duty.

Around the 1870's, ships were requiring power steering-gears and the general arrangement consisted of a steam engine placed somewhere near the engine room; the power was conveyed to the rudder by chains and rods, and control from the bridge to the engine was through shafting and bevel gears. Mr. Brown saw the advantage of ridding the ship of the troublesome rods and chains, and prepared a design for steam steering-gear acting directly on the rudder-stock—the quaint-looking steering-gear known as Brown's steam tiller. This revolutionary design, with the operating engine carried on the moving tiller, driving through a friction clutch and discarding all forms of spring connection between engine and rudder-stock, has stood the test of time and was the favoured gear in high-speed vessels until the coming of the electro-hydraulic gear. The most powerful steam tiller which the firm produced was installed in the Cunard liner Aquitania, and produced a torsion moment on the rudder-stock of 1,200 tons-ft. The installation of the engine acting directly on the rudder-stock produced the problem of distant control and Brown's answer was the hydraulic telemotor, which he patented and developed. While in the early days it proved to be rather troublesome, it has since been developed into an efficient form of control, and still holds the field.

In some of the early ships a simple hydraulic steering gear was supplied with power from a cargo-working power plant. This obviously was not economical, and in 1910 we designed an electro-hydraulic steering gear, telemotor-controlled—a simple self-contained installation in which the power consumption is directly proportional to the effort required at the rudder. With the advent of electric auxiliaries in ships, this type of equipment is now fitted in possibly 90 per cent. of the large vessels, steam or Diesel. Our outstanding installations are the steering gears of the Queen Mary and Queen Elizabeth, capable of exerting a torsion moment of 3,600 tons-ft. on the rudder-stock, controlled via servo gear by a very small duplicate telemotor transmitter on the bridge.

* Delivered in Glasgow on October 14, 1952. Abridged.

The Sperry Gyroscope Company supply automatic pilots for ships, and originally the control was entirely electrical, but in their recent developments they have also introduced hydraulics. Whereas previously the steering-gear control was operated by an electric motor controlled from a gyro compass, and this controlled motor operated through gearing to produce the required movement of the power steering-gear control, the Sperry Company are now installing an electrically-driven auto-controlled variable-delivery pump and operating the motion of the steering-gear control hydraulically through rams, with the vital valves electrically controlled from the gyro compass. At first sight, this appears to be, and is, an added complication, but I understand it is only by using hydraulics that they have been able to produce a gyro pilot capable of taking care of course, yaw, etc., more accurately than with direct electric control.

Forms of hydraulic equipment have also been found extremely useful when applied to catapults for launching aircraft. Where the propulsive medium was cordite, the retardation of the moving mass, in every instance, has been hydraulically controlled by filling the space in the power cylinder in front of the piston with fluid, allowing this fluid a free exhaust during the acceleration stroke of the catapult, and then, by throttling the exhaust, retarding and bringing the moving mass to rest. The catapult trolley is manœuvred by controlling the pressure-fluid supply to the piston, bringing the aircraft trolley accurately to the desired firing position. Where the catapults have been operated by compressed air, the actual power for continuous operation was provided by hydraulic equipment. In this instance, as previously, the power cylinder forward of the piston was filled with fluid and the power for acceleration of the piston provided by compressed air taken from air vessels. The same retardation method was used as in those operated by cordite, and the catapult was prepared for its next operation by pumping back the fluid into the cylinder and recompressing the air into the air vessels.

In the latest type of steam-operated catapult developed for the British Navy, which has been adopted for installation in all modern British aircraft carriers, hydraulics has again provided the force required for the retardation of the pistons and attached gear, necessarily brought to rest from very high speeds. A tapered ram is attached to the forward end of the pistons, and at the end of acceleration the ram enters a separate cylinder filled with fluid. The annulus between the tapered ram and a choke ring fitted in the mouth of the retardation cylinder is reduced gradually, thus choking the exhaust of the fluid and providing the retardation force required to bring to rest the operating pistons and connected equipment. The moving parts are brought to rest from very high speeds, in the space of a few feet, and pressure in the retardation cylinders increases to as high as 30,000 lb. per square inch. In an experimental equipment designed to test the retardation mechanism, the moving mass was subjected to retarding force exceeding 500*g*. It was found that, additional to the retarding force absorbed in the retardation cylinder, a very large retarding force was provided by the velocity of the jet of fluid ejected through the annulus of the retardation cylinder, acting on a shaped face of the advancing piston. It is now thought that this force, which was not taken into account in the original calculation, may represent one-third of the retarding force—a very welcome bonus. While the new catapult is steam-operated, it was found during the development of the design that hydraulic equipment alone provided the controlled movement required for the rapid retraction of the pistons and the accurate control of the pistons with their attached aircraft hook during the delicate operation of connecting the aircraft, tensioning the towing bridle, etc.

Another application of hydraulics is demonstrated in the Denny-Brown ship stabiliser. The idea of damping down the rolling of a ship by the use of angled fins projecting from the ship's side—fins that would produce lift with the ship steaming ahead—was suggested and patented in 1890 by a Mr. Wilson, a chemist in Stirling. He experimented with this equipment on a rowing boat, but the idea lay dormant for 40 years. Here again it was only by taking advantage of modern developments that an electro-hydraulic gear was designed that enabled the oscillation of the fins to be carried out rapidly and without shock. Such fins can be operated fast enough to produce the required righting moment in ships with a rolling period of only 7 to 8 seconds, "out to out."

Associated with this equipment I learned a lesson, and now do not accept too rapidly any suggested solutions without looking carefully into all sides of the problem. In certain Admiralty vessels, additional electrical equipment was installed, subsequent to the original design. This resulted in overloading the generators. The introduction of the stabiliser, calling for fairly high concentrated power, produced peak loads on the generator in excess of its capacity. A discussion with interested Admiralty officers produced an apparent solution of the problem. As mentioned earlier, it is essential that these stabilising fins should be operated very rapidly; the movement from hard-up to hard-down through an angle of 40 deg. in about 0·7 second meant high peak loading. The suggestion was that we should use a hydraulic accumulator to take care of the peak load, it being conceived that the accumulator could be charged prior to the next call for high output. We therefore worked on this proposal and installed a small electrically-driven pump and an accumulator capable of providing two complete cycles. During the trials, which are normally carried out by forced rolling of the ship, everything worked perfectly. Bad weather at sea demonstrated our error. In confused seas, anything but synchronous rolling was experienced; the ship's rolling period was drastically shortened, and the condition was reached when the small pump was unable to keep the accumulator charged, and the stabilisation of the ship became non-existent. Fortunately, only one class of ship was affected, as we had retained our original design, as installed in other classes of ships, where the peak load was eased by the use of compound-wound motors with heavy flywheels, mounted between the motor and pump.

(To be continued.)

Grease for Jet Engines.—The Shell Petroleum Co., Ltd., St. Helen's Court, Great St. Helen's, London, E.C.3, have developed a special lubricant for aircraft jet engines, known as AeroShell Grease 12, containing neither soap nor mineral oil. It has satisfactory lubricating properties over a temperature range from − 70 deg. C. to + 200 deg. C.

Diamond Dresser for Grinding Wheels.—Diamond Abrasives Ltd., 55, Greek-street, London, W.1, have developed a tool, known as the Nagy multi-pyramid diamond, for dressing grinding wheels. The cutting surface consists of an array of identical square diamond pyramids of even height, in which all the pyramid edges are arranged to lie in the direction of maximum hardness of the diamond. The resistance to wear, it is stated, is thereby considerably increased, and the tool is self-sharpening. When the outermost pyramids are worn to their bases, the tool can be reconditioned. Two types of Nagy dresser are available, one with wide-pitch grooves for heavy-duty on large wheels, giving a comparatively coarse finish, and a narrow-pitch tool for general use and fine finish.

Large Cold-Cathode Fluorescent Lighting Installation.—A cold-cathode fluorescent lighting installation, comprising over 23 miles of tubing, is nearing completion by the General Electric Co., Ltd. Kingsway, London, W.C.2, at the works of C. A. Parsons & Co., Ltd. at Heaton, Newcastle-on-Tyne. So far, a floor area of 450,000 sq. ft. in the engineering workshops has been illuminated in this way. In the new research building, which covers 120,000 sq. ft. and will be finished next year, anodised aluminium troughing connected to steam pipes will be used both for heating and to contain the cold-cathode tubing. A special heavy-duty fitting, which contains three 9-ft. 6-in. tubes, has been installed in the shops. This has been designed for connection to the ordinary lighting mains and contains tubes with a consumption of 250 watts. The average illumination level varies from 9 lumens per square foot in the heavy foundry and pipe division to as much as 60 lumens per square foot in the research laboratories.

ANNUALS AND REFERENCE BOOKS.

Metal Industry Handbook and Directory, 1952.

The Louis Cassier Co., Ltd., Dorset House, Stamford-street, London, S.E.1.

The 41st annual edition, that for 1952, of this well-known work of reference and source of data on non-ferrous metals, has been issued recently. It is divided into four main sections the first of which is headed "General Properties of Metals and Alloys." The metals are dealt with in alphabetical order, a concise but informative account being given of their properties and uses. Then follow statistics regarding production, tabulated data of physical properties of metals and alloys, descriptions of aluminium, copper, magnesium, nickel and other alloys, and summaries of British non-ferrous metal specifications. The second section includes general data and tables of weights and measures, conversion factors and tables, prices of metals and other information. The third section deals with electroplating, polishing and finishing processes and contains material of value not only to the practical plater but also to the user and to technical men in general. The final section consists of a directory of metal-trades associations and societies and of scientific and technical institutions; it includes also a classified-trades directory for buyers and lists of firms engaged in, or concerned with, the non-ferrous industries. The book, which runs to 448 pages, is well produced. It is available only to subscribers to the journal *Metal Industry*.

Electricity Undertakings of the World, 1952-53.

Edited by Stanley G. Rattee. 62nd edition. Benn Brothers, Limited, Bouverie House, 154, Fleet-street, London, E.C.4. [Price 30*s*., post free.]

Since the last edition of this useful annual was published, our old-established contemporary *The Electrician* has changed its name to *The Electrical Journal*, and this heading now appears for the first time as a sub-title to what is also known as *The Red Book*. The present edition, too, has been largely revised and extended, 3,000 place names, and the electricity supply details concerning them, having been added to the index. Guide guards have been introduced for the major sections to facilitate reference and Arabic "folios" are now used throughout, while "running lines" on each page indicate the subject matter contained therein. Details regarding the power stations and personnel of British Railways have been included for the first time and the list of the personnel employed by the British Electricity Authority and the North of Scotland Hydro-Electric Board has been augmented. All this, of course, is subordinate to the useful and very detailed information given about British electricity supply undertakings and to a less extent those in the British Commonwealth and foreign countries. The complaint is made that it is difficult to obtain information about countries behind the "Iron Curtain," but, considering the present political condition of the world, this is hardly surprising. We note with pleasure that the presentation of the output of generating stations in megawatts (against which we protested last year) has been abandoned in favour of the more correct term "output capacity" and that what is meant by this term is accurately defined. As a work of reference, the Red Book is very valuable and that value has been increased, rather than diminished, by the many changes it has undergone in the course of its existence.

University College Calendar, 1952-53.

The Secretary, University College London, Gower-street, W.C.1. [Price 7*s*. 6*d*, net., or 8*s*. 6*d*., post free; to students of the College 5*s*. net., or 6*s*., post free.]

As was the case with previous issues, the *Calendar* of University College London for the current 1952-53 session contains prospectuses of all the College Faculties and Schools, including the Faculties of Arts, Science, Laws and Engineering, and the Department of Town Planning, the Bartlett School of Architecture, and the School of Librarianship. Full particulars are given regarding scholarships, exhibitions, prizes and bursaries, research and publication funds, examination and other regulations, statutes of management, fees and other matters of interest to students. Lists of Fellows, past and present officers, members of the staff and professors emeritus are also given, and statistics of the numbers of students attending the College during the session 1951-52 are included. Of more general interest are the chapters or sections on the "History of College," the College Library and the museums and collections open to approved students. A point of interest is that the former light-buff cloth covers have now been replaced by dark blue cloth. Moreover, part at least, of the contents of the *Calendar* has been re-set.

BRITISH STANDARD SPECIFICATIONS.

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

Reference Tables for Thermocouples.—Two new publications concerned with reference tables for thermocouples have recently been issued. They are B.S. No. 1826, which deals with platinum-rhodium *v.* platinum thermocouples and B.S. No. 1827, relating to nickel-aluminium *v.* nickel-chromium thermocouples. The tables are for use in converting thermocouple voltages into the equivalent measured temperatures and in defining the relation between impressed e.m.f. and scale reading for pyrometers which indicate temperature directly. The tables for the platinum-metal thermocouples are based on those formulated by the National Physical Laboratory, which have been the basis of reference in this country for many years. The tables for the nickel-alloy couples are based on those formulated by the National Bureau of Standards of America, as no other tables are in common use in the United Kingdom. Reference tables for copper *v.* constantan thermocouples are in preparation and further tables may be issued in due course. [Price of No. 1826, 7*s*. 6*d*., and of No. 1827, 6*s*., postage included in each case.]

Dimensions of Foundry Moulding Boxes.—The purpose of a new specification, B.S. No. 1889, which covers the dimensions of foundry moulding boxes, is to provide a standard range of these boxes and their essential components for the foundry industry. The aim is to increase interchangeability, to reduce the excessive number of types at present in use, and to assist designing, work planning and costing. The compilers of the specification realise that special-purpose boxes will still be required, but it is considered that, in the majority of instances, the range of sizes specified will satisfy the main requirements of the industry. The dimensions of two-pin square, rectangular and round box parts, designed for loose pins, and of sizes ranging from 12 in. by 12 in. by 3 in. to 72 in. by 72 in. by 24 in., are specified. The pin diameters specified range from $\frac{3}{4}$ in. to $1\frac{1}{4}$ in., and the distances between the pin centres, from 15 in. to 77 in. The dimensions of lugs and bushes, which may be single or double, are also specified. [Price 2*s*. 6*d*., postage included.]

TRADE PUBLICATIONS.

High-Speed Diesel Engines.—Details of their range of Sirron high-speed Diesel engines are given in a leaflet received from the Newbury Diesel Co., Ltd., Newbury, Berkshire. The Sirron range of engines covers two sizes of cylinder built in a number of combinations to give outputs ranging from 20 brake horse-power to 120 brake horse-power. These engines are particularly suitable for supplying auxiliary power in medium-size vessels but can, of course, be used equally well on land. They can also be employed for the propulsion of yachts, launches and similar small craft.

Earth-Moving Equipment.—A description of their Model 440 one-cubic yard shovel is given in a booklet issued by Ransomes and Rapier, Ltd., Ipswich. This machine can be fitted with interchangeable front-end equipments and used as a shovel, drag-shovel, a dragline excavator or a crane. When fitted with the drag shovel equipment it can be employed for deep-trenching work, it being possible to dig down to a depth of 17 ft. when so equipped. Three lengths of boom are available for the dragline conversion, the same three booms being employed when the machine operates as a crane.

Fume-Extraction Plants.—A leaflet containing brief particulars of some typical fume-extraction plants has been received from Perfectair Limited, 314, Balham High-road, London, S.W.17. The leaflet includes short illustrated descriptions of four different plants and makes a brief mention of the firm's activities in other directions, such as the construction of metal-finishing plants and water-washed paint-spraying booths.

Gasworks Plant.—Some particulars of their range of gasworks plant is given in a brochure issued recently by Ashmore, Benson, Pease & Co., Ltd., Stockton-on-Tees. The brochure gives a brief description of the plant which they regularly manufacture and illustrates several types of gasholders, purifiers and condensers.

Four-Stroke Petrol Engine.—The Villiers Engineering Co., Ltd., Marston-road, Wolverhampton, have issued a leaflet giving brief details of their Mark 10 four-stroke stationary and agricultural petrol engine. This unit has a capacity of 395 c.c. and gives a 12-hour continuous output of 4 h.p. It is available in several forms and can be fitted with the necessary equipment for operation on paraffin oil.

CONTRACTS.

Vickers-Armstrongs Ltd., Vickers House, Broadway, London, S.W.1, have received a contract from Trans-Canada Air Lines for 15 Vickers Viscount propeller-turbine air liners. The approximate value of the order, including spare parts, is 11·5 million Canadian dols., or 4,100,000*l*. Deliveries will begin in September, 1954, and are to be completed by April 1955. The Viscount is designed for operation on short and medium-range routes. It is propelled by four Rolls-Royce Dart engines, each developing 1,400 brake horse-power, plus 365 lb. static thrust. The aircraft is at present being manufactured at Vickers-Armstrongs' Works at Weybridge and this production is being augmented by the firm's works at Hurn, near Bournemouth, where arrangements are in hand for production at a rate of 100 of the aircraft per annum.

Bagguley and Barker, Ltd., Gordon House, Carrington-street, Nottingham, have received an order from British Railways, London Midland Region, for drainage and formation renewal work on a stretch of the Roade to Rugby railway line.

The Rhodesia Railways have recently placed a contract with the English Electric Co. Ltd. Kingsway, London, W.C.2, for 23 main-line Diesel-electric locomotives for use on the 3 ft. 6 in. gauge main line between Salisbury and Umtali. This line is 170 miles long and includes gradients as steep as 1 in 40. The locomotives will be of the 1-Co-Co-1 type and will weigh 113 tons, of which 90 tons wil be available for adhesion. They will be powered by a 1,710-h.p. 16-cylinder engine, running at 850 r.p.m. and having a starting tractive effort of 60,000 lb. A single unit will be able to haul trains up to 850 tons.

Birlec Ltd., Tyburn-road, Erdington, Birmingham, 24, have been commissioned by Samuel Fox & Co. Ltd., in association with the United Steel Companies Ltd., Sheffield, to supply a very large electric-arc melting furnace. This Birlec Lectromelt equipment will have a normal capacity of 60 tons and will be rated at 15,000 kVA with on-load tap-change gear. The furnace will be installed at the firm's Stocksbridge Works, where it will be used for the production of high-quality alloy-steel ingots.

The Gloster Aircraft Co., Ltd., Hucclecote, Gloucester, have obtained a contract worth over 5,000,000*l*., for the supply to the Brazilian Government, of 60 Meteor-8 ground attack jet fighting aeroplanes and ten Meteor-7 training jet aeroplanes. The aircraft will be sent by sea and re-assembled in Brazil by the Gloster Company's technicians.

BOOKS RECEIVED.

Bergsteigefähigkeit und Literleistung. By Wolfgang Flössel. Franckh'sche Verlagshandlung, Pfizerstrasse 5-7, Stuttgart, Germany. [Price 25 D.M.]

United States National Bureau of Standards. Annual Report 1951. The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 50 cents.]

United States National Bureau of Standards. Miscellaneous Publication No. 205. *Hydraulic Research in the United States.* Edited by Helen K. Middleton and Sonya W. Matchett. The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 1 dol.]

Brown Coal, with Special Reference to the State of Victoria, Commonwealth of Australia. By Dr. H. Herman. The State Electricity Commission of Victoria, 22-32, William-street, Melbourne, Australia; distributed by Tait Book Company, Limited, 349, Collins-street, Melbourne, Australia. [Price 4 guineas net, postage 4*s*.]

Building Technicians' Pocket Diary, 1953. Association of Building Technicians, 5, Ashley-place, London, S.W.1. [Price 5*s*. 6*d*. post free.]

Structure of Metals. Crystallographic Methods, Principles, and Data. By Professor Charles S. Barrett. Second edition. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 36, U.S.A. [Price 8·50 dols.]; and McGraw-Hill Publishing Company, Limited, 95, Farringdon-street, London, E.C.4. [Price 72*s*. 6*d*.]

Steam Power Stations. By Dr. Gustaf A. Gaffert. Fourth edition. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 36, U.S.A. [Price 8 dols.]; and McGraw-Hill Publishing Company, Limited, 95, Farringdon-street, London, E.C.4. [Price 68*s*.]

Praktische Verzahnungstechnik. By Walter Krumm. Fourth enlarged edition. Carl Hanser Verlag, Leonhard-Eck-Strasse 7, Munich 27. [Price 16·50 D.M.]

Report of the Mechanical Engineering Research Board, with the Report of the Director of Mechanical Engineering Research for the Year 1951. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2*s*. net.]

World Railways. 1952-53. Edited by Henry Sampson. Sampson Low, Marston and Company, Limited, 25, Gilbert-street, London, W.1. [Price 4 guineas net.]