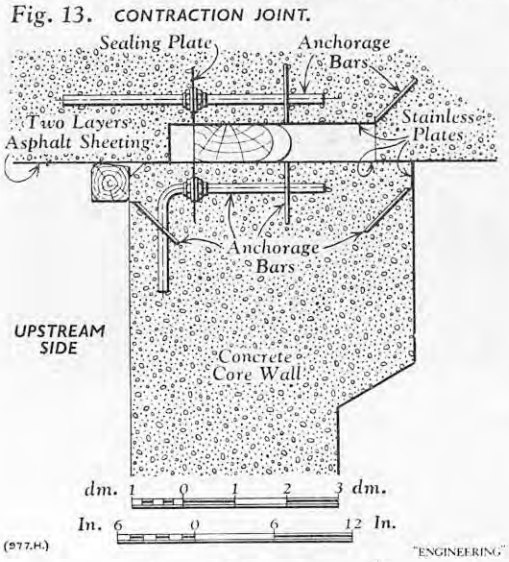
350-MW HYDRO-ELECTRIC GENERATING STATION AT HARSPRÅNGET, SWEDEN.

(*Concluded from page* 587.)

To ascertain the displacements and stresses which will develop in the various parts of the dam, and to collect information for future use, wells were formed at three places in the downstream part of the dam to house instruments for measuring the horizontal and vertical settlements. Instruments have also been provided to measure the lateral pressure on the core wall at different heights, as well as the pressure in three directions at different points in the fill. Special gauges have been installed for measuring settlements in the upstream portion of the dam. Illustrations of the dam in course of construction appear in Fig. 5, on page 587, *ante*, and Figs. 14 and 15.

A spillway has been formed at one end of the dam and is capable of passing 77,000 cusecs. It has three equal-sized openings, separated by concrete piers and opened or closed by Taintor gates. Two of these gates are operated electrically and

Fig. 13. CONTRACTION JOINT.



in one case the machinery is supplemented by counterweights so that the gate can be opened quickly, if the turbines are shut down suddenly and no power is available for closing. The third gate, which will be used only on rare occasions, is operated by hydraulic jacks. When required, steel stop-dogs may be placed in front of the gates by means of a jib crane moving on rails. In addition, an emergency spillway with two openings has been built next to the main spillway and is normally closed by concrete slabs. Unlike many of the dams connected with Swedish power stations, there are no log chutes. A roadway will, however, be carried over the spillway and over a railway on the right bank by a steel bridge.

The intake to the power station has been built farther into the river than is usual, to avoid the rock fault previously mentioned. It is connected to the core wall of the dam, illustrated in Fig. 5, by expansion joints, the design of which will be clear from Fig. 13. It consists of a concrete shaft which is divided internally so as to provide a separate inlet for each turbine ; and each of these inlets is equipped with an hydraulically-operated gate which can be closed, if necessary, in 10 seconds in case of damage to the spiral casings. Trash racks are mounted over the gates and upstream of them again there are steel stop-logs, which can be operated by a crane of similar design to that on the spillway. This crane can also be used for cleaning the trash racks. From the inlets the water passes into vertical penstocks, excavated from the rock. The upper parts of these penstocks are lined with reinforced concrete and are so designed that the rock takes up the greater part of the internal water pressure and the reinforced concrete any external pressure that may be set up. At a level corresponding to the roof of the machinery hall steel tubes have been embedded in concrete and have been designed to resist both the internal and external water pressures. The cross-section of the upper portions of the penstocks is 40 per cent. greater than that of the lower portions, as they were cheaper to construct. Although, as a result, the frictional losses in the upper portion are less than those in the lower, the overall figure is the same as if the cross-section had been constant throughout.

The generator room and transformer chamber at Harsprånget have been excavated from the rock, as shown in Fig. 16. This practice has recently been increasingly adopted in Sweden for technical, economic and strategical reasons. Generally speaking, the head available is comparatively low, being frequently less than 150 ft. and only more than 300 ft. in exceptional cases. As, moreover, the falls that are being developed often extend over long distances, this head has to be "gathered," while, as the flow to be utilised may amount to 16,000 cusecs, the volume of water to be dealt with

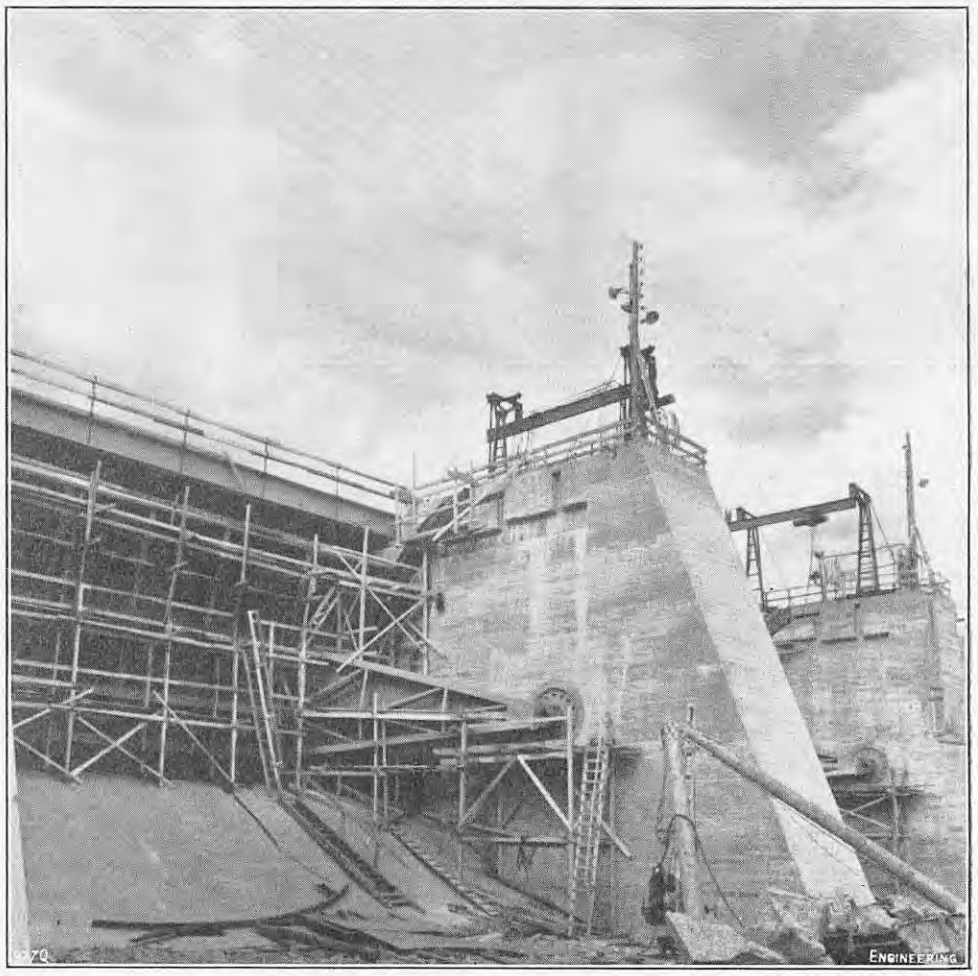


FIG. 14. SPILLWAY UNDER CONSTRUCTION.

is relatively large. Kaplan turbines are employed when the head does not exceed 135 ft., and Francis turbines when it is more than this figure.

In designing a power station to meet these conditions every effort is naturally made to utilise the head to the best advantage at the lowest annual cost. In this connection it has been found that the maintenance of chambers excavated from the rock is lower than of surface buildings, owing to the large amount of concrete which must be employed in the latter. Moreover, owing to the fact that the banks of the Swedish rivers often lie only a few feet above the natural water level and are surrounded by land which it is too valuable to submerge on a large scale the head must be mainly "gathered" by dredging the bed and driving tunnels and canals. If the rock is of good quality and is sufficiently near the surface, the intake can then be incorporated in the dam itself and the water led to the turbines through vertical and relatively short penstocks, thus reducing the difficulties of turbine regulation. Finally, the cost, which in recent Swedish stations has not been more than about 40*l.* per kilowatt for capacities from 100 to 300 MW, is no greater, since the expense of excavating large quantities of rock is partly compensated by the decreased cost of the walls and roof. It is interesting to note, in fact, that in every case where an underground station has been built in Sweden it has been the most economic solution that could have been adopted. The greater safety which would thus accrue in war has been an additional, but not a decisive, factor in the choice.

The layout of the generator room and transformer cubicles at Harsprånget will be clear from the drawings reproduced in Figs. 17 to 20, on page 619. The view in the generator room, given in Fig. 1, on page 585, *ante*, shows its striking appearance. It is 328 ft. long by 59 ft. wide, and is large enough to accommodate four units. The roof is 200 ft. below ground level, and the bottom of the draft tubes are 141 ft. farther down. Although the rock is of sound granite above the roof, it has been strengthened by the insertion of steel bars, one to every 11 sq. ft. of area. These bars are 1 in. in diameter and have been grouted into holes to a depth of from 10 ft. to 16·5 ft. Concrete pipes of semi-circular section have been inserted for drainage purposes and the surface of the rock is covered with Gunite, reinforced by welded steel netting. These drains are connected to pipes which carry the water to a pumping shaft. Up to the present, little or no leakage has been experienced, but, should it occur, provision has been made for the erection of an inner ceiling to the generator room. The fresh air for ventilating and warming the power station is mixed with the

HYDRO-ELECTRIC GENERATING STATION AT HARSPRÅNGET, SWEDEN.

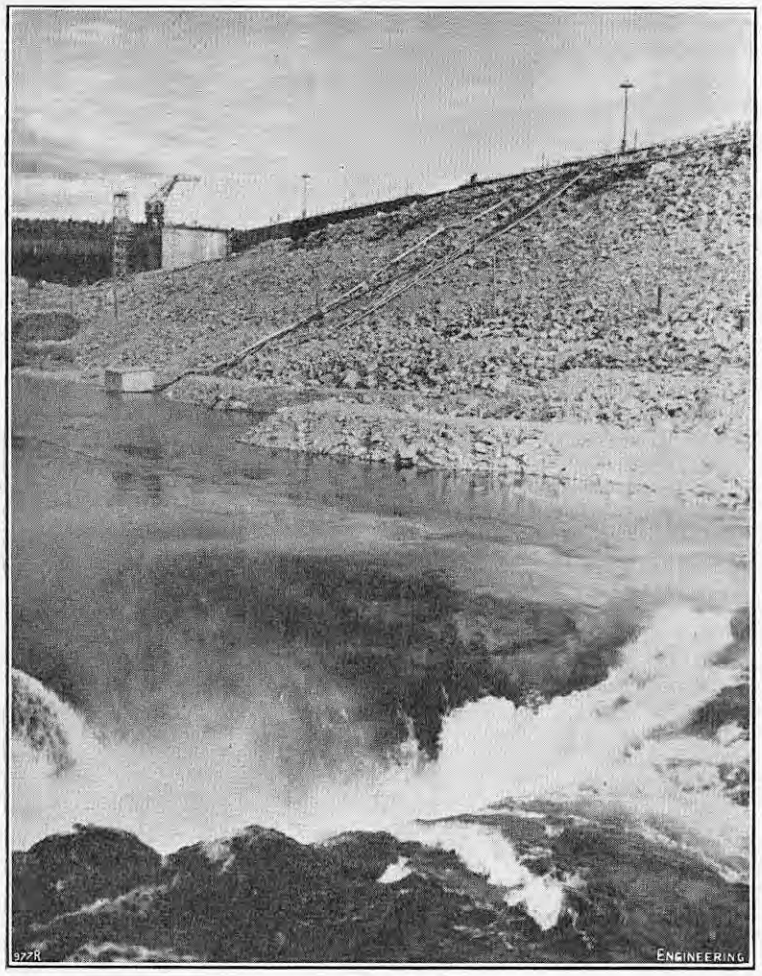


FIG. 15. UPSTREAM FACE OF DAM.

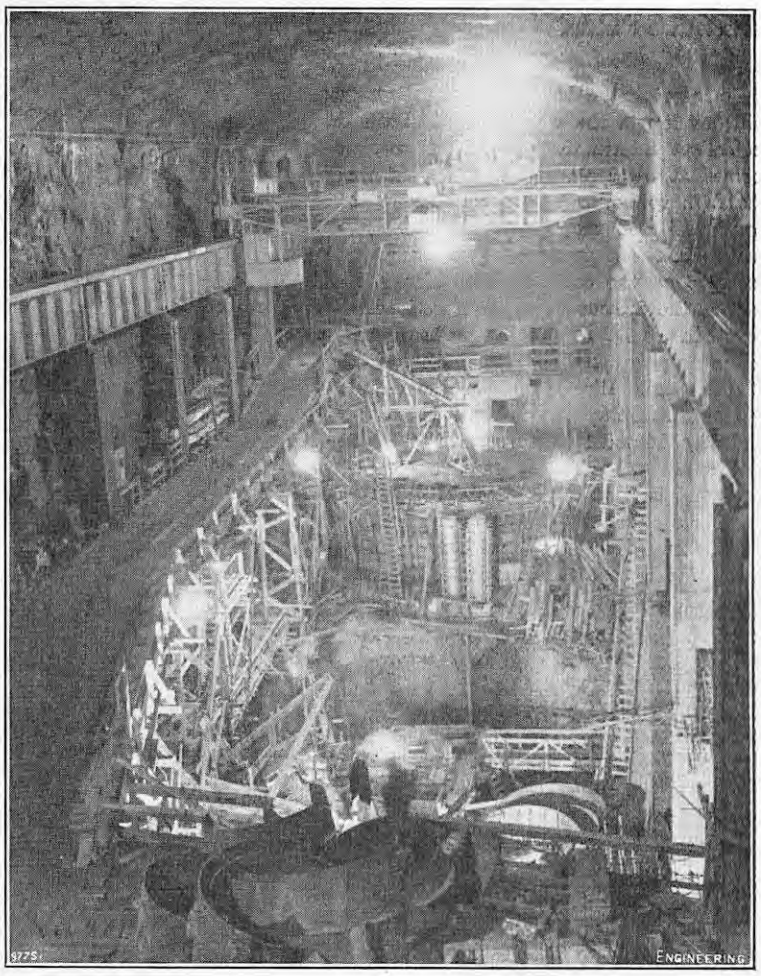


FIG. 16. GENERATOR ROOM UNDER CONSTRUCTION.

exhaust air from the station, drawn over heaters which are warmed by heat from the transformers, and is then discharged into the station.

To enable plant to be transported to the power station, a branch was laid from the main railway line to the site and run into an unloading hall, which was built some 500 ft. downstream from the power station. From this hall a shaft was sunk to the level of the generator room floor and a tunnel driven to the latter, as shown in Fig. 19, with a branch to the transformer cubicles. This shaft is surmounted by a 160-ton travelling crane and is equipped with both passenger and goods lifts and a staircase. A second passenger lift provides access from the crest of the dam to the generator room.

The generating plant at present consists of three Francis turbines, which were built by Nydqvist and Holm AB, Trollhättan, and AB Karlstads Mekaniska Werkstad, Karlstad. Each generator set has a rated output of 96 MW when operating under a head of 345 ft. at a speed of 167 r.p.m. Air can be admitted through the turbine shaft to prevent cavitation. The turbines are equipped with electrically-operated governors of a type which has been largely used in Sweden to secure close frequency regulation of a number of interconnected stations.* The turbine gates are operated by two servo motors, which can be seen in Fig. 22, Plate XLIX, the valve of which is actuated by a hydro-electric device. This device is in turn, controlled by an electronic regulator, which consists of two balanced electronic valves in push-pull and a resonance and damping circuits. The resonance circuit is connected to a tachometer generator on the main shaft of the turbine, while the damping circuit is fed from a potentiometer, which is mechanically operated by the gates. The delivered voltage is therefore a definite function of the gate opening. The hydro-electric device consists of a regulation coil, suspended in the field of a permanent magnet. When a current is passed through this coil it is deflected from its neutral position and actuates a piston controlling a valve, so that very rapid and considerable amplification of the power takes place. The input signals are analysed, mixed and partly amplified in the electronic regulator in such a way that when they are balanced the resultant voltage is zero, the coil of the regulator is in its neutral position, and the servo motor is at rest. If, however, the resultant is not equal to zero, the servo motor operates at a speed proportional to its amount.

The turbines are directly coupled to alternators, constructed by Allmänna Svenska Elektriska A B, Västerås. These machines are rated at 105 MVA, with a power factor of 0·9, and generate three-phase current at 16 kV, but they have been run on a load of 118 MW without overheating. Some idea of their size may be obtained from Figs. 21 and 23, on Plate XLIX, which show one of the rotors in course of erection. A 1,200-kVA synchronous alternator, for auxiliary service, and an exciter are also mounted on the main shaft. Owing to the length of the lines to which they are connected, these alternators have been designed with sub-transient and transient reactances of 15 and 22 per cent., respectively. Connection between the alternators and the step-up transformer group, which is installed in cubicles in the rock, as shown in Fig. 19, is made by bare copper conductors. This transformer group consists of four single-phase transformers, each with a rating of 115 MVA, $16/0{\cdot}370\sqrt{3}$ kV, and four single-phase regulating transformers, each with ratings of 9·3 MVA, $16/\pm 0{\cdot}30\sqrt{3}$ kV, which are connected to the neutral point of the 380-kV windings. One of these transformers is used as a stand-by and is equipped with circuit-breakers and isolating switches, so that it can be connected to any of the others without interrupting the supply. The regulating transformers are arranged in the same way.

As a single generator 'bus-bar would have led to excessive currents, each main transformer has five cores. The windings are carried on the middle three of these cores and each generator is connected to one winding through separate 'bus-bars and double-pole circuit-breakers, the system being designed so that the three circuit-breakers which are controlling the 'bus-bars in service are operated simultaneously. The double-pole circuit-breakers and isolators in each phase can also be operated individually so that a phase can be transferred from one transformer to another. The short-circuit currents on the 16-kV 'bus-bars are thus limited to 1,500 MVA, so that control by air-blast breakers, using normal 'bus-bar construction, has been possible. A 40-MVA reactor is connected to each of the generator 'bus-bars. A supply to the local 154-kV system is given from the main 'bus-bars through a 60-MVA 16/154-kV transformer. Space has been left for another similar transformer, but this is temporarily occupied by a 135-MVA 16/240-kV unit, which will enable the 380-kV system to be operated at 220 kV, if necessary. The secondaries of the main transformers, which are wound in star, are connected to an outdoor switching station at ground level through oil-filled single-phase cables, carried in a vertical shaft. This switching station is equipped with six single-pole circuit-breakers, each with a rupturing capacity of 8,000 MVA. One group of breakers controls the transformers, and its poles, as well as

* See *Electrohydraulic Regulations of Water Turbines*, by E. Brodersen and S. E. Hedström. Paper No. 315. Conférence Internationale des Grands Réseaux Électriques à Haute Tension, 1950.

HYDRO-ELECTRIC GENERATING STATION AT HARSPRÅNGET, SWEDEN.

(*For Description, see Page* 617.)

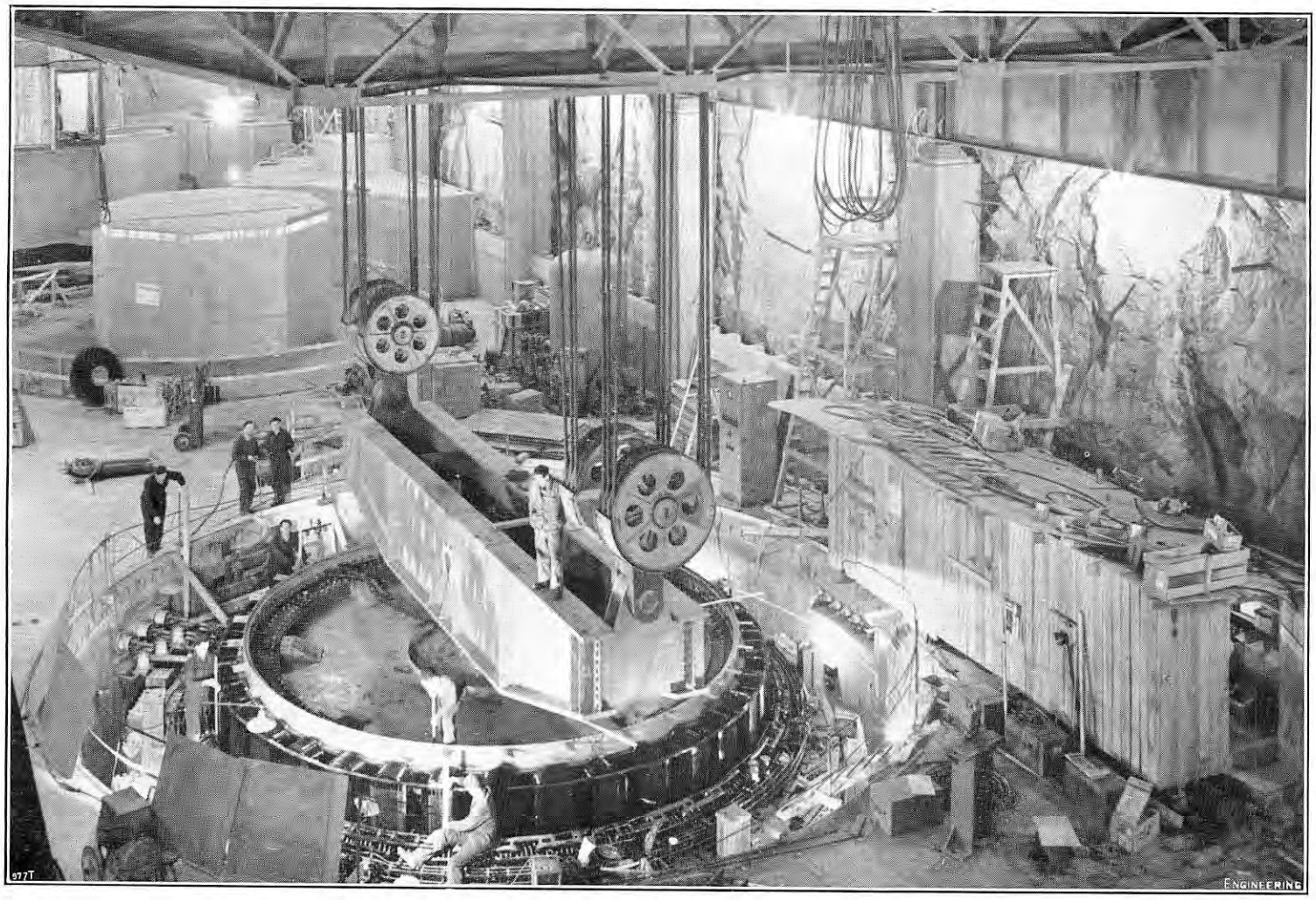


FIG. 21. INSERTING ROTOR IN ALTERNATOR.

FIG. 22. TURBINE SHAFT.

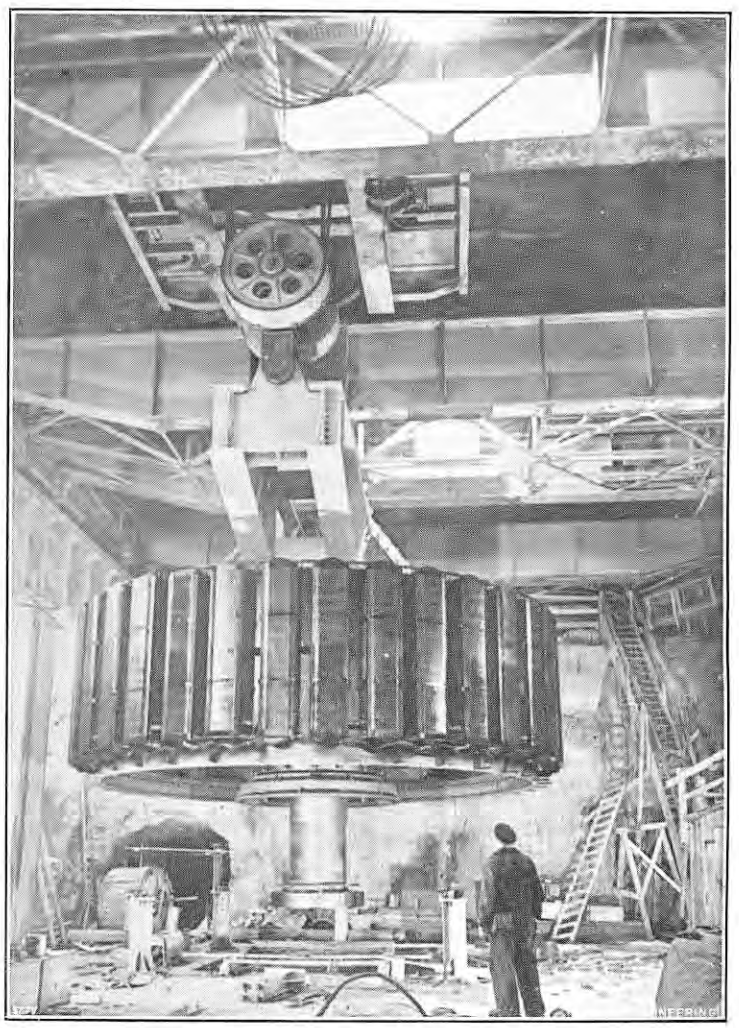


FIG. 23. ALTERNATOR ROTOR.

HARSPRÅNGET HYDRO-ELECTRIC STATION.

Fig. 17. VERTICAL SECTION OF POWER STATION.

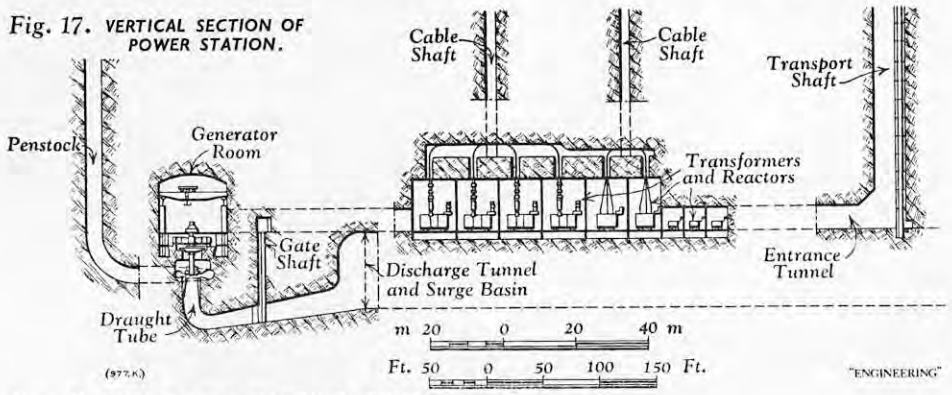
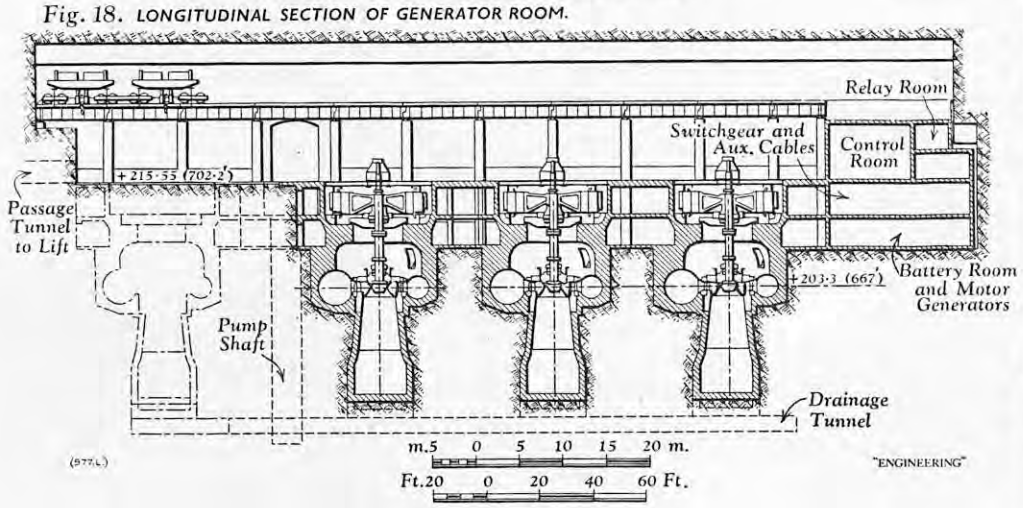


Fig. 18. LONGITUDINAL SECTION OF GENERATOR ROOM.



HORIZONTAL SECTION OF POWER STATION AND CROSS-SECTION OF 380-kV TRANSFORMER ROOM.

Fig. 19.

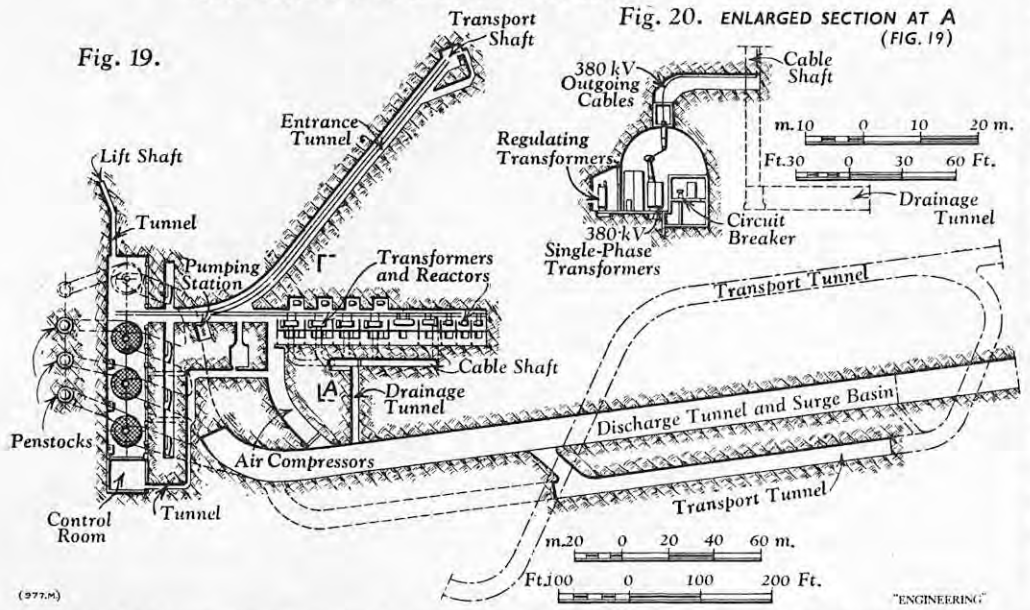


Fig. 20. ENLARGED SECTION AT A (FIG. 19)

its associated isolators, can be operated together or separately to bring the stand-by unit into service.

On leaving the turbines, the water is discharged into an underground surge basin which has been excavated in the rock to a depth of 72 ft., and is 985 ft. long. Thence it flows into the river at Djupselet through a tunnel 1·8 miles long, with a cross-section of 2,045 sq. ft. This large cross-section was chosen for economical reasons, since the use of modern machinery and methods of construction enabled the rock to be excavated very cheaply and, as has been said, utilised for building the dam, thus minimising the employment of borrow-pits. Moreover, the rock was of such good quality that the tunnel did not have to be lined. It was driven by first excavating the lower half to the extent of about 50 per cent. of the finished section, with the help of drilling machines and explosives. After the spoil had been removed by bucket dredgers which discharged into lorries, the upper part was removed in the same way, the drilling machines for one section of the work being supported on the spoil obtained from the previous operation.

The water level at Djupselet has been lowered by about 6·5 ft. by excavating a canal at Pakkoforsen, as it was found more economical to use this head at Harsprånget than in the future station, which it is proposed to build some six miles downstream.

The whole of the civil engineering work in connection with this interesting station was carried out by direct labour under the supervision of the engineers of the State Power Board, to whom, and their civil engineering director, Mr. Gösta Westerberg, we are indebted for the information on which this article is based. The resident engineer at Harsprånget was Mr. Bertil K. E. Eklöf.

LITERATURE.

Dimensional Analysis.

By Professor H. E. HUNTLEY, B.Sc., Ph.D. Macdonald and Company (Publishers), Limited, 16, Maddox street, London, W.1. [Price 20s. net.]

IT is remarkable that the principles underlying dimensional analysis, enunciated by Newton, developed by Fourier, brilliantly exploited in many unexpected directions by Rayleigh, and promising widespread applications throughout the mechanical sciences, should have been, until comparatively recent times, so slightly regarded in the formal instruction of engineers and physicists. It is hardly too much to say that, even to-day, the only problems in which the dimensional approach is at all widely known and used are those involving fluid motion, and the enterprising student must often, and uncertainly, study by himself the possibilities of dimensional analysis in other technologies that may be his particular concern.

The main purpose of Professor Huntley's book is to remedy this situation by presenting, in a manner adapted especially to the needs and abilities of undergraduates, a more systematic and comprehensive treatment of dimensional analysis than has yet been published. He himself has studied the subject deeply enough to appreciate many of its purely philosophical implications, and to interest his readers to the point of sharing his enthusiasm and of thinking originally about such abstractions as the absolute nature of dimensions and the relationships among them. Far from deterring any thoughtful student, the author's inclusion of some fundamental ideas in the course of a brief historical outline is a stimulating feature of the early part of his book, without which the arguments developed in the later chapters could not be fully appreciated. The remaining introductory matter serves to explain the methods of studying physical quantities and equations dimensionally, and to demonstrate by a variety of examples how they can be used to study physical problems or to interpret experimental results. Professor Huntley then proceeds to show how these elementary types of analysis can become much more complete and instructive by treating the spatial dimensions vectorially, and by distinguishing between mass, regarded as a quantity of matter, and mass as the cause of inertia. The scope and power of dimensional analysis are greatly extended by such resolution of dimensions into two or three components, since it increases the number of simultaneous equations from which a conclusive result may be derived. The author does not suggest, however, any analogous conception in the case of the time dimension, and has little to say that is new, though much that is interesting, about the dimensions, additional to those fundamental in mechanics, needed for the analysis of thermal and electrical problems.

Since his book is intended primarily to help and guide students of physics, it is to be regretted rather than criticised that Professor Huntley has not exemplified a number of applications of dimensional theory which are of especial interest to engineers. On the other hand, hardly any of the illustrative examples considered lies outside the scope of engineering, and the desirable extensions of dimensional analysis to structural and hydraulic problems can be readily undertaken, under Professor Huntley's guidance, as instructive exercises. In common with the student of physics, the engineer who studies this admirable book with the care it deserves will at least acquire the habit of testing physical relationships for dimensional homogeneity, and at best may explore by original research some of the attractive dimensional avenues, of which Professor Huntley has had to restrict his readers to no more than a passing glimpse.

Rocket Propulsion, with an Introduction to the Idea of Interplanetary Travel.

By Eric Burgess, F.R.A.S. Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 21*s.*]

This book, by an official of the British Interplanetary Society, contains a survey for non-specialists of the problems, achievements and future possibilities of rocket propulsion. The material has been collated from lectures given by the author over a number of years to audiences both scientific and non-scientific, and its character might be described as semi-technical. Most of the book could be read with interest and profit by persons with little, if any, scientific knowledge, but a few parts require a moderate acquaintance with the engineering sciences and mathematics. The first chapter deals with the general principles of rocket propulsion, and in it the author brings out clearly the important fact that a rocket is most effective when travelling in a vacuum, contrary to the popular and widespread misconception that such missiles are propelled forward by the pressure of the jet on the air behind them. The three succeeding chapters, which amount to half the book, deal with fuels, rocket motors and problems of fuel feed and fuel tanks. They contain a considerable amount of information, supplemented by numerous illustrations and diagrams. A short chapter on the control of flight follows, in which brief details of a number of control systems are given, although the treatment of stability, inseparable from control, is somewhat superficial.

A chapter on long-range rocket projectiles contains an interesting discussion on ranges and methods of extending them, the suggestion being made that a high-altitude rocket fitted with wings could be made "to ricochet from the top of the atmosphere like a flat stone from the surface of water." The end of the chapter is a reprint of an essay by the author on the effects of directed missiles in warfare and contains very decided views on the national and international action necessary to avert a world catastrophe. However admirable and sincere these views, this digression from technicalities seems somewhat out of place in the book. The last two chapters, which discuss future possibilities, such as interplanetary travel by means of rocket-propelled vehicles, will be read with avidity by those to whom such possibilities are intriguing, but the author's suggestion that the value of such travel from a scientific point of view would be priceless, "for many sciences are coming up to blank walls and stopping due to the fact that the observations on which they are based must be made on earth," seems an over-statement. The book can be recommended as a readable account of a very live subject.

Introductory Soil Mechanics and Foundations.

By Lieutenant-Colonel George B. Sowers and Professor George E. Sowers. The Macmillan Company, 60-62, Fifth-avenue, New York, U.S.A. [Price 4·75 dols.]; and Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 32*s.* net.]

This book differs from most American text-books on soil mechanics in being of an introductory character. It was written, as the authors state, "for undergraduates and civil and architectural engineering students who are not soils specialists and also for practising engineers who encounter soil problems in their everyday work." The book opens with a chapter on the nature of soils. In the second chapter, on "Physical Properties," the treatment of the compressibility of soils and of shear strength is, perhaps, rather brief, and the reader is left to take a good deal for granted. Although the principles of the shear and consolidation tests are outlined with the aid of diagrammatic sketches, details are not given of the apparatus and procedure. Slow, consolidated-quick and quick shear tests are mentioned, but their relationship to the determination of shear strength in practical problems is left somewhat obscure. Chapter 3 deals with the geological origins of soils and soil deposits, leading to systems of classification; and the next chapter is devoted to seepage, drainage and frost action, including the construction and use of flow-nets. We note that, in Chapter 5, on "Foundations," the formulæ for ultimate bearing capacity are based on assumed straight-line failure planes; most authorities on soil mechanics, however, now favour analyses in which zones of plastic stress distribution, with curved boundaries, are assumed. The need to consider both ultimate bearing capacity and settlement in the design of foundations is clearly brought out, and the significance and limitations of the loading test are described. The next chapter, on "Deep Foundations," includes not only the soil-mechanics aspect of pile foundations, but also practical information on types of pile, pile-driving, the construction of piers and caissons, and underpinning. The inclusion of such material, unusual in a book on soil mechanics, is a valuable feature.

In the discussion of earth pressure, practical civil engineering applications are described, with particular reference to retaining walls and timbered cuts, but the authors' treatment of the Rankine and wedge theories introduces some controversial points; and their analysis of the stability of slopes, in the chapter on "The Stability of Earth Masses," is treated rather sketchily, though Taylor's stability curves for cohesive soil are presented in a simplified and clear form. The serious effect on stability of sudden drawdown, mentioned in connection with reservoir banks, might well have been emphasised by a numerical example. The book ends with a chapter on "Underground Investigation."

Mechanical Properties of Metals at Low Temperatures.

National Bureau of Standards Circular 520. Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 1.50 dols.]

The nine papers contained in this volume were presented and discussed at the Semicentennial Symposium on Mechanical Properties of Metals at Low Temperatures, held at the National Bureau of Standards on May 14 and 15, 1951. As now available in book form, they provide a compact, but comprehensive, survey of a branch of metal physics which has gained immensely in importance during the past decade as a result of military and aerial requirements and, in more peaceful connections, the growth of the refrigeration industry, the increasing demand for the liquefaction of various gases, and the effect of brittleness in steel, especially ship plates. All of these aspects are authoritatively covered, and illustrated by many examples of great interest. It is not commonly known, for instance, that, of some 5,000 merchant ships (mainly welded) which were built during the second World War, more than 20 per cent. had developed cracks before April, 1946, when most of them were less than three years old; or that, since November, 1942, more than 200 had sustained fractures which were classed as "serious." Bridges, tanks and pressure vessels have failed similarly, most of them at low temperatures. The reciprocal selling arrangements between the United States Government Printing Office and H.M. Stationery Office, in certain international connections, certainly should be extended, if necessary, to include this report, which deserves the attention of all who are concerned with the design and construction of machinery or structures liable to be exposed for long periods to sub-zero temperatures. All of the papers are of American origin except the first, by Dr. N. P. Allen, of the National Physical Laboratory, Teddington, who surveyed "Recent European Work on the Mechanical Properties of Metals at Low Temperatures."

A VECTOR METHOD OF SOLVING VIBRATION PROBLEMS.

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

One of the consequences of the use of fast-running machinery, as is common to-day, is the frequent occurrence of trouble from vibrations set up by the periodic forces of the machinery. Engineers have learnt, often by costly experience, that vibration when it occurs cannot be lightly disregarded since it may cause excessive stresses and lead to fatigue fracture of vital parts, as well as other troubles. The insistence of this problem has caused a great increase in the study of the theory of vibrations and a number of excellent works on the subject are in existence. However, the subject is still regarded by many as difficult, possibly because of the oscillatory character of the motion, but more probably because the analysis is often expressed only in mathematical symbols, and differential equations.

The purpose of this article is to present a graphical method using vector diagrams for the solution of mechanical vibration problems, a method devised in the Applied Mechanics Department of the Royal Naval College, Greenwich, where it has been successfully used for a number of years. The chief advantage of this graphical treatment lies in the fact that by its use the principles of natural and forced oscillation can be appreciated by engineers who are not attracted by a purely mathematical treatment. Even for those who find no great difficulty in a mathematical treatment, the vector method is a valuable means of illustration which facilitates the appreciation of the physical significance of the theory. The use of vectors in the study of mechanical vibrations is not new, but graphical solutions have not been developed elsewhere to the same extent or in the way shown here. Cases of both natural and forced vibrations are dealt with.

Natural Damped Oscillation.—Fig. 1 shows the simple system used as the basis of this treatment. A mass is suspended on a spring, the upper end of which is first considered as fixed to a rigid support. A dashpot or its equivalent, say, well lubricated guides, applies the damping or resistance to motion. It is assumed that this resistance follows the viscous law, i.e., it is proportional to the velocity of motion of the mass. Another assumption is that the mass can move only in vertical linear motion. It is then described as having one degree of freedom. By the definition of natural oscillation no external force is applied. The appearance of an actual vibrating system may not be anything like that shown in Fig. 1 but, provided the same essential features are present, namely, mass, elastic stiffness and viscous damping with one degree of freedom, it may be reduced or "idealised" to that shown. Also there are numerous practical cases which, although they do not correspond exactly with the system of Fig. 1, are sufficiently near it for the analysis of this system to be a useful guide.

With the convention that the downward direction is positive for displacement, velocity and acceleration, the mass is assumed to have moved through a small positive displacement, x, measured from the position of static equilibrium. Then the force exerted by the spring is $-sx$, where $s = \frac{\text{elastic force}}{\text{displacement}}$ and is, of course, the "rate" or stiffness of the spring. If at the same time the mass is moving with a positive velocity, the force of resistance due to the dashpot is $-q\frac{dx}{dt}$, where $q = \frac{\text{force of resistance}}{\text{velocity of mass}}$ and may be called the damping coefficient (not to be confused with the damping factor which, although related, is not the same, as will be seen later). These two forces act on the mass m. Hence, applying the second law of motion ($F = m\,a$), the equation of motion of the system is obtained

$$-q\frac{dx}{dt} - sx = m\frac{d^2x}{dt^2}$$

or

$$m\ddot{x} + c\dot{x} + sx = 0.$$

Dividing this equation through by m gives

$$\ddot{x} + \frac{q}{m}\dot{x} + \frac{s}{m}x = 0. \quad . \quad . \quad (1)$$

It will help if we anticipate here by replacing $\frac{s}{m}$ by ω^2_n. Later it will be seen that ω_n is the "angular frequency" of the oscillation of the system without damping. Also, we write

$$\frac{q}{m} = 2\frac{q}{2\sqrt{m\,s}} \cdot \sqrt{\frac{s}{m}} = 2\,\mathrm{K}\omega_n$$

where $\mathrm{K} = \frac{q}{2\sqrt{ms}}$, and is known as the damping factor. The reason for the introduction of this new symbol K is that its value determines the character of the motion of the system, as shown later. We may note here that K is a pure number, its value depending on the three quantities q, m and s.

Equation (1) may now be re-written in the form

$$\ddot{x} + 2\,\mathrm{K}\,\omega_n\dot{x} + \omega_n{}^2 x = 0 \quad . \quad . \quad (2)$$

The physical interpretation of equations (3), (4) and (5) is shown in the polar diagram Fig. 2.

From the origin O, a vertical line OA is drawn as the reference line for zero time. OB is drawn at an angle β (counter-clockwise for a positive angle) to represent X, the maximum value of the displacement. At 90 deg. counter-clockwise from OB, the line OC is drawn to represent the maximum value of the velocity, $\mathrm{V} = \omega_n\mathrm{X}$, and OD at 180 deg. from OB to represent the maximum value of the acceleration, $\mathrm{A} = \omega_n{}^2\mathrm{X}$. The time is represented by a line rotating clockwise about O at a constant angular rate ω_n (like a double-ended clock hand). This rotating line, which starts from the vertical position when $t = 0$ and has a displacement $\omega_n t$ at any time t, gives a tangible meaning to the term "angular frequency," or "phase rate." The instantaneous displacement $x = \mathrm{X}\cos(\omega_n t + \beta)$ is shown by Ob, the projection of OB on the rotating time line. Likewise, the instantaneous values of velocity and acceleration are shown by Oc and Od, the projections of their respective maximum value vectors OC and OD on the time line.

The diagram need not be drawn to scale, its main value being that of giving a clear picture of the relationships involved, and for this purpose a freehand sketch is usually sufficient. Moreover, once this "phase diagram" is understood the various instantaneous values can, if so desired, be found by simple calculation from the geometry of the diagram without the use of equations (4) and (5). When used in this way, it should be noted that projections, e.g., Oc and Od, which fall on the "tail" portion of the time line, must be taken as negative.

Although there is usually a distinct advantage in leaving the vectors fixed and revolving the time line, as described above, it is evident that the same relative motion occurs if the time line is considered as fixed in the vertical position and the vectors thought of as revolving counter-clockwise. Alternatively, if it is preferred to follow the convention used in the modern presentation of alternating-current circuits of electrical engineering, the position of the line for zero time can be made horizontal, i.e., pointing to "three o'clock" instead of "twelve o'clock." These arbitrary variations in no way invalidate the method.

Fig. 1.

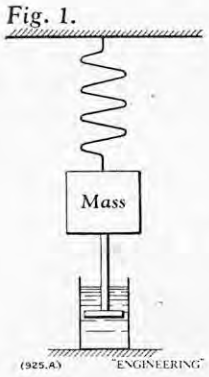


Fig. 2.

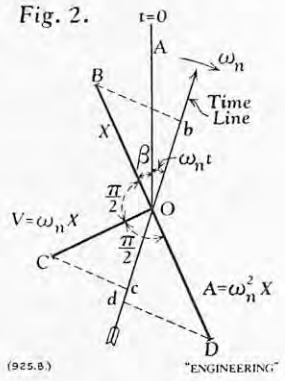
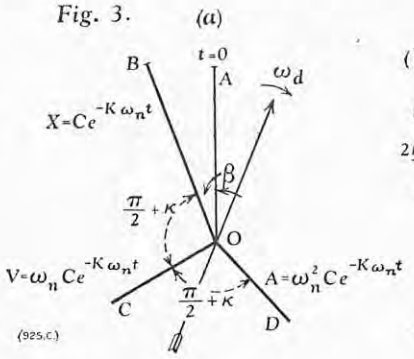


Fig. 3. (a)



(b)

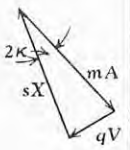
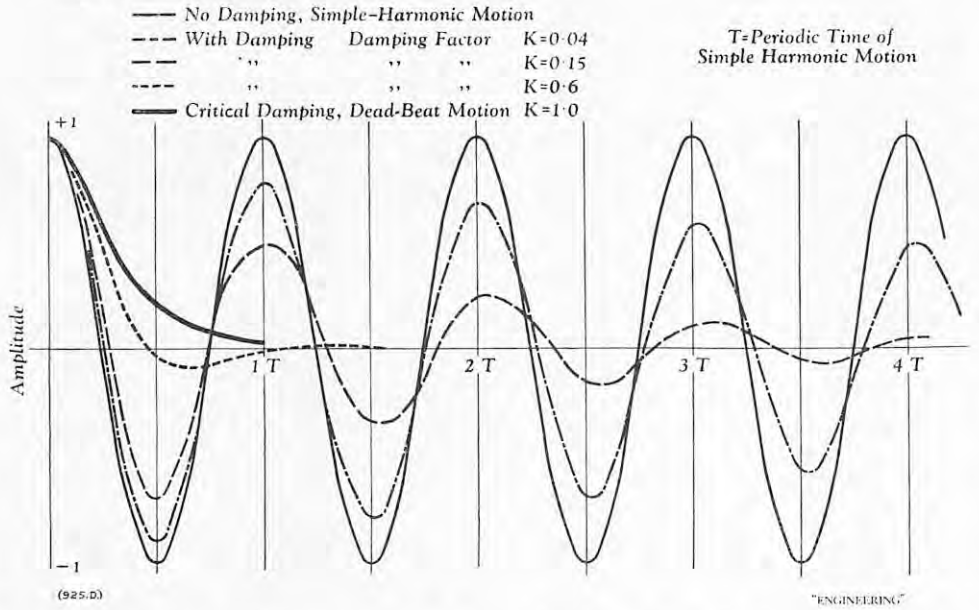


Fig. 4.



The form of the solution of this equation depends on the value of the coefficient of the second term, $\dot{x}$, and hence on the value of K. There are four possibilities (i) $\mathrm{K} = 0$, (ii) $1 > \mathrm{K} > 0$, (iii) $\mathrm{K} = 1$, (iv) $\mathrm{K} > 1$, but only the first two will be considered here, since if K is equal to or greater than unity the damping is sufficient to prevent any oscillation.

(i) $\mathrm{K} = 0$. This is the case of an undamped system—a particular case of the more general problem. Equation (2) now simplifies to $\ddot{x} + \omega_n{}^2 x = 0$, which is the differential equation of simple-harmonic motion. Its solution

$$x = \mathrm{X}\cos(\omega_n t + \beta) \quad . \quad . \quad (3)$$

gives the instantaneous displacement x as a function of the time t. The quantities X and β are constants, the former being the amplitude, i.e., the maximum displacement from the mean position, and the latter the initial phase, i.e., at zero time, as shown in Fig. 2.

By differentiating equation (3) once, and then again, we get the equations for the velocity v and the acceleration a at any instant of time t, thus:

$$v = \omega_n \mathrm{X}\cos\left(\omega_n t + \beta + \frac{\pi}{2}\right) \quad . \quad (4)$$

$$a = \omega_n{}^2\,\mathrm{X}\cos(\omega_n t + \beta + \pi) \quad . \quad . \quad (5)$$

(ii) $1 > \mathrm{K} > 0$. This is the case of a damped oscillating system. The solution of equation (2) is usually given in the form

$$x = e^{-\mathrm{K}\omega_n t}\left\{\mathrm{A}\cos(\omega_n\sqrt{1-\mathrm{K}^2})t + \mathrm{B}\sin(\omega_n\sqrt{1-\mathrm{K}^2})t\right\}.$$

It is, however, more useful for the present purpose if it is rearranged in the form

$$x = \mathrm{C}\,e^{-\mathrm{K}\omega_n t}\cdot\cos(\omega_d t + \beta) \quad . \quad . \quad (6)$$

where C is a constant, its value depending on initial conditions, and β is the phase of the displacement vector OB when

$$t = 0 \quad \text{and} \quad \omega_d = \omega_n\sqrt{1-\mathrm{K}^2} \quad . \quad . \quad (6a)$$

The right-hand side of equation (6) is the product of two terms. The cosine term shows that the motion is oscillatory but the exponential shows that the amplitude decreases with time.

The corresponding equation for the velocity is obtained by differentiating equation (6), which then gives

$$v = \omega_n\,\mathrm{C}e^{-\mathrm{K}\omega_n t}\cdot\cos\left(\omega_d t + \beta + \frac{\pi}{2} + \kappa\right) \quad . \quad (7)$$

and differentiating again gives the acceleration

$$a = \omega_n^2\,\mathrm{C}e^{-\mathrm{K}\omega_n t}\cdot\cos(\omega_d t + \beta + \pi + 2\kappa) \quad (8)$$

where $\kappa = \sin^{-1}\mathrm{K}$ and therefore $\cos\kappa = \sqrt{1-\mathrm{K}^2}$.

It will be noticed that the phase difference between the vectors representing displacement and velocity is the same as that between velocity and acceleration, namely $\frac{\pi}{2} + \kappa$, as compared with $\frac{\pi}{2}$ in the case of undamped motion. Also ω_d plays the same part in equations (6), (7) and (8) as ω_n did in the corresponding equations for undamped motion, viz., equations (3), (4) and (5). Moreover, since K is a pure number, ω_d is dimensionally the same as ω_n. Hence, ω_d can be regarded as the angular frequency or phase rate of the damped oscillation. Its value, however, differs only slightly from the undamped angular frequency ω_n when K is small.

These three equations (6), (7) and (8) also have a simple graphical interpretation as shown in Fig. 3(*a*). As before, OA, drawn vertically, represents zero time and OB, drawn at an angle $+\beta$, is the vector representing the maximum value of the displacement, namely, $\mathrm{X} = Ce^{-\mathrm{K}\omega_n t}$. The velocity vector OC ($\mathrm{V} = \omega_n Ce^{-\mathrm{K}\omega_n t}$) is drawn at an angle $\left(\frac{\pi}{2} + \kappa\right)$ counter-clockwise from OB, and OD, the acceleration vector ($\mathrm{A} = \omega_n{}^2\,Ce^{-\mathrm{K}\omega_n t}$) at a further $\left(\frac{\pi}{2} + \kappa\right)$ counter-clockwise.

The time line revolves clockwise from the vertical position at an angular rate $\omega_d = \omega_n\sqrt{1-\mathrm{K}^2}$, i.e., at a slower rate than the time line for undamped oscillation. Thus, one effect of the damping is to slow down the oscillation, although only slightly, as already noticed. Instantaneous values of the three quantities displacement, velocity and acceleration, are shown as in the previous case by the projection of the respective vectors on the time line, but in this case these vectors are themselves shrinking with time. If the alternative convention of allowing the vectors to revolve counter-clockwise is used then the tips of the vectors will each trace a true, i.e., logarithmic spiral.

If the instantaneous values of the displacement are plotted as ordinates on a base of time we get the familiar decay curve for natural damped oscillation, shown in Fig. 4 for different values of K. Fig. 3(*b*) shows the vector diagram of the forces acting in the system. The displacement, velocity and acceleration vectors when multiplied respectively by their appropriate coefficients, viz., s, q and m, represent the maximum values of the forces. These force vectors together give a closed diagram, and hence their instantaneous values, shown by their projections on the time line, will have zero resultant at all times during the cycle, which is consistent with the definition of natural motion, i.e., that no external force is applied. For very small values of the damping factor, K, the damping force (qV) vector is also small. If $\mathrm{K} = 0$, we have the undamped case and the only forces are the elastic force and the mass acceleration force.

(*To be continued.*)

THE INSTITUTION OF CIVIL ENGINEERS: PRESIDENTIAL ADDRESS.*

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

(*Continued from page* 606.)

Report of General Board of Health, 1850.

In 1847, a Royal Commission was appointed to inquire into the measures requisite for the improvement of the health of the Metropolis, with particular reference to drainage, street cleansing, paving, the removal of refuse, and the better supply of water. The cholera outbreak of 1848 diverted their attention from water supply and this was delegated to the General Board of Health, a body which had been set up under the provisions of the 1848 Public Health Act. The Board consisted of the Earl of Carlisle, Lord Ashley (afterwards the seventh Earl of Shaftesbury), Edwin Chadwick, the great sanitary reformer, and Dr. Southwood Smith, and in 1850 they presented a voluminous report of 350 pages, concluding with 63 findings.

Briefly, the Board considered that the London water supply was inferior to that of other towns, principally on account of its hardness. They condemned the intermittent supply and drew attention to the great waste of water which it occasioned. Further, they recommended the abandonment of the Thames as a source of supply and its substitution by water to be obtained from the Greensand on the Surrey and Hampshire borders. The report also dealt with drainage and the Board recommended that the water supply and drainage of the Metropolis should be placed under the control of one and the same body.

With regard to cholera, this was not attributed so much to the water supplied by the companies as to the inefficient service which they rendered, resulting in the poorer classes seeking and obtaining water from polluted ditches, sewers, and wells. Another alleged disadvantage of the inferiority of the water supplied by the companies was that "a large proportion of the population is rendered averse to the daily use of water as a beverage and is inclined and almost forced to the use of fermented liquors and ardent spirits." It is no reflection on the quality of the Metropolitan Water Board supply that in some quarters this preference still exists.

In the next year (1851) the Government appointed yet another Commission, generally known as the Chemical Commission, to report upon the chemical qualities of the water supplied by the companies. A great deal of their report, which was issued in June, 1851, was concerned with the hardness of the London water, and, while expressing a preference for softened chalk spring water as the ideal, the Commission nevertheless recommended in favour of the Thames, provided that the intakes were removed above Teddington weir and the whole of the water filtered. The prominence given to the hardness of the water, to which the first references were made in the reports of the General Board of Health and the Chemical Commission, arose from the then recent work of Dr. Clark of Aberdeen, who, in 1841, took out a patent for "a new mode of rendering certain waters less impure and less hard by the well-known method of the addition of lime." Dr. Clark also invented "Clark's Scale," by which hardness is measured in grains of calcium carbonate in one Imperial gallon, or in parts per 70,000. It is now usual to express the hardness in parts per million, and on this latter method the average hardness of the water at present supplied from the Thames, Lee, and chalk wells, is approximately 230, 270 and 300, respectively.

Another interesting fact emerging from a perusal of contemporary evidence and reports is the consciousness of doctors and chemists that the appraisement of the purity of the water based on chemical analyses left much to be desired. They appear to have been groping for an explanation of the connection between water and disease, and it was not until bacteriological methods of examination were introduced some years later that this link was finally established. So far as London is concerned, the first routine examination of the water by this method was undertaken by Dr. Percy Frankland in 1885.

Metropolis Water Act, 1852.

In 1851, the Government at length took action and the Home Secretary introduced a Bill for the amalgamation of the water companies. The Bill failed, but in the following year the first Commissioner of Works presented another Bill which passed into law as the Metropolis Water Act, 1852. Briefly, the requirements of this Act were as follows. After August 31, 1855, the companies were prohibited from taking water from any part of the Thames below Teddington lock or from any tributary stream at any place below the highest point to which the tide flowed. All reservoirs within a distance of five miles of St. Paul's were to be covered unless the water were filtered after leaving the reservoir. In addition, all water was to be filtered unless drawn from wells.

As might be expected, these requirements resulted in extensive works being undertaken. The Lambeth Company, which had been forced by the bad condition of the water at Hungerford Bridge to anticipate this measure, completed their new works at Ditton in 1852 and closed their intake at Belvedere-road in 1853. Besides being the first of the London waterworks to be constructed above Teddington weir, this new station was remarkable for the pumping plant which it contained. Before deciding on the machinery, Simpson asked David Thomson, M.I.C.E., and Dr. William Pole, M.I.C.E., to investigate the type of engine which should be employed. Thomson proposed compound rotative beam engines which, so far as can be ascertained, had not previously been used for waterworks purposes, and he was subsequently entrusted with the design and manufacture of two pairs of this type of engine, each of 300 h.p. He introduced an innovation into these engines, namely, the bucket-and-plunger pump, by means of which water was delivered on both the up and the down stroke. This arrangement had been suggested by Smeaton in 1759, but it appears that hitherto it had not been applied. The firm of James Simpson and Company built large numbers of these engines for use in Great Britain and elsewhere.

Of the other companies, the Chelsea built a new works at Surbiton adjacent to the Lambeth Company's Ditton works, while the Southwark and Vauxhall, the Grand Junction and the West Middlesex companies constructed intakes and engine houses at Hampton and pumped raw water to their respective works at Battersea, Brentford (Kew Bridge) and Barnes through mains specially laid for that purpose. On the other side of London, the New River Company built filter beds at Stoke Newington and New River Head, and the East London Company installed filtration and pumping plant at Lea Bridge. The Kent Company had already built filters at Deptford.

Supplies from Underground Sources.

Although from time immemorial water supplies have been obtained from wells, no serious attempt seems to have been made to obtain a public supply from the chalk under London until 1833, when the Hampstead Water Company (later, in 1859, absorbed by the New River Company) sank a deep well near the south-west corner of the lower of the Hampstead Ponds. The yield was small and the well became disused by 1858. The first well sunk by the New River Company was at Hampstead-road (by Warren-street tube station) in 1838, and this was filled-in some time before 1889. In 1846 and 1848, the company also sank shallow wells at Cheshunt, Amwell End, and Amwell Hill, respectively, from which water was pumped into the New River, and in 1853 a new company, styling themselves "The Plumstead, Woolwich and Charlton Consumers Pure Water Company," sank a well at Plumstead from which they afforded the first public supply of softened water, the method used being the excess-lime process. The company was purchased by the Kent Company in 1861. In spite of the fact that the latter company had constructed filter beds at Deptford to purify the supply from the Ravensbourne, the results were not satisfactory and in 1856 the company sank a well about 95 ft. deep into the chalk. By a coincidence, the works had been sited near the Wimbledon-Deptford fault and a prolific supply was obtained. Additional wells and borings were subsequently sunk at this site and the Ravensbourne was abandoned as a source of supply in 1863. To-day the station still yields about 4 million gallons per day from the chalk. Other well stations in Kent and the Lee Valley quickly followed and eventually five of the eight water companies obtained supplies from underground sources.

Except for two small reservoirs belonging to the New River Company at Cheshunt and dating from about 1835, all the early reservoirs (apart from service reservoirs) had been designed for the settlement of the suspended matter in the water, but in the early 'sixties the need for storage began to be felt in the Lee Valley, where the increasing demands coupled with the low summer flows of the River Lee impelled the East London Company to construct their first reservoir to be "available in times of drought." From then onwards, more and more reservoirs were constructed in this valley until, with the recent completion of the William Girling Reservoir, all the available sites have been utilised. In the Thames Valley, the Chelsea and Lambeth Companies constructed reservoirs at Molesey and Walton in 1871, but the purpose of these was to provide water in times of flood when the river water was too turbid for use. It was not until more than 20 years later, due to the findings of Lord Balfour's Commission and to the fact that the demands were overtaking the authorised abstraction, that consideration was given to the construction of large reservoirs for use in times of drought, when the Southwark and Vauxhall Company promoted a Bill for two reservoirs at Walton, the Lambeth Company for one at Island Barn (Molesey), and the Grand Junction, New River, and West Middlesex Companies jointly for two reservoirs at Staines.

The Duke of Richmond's Royal Commission.

Notwithstanding the improvement in the quality of water resulting from the removal of the intakes from the lower reaches of the river, apprehensions were felt about the discharge of sewage into the upper reaches of the Thames, and in 1866 a second Royal Commission (the Duke of Richmond's) was appointed, with wide terms of reference, "to inquire into the present water supply of the Metropolis and whether there are other districts in addition to the high districts in England and Wales from which a good supply of unpolluted and wholesome water can be obtained and to report . . . which of such sources are best suited for the supply of the Metropolis and its suburbs." Among the members were Mr. T. E. Harrison, a railway and dock engineer, who became President of the Institution in 1874, and Sir Joseph Prestwich, the geologist. The secretary of the Commission was that remarkable man, Dr. William Pole, to whom reference has already been made. This Commission, the first official body to consider proposals for a supply of water to London from a distance, took a great deal of evidence and considered a number of schemes. These included a proposal by Mr. J. F. La Trobe Bateman (later President of the Institution) to obtain water from gathering grounds lying south of Snowdon and draining into the Severn, and that of G. W. Hemans and R. Hassard, MM.I.C.E., for a supply from the Lake District by damming the outlets of Thirlmere and Hawes Water (now both utilised by Manchester) and by obtaining a small supply from Ullswater. Another Welsh scheme was put forward by a Mr. Hamilton Foulton, M.I.C.E., for tapping the headwaters of the Wye, and a Mr. Remington advocated the Derbyshire hills. The Commission also considered a number of suggested methods of providing water for London from the Thames, the Lee, the chalk and oolite formations in the Thames Valley, and a few miscellaneous sources.

At the end of a report consisting of more than 120 pages, the Commission set out their findings, in which they rejected the Lake District and the Welsh schemes on financial grounds and expressed the opinion "that the River Thames, supplemented if necessary by works for storing the flood waters, together with the River Lee and water obtainable

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

RECONSTRUCTION OF BALLOCH PIER, LOCH LOMOND.

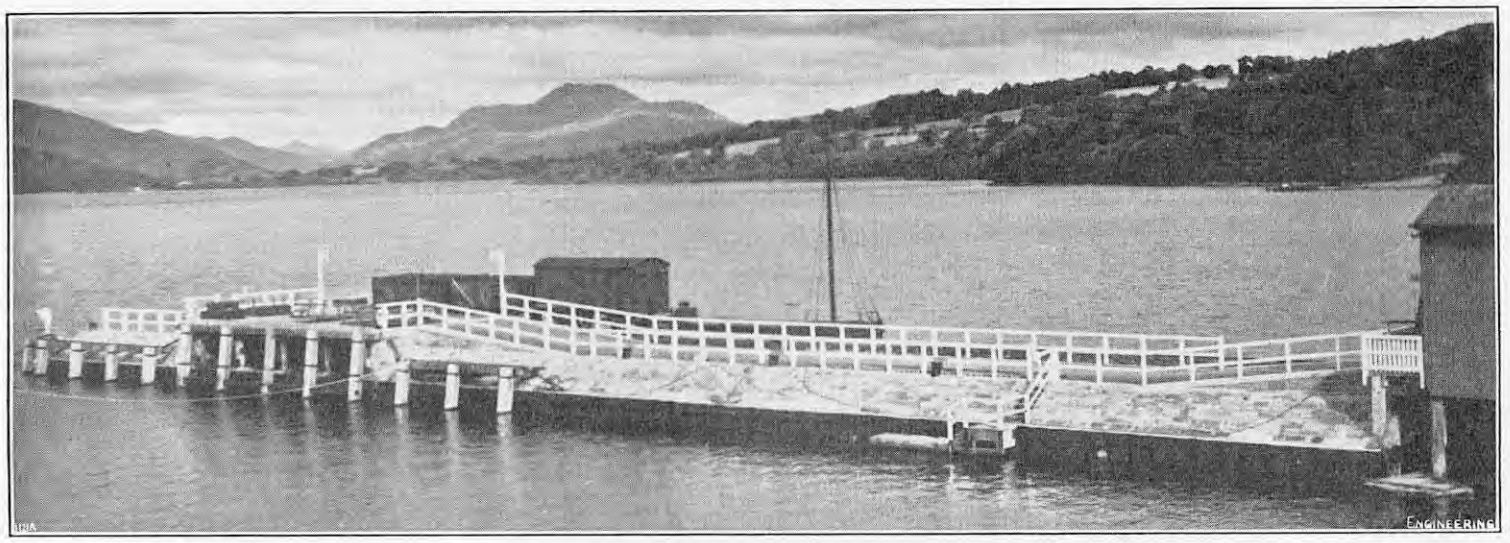


FIG. 1.

Fig. 2. TYPICAL CROSS-SECTION.

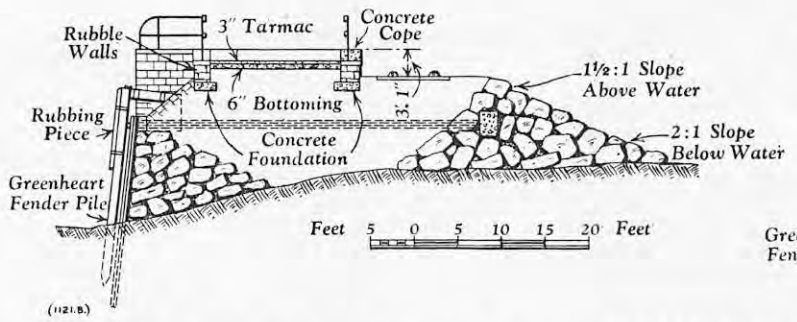
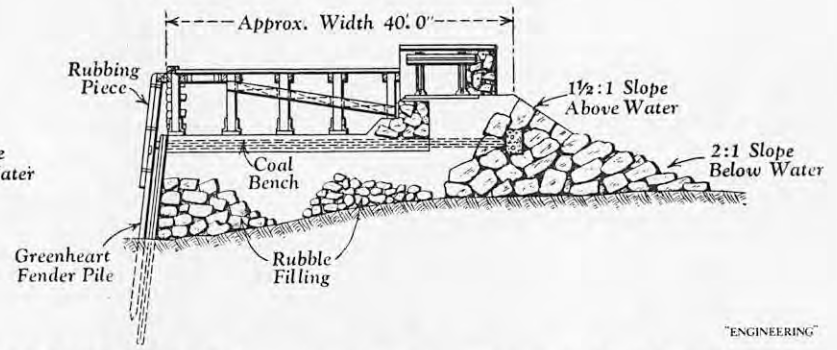


Fig. 3. CROSS-SECTION THROUGH COAL BENCH.



from the Chalk to the south and south-east of London, as well as probably from the Lower Greensand, will furnish a supply sufficient for any probable increase of the Metropolitan population." Then followed some remarks upon the quality, in which it was stated that there was no evidence that the water then supplied by the companies was not generally pure and wholesome, and that, while this water was hard, it was not injurious to health, but that the filtration process was in many cases improperly performed.

Although provisions had been included in the 1852 Act under which a constant supply could be required, they proved in practice to be of no value, and for many years the lack of this essential amenity had been the cause of complaint and ill-feeling against the water companies. The Commission gave consideration to this question and recommended that the system of constant supply should be promptly introduced, but since, in their opinion, this could not be effected by private companies on account of the difficulties which these companies would have in obtaining entrance to premises and exercising control over fittings, they were, in consequence, of opinion that the management of the water supply should be entrusted to a public body. With regard to the future population and demands, the Commission considered that the former might rise to 4½ or 5 million persons, and that 200 m.g.d. would be the most that need be reasonably looked forward to for the Metropolitan supply.

As a result of the Commission's report, the Government passed the Metropolis Water Act, 1871, which contained provisions for the extension of the constant supply. It also required the companies to make regulations for governing the "waste or misuse" of water and gave them power to control the use of water fittings. Apart from the appointment of an independent Water Examiner, to ensure that the requirements of the Act of 1852 as to the filtration of domestic supply were carried out, the 1871 Act did not otherwise disturb the control or the operations of the water companies.

(To be continued.)

RECONSTRUCTION OF BALLOCH PIER, LOCH LOMOND.

BALLOCH Pier, situated at the extreme southern end of Loch Lomond, is the terminus of the branch railway from Glasgow along the Vale of Leven and is the base for British Railways' pleasure steamers, which operate on the Loch during the summer months. Last winter (1951-52) the pier was completely demolished and the original structure of framed timber replaced by a new pier of steel sheet piling, retaining a hard-core filling faced with red sand-stone pitching. The old pier, about 245 ft. long by 62 ft. in width, was built about 60 years ago, as a timber structure in the orthodox fashion of that date. The depth of water normally available for the steamers varies from about 4 ft. 6 in. at the landward end to more than 12 ft. at the outer end. Part of the passenger station platform and track, together with three sidings, were on the pier structure. The condition of the pier was such that entire replacement was necessary and, because of the scarcity of timber, consideration was given to other methods of construction. That part of the passenger platform formerly on the pier and two of the sidings were no longer required, so could be dispensed with. The design adopted, and now carried out, comprised an embankment filled with hard-core, extending for the full length of the pier and on the same line as the former structure.

On the berthing side, the filling is retained by Larsen No. 2 sheet-steel piles driven into the bed of the loch and with a finished height at approximately top water level. The sheet piling is secured by steel ties anchored in a continuous concrete block running the full length of the pier and buried about 40 ft. back in the hard-core filling. The new pier is illustrated in Fig. 1, above, and a typical cross-section is shown in Fig. 2. The steamer berth is about 200 ft. from the end of the platform and consists of a timber structure 45 ft. in length by 28 ft. broad, with a timber deck at platform level. Access from the platform to the berth is along the ramped approach road, 15 ft. wide, with wooden hand-rails. Beneath this deck there is a concrete coal bunker from which the steamers are refuelled; it is reached from the deck through hatches with wooden covers, and coal arriving at the pier by train can be shot directly from the wagons into the bunker below. A cross-section through the pier at the steamer berth is given in Fig. 3. If, at a later date, it is decided that the Loch Lomond steamers are to be oil-fired, storage tanks can be built into the present bunker space.

Substantial greenheart fenders and berthing gangways, together with mooring bollards, are spaced at appropriate intervals on either side of the berth. The stone filling above the level of the piling and round the sea-end of the embankment has been faced with red-sandstone pitching set in a cement mortar. The remainder of the back face of the filling is protected by a heavy rip-rap pitching. Practically all the timber of the former pier was removed but, where it was suitable, the recovered material has been re-used in the new structure.

The work was begun in October, 1951, and the demolition of the old pier and construction of the new proceeded without serious interruption, despite adverse weather conditions. The new pier was brought into use on Monday, May 26, the date of the opening of the seasonal sailings on Loch Lomond, and the subsidiary works have since been finished. The contractors for the whole of the work were Messrs. P. Caulfield and Company, Limited, Bonhill, Dunbartonshire, and the design and supervision of the work were the responsibility of the Civil Engineer, British Railways (Scottish Region). The total cost was in the region of 15,000*l.*, a figure substantially less than the cost of replacement by a structure similar to the old. It is hoped that maintenance costs will be much lower than formerly.

FOURTH ANGLO-AMERICAN AERONAUTICAL CONFERENCE.—The Royal Aeronautical Society have announced that the fourth Anglo-American Aeronautical Conference is to be held in London from September 14 to 17, 1953.

THE ROYAL GREENWICH OBSERVATORY.

(*Concluded from page* 573.)

As usual, a good deal of the year's routine work by the Observatory has been concerned with the sun as normally seen from England; in which connection it is of interest to note that, since the removal of the Photoheliograph to Herstmonceux, the record of solar photographs shows a marked improvement, not only as regards numbers, but also as regards quality. The sun was, in fact, photographed on 297 days and on a number of the plates, especially those taken in May, 1951, and March, 1952, the granulation of the photosphere is clearly exhibited. Sunspots were less noteworthy than during the previous year, the mean daily sunspot number for the 12 months under review being 57, as compared with 70 for the preceding period. The largest sunspot of the year attained a maximum area equal to nearly 5,000 millionths of the sun's hemisphere. It crossed the sun's central meridian on May 16, 1951, and its mean area while passing across the disc was 3,900 millionths of the hemisphere. On the basis of this mean area, it counts as the fourth largest ever to be recorded at Greenwich and justifies both the title of a "giant" group and the exhibition of photographs at the Science Museum. It was exceptional in two other respects, first because it occurred four years after the sunspot maximum, and secondly because it was not associated with any geomagnetic disturbance during its passage over the central half of the sun's disc. By contrast, a far smaller sunspot group, having a maximum area ratio of 2,350 millionths, which had its central meridian passage on June 18, 1951, was accompanied by a high degree of solar noise. From February 25 to March 2, 1952, there were six consecutive days on which no sunspots were visible, and from the additional fact that no small spots at high latitudes were observed during the year, the Astronomer Royal infers that at least another 18 months will elapse (after April, 1952) before solar minimum is reached. All the giant sunspots recorded since 1874, having mean areas exceeding 1,500 millionths of the sun's hemisphere, are being systematically analysed at the Observatory. An investigation of the association between sunspots and solar flares has led to the conclusion that the incidence of intense solar flares is not related to any systematic change of area in the associated sunspot.

Thirty-five solar flares were observed by spectrohelioscopes during the year, but of these only two, which occurred on May 18 and September 3, 1951, are regarded as of major importance. The frequency of flares became, in fact, progressively less as the year covered by the report advanced, and it appears that flare activity is now at a low level, notwithstanding that sunspot minimum is not expected for another year or more. Nevertheless, a fade-out on short-wave radio transmission, indicating a solar flare of moderately high intensity, was reported on April 22, 1952, by Cable and Wireless, Limited, its occurrence being confirmed by the Observatory's "Sudden Enhancement of Atmospherics" recorder at Herstmonceux. Further, the year under review has disclosed unusual activity as regards solar particle radiation, as indicated by the frequency of geomagnetic disturbances. These geomagnetic storms and disturbances tend to occur in sequences, lasting in some instances for three to four weeks, and there appears to be a general inverse correlation between such sequence storms and the occurrence of large sunspots on the earthward side of the sun. For example, a storm observed on April 21, 1952, appears to be associated with a growing sunspot which passed the sun's central meridian some $2\frac{1}{2}$ days earlier. In addition to observations of the progress of solar flares, for which a small camera attachment to the Newbegin spectrohelioscope is proving helpful, the Observatory has made a large number of measurements of the line-of-sight motions of dark hydrogen flocculi on the sun's disc, the measured velocity being over 100 km. per sec. on six occasions. A number of prominences at the sun's limb have been examined and many bright patches of normal bright flocculi have also been measured around sunspots, but these seldom show significant line-of-sight motions.

For indicating sudden enhancement of atmospherics, mentioned in the preceding paragraph, a new recorder was installed last November. The receiver works on a frequency of 27 kilocycles per sec. (wavelength 11·1 km.), but the equipment permits the operating frequency to be selected from a considerable range. The original S.E.A. recorder, now superseded, has been modified to serve as a sudden-phase anomaly indicator, exhibiting the combined amplitude of sky and ground waves: It receives G.B.R. Rugby on a frequency of 16 kilocycles per sec. (wavelength 18·7 km.), and a double-pen recorder produces the dual traces for direct comparison.

The time service maintained throughout the year by the Observatory is based on astronomical observations of stars carried out at Greenwich, by means of an instrument designated Small Transit B, and at the laboratory at Abinger Hammer by means of the Bamberg Broken Transit. The transit observations serve to check the detailed timekeeping of a number of quartz-ring oscillator clocks, and the latter in turn control the various wireless time signals. Analysis of the performance of the clocks has been continued, as in the past, and the results now provide strong evidence that the annual fluctuations in the rate of rotation of the earth are subject to considerable changes in phase and amplitude, the values obtained for 1950-51 being significantly smaller than those given by many previous concordant analyses. It is consequently not practicable to apply corrections month by month to the time determined astronomically so as to produce a uniform time system. Instead, the best of the quartz clocks must be accepted as defining a time system which is uniform to a very close approximation, while the astronomical determinations over two or three years are used to determine, for each clock, the error at a given epoch and the rate of the clock. This technique is used to control the annual fluctuations, but it is applicable only to clocks of the highest precision, capable of uniform runs extending over two or three years. The influence of the polar motion of the earth's axis on time determinations is estimated from observations of current latitude variation made by the United States Naval Observatory, and the corrections are found to be in satisfactory agreement with those based on the international latitude variation data.

Two new quartz ring oscillators were installed at Abinger in August, 1951. One of them, equipped with long-life valves, behaved disappointingly for a while, but its short-term stability has much improved since its electrical circuit was modified last March; and if its long-term stability, now under observation, exhibits a corresponding improvement, the circuits of the other new oscillator will be similarly altered. At Greenwich, two brief interruptions in the high-tension supply to the quartz clocks there have occurred during the year without, fortunately, producing any change of rate. To minimise risk of trouble due to failure of the mains electrical supply at Abinger, a three-phase 45-kVA Diesel-driven alternating-current generator has been installed and fitted with automatic starting gear which brings it into operation immediately the mains voltage fails. The quartz clocks have also to be kept at constant temperature, which is closely controlled by thermostats. In the event of mains failure, the latter are energised by 50-cycle alternating-current from a motor generator. Among new electrical equipment, used for the time service installation at Greenwich, may be mentioned five regenerative dividers of a new type, two long-wave receivers and two decimal counter chronometers. A transmitting motor, together with its ancillary circuits for the reserve broadcasting service of the six pips and hourly time signals, and also a number of send relays with a control panel and line-meter panel, have been assembled at Abinger for use in the first instance at Greenwich. The whole of this equipment is in rack units to facilitate re-erection at a new site. Meantime, the regular international time signals, the six pips, and the hourly signals controlling the Post Office speaking clock service are sent out from phonic motor transmitters at Abinger.

To accelerate the computation and analysis of time records, greater use is now made of calculating machines. Noteworthy among such work is the use, at Abinger, of a National Accounting machine for analysing the six-figure beat counter readings, and of the Hollerith punched-card equipment at the National Physical Laboratory for dealing with the Bamberg Broken Transit instrument readings. It appears, in the time service as throughout the Observatory generally, that the higher standard of accuracy now demanded calls for rigorous computing procedures where formerly simpler graphical methods were adequate, while computations of all sorts now need to be carried to an increased number of significant figures.

In addition to the time service, the Observatory laboratory at Abinger is responsible for routine measurements of the elements of terrestrial magnetism, which serve to establish the base-line values of the recording instruments. The mean annual values, estimated for 1952 and compared with those for the previous four years, are tabulated below:—

Year.	Declination (West).	Horizontal Intensity.	Vertical Intensity.	Inclination.
	deg. min.			deg. min.
1948	9 35·4	0·18593	0·43255	66 44·4
1949	9 27·5	0·18607	0·43273	66 44·0
1950	9 19·7	0·18628	0·43288	66 43·0
1951	9 12·2	0·18648	0·43305	66 42·1
1952	9 5·2	0·18666	0·43323	66 41·4

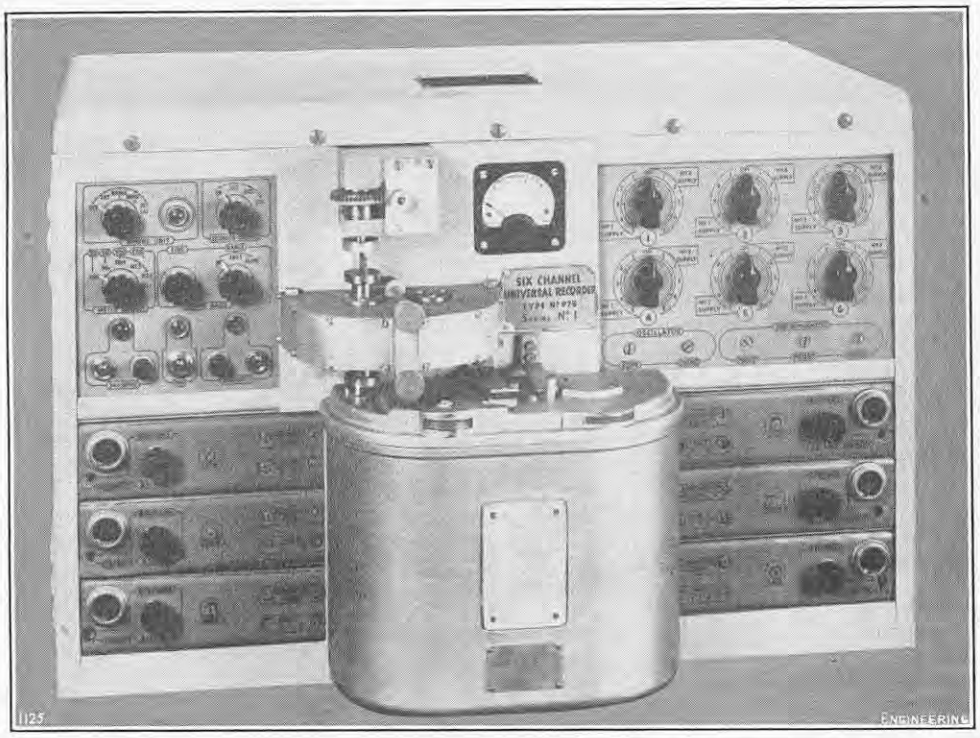
These results show regular trends for all the elements, and call for no other comment. It is worth remarking, however, that the instruments used for magnetic measurements are periodically tested with the utmost precision, and that some improvements in auxiliary apparatus have been achieved during the year. Among the latter is the insertion of a relay in the time-signal circuit, whereby increased light intensity has improved the reproduction of the magnetograms for publication.

The laboratory has also started to prepare the Admiralty Magnetic Charts for the epoch 1955. In this connection, the Astronomer Royal deplores the continued dearth of recent observational data, particularly in the vast ocean regions and in central Asia, remarking that the task of constructing charts of secular variation is at present a matter largely of conjecture and consequently liable to serious error. He recalls that the first magnetic chart, showing the variation of the compass, was constructed in 1700 by Edmund Halley, who later was appointed the second Astronomer Royal. As more than two-thirds of the earth's surface is covered by water, magnetic data for ocean areas are essential to accurate marine and air navigation. When iron and steel superseded wood in ship construction, magnetic data became difficult to obtain at sea, and for many years the Department of Terrestrial Magnetism of the Carnegie Institution of Washington operated a non-magnetic ship called the Carnegie, the data which it obtained being made freely available to all the world. The great increase of knowledge thereby gained about the changing and unpredictable magnetic field of the earth was suddenly arrested when the Carnegie was destroyed by an explosion in 1929. To meet this serious deficiency, the British Admiralty undertook the construction of another non-magnetic ship, the R.R.S. Research, of which the hull was launched in 1939. Her completion was left in abeyance during the war, and subsequent financial stringency has recently led to the reluctant decision that the ship must be broken up and a fine project abandoned.

Appreciating, not without regret, the necessity for this step, the Astronomer Royal proceeds very constructively to remind all concerned that the magnetic airborne detector, developed during the war for spotting submarines, is capable of measuring variations in the total intensity of the earth's magnetic field with high accuracy, and that, with suitable modifications, the equipment can be made to record three components of the field. The way is thus opened, he asserts, for magnetic surveys to be made by aircraft and data accumulated far more widely and rapidly than by a non-magnetic ship. He strongly advocates, therefore, that such surveys should be made as soon as possible over the more accessible ocean areas, pointing out that if reliable

SIX-CHANNEL PHOTOGRAPHIC RECORDER.

BOULTON PAUL AIRCRAFT, LIMITED, WOLVERHAMPTON.



data are available for the greater part of the earth's surface, harmonic analysis can be used to interpolate for regions not conveniently accessible.

As a consequence of repairs, alterations and other building operations at Greenwich, some interruptions in the routine meteorological readings have been inevitable, but at one or other of the Observatory stations continuous records of atmospheric temperature and pressure, sunshine and night sky clarity have been maintained throughout the year, from which various average and extreme values are likely to prove of interest, if only as confirming that the year was not conspicuous for fine weather. The maximum temperature at Greenwich was 84·4 deg. F., recorded on July 28, 1951, while the minimum was 21·4 deg. F., on January 27, 1952. There were six days, all in July, when the temperature rose above 80 deg. F., and 42 nights during the winter when it fell below freezing point. Out of a theoretically possible figure of 4,493 hours, bright sunshine was recorded on only 1,310·2 hours, and there were 65 entirely sunless days. At night, the night-sky camera recorded a completely unbroken trace of δ *Ursae Minoris* on only 31 occasions, whereas on 80 nights no trace of the star appeared, while on a further 51 nights not more than 10 per cent. of the possible visibility was recorded. At Herstmonceux, by contrast, 1,826·6 hour of bright sunshine were recorded, with only 49 entirely sunless days. The night-sky camera also recorded a completely unbroken trace on 49 nights, and while there were 78 nights on which no trace was obtained, the nights on which no more than 10 per cent. of the possible trace was recorded numbered only 30. The total rainfall at Greenwich was very close to the average, amounting to 24·65 in. as compared with 24·33 for the hundred years 1841 to 1940. There were, however, a relatively large number of wet days. The number of days on which the rainfall exceeded 0·005 in. was 179. Where comparable records are available, they confirm very decidedly the superiority (from the astronomical standpoint) of atmospheric conditions at Herstmonceux over those at Greenwich. More extensive records, including those of wind, will be taken at Herstmonceux when the building planned to accommodate the anemograph and enclose the other necessary apparatus is completed. Meanwhile, it has been possible to measure air pollution at Herstmonceux and the records accumulated during the year have been supplied to the Department of Scientific and Industrial Research.

The Astronomer Royal refers to a considerable increase, during the year under review, in the work carried out by the Observatory on the repair, adjustment and rating of Admiralty and Air Ministry chronometers and watches. The Observatory has been consulted about the technical problems of clock mechanisms used in under-water weapons. Facilities for routine work and the improvement of special time-pieces maintained by the Observatory have been improved during the year by an extension to the chronometer workshop. As regards the activities of H.M. Nautical Almanac Office, another heavy year of navigational work is reported, but on the routine computational side the increasing use of punched-card machines has permitted a slight reduction of personnel engaged on this particular branch. Two outstanding sections of "Greenwich Observations" for 1937, namely, "Astronomical Results" and "Photoheliographic Studies," were published and distributed during the year, but the complete volume is still to be issued.

Progress with the new 100-in. telescope for the Isaac Newton Observatory is also being hampered by the general financial stringency of the times, for while expenditure amounting to 6,000*l.* has been approved for the current financial year, the Observatory has been instructed that no commitments involving payments beyond the year 1952-53 may be undertaken without prior approval. As regards the technical progress of the telescope, however, it is cheering to be able to state that further diamond milling of the 98-in. disc, to achieve a precisely spherical form, has been carried out with no tendency for the cracks, which it had previously caused, to extend. Dr. Bowen, Director of the Mount Wilson and Palomar Observatories, has reported that cracks of a similar nature developed during the machining of the American 200-in. disc, but that no measurable increase of the cracks occurred during the whole of the subsequent grinding and polishing processes. Moreover, the final Hartmann and knife-edge tests of the mirror showed no indication of the presence of the cracks, and the latter have in no way affected the proper functioning of the mirror. It is evident, none the less, that diamond milling introduces greater surface strain than conventional grinding processes with loose abrasive, and diamond milling of the Isaac Newton disc has, therefore, been stopped. Consideration of the mechanical design of the telescope is temporarily in abeyance pending the results of an investigation of a novel method, suggested by Mr. B. N. Wallis, the aircraft designer, for controlling the flexure of the structural components.

SIX-CHANNEL PHOTOGRAPHIC RECORDER.

THE accompanying illustration shows a six-channel photographic recorder developed by Messrs. Boulton Paul Aircraft, Limited, Wolverhampton. The recorder was produced in the first place for their own research and development departments, and is suitable for carrying out a wide range of dynamic measurements on structures or mechanisms. The six display channels are self-contained units in removable trays, and comprise reactive and resistive transducer balance controls, an amplifier, a cathode-ray display tube, and camera lens. A 2,000-cycle oscillator is provided for energising the various types of transducer, but alternative arrangements can be provided if it is desired to use self-generators or direct-current transducers. Calibration signal levels are selected by controls on the oscillation unit panel; these reference signals can be injected periodically on to the recording film, or by manual control before and after a recording sequence. An electrically-derived time marker is available, or timing marks can be provided from an external source such as a mechanical timing contactor. Brilliance modulation can be introduced to define the phase of the output signal, and hence the sign of the actuating force.

The recorder uses film or paper 5½-in. in width, loaded on to a standard magazine in lengths of approximately 50 ft. Film speeds of ½ in., 3 in., 9 in. and 20 in. per second are provided. The camera motor can be regulated from a remote control unit, which is also fitted with calibration and tuning controls, indicator lights, and main control switches, and is suitable for use during flight trials. The sensitivity range allows for full-scale deflection to be obtained for input signals ranging between 1 volt and 1 millivolt. The response of the amplifier and display units is flat within ± 1 decibel between 50 and 20,000 cycles. In general, measurement of the amplitude ordinates can be made with an overall accuracy of about 2½ per cent. The recorder is suitable for operation from supplies of various voltages and frequencies. It weighs 120 lb.

SYMPOSIUM ON CAUSTIC CRACKING IN BOILERS.

THE Corrosion Group of the Society of Chemical Industry are holding a symposium on "Caustic Cracking in Steam Boilers" in the lecture hall of the Institution of Mechanical Engineers, Storey's-gate, St. James's Park, London, S.W.1, on Thursday, November 20.

The meeting opens at 9.45 a.m. and during the first part of the morning session three papers will be presented and discussed, namely, "The Prevention of Caustic Cracking in Steam Boilers by Chemical Methods," by Dr. C. D. Weir, of Merz and McLellan and Mr. P. Hamer, of Imperial Chemical Industries, Limited; "The Use of Alkaline Phosphates for the Protection of Boiler Metal in Certain Cases of Stress Corrosion," by Dr. R. Rath, of Electricité de France; and "Embrittlement Cracking in the United States," by Dr. A. A. Berk, of the U.S. Bureau of Mines. The second portion of the morning session will be devoted to the presentation and discussion of two papers, the first on "The Intercrystalline Corrosion of Mild Steels," by Dr. R. N. Parkins, of the University of Durham, and the second, "A New Method for the Determination of the Relative Susceptibility of Steels to Intercrystalline Attack," by Dr. J. Lodder, of Holland. At the afternoon session, from 2.15 to 4.45, a paper by Mr. R. Ll. Rees, of the British Electricity Authority, on "A Boiler User's View of the Problem of Caustic Cracking in Water-Tube Boilers with Riveted Drums," will be presented.

The chairman of the Group is Dr. W. H. J. Vernon, O.B.E., and the honorary secretary, Dr. S. G. Clarke. Advance summaries of the papers and further information regarding the meeting may be obtained on application to the assistant secretary of the Society of Chemical Industry at 56, Victoria-street, London, S.W.1.

EXHIBITS AT THE PUBLIC WORKS EXHIBITION, OLYMPIA.

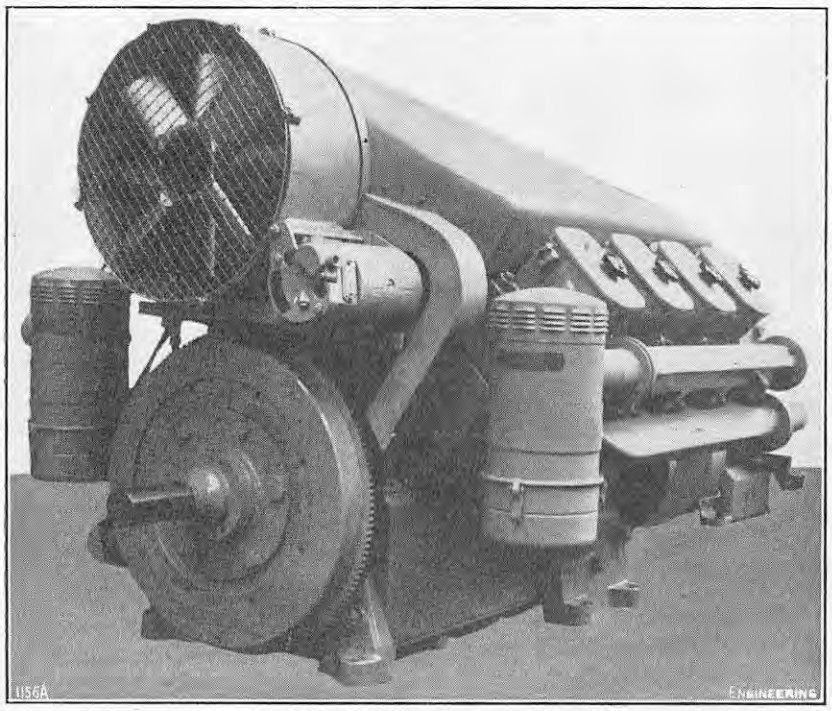


FIG. 17.

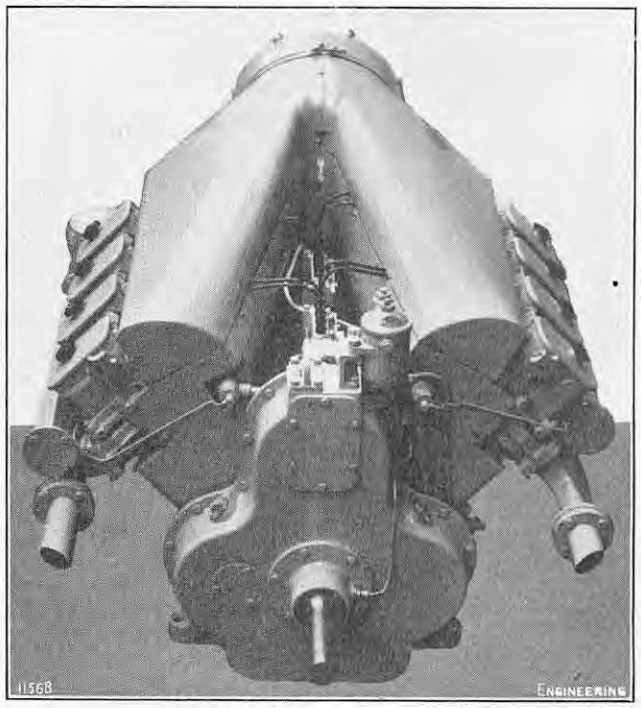


FIG. 18.

FIGS. 17 AND 18. PETTER AIR-COOLED DIESEL ENGINE; ASSOCIATED BRITISH OIL ENGINES, LTD.

PUBLIC WORKS AND MUNICIPAL SERVICES CONGRESS AND EXHIBITION.

(*Concluded from page* 597.)

THE PERKINS L4 DIESEL ENGINE.

ON their stand, Messrs. F. Perkins, Limited, Peterborough, Northamptonshire, showed their full range of Diesel engines, including a prototype model of the new L4 which has now completed its trials and is about to be put into production. This new water-cooled engine has been designed to give the industrial user or tractor owner the advantages of simplicity, accessibility and ease of maintenance, engendered by the absence of external piping and fitments, combined with the low fuel consumption. Built around the company's established principle of "aeroflow" system of combustion, the L4 has been designed to give a continuous output of 48 brake horse-power at speeds up to 2,000 r.p.m., with a maximum of 62 brake horse-power for intermittent working; the four cylinders are each of $4\frac{1}{4}$ in. bore by $4\frac{3}{4}$ in. stroke giving a total swept volume of 269·5 cub. in. (4·42 litres). The engine, less flywheel, which will vary according to the use to which the engine will be put, weighs 690 lb.

The basis of the engine is the cylinder block and crankcase which has been cast in one piece from a high-duty cast iron. Pre-finished, easily replaceable wet-liners, of centrifugal cast iron, with flanged top end and sealing rings at the lower end, have been specified for the cylinders, while the light-alloy pistons are fitted with three compression rings and two oil-scraper rings. The gudgeon pins are fully floating. Both the crankshaft and the connecting rods have been made from alloy steel stampings with appropriate hardened steel journals; the shell bearings for the crankshaft are copper-lead lined in the lower half and are topped by white-metal liners. The camshaft, of alloy cast iron and working inside the cylinder block, together with the fuel pump, is gear-driven from the crankshaft. A separate casting secured to the front of the cylinder block covers the timing mechanism. Operation of the overhead valves is by push rods from flat-faced tappets in the cylinder block with the rocker gear mounted above the cylinder head. An alloy cast-iron has been specified for the cylinder heads. The centrifugal pump in the circulating water system, the fan and the dynamo are mounted together at the front end of the engine and are driven by a V-belt off the engine crankshaft. The electrical equipment comprises a 12-volt axial-type starter, mounted on the flywheel housing; a 12-volt induction heater, to assist starting in exceptionally cold weather, has also been fitted. Provision has also been made for fitting de-compressor gear to the exhaust valves, so that, with a suitable flywheel, the engine can be started by hand. The overall dimensions of the engine are: length (including fan), $37\frac{1}{2}$ in.; width, $24\frac{3}{4}$ in.; depth, $35\frac{3}{4}$ in.

AIR-COOLED PETTER DIESEL ENGINE.

Associated British Oil Engines, Limited, Causeway Works, Staines, exhibited a number of petrol, oil and Diesel engines manufactured by their associated companies, Mirrlees, Bickerton and Day, Limited, Petters, Limited, J. and H. McLaren, Limited, the National Gas and Oil Engine Company, Limited, and Henry Meadows, Limited. The display included a new 80-h.p. air-cooled Diesel engine manufactured by Petters, Limited, Staines, illustrated in Figs. 17 and 18, herewith. The model is a prototype from which a new Petter series, "P B V," developed from the B. II series, will be manufactured. The complete series of five models will give total power ratings ranging between 13 and 80 brake horse-power at between 1,000 and 1,500 r.p.m.

The leading dimensions of the new PBV8 engine, in which the eight cylinders are arranged in a 90-deg. V, are as follows: bore, 110 mm.; stroke 110 mm.; and cubic capacity, 8·36 litres. Combustion is aided by the direct injection of the fuel into a hemispherical bowl in the top of the aluminium-alloy pistons. The pistons are each fitted with two oil scraper rings and three compression rings, the top one of which is chromium plated to promote long life and to reduced cylinder wear.

Both the cylinder and the cylinder head are necessarily heavily finned to achieve adequate cooling by the air delivered from a high-speed axial-flow fan, belt driven from the crankshaft; a detachable cowling ensures that the air reaches the back cylinders and also helps to give the engine a clean external appearance. The cylinder heads are independent of the valve gears, which are also totally enclosed but still readily accessible. A H-section forging has been used for the connecting rod, which has been machined to take thin-wall precision type copper-lead bearings; the bearings of the main crankshaft are of a similar pattern, but are lined with white metal. A power take-off is available from either end of the engine and provision has been made for incorporating an industrial type clutch. To suit any particular installation, the exhaust manifolds have been made reversible while the inlet valves are flanged to receive air cleaners at either end. The standard equipment for starting is a 24-volt battery system, but alternative hydraulically-aided starting may be adopted. The engine can be mounted either on a chassis or on a fixed base.

The centrifugal governor controlling the engine speed is totally enclosed and mounted on the fuel-pump drive gear wheel; a speed adjusting spring, accessible from outside, enables the speed to be varied by 10 per cent. up or down, and the mean governed speed of the engine may be adjusted between 1,000 and 1,500 r.p.m. by changing the spring. Provision has been made for fitting a variable speed control. A submerged gear-type pump is used to draw the oil from the sump and to pass it to the cooler whence it is fed into the main bearings through drilled oilways.

PORTABLE PILE-DRIVING FRAME.

The main exhibit on the stand of the British Steel Piling Company, Limited, 10, Haymarket, London, S.W.1, was a 52-ft. self-erecting pile frame, mounted on rollers and designed for transport as a complete unit on a "low-loader." The plant, illustrated in Fig. 20, on page 635, comprises the roller-mounted pile frame, a double-drum Diesel-engine powered winch and a $2\frac{1}{2}$-ton drop hammer. It is capable of driving piles up to 6 tons in weight and the maximum length of pile that can be handled conveniently is 45 ft., measured from ground level. The superstructure is a welded framework hinged to the base, with leaders consisting of two channels, 8 in. deep spaced 6 in. apart, and rigidly connected by cast-steel yokes. The head is provided with two main sheaves and one guide sheave for the hammer and pile-lifting ropes, together with anchorages for the four guy ropes and the return end of the pile rope. The raking gear may be either hand operated or power driven from the winch to give maximum working inclinations of 1 in 3 backward and 1 in 10 forward. The raking gear also serves to fold the frame down for transport, and for this purpose the superstructure pivots about two pins carried by A-frames on either side of the base. Welded fabrication has also been used for the base, which is fitted with bearings for mounting on two 25-ft. rollers of 12 in.

outside diameter. The drums are driven through Ferodo-lined friction cones that are brought into engagement by twin thrust screws operated by a hand lever, and are powered by a 46·5-h.p. Pelapone Diesel engine fitted with an isolating clutch. A triplex roller chain is used to drive the winch and raking mechanism.

The total weight of the plant is nearly 20 tons and it can be carried on a low-loading vehicle of this capacity that has a "well" length of 20 ft. The pile frame is equally suitable for use with steam equipment, when additional provision will have to be made for transporting the boiler. Steam hammers, up to a McKiernan-Terry No. 9B3 3-ton single-acting, may be used and the base has been designed to accommodate a No. 20 Spencer-Hopwood boiler, together with a No. 4N double-drum steam-winch. A 10-ft. pile-pitching extension can be supplied for use when pitching and driving steel shell piles in panels.

Diesel-Operated Pile Driver.

Also shown at Olympia was the same company's No. 0 Diesel-operated pile driver, comprising a new small pile hammer and light frame, the total weight of the complete plant being within the capacity of a 15-cwt. vehicle. The special frame consists of a lightweight steel joist "leader" hinged to a base of steel channels, supported by a tubular backstay and by side guy ropes. The No. 0 hammer is intended for driving piles of light section and up to 16 ft. in length, such as may be used in sea-defence and river-bank protection works. The hammer is of the single-acting type, in which the ram (weighing 310 lb.) is raised by the combustion of the fuel and then falls under its own weight assisted by the recuperative effect of the air compressed between the ram and the cylinder head. The length of the ram stroke is 12 in. and 130 strokes per minute may be attained for a fuel consumption of approximately 1 pint per hour.

⅜-Cubic Yard Excavator.

The principal exhibit on the stand of Priestman Brothers, Limited, Holderness Engineering Works, Hull, was the "Wolf" Mark IIIB, a crawler excavator shown equipped with a ⅜-cub. yd. drag bucket. Other excavators in the company's range, but not exhibited, were the ½-cub. yd. "Panther" and the larger "Tiger" and "Lion" models of ⅝ and ¾ cub. yd. capacity, respectively. In Fig. 21, on page 635, we show the "Wolf" fitted with a trenching bucket. A particular feature of this excavator is the modified undercarriage with lengthened crawler tractors, fitted with five idler rollers to ensure good distribution of the weight and an improved adjusting unit that enables any slack in the tracks to be taken up. The approximate working weight of the machine is 20,700 lb., giving an average bearing pressure of 6¼ lb. per square inch on the 18-in. tracks. Power is obtained from a four-cylinder Diesel engine of 31 brake horse-power, constructed by W. H. Dorman and Company, Limited, Stafford; alternatively, an electric drive can be supplied. The revolving superstructure turns on a multi-roller race mounted in a 4-ft. diameter ring with machine-cut gear teeth. Independent tubular struts have been used for the construction of the "A" frames that carry the hoisting blocks; the front strut, also a tubular member, is mounted on the jib-foot pins and is so arranged that the front-end equipment can be removed as a single unit. The front strut has been kept high to give a rapid and easy lift.

The model on view at the exhibition was fitted with a re-designed drag shovel, but alternative equipment includes a skimmer bucket, a trencher, as illustrated, and a luffing shovel, all to be operated from a single universal jib of welded box section. Each of these buckets or shovels is fitted with interchangeable teeth fixed into sockets in an alloy-steel lip casting. By replacing the universal jib with a boom of tubular lattice construction the "Wolf" can be used as a dragline or grab-crane, as well as an ordinary lifting crane. For work involving a particularly long reach, the boom can be readily extended from its standard length of 32 ft. to a maximum of 40 ft. Special equipment available for the machine includes a side-dragline and a Teredo trencher.

"Express" Loading Shovel.

The Cheshire Engineering Company, Limited, Alliance House, Caxton-street, S.W.1, had four items on display: a modified version of their "Express" loading shovel; a "Highway" earth-boring machine, of American origin; the "Ditch-Witch," a small hand-operated trenching machine; and a set of road signs made with a highly reflective surface produced in "Webslight," as described below.

The Express loader, illustrated in Fig. 22, on page 635, has an all-up weight of 6¼ tons and is powered by a Ford V8 petrol engine developing 100 brake horse-power. For normal road travelling, standard two-wheel drive is used, but for heavier working conditions where additional grip has to be obtained a four-wheel drive is available. Servo-assisted brakes have been fitted to all four wheels to ensure that "backing-off" is eliminated. The scoop, which has been fabricated from ⅝-in. mild-steel plate, has a capacity of 1 cub. yd. and is fitted with a replaceable leading edge which is a manganese-steel forging. When fully raised, the scoop has a clearance of 10 ft. 5 in., but this is reduced to 9 ft. when the scoop is in the discharging position. Taken in conjunction with the jib clearance of 11 ft. 3 in., these dimensions are sufficient to allow the shovel to be used for loading most lorries at present in use.

Fig. 19. Truck Concrete Mixer; Ransomes & Rapier, Ltd.

The "Highway" earth-boring machine is a self-contained unit that can be mounted on the back of any heavy lorry and is designed to drill holes of up to 24 in. in diameter and to a depth of up to 10 ft. in any soil except solid rock. Power is supplied to the boring unit by either a Ford 226 or a Nuffield M.E.B. industrial power pack which is coupled to the boring unit through multi-disc clutches. Appropriate gearboxes permit the borer to drill raking holes either at right-angles to, or in line with the lorry. The head of the auger bar is fitted with a pulley block that enables the bar to be used as a derrick for slinging poles up to 55 ft. long before setting them in the holes that have been bored. Overall base dimensions required for mounting the machine on a lorry are 100 in. by 34 in.

The Cheshire trench digger, or "Ditch-Witch," is a small powered ditching or trenching machine, mounted on a four-wheel undercarriage, that can be used to prepare trenches of varying widths suitable for drainage pipes, conduits for services, or for footings. The bucket width is only 6 in. but, by taking additional runs, trenches up to 20 in. wide can be cut to a maximum depth of 3 ft. An adjustable scraper blade follows the digger so that a clean-cut trench is obtained. Power for the digger is transmitted through a belt-drive from a small air-cooled petrol engine of 6 h.p., while the depth of cut is altered by the driver operating a light hand lever that controls a hydraulically-powered mechanism for raising or lowering the boom. The spoil can be deposited on either side of the trench by a spoil-chute. The approximate weight of the machine is 5 cwt. and the overall dimensions are: length, 72 in.; width, 36 in.; and wheelbase, 42 in.

The last item on the stand, was a set of road signs reproduced in "Webslight," a patented material manufactured by a subsidiary company of the Cheshire Engineering Company. "Webslight" road signs are manufactured to give a highly reflective surface that will be clearly seen in the lights of oncoming traffic. The reflecting surface consists of an aluminium-alloy base plate to which layers of pigment or lacquer have been applied, each layer being subjected to a full stoving treatment. Minute spherical beads of clear glass are then affixed electrostatically to this surface at a density of 45,000 beads to the square inch. The result is a surface with high powers of reflection and with low light-absorption characteristics; the plates are shatterproof, do not rust, have a high resistance to flaking, and are easily cleaned.

Heater and Mixer for Tarmacadam Plant.

Stothert and Pitt, Limited, Lower Bristol-road, Bath, exhibited a number of concrete mixers of various sizes, vibrating rollers, as well as a batch heater and paddle mixer that has been built for incorporation in a tarmacadam plant. This heater and mixer unit, the largest of its type yet built by the Company, has been designed to handle three batches of stone simultaneously, one in the feed hopper before the batch heater, one in the batch heater and one in the paddle mixer. The standard batch is 60 cub. ft. of stone with a specific volume of 23 cub. ft. per ton. The gross output is intended to reach 75 tons per hour of stone at 220 deg. F. where the input was initially dry and had a body temperature of 50 deg. F.; where the initial water content amounts to 6 per cent. by weight the output will be reduced to 30 tons per hour.

Generally speaking, the hopper, the drum and the paddle mixer body have been made with double skins, the internal skin being renewable after wear. The steel underframe and main superstructure carrying the hopper, drum and mixer, has been constructed from rolled-steel sections stiffened by cross-members as necessary. The hopper itself is carried on a weighing machine fitted with a dial reading up to 6,500 lb. on a 23-in. long scale. The hinged discharge door of the hopper is operated by an electro-hydraulic "Thrustor" that embodies its own motor flexibly coupled to an impeller shaft; the action of the impeller is to pump oil from above the "Thrustor" piston to below the piston, so forcing it to rise. When the door is open the motor stops, the oil returns to its final position, so allowing the piston to return and the door to close. An adjustable dashpot ensures smooth working. An independent button switch has been provided for the control of the "Thrustor." From the hopper to the heater drum the stone is conducted in a feed chute, the mouth of which is designed to minimise the leakage of cold air into the drum.

The drum itself is mounted in a system of Timken taper-roller bearings and is driven through a gear ring and pinion; the pinion is mounted on the low-speed shaft of a worm reduction unit coupled to a 35-brake horse-power electric motor. An Urquhart oil burner has been fitted inside a baffle chamber on the discharge side of the drum; the flame plays directly into the drum, but when the discharge gate is open the flame is automatically reduced to a pilot jet. The fuel used is light Diesel oil from a 250-gallon reservoir mounted above the drum and atomised by compressed air from a built-in compressor directly coupled to 7 brake horse-power electric motor. Provision has been made for adding a Keith Blackman fan to draw off moisture and dust-laden gases from the drying drum.

In order to minimise loss of hot gases from the burner, the drum discharges first into the baffle chamber before being passed down a fixed chute into the paddle mixer. The mixer, which can be covered by a plate to exclude dust, is of the double-screw paddle type, the two sets of paddles rotating in opposite directions to churn the material both upwards and towards the centre so as to produce an intimate mix, for which a period of two minutes is allowed. The bucket has a

capacity of 45 gallons and is suspended independently from a second weighing machine. "Follsain" metal tips have been fitted and secured by bolts to the blades of the mixer; when a tip has worn the blade can be suitably lengthened by slackening the holding bolt and relocating the tip accordingly. The paddle mixer is driven by a 75 brake horse-power motor coupled to the paddle shaft by a totally-enclosed worm reduction unit; a heavy duty automatic slip-ring starter has been fitted, comprising one triple-pole main contactor, four accelerating contactors and three magnetic-type overload release relays with suitable time lag. Final discharge of the tarmacadam is through an opening extending the full width of the mixer, the rate of discharge being controlled by the electrically-operated hinged doors.

Concrete Mixers.

Ransomes and Rapier, Limited, Waterside Works, Ipswich, exhibited examples from their range of excavators, mobile cranes and other contractors' plant, particularly concrete mixers. A relatively small RapieR 423 with a $\frac{5}{8}$ cub. yard shovel represented the excavators and cranes which were otherwise shown only in model form, including a model of the RapieR W1400, which is the world's largest walking-dragline excavator.

A small trailer mixer on a sprung undercarriage, the 3½T, with a capacity of 3½ cub. ft. of mixed concrete, was on view on the stand for the first time. The drum is of a tilting type fitted with two special lattice mixing blades, and is carried in ball-bearing mountings in a substantial cradle bracket. A Lister 1½-h.p. single-cylinder four-stroke hopper-cooled petrol engine, enclosed in a steel housing, is used as the power unit. For trailing behind a lorry, the mixer is fitted with two industrial pneumatic-tyred road wheels, with roller-bearing hubs and internally-expanding brakes, the wheels being independently sprung to give good road-holding qualities and steady towing over rough ground. The springs are totally enclosed in tubular members of the mixer frame, so that they cannot be fouled by any split concrete.

Another exhibit on display for the first time was the company's largest truck-mounted mixer, which we illustrate in Fig. 19, on page 627. It is of 4½ cub. yd. mixed-batch capacity; alternatively, this unit may be used as an agitator for up to 6½ cub. yd. of pre-mixed concrete. The drum is 6 ft. 8 in. in diameter by 8 ft. 1 in. long and is welded from $\frac{3}{16}$-in. plate. The forward end of the drum is supported by a trunnion bearing while at the rear, into which the discharge gate is built, it is carried on a roller path. Thrust bearings have been fitted to prevent fore and aft movement of the drum when travelling. Access to the aggregate or pre-mixed concrete is through a circular door of pressed steel, a quick-release lock being fitted to a machined frame let into the wall of the drum. Three continuous spiral blades and two spade blades give a double end-to-end mixing which is both rapid and thorough. A patented bell-mouthed spray, carried on a steel tube running through the horizontal axis of the drum, delivers the water uniformly into the aggregate. Discharge is through a gate in the rear of the drum, where hand-wheel control of the opening allows a close check to be kept on the concrete which is placed behind the shuttering by a chute slung from the mixer frame.

The power drive for the mixer may be taken from a Perkins power pack, embodying a P.6 six-cylinder Diesel engine of 35 h.p.; or alternatively, the power take-off can be taken from the lorry gearbox through a suitable over-run clutch. When the mixer with the Diesel-engine drive is used as a 4½ cub. yd. mixer or as an agitator for up to 5½ cub. yd. pre-mixed concrete, the loaded chassis comes within the British Road Traffic Regulations of 19 tons gross laden weight if fitted to the following lorries: A.E.C. Mammoth Major, model 3671H; E.R.F. model 66T; Thornycroft, model ON/NR6; and Albion model HD55T. The Foden FG6/15, an eight-wheel lorry, will accommodate the power take-off driven machine, either as a 4½-cub. yd. mixer or as an agitator for pre-mixed concrete up to its maximum capacity of 6½ cub. yd.

The Exhibition closed on Saturday last, November 8.

POWER PLANT AT SEWAGE WORKS

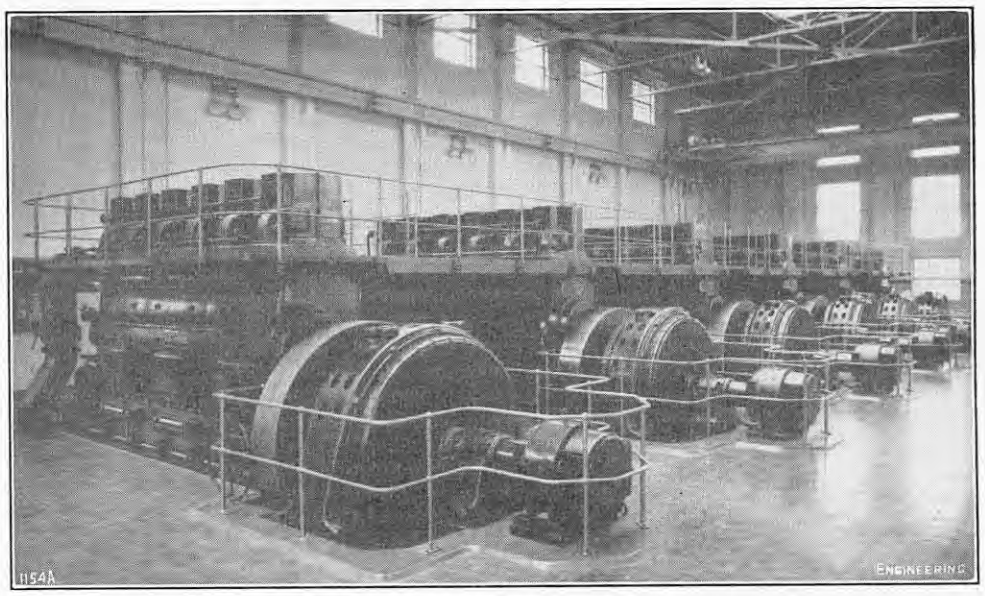


Fig. 1. Diesel-Engine Driven Alternators.

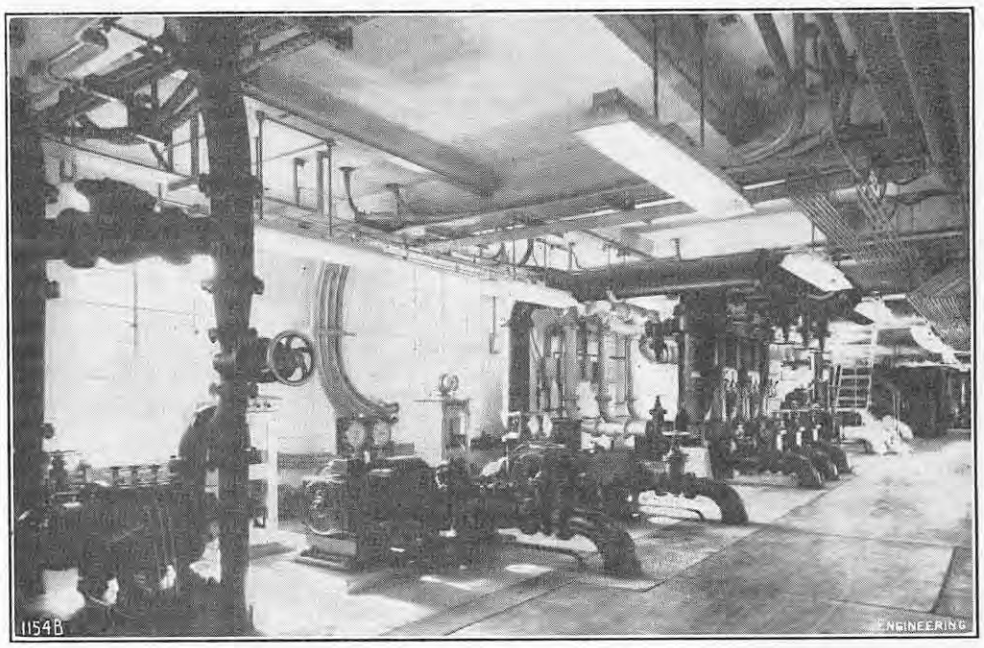


Fig. 2. Electrically-Driven Cooling-Water Pumps.

POWER PLANT AT MAPLE LODGE SEWAGE WORKS.

In most Diesel-engine installations large quantities of heat are wasted in the exhaust gases and engine-cooling systems. The word "most" is used advisedly as in many cases the heat losses are reduced considerably by using the high-grade heat in the exhaust gases for such duties as space heating. As a rule, however, the low-grade heat in the engine-cooling system is wasted, the general opinion being that the cost of the equipment required for its recovery outweighs the advantages. The power plant installed at the Maple Lodge works of the Colne Valley Sewerage Board, therefore, is of more than usual interest in that the high-grade heat from the Diesel engines is used for space heating and the low-grade heat for processing the primary sludge. Furthermore, the processing plant for the primary sludge is designed to liberate considerable quantities of sludge gas; this is collected and burnt in dual-fuel engines, thus making the plant largely self-sufficient.

The contract for the power-plant installation was awarded by the consulting engineers, Messrs. Sandford Fawcett and Partners, to the National Gas and Oil Engine Company, Limited, Ashton-under-Lyne. This contract was unique in that it was, we believe, the first order placed in the world for a power-house equipped with dual-fuel engines. The engines had to give specified outputs when operating on gas under dual-fuel conditions, on oil fuel alone and on oil fuel under pressure-charged conditions, the third condition being required to meet the large emergency demands for power under storm-water conditions. This type of contract was, of course, not new to the National Gas and Oil Engine Company, as the dual-fuel engine was pioneered by this company and for several years they had supplied and erected engines running on sludge gas, blast-furnace gas, etc.

In all, six National dual-fuel engines are installed in the power house, each of which is coupled directly to a Crompton Parkinson 750-kVA alternator. Each engine develops 666 h.p. when operating as a normally aspirated unit on sludge gas or fuel oil. During periods of heavy rainfall, however, a considerable quantity of storm water has to be handled by the sewerage plant and the various pumping stations make heavy demands for power. To meet this, two Holmes-Connersville Root's-type blowers are arranged to furnish air at 4·2 lb. per square inch to a 'bus main, thus enabling any two engines to operate as pressure-charged Diesel units at very short notice and obviating the need to start up another engine. When operating as pressure-charged units, each engine develops 866 h.p., this figure being the net output after deducting the

POWER PLANT AT MAPLE LODGE SEWAGE WORKS.

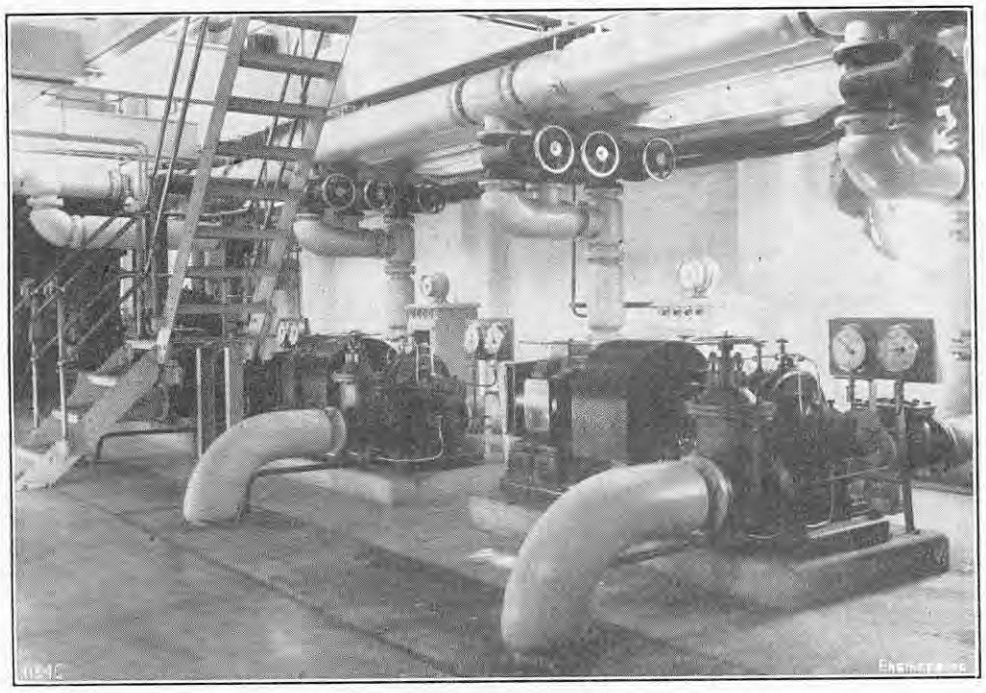


Fig. 3. Emergency Booster Pump For Fire Services.

Fig. 4. Superchargers and Compressed-Air Receivers.

power required to drive the electrically-operated blowers.

The sludge gas for operating the engines is obtained from the digestion tanks in which the sludge undergoes fermentation or digestion with the aid of bacteria of a kind not requiring oxygen. These organisms break down much of the solid matter into simpler products including sludge gas, a mixture of methane and carbon dioxide. The gas is collected in holders and is conveyed to the power house through pipes, arriving at a pressure of approximately 4-in. water gauge, Peebles mercury-sealed gas-pressure regulators being used to reduce this pressure to 0·5-in. water gauge for use in the engines. As previously mentioned, waste heat from the engines is used to maintain the sewage sludge in the digesters at a suitable temperature, approximately 85 deg. F. Waste heat is also used to heat the power house, administration buildings, workshops, etc. To meet these requirements, the waste-heat recovery system is divided into two independent circuits providing low-grade and high-grade heat, respectively. The first circuit, that is, the low-grade circuit, utilises the heat from the engine cooling water; this is pumped from the hotwell through the sewage sludge digesters and returned to an elevated cooled-water tank which feeds the engines.

At times, the demand for heat in the digesters falls below that contained in the cooling water and provision is, therefore, made to remove the surplus heat by means of Serck heat exchangers in which sewage effluent is used as the coolant. Conversely, there are times when the heat in the cooling water is insufficient to maintain the sludge at the optimum temperature. On these occasions, heat is transferred from the high-grade heat circuit by means of a Royle tubular calorifier, the supply of high-grade heat to the calorifier being regulated by a Drayton thermo-hydraulically operated control valve. Duplicate Harland electrically-driven cooling-water pumps are installed and there is also a National Diesel-engined standby pump; continuity of service is assured, therefore, at all times. The two electrically-driven cooling water pumps are illustrated in Fig. 2, opposite.

The high-grade heating circuit is supplied with heat from the exhaust gases of Nos. 1 and 2 engines. This system comprises two Spanner "Spiralflo" double-pass thimble-tube waste-heat boilers, a single Spanner "Spiralflo" vertical oil-fired boiler fitted with Urquhart automatic oil-burning equipment, one thermal-storage tank, and the calorifier previously referred to, all these units being arranged in series on a ring main. The input of heat to this system is controlled automatically by the temperature in the thermal-storage tank. Should this temperature fall, a thermostatically-controlled electro-hydraulically operated three-way diverting valve in the exhaust system of No. 1 engine is actuated to divert the exhaust gases through No. 1 waste-heat boiler. If the resulting heat input proves excessive then the valve operates to by-pass the boiler, but if the heat input is insufficient and the temperature in the tank continues to fall, then a diverting valve in No. 2 engine exhaust line operates to direct the gases to No. 2 boiler. If the combined heat input from the two boilers is still insufficient to meet the demand, the auxiliary oil-fired boiler is brought into operation and does not cut out until the temperature inside the thermal storage tank has reached the desired maximum.

The cooling and waste-heat recovery plants are situated in the basement of an annexe to the power house and a close check on the operating conditions is maintained by means of Kent Venturi-type flow meters and Cambridge temperature indicators, arranged for distant reading in the power house. Two controlling thermostats for each boiler are mounted on the thermal-storage tank and are wired in pairs, each pair forming one thermostat with an exceptionally wide range for adjustment of temperature and differentials. Thermostatic control is centralised in a rheostatic panel, the controlling thermostats being connected to selector plugs, which enable any boiler to be controlled by any pair of thermostats; the boilers, therefore, can be brought into operation in any desired sequence. As a safeguard, each boiler is fitted with a master thermostat which operates to shut the boiler down in the event of an excessive rise of temperature, such as may be caused by failure of the circulating-water pumps. The water supply for the power house and for the works generally is obtained from a borehole well in the annexe basement, the water being raised to a main elevated storage tank in the power house by a Harland electrically-driven vertical-spindle pump. A Harland multi-stage centrifugal pump can be brought into operation to provide high-pressure water for fire-fighting services; this unit is illustrated in Fig. 3, herewith.

The complete power plant, as previously mentioned, is largely self-sufficient. Compressed air for starting the Diesel engines is supplied by an electrically-driven Reavell two-stage compressor and is stored in four vertical air receivers. A compressor, driven by a National Diesel engine is also installed as a safeguard. The four vertical receivers for the compressed air are illustrated in Fig. 4; the two electrically-driven blowers for the main engines are visible in the left background. The fuel oil is delivered by road tankers to four 25-ton storage tanks housed in a separate building and is transferred by a Drum fuel-transfer pump to an elevated auxiliary storage tank from which it flows by gravity through filters and meters to the ready-use tanks. A De Laval fuel-oil separator is installed so that, if required, the fuel can be centrifuged as it passes from the auxiliary storage tank to the ready-use tanks. A De Laval centrifuge is also provided for dealing with the lubricating oil.

As a safeguard against temporary failure of the main lighting system, an Austinlite 5-kW automatic lighting set is installed. This is driven by a National Diesel engine of 9-h.p. In the event of a failure in the main lighting circuit the set starts up automatically and supplies current to a pilot lighting system within 10 seconds. The main engines are protected from being damaged by failure of the lubricating or cooling systems by Monitor alarms, which, with their controls, are centralised in a wall-mounted instrument panel. A smaller panel is also provided for each engine and is fitted with the usual range of instruments to indicate lubricating-oil temperatures and pressures, etc. Each engine panel also carries exhaust temperature indicators and an electric tachometer, the latter incorporating an over-speed shut-down relay which stops the engine by acting through a booster on the fuel-pump control rod.

Royal Statistical Society.—A Glasgow group of the Industrial Applications Section of the Royal Statistical Society is in process of being formed and a preliminary meeting was held last month. Further particulars of the group may be obtained from Mr. Andrew Kirk, 16, Battlefield-avenue, Langside, Glasgow, S.2.

Rural Electrical Development.—Two years ago the Committee on Electric Power of the Economic Commission for Europe planned a study of the problem of effectively using electricity in rural areas, especially in countries which were economically poorly developed. As a result, monographs from 14 different countries were submitted and are now being analysed with the object of preparing a reference work setting out the best methods of electrifying various kinds of agricultural regions. In making this analysis account is also being taken of the proceedings at a conference, which was held in Geneva on Monday, October 27, and at which 15 countries were represented. The results are due for publication early next year.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

Tongland, Castle Douglas and Dalbeattie Electricity Network.—A scheme for reinforcing the electricity-supply network between Tongland, Castle Douglas, and Dalbeattie, at an estimated cost of 92,000*l.*, has been approved by the South-West Scotland Electricity Board. Larger insulators will be installed on the existing 11,000-volt overhead lines over a distance of 24 miles so that they may operate at 33,000 volts. Two large outdoor electricity substations will be constructed. The work is expected to be completed by 1955.

Mining Developments at Leadhills and Wanlockhead.—The Siamese Tin Syndicate and the associated Bangrin Tin Dredging Company, who have been investigating the possibility of producing lead and zinc at Leadhills and Wanlockhead, have reached a tentative agreement with the Rio Tinto Company for the dewatering and examination of the properties and, if warranted, the subsequent formation of an operating company. The Rio Tinto Company will provide 51 per cent. of the necessary funds.

Submarine Depot Ship to be Broken Up.—The former naval submarine depot ship Montcalm, which has been laid up in the Kyles of Bute for the past two years, has been towed to the Gareloch to be broken up at Faslane by Metal Industries, Ltd. She was built in 1921 by John Brown & Co., Ltd., Clydebank.

Manufacture of Adding Machines at Strathleven.—Burroughs Adding Machine Company are now manufacturing calculators entirely in Scotland. Mr. Clarence Dunlop, vice-president of the company, speaking on November 5 to industrialists who visited the factory at Strathleven in connection with a Business Efficiency Exhibition at the Kelvin Hall, Glasgow, said that there had been difficulty in finding sufficient skilled precision engineers, but they had overcome it by selecting suitable employees on the Scottish staff, flying them to America to study methods there, and subsequently appointing them as instructors at Strathleven.

Cranhill Water Tower.—Members of the Glasgow and West of Scotland Association of the Institution of Civil Engineers recently visited the water tower which is being erected at Stepps-road, near Edinburgh-road, to serve the new Cranhill housing scheme. The tank has a capacity of 500,000 gallons and is divided into two equal compartments. The top water level is 366·5 ft. above Ordnance Datum, and the height of the structure is 98 ft. above ground level. The depth of water is 16 ft. 6 in., with 1 ft. freeboard to the tank roof. The tank floor is a flat slab, 24 in. thick, supported on 16 circular columns 36 in. in diameter, placed at 20-ft. centres. The columns are supported on independent bases 15 ft. square, giving a maximum ground pressure of 1½ tons per square foot when wind pressure on the structure is taken into consideration.

CLEVELAND AND THE NORTHERN COUNTIES.

Shipyard Extensions at Sunderland.—William Doxford & Sons, Ltd., Sunderland, are planning extensions to their shipbuilding berths, and improvements at the fitting-out quay, to permit the building of larger vessels. This was referred to by Dr. E. P. Andreae, chairman of the company, at the annual meeting. Particulars of the re-organisation were given in a paper read by Mr. Clement Stephenson before the North Eastern Branch of the Institute of Welding and printed in Engineering of June 27, 1952 (vol. 173, page 821). At present, Messrs. Doxford are equipped to build ships of up to 16,500 tons deadweight, but it is understood that they propose to increase this capacity to at least 20,000 tons deadweight.

The Late Mr. W. J. Paulin.—Mr. William Joseph Paulin, a director of Donkin & Co., Ltd., steering-gear manufacturers, Newcastle-on-Tyne, and former managing director of the company, has died at the age of 82. Mr. Paulin started with the company as an apprentice in 1888 and became works manager in 1919. He was a Fellow of the North-East Coast Institution of Engineers and Shipbuilders.

Stephenson Engineering Society.—The recently-formed King's College Stephenson Engineering Society, Newcastle-on-Tyne, is to hold its inaugural meeting on November 28. One of the speakers will be Sir David Pye, President of the Institution of Mechanical Engineers. The Society's first Senior Lecture will be given on December 11 by Sir Claude Gibb, F.R.S., of C. A. Parsons & Co. Ltd., who will speak on "Engineering Achievements on Tyneside."

50th Anniversary of T. R. Dowson & Co.—The South Shields ship repairing firm of T. R. Dowson & Co., Ltd., are this month celebrating their jubilee as a limited liability company. The firm, which employs about 300 men, was founded towards the end of the last century by Mr. T. R. Dowson.

Drilling for Natural Gas at Grosmont.—The Bremner Well Drilling Co. Ltd. have started to drill for natural gas at Grosmont, near Whitby, on behalf of Imperial Chemical Industries, Ltd. The borehole will go down about 4,400 ft. and it is expected to be next February or March before gas is reached.

The Late Mr. G. R. Collinson.—Mr. George R. Collinson, formerly general manager of the Tees Valley Water Board, Middlesbrough, has died at West Tanfield, North Yorkshire, at the age of 66. He resigned his post with the water board in 1941 on account of ill-health.

The Late Mr. H. H. Vick.—The death has occurred in a nursing home, at the age of 72, of Mr. Henry Hampton Vick, of Newcastle-on-Tyne, a representative of the English Steel Corporation, Ltd., and other heavy-engineering firms. Mr. Vick was a member of Newcastle-on-Tyne City Council for ten years, until 1945, when he resigned, and had served as Deputy Lord Mayor.

LANCASHIRE AND SOUTH YORKSHIRE.

Coal-Output Records.—Yorkshire collieries, in the week ended November 1, again raised more than a million tons of coal, the actual figure being 1,135,939 tons, the highest weekly output since Easter.

Decline in Unemployment.—There are only 353 registered as unemployed in the Doncaster area, and the majority are disabled, capable of doing only light work. Rapid expansion of the agricultural-engineering industry at Doncaster is the chief reason for the low rate of unemployment. When the industry was established in the town, shortly after the war, only about 100 men were found employment. To-day, the figure is about 1,700 and expansion is continuing.

Exodus from the Cutlery Industry.—The Regional Controller has reported to the Regional Board for Industry that the continued exodus of skilled labour from the cutlery industry has been exercising the minds of manufacturers for some time; the drift of labour is to the steel industry and public transport. It seemed, he said, that the cutlery industry was unlikely ever to assume the proportions it held before the war. Export orders continued to be generally scanty.

The Late Mr. H. Swift Levick.—Mr. Henry Swift Levick, who died suddenly at Bournemouth on November 4, was chairman of Swift Levick and Sons, Ltd., steelmakers, a firm founded by his father in 1895. Outstanding among his achievements was his introduction of the magnet industry to Sheffield before the war of 1914-18. As a young man he became the firm's representative in the South Wales area. He resigned the managing directorship in 1948 in favour of his son, Mr. Spencer J. Levick. Mr. H. Swift Levick was in his 74th year.

York Power Station.—The British Electricity Authority have received the consent of the Minister of Fuel and Power to the installation in York power station of a 20,000-kW turbo-alternator set and two boilers, each having an evaporative capacity of 100,000 lb. of steam per hour, in replacement of the plant which was destroyed when a boiler exploded in the station in October, 1949.

THE MIDLANDS.

The Industrial Areas of Birmingham.—Mr. H. J. Manzoni, city engineer and surveyor of Birmingham, addressing the Birmingham and District Property Owners' Association on October 31, said that industry occupied, at present, 4,400 acres in the city. It was planned to increase this to 5,400 acres. Mr. Manzoni added that there was no need for new industries to come to Birmingham from outside; the city already had well over 1,200 trades, and there was a distinct tendency for new industries to be developed there. The balancing of the labour requirements of the many different trades was a delicate matter, and it would be possible for the balance to be upset badly if a new industry were to come to the city.

Aluminium in the Building Industry.—At an exhibition of aluminium castings, held in Birmingham on November 7 under the auspices of the aluminium Development Association, new uses for aluminium in the building industry were suggested. Mr. L. R. Carr, chairman of the Association's castings sub-committee, said that many factory-produced aluminium components were now accepted by architects and contractors, but, as yet, very few large components were made as castings. He suggested that cast aluminium sections might be made to provide complete roofs for small houses. They could be finished in the factory for rapid assembly on the site.

Experimental Motor 'Bus.—With the approval of the Ministry of Transport, Wolverhampton Corporation Transport Department have adapted a single-deck 34-seater 'bus to accommodate 58 passengers—34 seated and 24 standing. Wolverhampton Corporation is the second Midland transport authority to undertake this experiment for handling large numbers of passengers at rush-hour periods. Birmingham City Transport Department have had a similar vehicle in service for some months.

Sale of Factory.—Joseph Lucas, Ltd., Great King-street, Birmingham, have purchased the factory at The Radleys, Marston Green, near Birmingham, which formerly belonged to Richards & Son (Prams and Folders), Ltd. The premises are to be adapted to suit Messrs. Lucas's business, and the existing plant and machinery are to be sold by auction.

Transfer of Mineworkers.—A re-organisation scheme at Brereton Colliery, near Rugeley, Staffordshire, has resulted in 74 miners becoming redundant. All the men are being transferred to other collieries nearby. Brereton Colliery, which produces household and industrial coal, has been employing nearly 1,000 men, but it has a limited life. A new colliery is being developed in the vicinity, but the work of shaft-sinking has not yet been completed.

Chimney Stack Demolished by Royal Engineers.—A disused chimney stack at East Cannock Colliery, near Cannock, Staffordshire, was felled by a company of Royal Engineers on October 26. The stack, which was built 90 years ago to serve a now disused colliery, was 120 ft. high and 13 ft. square. Land subsidence had caused it to lean dangerously, and the Royal Engineers undertook to demolish it as part of their training programme. The stack was felled with plastic explosive, detonated electrically.

SOUTH-WEST ENGLAND AND SOUTH WALES.

Port Traffic at Swansea.—With two months still to go, the port of Swansea has already broken all past records in the quantity of trade handled at the docks. The previous record year was 1951, when a total of 9,648,833 tons of merchandise passed through the port, but, by the end of October this year, this figure had been exceeded by 68,169 tons. The indications are that this year's total will exceed the 10,000,000 tons mark. The chief factor for the expansion in trade at Swansea has been the rapid growth of the oil trade.

Cardiff Industrial Development.—A further 403 acres in the city of Cardiff are scheduled for industrial development in a 20-year plan scheme, costing 13,000,000*l.*, drawn up by the city surveyor, Mr. E. C. Roberts. One of the first priorities of the plan is the transformation of much of the derelict property near the docks. In this Butetown area—once notorious as the "Tiger Bay" district—it is proposed to erect four-storey maisonettes, and blocks of shops with flats above.

Works on River Taff, Cardiff.—Plans to confine the River Taff, at Cardiff, to a permanent channel by means of training walls so as to reduce silting at the entrance to Cardiff docks are under examination. Members of the Navigation Improvement Committee of the Cardiff Port Development Association visited the Department of Scientific and Industrial Research Station at Wallingford on November 5 to discuss the matter and inspect harbour models. Some 420 acres of land suitable for industrial development would be reclaimed under the scheme.

NOTICES OF MEETINGS.

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

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS.—Monday, November 17, 2.15 p.m., Institution of Electrical Engineers, Victoria-embankment, W.C.2. "Are Official Tractor Test Results a Realistic Guide to Performance on the Farm ?" by Mr. T. C. D. Manby.

INSTITUTE OF MARINE ENGINEERS.—Monday, November 17, 3 p.m., Royal Technical College, Salford. "Electric Propulsion of Ships," by Mr. M. W. T. Rees and Mr. G. J. Tuke.

INSTITUTION OF ELECTRICAL ENGINEERS.—Monday, November 17, 5.30 p.m., Victoria-embankment, W.C.2. Discussion on "The Field of Application of Metal Rectifiers," opened by Mr. S. A. Stevens. *Merseyside and North Wales Centre:* Monday, November 17, 6.30 p.m., Town Hall, Chester. "Inherent Current, Voltage and Speed Control in Dynamo-Electric Machinery," by Mr. J. C. Macfarlane, Dr. J. W. Macfarlane and Mr. W. I. Macfarlane. *Measurements and Radio Sections:* Tuesday, November 18, 5.30 p.m., Victoria-embankment, W.C.2. (i) "Harmonic Response Testing Apparatus for Linear Systems," by Mr. D. O. Burns and Mr. C. W. Cooper. (ii) "A Simple Connection Between Closed-Loop Transient Response and Open-Loop Frequency Response," by Mr. J. C. West and Mr. J. Potts. *East Midland Centre:* Tuesday, November 18, 6.30 p.m., Electricity Service Centre, Derby. Discussion on "Electronics in Heavy Industry," opened by Mr. H. E. Knight. *Utilization Section:* Thursday, November 20, 5.30 p.m., Victoria-embankment, W.C.2. "Electricity in Farm Crop Drying," by Mr. C. A. Cameron Brown and Mr. P. G. Finn-Kelcey.

INSTITUTION OF PRODUCTION ENGINEERS.—*Derby Section:* Monday, November 17, 7 p.m., College of Art, Green-lane, Derby. "Centreless Grinding," by Mr. A. Scrivener. *Birmingham Section:* Wednesday, November 19, 7 p.m., James Watt Memorial Institute, Birmingham. "Metal Finishing," by Mr. H. Silman. *Edinburgh Section:* Wednesday, November 19, 7.30 p.m., North British Station Hotel, Edinburgh. "The Domestic Gas Meter," by Mr. J. L. Bennet. *Coventry Section:* Thursday, November 20, 7 p.m., Geisha Café, Coventry. "Engineering Metrology," by Mr. O. G. Taylerson. *Glasgow Section:* Thursday, November 20, 7.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. "Tracer-Controlled Machine Tools," by Mr. P. K. Eisner.

INCORPORATED PLANT ENGINEERS.—*Liverpool and North Wales Branch:* Monday, November 17, 7.15 p.m., Radiant House, Bold-street, Liverpool. "Pneumatic Control in Industry," by Col. R. W. W. Taylor. *Glasgow Branch:* Tuesday, November 18, 7 p.m., 351, Sauchiehall-street, Glasgow. Open Discussion. *Kent Branch:* Wednesday, November 19, 7 p.m., Bull Hotel, Rochester. "Can Additives in Lubricating Oil Help the Plant Engineer ?" by Mr. A. V. Driver. *Blackburn Branch:* Thursday, November 20, 7.30 p.m., Chamber of Commerce, Richmond-terrace, Blackburn. "Care and Maintenance of Diesel Equipment," by Mr. J. W. Armstrong.

INSTITUTE OF REFRIGERATION.—Tuesday, November 18, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, Westminster, S.W.1. "Use of Aerated Concrete for Cold-Store Insulation," by Mr. H. E. Evans.

INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 18, 5.30 p.m., Great George-street, S.W.1. "Creep in High-Tensile Steel Wire," by Mr. N. W. B. Clarke and Mr. F. Walley. *Yorkshire Association:* Friday, November 21, 7 p.m., Great Northern Hotel, Leeds. Special Meeting to consider revision of constitution and by-laws.

ILLUMINATING ENGINEERING SOCIETY.—*Liverpool Centre:* Tuesday, November 18, 6 p.m., North Wales Electricity Board's Service Centre, Whitechapel, Liverpool, 1. "Design of Interior Lighting Equipment," by Mr. L. H. Hubble.

INSTITUTE OF FUEL.—*Midland Section:* Tuesday, November 18, 6 p.m., James Watt Memorial Institute, Birmingham. "Flame Radiation and Furnace Design," by Mr. G. J. Gollin.

INSTITUTION OF STRUCTURAL ENGINEERS.—*Scottish Branch:* Tuesday, November 18, 6 p.m., Ca'doro Restaurant, Glasgow. "Tubular Structures," by Mr. E. McMinn. *Wales and Monmouthshire Branch:* Wednesday, November 19, 6.30 p.m., Mackworth Hotel, Swansea. "Electric Screw Piling," by Mr. R. G. Braithwaite. *Yorkshire Branch:* Wednesday, November 19, 6.30 p.m., The University, Leeds. "Concrete Grain Silos at Louth," by Mr. G. C. Cummings.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, November 18, 6.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. "Radiography in a Clyde Shipyard," by Mr. E. J. Duffy.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—Tuesday, November 18, 6.30 p.m., Magnet House, Kingsway, W.C.2. "Research on, and Development of, Crystal Rectifiers and Amplifiers and Their Use as a Tool in Industry," by Mr. R. W. Douglas and Dr. E. G. James. *Manchester Branch:* Wednesday, November 19, 7 p.m., Engineers' Club, Manchester. "Power-Factor Correction," by Mr. F. L. Johnson.

ROYAL STATISTICAL SOCIETY.—*Merseyside Industrial Applications Group:* Tuesday, November 18, 7 p.m., Radiant House, Bold-street, Liverpool. "Transformations Used in Statistical Analysis," by Mr. R. L. Plackett. *London:* Wednesday, November 19, 5.15 p.m., London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Presidential Address on "The Expansion of Statistics," by Sir Ronald Fisher, F.R.S.

SHEFFIELD SOCIETY OF ENGINEERS AND METALLURGISTS.—Tuesday, November 18, 7 p.m., Grand Hotel, Sheffield. "Metallurgical Problems Imposed by Stratospheric Flight," by Major P. L. Teed.

ROYAL AERONAUTICAL SOCIETY.—Tuesday, November 18, 7.30 p.m., 4, Hamilton-place, W.1. Graduates' and Students' Lecture on "An Introduction to Helicopters," by Mr. J. D. Sibley. Thursday, November 20, 7 p.m., 4, Hamilton-place, W.1. Section Lecture on "The Design of a Wind Tunnel Balance," by Mr. L. E. Leavy and Mr. C. J. Saunders.

INSTITUTION OF MECHANICAL ENGINEERS.—*Luton Graduates' Section:* Tuesday, November 18, 7.30 p.m., at works of W. H. Allen, Sons and Co., Ltd., Bedford. "Presentation of Technical Information," by Mr. J. K. Marshall. *East Midlands Branch:* Wednesday, November 19, 7.30 p.m., Loughborough College, Loughborough. "Full Application of Motion Study," by Miss Anne G. Shaw. *Midland Branch:* Thursday, November 20, 6 p.m., James Watt Memorial Institute, Birmingham. "Control and Recovery of Dust and Fume in Industry," by Mr. R. Ashman. *Institution:* Friday, November 21, 5.30 p.m., Storey's-gate, S.W.1. Meeting with *Applied Mechanics Group*. "Recent Developments in the Machinability of Steel," by Mr. K. J. B. Wolfe. *North-Eastern Automobile Centre:* Wednesday, November 19, 7.30 p.m., The University, Leeds. "The Diesel Engine and Its Fuel," by Mr. S. Wightman.

INSTITUTE OF METALS.—Wednesday, November 19, 9.45 a.m., Royal Institution, Albemarle-street, W.1. All-Day Symposium on "Properties of Metallic Surfaces."

ROYAL SANITARY INSTITUTE.—Wednesday, November 19, 10.15 a.m., Town Hall, Peterborough. "Housing in Rural Districts," by Mr. D. Ward Griffiths.

ROYAL UNITED SERVICE INSTITUTION.—Wednesday, November 19, 3 p.m., Whitehall, S.W.1. "Bismarck Operation in the Light of the German Records," by Commander R. F. Jessel.

ROYAL MICROSCOPICAL SOCIETY.—Wednesday, November 19, 5.30 p.m., Tavistock House South, W.C.1. "X-Ray Microscopy," by Dr. V. E. Cosslett.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—Wednesday, November 19, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, S.W.1. "Stresses in Locomotive Coupling and Connecting Rods," by Dr. H. I. Andrews.

INSTITUTE OF WELDING.—*North London Branch:* Wednesday, November 19, 7.30 p.m., Technical College, Enfield. "Arc-Welding Electrodes," by Mr. H. D. Young.

INSTITUTE OF BRITISH FOUNDRYMEN.—*North-East Scottish Section:* Wednesday, November 19, 7.30 p.m., Imperial Hotel, Arbroath. "Mechanisation in the Foundry," by Mr. J. Aitken.

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—*North-West Centre:* Wednesday, November 19, 7.30 p.m., Victoria Hotel, Wigan. "Air-Pressure Braking," by Mr. W. A. Kirk. *London:* Thursday, November 20, 6.30 p.m., Royal Society of Arts, John Adam-street, Adelphi, W.C.2. "Synthetic Resin Adhesives in the Road-Transport Industry," by Mr. T. Maxwell-Hudson.

DIESEL ENGINE USERS ASSOCIATION.—Thursday, November 20, 2.30 p.m., Caxton Hall, S.W.1. "Torsional Vibration in Diesel Engines," by Mr. C. H. Bradbury.

INSTITUTION OF MINING AND METALLURGY.—Thursday, November 20, 5 p.m., Geological Society, Burlington House, Piccadilly, W.1. (i) "Prospecting with the Diamond Drill for Lead-Zinc Ores in the British Isles," by Mr. J. B. Dennison and Mr. W. W. Varvill. (ii) "Rotary Blast-Hole Drilling in the Jurassic Rocks of Lincolnshire," by Mr. R. J. M. Dixie and Mr. T. M. Dover.

JUNIOR INSTITUTION OF ENGINEERS.—Friday, November 21, 7 p.m., Townsend House, Greycoat-place, S.W.1. "Comparisons Between Shell and Water-Tube Boilers," by Mr. J. N. Williams.

ROYAL INSTITUTION.—Friday, November 21, 9 p.m., 21, Albemarle-street, W.1. "The Comet," by Mr. C. T. Wilkins.

PERSONAL.

SIR JOHN DALTON is to join the board of W. T. Henley's Telegraph Works Co. Ltd. At the last annual general meeting of the company, SIR MONTAGUE HUGHMAN announced his intention to retire and it is understood that Sir John will succeed him as chairman of the parent and subsidiary companies.

AIR COMMODORE SIR VERNON BROWN, C.B., O.B.E., M.A., F.R.Ae.S., R.A.F. (ret.), is retiring from the position of chief inspector of accidents at the Ministry of Civil Aviation, on December 31. MR. P. G. TWEEDIE, O.B.E., at present deputy chief inspector of accidents will succeed Sir Vernon as from January 1, 1953.

SIR HUGH BEAVER, M.I.C.E., M.I.Chem.E., managing director of Arthur Guinness, Son and Co., has been appointed a member of the Advisory Council for Scientific and Industrial Research. MR. I. A. R. STEDEFORD, chairman of Tube Investments Ltd., has resigned his membership of the Council on account of the pressure of other duties.

MR. ROBERT T. WOOD has been appointed chief engineer of the Bristol Waterworks Co., Telephone Avenue, Bristol, 1, with effect from January 1, 1953. Mr. Wood, now deputy chief engineer, joined the company in 1920. MR. R. W. MELVIN, B.Sc., M.I.C.E., M.I.W.E., the general manager of the company, holds at present the appointment of chief engineer.

MR. C. R. WHEELER has been appointed a director of Guest, Keen and Nettlefolds Ltd.

MR. BRYAN DONKIN, the eldest son of Mr. Sydney Bryan Donkin, M.I.C.E., has been elected chairman of the general council of the Engineers' Guild Ltd., 78, Buckingham-gate, London, S.W.1, for the year 1952-53; MR. T. M. MEGAW, M.Sc, M.I.C.E., has been elected vice-chairman. MR. W. A. M. ALLAN, A.C.G.I., M.I.C.E., M.I.San.E., has been made chairman of the executive committee and MR. C. L. CHAMPION, B.Sc., A.C.G.I., A.M.I.C.E., M.I.Mech.E., A.M.I.E.E., vice-chairman of the executive committee.

MR. J. W. M. SWANSON, hitherto assistant engineer-in-charge at the monitoring station of the British Broadcasting Corporation, at Caversham, has now been appointed engineer-in-charge of the Corporation, at Newcastle.

MR. T. G. FALLON has been appointed managing director and MR. C. G. PETTIT, M.I.P.E., assistant managing director of the Incandescent Heat Co. Ltd., Cornwall-road, Smethwick, Birmingham. The chairman is MR. JOHN FALLON, J.P., M.I.Mech.E.

MR. H. ALTON and MR. W. MOORE have been appointed directors of Redpath Brown & Co. Ltd. Mr. Alton has been chief accountant of the company since 1945, and Mr. Moore was appointed, last year, manager of the Redpath Brown Glasgow works.

MR. W. A. COATES, M.I.E.E., has been appointed general sales manager, Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17. MR. F. GURNEY, M.I.E.E., has been appointed manager, home sales. Mr. Coates, who succeeds the late MR. DUNCAN MACARTHUR, retains his seat on the board.

MR. C. G. ABBEY, of Montreal, President and general manager of Bepco Canada Ltd., a subsidiary company of Lancashire Dynamo Holdings Ltd., will assume, as from March 31, 1953, the newly-created position of chairman of the board. Mr. Abbey will be succeeded as President and general manager by MR. B. M. BURT, B.Sc.Tech.(Manch.), who has been associated with Mr. Abbey as vice-president and chief engineer since the establishment of the company in 1933. MR. F. E. REGAN, the Ontario branch manager, will become vice-president.

MR. W. R. WALKER, B.Sc.(Lond.), of Marlow, Buckinghamshire, MR. HAROLD WALSH, B.A.(Cantab.), of Blackburn, MR. R. J. IGO, B.Sc., of Derby, MR. J. B. G. BLACKETT, B.Sc.(Dunelm), of Durham, and MR. C. B. STEVENS, B.Sc.(Lond.), of Paignton, have been appointed to the Colonial Engineering Service, Messrs. Walker and Walsh on the Gold Coast, Messrs. Igo and Blackett in Malaya and Mr. Stevens in Nigeria.

MR. J. L. FURNER has been made sales manager of the telecommunications division of the Plessey Co., Ltd., Ilford, Essex, in succession to AIR COMMODORE T. P. FAGAN, who has a new appointment entailing liaison with foreign Government departments on behalf of the company.

SMAIL, SONS & CO. LTD., 62, Robertson-street, Glasgow, C.2, and Edinburgh, have been appointed technical representatives for ELECTROPOWER GEARS, LTD., throughout Scotland.

The Scottish Office of the CEMENT AND CONCRETE ASSOCIATION has moved from No. 22 to No. 2, Rutland-square, Edinburgh. The telephone number, Fountainbridge 5085, remains the same.

MR. EDWIN GRAHAM, M.Inst.N.A., has been appointed general manager of William Gray and Co. Ltd., West Hartlepool, in succession to MR. J. LENAGHAN, who, as stated on page 567, *ante*, has been appointed shipbuilding director, FAIRFIELD SHIPBUILDING AND ENGINEERING CO., LTD., GLASGOW.

EXHIBITS AT THE PUBLIC WORKS EXHIBITION, OLYMPIA.

(*For Description, see Page* 626.)

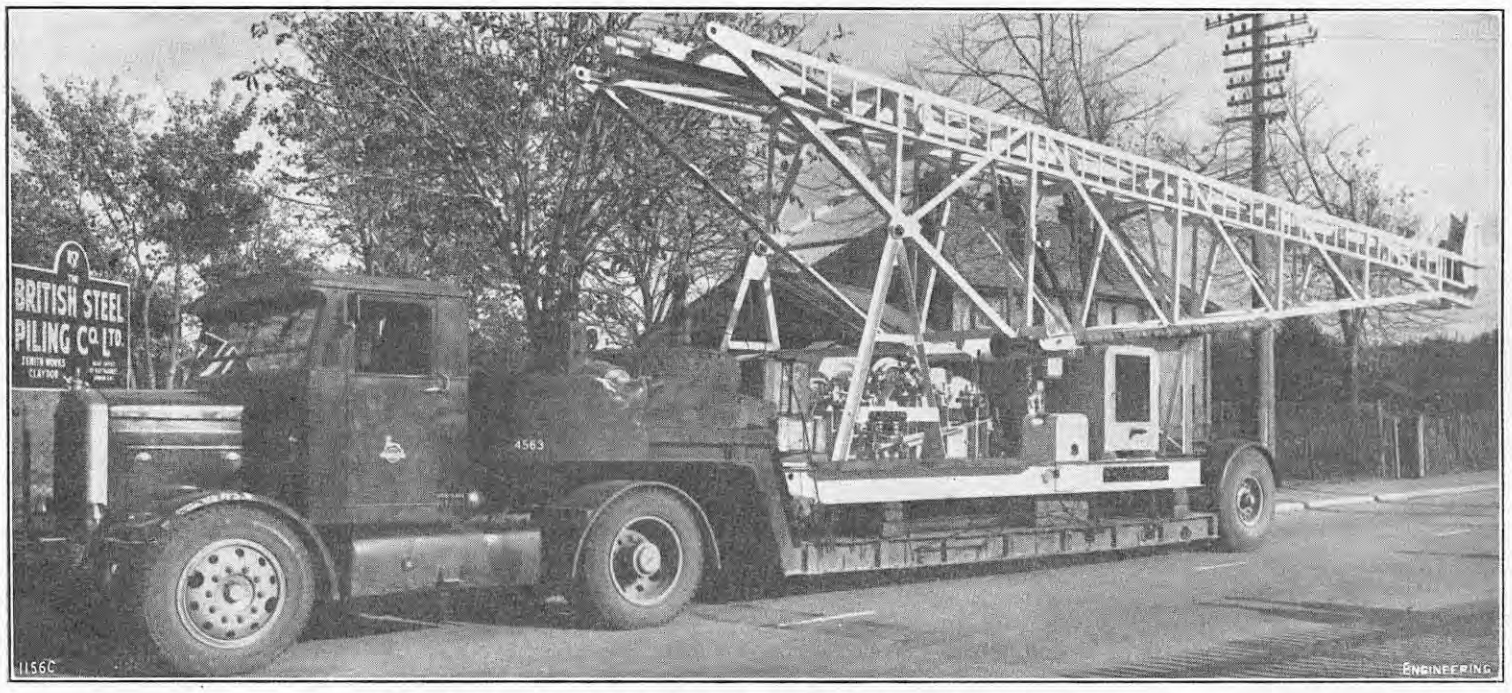


Fig. 20. Portable Pile Driver; British Steel Piling Co., Ltd.

Fig. 21. Excavator with Trenching Bucket; Priestman Brothers, Ltd.

Fig. 22. "Express" Loader; Cheshire Engineering Co., Ltd.

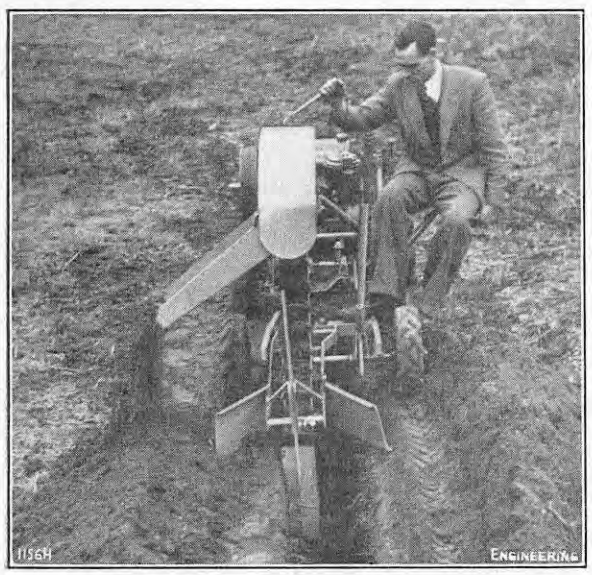


Fig. 23. Trench Digger; Cheshire Engineering Co., Ltd.

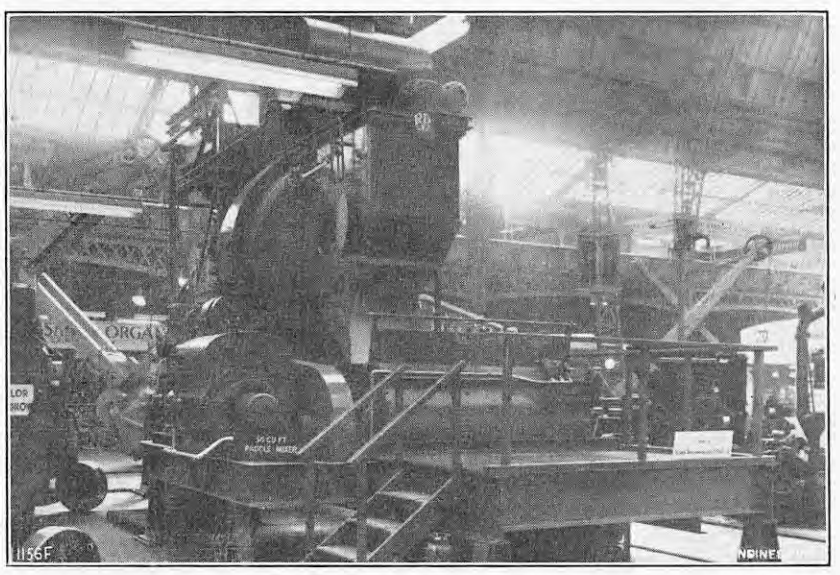


Fig. 24. Batch Heater and Paddle Mixer for Tarmacadam; Stothert & Pitt, Ltd.

ENGINEERING

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

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For Canada	£5 5 0

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Terms for displayed advertisements can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 10*s.* for the first four lines or under, and 2*s.* 6*d.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 30*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

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

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

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

CONTENTS.

ENGINEERING

FRIDAY, NOVEMBER 14, 1952.

VOL. 174. No. 4529.

THE IRON AND STEEL BILL.

THE long-awaited Bill for the denationalisation of the British iron and steel industry, which the Government had pledged themselves to undertake, was published last week, 24 hours too late for any comment on its provisions to be included in our issue of November 7. We are not disposed, however, to regard that circumstance as an editorial inconvenience, for the proposed measure is not one to be skimmed through rapidly, especially in view of certain differences of some importance between its scope and that of the Iron and Steel Act, 1949, which it is the first declared object of the new Bill to repeal. In fact, the two documents ought to be considered side by side; and when that process is begun by comparing the respective titles, the differences in scope become apparent at once. The Act of 1949 is described as "An Act to provide for the establishment of an Iron and Steel Corporation of Great Britain and for defining their functions, and for the transfer to that Corporation of the securities of certain companies engaged in the working, getting and smelting of iron ore, the production of steel, and the shaping of steel by rolling, and of certain property and rights held by a Minister of the Crown or Government department; for the licensing of persons engaged in any such activities; for co-ordinating the activities of the Corporation, the National Coal Board and the Area Gas Boards relating to carbonisation; and for purposes connected with the matters aforesaid."

The new Bill requires fewer words to describe its general purpose. It is "A Bill to repeal the Iron and Steel Act, 1949, and to dissolve the Iron and Steel Corporation of Great Britain; to establish an Iron and Steel Board for the supervision of the iron and steel industry and to define the functions of that Board, and to make other provision as to the said industry; to provide for the return of iron and steel undertakings to private ownership and for the disposal of the property, rights, liabilities and obligations of the said Corporation; and for purposes connected with the matters aforesaid." The Act provided that the Corporation should consist of a chairman and not less than six or more than ten other members. The new Board is to consist of a chairman and not less than seven or more than eleven other members; so that, in practice, the Board and the Corporation are likely to be substantially equal in numbers, and in the breadth of interest and experience that they bring to their tasks.

The Board's duties would be supervisory only, so long as the new (or restored) owners of the individual undertakings carry out satisfactorily their primary purpose of producing iron and steel in sufficient quantity, of suitable quality, and (by implication) at the right price; but it is clearly laid down that the purpose of the Board's supervision is that of "promoting the efficient, economic and adequate supply under competitive conditions of iron and steel products" and, if the producers fail to do so, the Board can take certain steps to correct the producers' shortcomings. To this end, the Board would be empowered to take positive action to arrange for the provision of additional production facilities, with the approval and assistance of the Minister of Supply. If necessary, the Minister may (subject to the approval of the Treasury) "provide and use those facilities" himself or may make arrangements for these powers to be exercised on his behalf, even to the extent, apparently, of taking over and operating any plant which the industry cannot or will not operate when required to do so. The Board would also be empowered to refuse consent to any proposals of the industry which, in their opinion, "would be unlikely substantially to affect the efficient and economic development of production facilities in Great Britain." The Bill, as printed, uses the word "affect," though it would seem that the intended meaning is to "effect."

One of the most significant differences between the existing Act and the new Bill, and one which would widen considerably the field of industrial operations affected by the proposed measure, relates to the activities which would come under the supervisory control of the Board. The 1949 Act gave the Corporation power to acquire (subject to certain limits of annual output) any companies concerned in the working or getting of iron ore; the smelting of iron ore in a blast furnace, with or without other metalliferous materials; the production in the form of ingots of steel, including alloy steel; and "the changing of the cross-sectional dimensions or cross-sectional shape of steel by hot rolling in a rolling mill." The Bill, however, goes farther than this. As stated in its Third Schedule, it covers "the quarrying or mining of iron ore or the treatment or preparation of iron ore for smelting; the smelting of iron ore in a blast furnace, with or without other metalliferous materials, or the production of iron by any other process; the production of steel by any process; the casting of iron or steel by any process; the processing, with or without heat, of iron or steel by rolling or forging (other than drop forging, smiths' hand forging,

and the forging of bolts and rivets); the production from iron or steel of hot-finished tubes or pipes or bright bars; and the production of tinplate or terneplate." It will be seen, therefore, that the effect of the Bill, if enacted, would be to bring under the supervision of the Board a large number of undertakings which at present are outside the purview of the British Iron and Steel Corporation.

Whether this extension would be entirely beneficial is a matter on which strong views are likely to be held. Certainly, it would add greatly to the administrative and statistical work of supervision. It may be argued, however, that much of this paperwork must have been done in any event, because of the ramifications of many of the larger undertakings which were taken over under the terms of the 1949 Act; and that the changes in the industry since the Act was passed make it impracticable to restore wholly the *status quo*. The process of integration and rearrangement has gone too far, and it is obvious that, taking account only of the 96 firms, listed in the Third Schedule to the Act, whose properties became vested in the Corporation, these properties, when disposed of by the new Board, would not be acquired by 96 exactly equivalent new firms.

Some of the activities which have been coordinated under the ægis of the Corporation are to be continued, evidently, under that of the Board; for example, the importation of raw material for the industry, the promotion of research, and "the training and education of persons employed in or to be employed in the industry." With regard to imports, the Bill is permissive and not mandatory; the Board "may" make arrangements for the importation and distribution of raw material, but only if they are satisfied, after consultation with "such representative organisations as they consider appropriate," that it would be beneficial to do so "as a common service for the iron and steel industry." In practice, it is more than likely that they would, to some extent; the machinery exists and, in any case, questions of international finance make it unlikely that such a fiscally important market could be left entirely free in present circumstances or in the immediate future.

With regard to research and to education, the powers which it is proposed to confer upon the Board are again contingent upon their satisfaction or otherwise with the existing arrangements. "If and so far as" these existing facilities "appear to the Board to be inadequate," they may and "shall take such steps as may from time to time appear to them to be practicable and desirable" to promote these objects. It may be supposed, however, that they would not interfere materially with the work already done and in hand by the British Iron and Steel Research Association. Research is essentially a long-term activity, and much of the work of the B.I.S.R.A. was planned before the passing of the 1949 Act; to interfere with it would appear to offer no particular advantage. It is improbable, in any event, that the Board would have the time or inclination to complicate further their main task until the process of acquisition and sale of the material assets of the industry is at least in train. Those assets would have to be transferred first to a holding and realisation agency, appointed by the Treasury, which would sell them by degrees to private enterprise. It is expected that the Bill will become law by Easter, 1953, but several years must elapse before the realisation of assets is completed. The task is one of such magnitude and complexity that it is to be hoped (and seems probable) that no future Government with any commonsense would consider seriously a forced reversion to public ownership, merely on doctrinaire grounds. It will be the responsibility of the purchasers of the industry's assets to see that no better justification arises for suggesting it.

THE PROSPERITY OF CUBA.

Although natural endowments may be an important factor, the prosperity of a country essentially depends on how much work its inhabitants are prepared to do. It has been asserted that in Cuba "the average countryman is said to work from Tuesday to Thursday and play the guitar, dance, and attend cock-fights for the rest of the week." This may be libellous and, in a report prepared by an Economic and Technical Mission which visited the country in 1950, it is stated that "Cuban workers are resourceful and quick to learn manual skills"; but as it is added that 'the widespread seasonal unemployment following the annual sugar harvest is one of the outstanding features of Cuban national life," the natural indisposition of most men to work themselves out of a job may have influenced a voluntary reduction of the length of the working week. The additional statement that "Cuban workers spend their money when they get it" merely suggests a light-hearted attitude towards life and its problems.

The Mission, organised by the International Bank for Reconstruction and Development in collaboration with the Government of Cuba, has published a voluminous report,* of more than 1,000 pages. This document reviews every aspect of the financial and trade position in Cuba and makes various recommendations. While it does not indulge in the harsh criticism of Cuban workers which is quoted above, it does emphasise that improvement in the economic position of the country must depend on the actions of the Cubans themselves. Improvement can come "only by concerted effort in many spheres, by diligent improvement of her institutions and by new attitudes in many people." Energetic, resolute and united action is required "by the Government, by private groups, by individuals and by the nation as a whole."

These reforms will be more easily suggested than carried out. Present conditions in Cuba are probably a reflex of the country's history. Cuba has been an independent republic only since 1901, this status being granted after the Spanish-American war. Earlier history saw continual political unrest and disturbance. Colonised by Spain in 1510, the country was constantly harassed by English, French and Dutch raids in the Eighteenth Century and between 1868 and 1898 there were two wars of independence. Frequent unrest resulted in intervention by the United States in attempts to impose some sort of order in a country lying so close to its own shores. This mediation is, no doubt, one of the reasons why Cubans have been prepared to leave the development of their territory so largely to American enterprise, but, measured by Western standards, this development has not gone very far. Reasonable political stability is a necessary concomitant for the investment of foreign capital.

A good deal has been heard of late about the insecure economic position of various areas in Great Britain which are dependent on a single industry. Cuba forms an example of a whole country which suffers from the same type of limitation. Broadly speaking, the whole economy is dependent on sugar. In 1949, sugar exports were valued at 511·5 million dollars, tobacco exports at 29·9 million dollars and mineral products at 6·5 million dollars. The dominating position which sugar holds in the industry of the country is illustrated by the facts that the sugar mills operate a rail mileage almost double that of the public railway system and provide 80 per cent. of the traffic tonnage of the latter, and that half the country's electric power is controlled and utilised by the mills. As exports provide some 40 per cent. of the national income (44·4 per cent. in 1947), reliance on a single product is a serious weakness. World conditions may have a devastating effect, as was shown in the great depression following the year 1930; in 1924, exports were valued at 435 million dollars, and in 1932 at 81 million dollars.

Although a large proportion of the total sugar export is to the United States, other markets are of importance, but in most, including the United States, sugar imports are controlled by quota. Quotas are reduced as domestic production increases, and it is of direct significance to Cuba that European beet-sugar production rose from 2,839,049 long tons in 1945-46 to 6,056,000 long tons in 1950-51. In recent years, the Cuban sugar industry has been reasonably prosperous, but, as the report points out, it exists on a very shaky basis. Apart from the fact that it is subjected to hampering Government regulations, it is suffering from "technological stagnation." There is little or no research, and mechanisation is meeting with opposition from organised labour. The present sugar-mill equipment, which at present is apparently being used to the full, was supplied to a considerable extent from Great Britain, and if the recommendations made by the Mission in connection with the development of by-product recovery have any effect, there should be possibilities of business for British engineering firms, even though Cuba is a dollar area.

This report is in no way directed to the consideration of British manufacturing interests, but the extremely detailed analysis of what should be an expanding market is worthy of study by British manufacturers. As figures already quoted will have indicated, tobacco is the second export in order of importance, and in connection with it the recommendations about the greater mechanisation of agriculture, if they have any effect, should provide openings for machinery. The relatively low position taken by mineral products in export values seems to be partly due to lack of enterprise, absence of technical knowledge, and Government neglect. Processing industries are gravely hampered by the fact that the country has no coal and, although there is no reason to suppose that oil is plentiful, adequate surveys of possible sources have never been carried out. The report suggests that mineral products might become an important export were mining laws revised, proper surveys undertaken, and public interest stimulated.

It is insisted many times in this report that adequate prosperity can only be established in Cuba by the will and activities of its own people. A mental revolution is required. This is not likely to be brought about rapidly, but if some of the recommendations made in the report are acted on, a start may be made. It is proposed, for instance, that a Ministry of Mines, Water and Forests should be set up. Were such a body constituted, action in some directions might follow. One of the detailed proposals is that a proper study should be made of the problem of water supply to the city of Santiago; the present supply is inadequate and impure. This matter necessitates surveys which might take some time, but the establishment of a water-treatment plant for the city is recommended as an immediate object. Other proposals demanding capital expenditure relate to roads and railways. The latter require "more modern locomotives and passenger and freight equipment," and major track improvements. The sweeping reforms suggested are not likely to be carried out in their entirety for many years, but the inherent possibilities make it desirable that this exhaustive report should be studied by British engineering firms.

* *Report on Cuba. Findings and Recommendations of an Economic and Technical Mission Organised by the International Bank for Reconstruction and Development in collaboration with the Government of Cuba in* 1950. Published for the International Bank for Reconstruction and Development by the John Hopkins Press, Baltimore 18, Maryland, U.S.A. [Price 7.50 dols.]; and by Geoffrey Cumberlege, Oxford University Press, Amen House, Warwick-square, London, E.C.4. [Price 60*s.* net].

NOTES.

MULTIPLE-UNIT DIESEL TRAINS FOR BRITISH RAILWAYS.

BRITISH Railways are to introduce multiple-unit Diesel trains for passenger traffic. With the approval of the British Transport Commission, the Railway Executive are undertaking an immediate initial expenditure up to 500,000*l*. This is the first practical step in the policy, now announced, to employ light-weight Diesel units wherever suitable on British Railways, to reinforce or to replace steam services. The first area which it is proposed to serve by the new Diesel trains wll be the West Riding of Yorkshire, where, it is considered, new and frequent services by Diesel coach between certain large centres of population will be most effective in improving rail services and developing travel. The West Riding has been chosen first because centres such as Bradford and Leeds form good natural bases for a fleet of Diesel units operating over a series of inter-connected lines through busy industrial areas. A number of other areas, including Scotland, have been surveyed for development later. The Diesel trains intended for the West Riding are likely, subject to practical test, to become the standard for the whole country. They are being designed under the supervision of Mr. R. A. Riddles, member of the Railway Executive responsible for mechanical and electrical engineering. Each Diesel unit will consist of two coaches, and either one or both of the vehicles will be driven by two 125-h.p. 'bus engines, according to the power requirements of the different services, the engines being located under the floor. These units will be capable of being driven from either end and of being run either as a two-coach train or as part of a train of up to four units (eight vehicles), coupled together. Mechanical transmission will be used, and the cars will be of light-weight construction, the body and underframe being made together. British Railways have kept in close touch with recent developments of Diesel traction in Northern Ireland, the Republic of Ireland and overseas. Last year, the Railway Executive made a full-scale survey of the possibilities of introducing Diesel units in this country on the type of work for which they are likely to be most suitable and most economic. The survey included an investigation of Diesel development in France, Belgium, Germany and Ireland. Given the right conditions, Diesel cars have the following advantages over steam traction, on suitable services: lower operational costs, as the Diesel engine consumes no fuel when not running; improved traffic availability (for example, ability to run for several turns without servicing); greater frequency of service and high daily mileage; higher rate of acceleration; cleanliness, because of absence of smoke; and the facility of driving from either end, making possible a quicker turn-round at terminals and avoiding line occupation. The new Diesel units will be employed on routes where they can be fully engaged on passenger work and where they will be able to provide for the heavy fluctuations in traffic between, say, mid-week and the week-end. It is intended to place the first contract for the provision of power equipments for 16 motor car units with Messrs. Leyland Motors, Limited, Leyland, Lancashire, who will supply the engines, and with Messrs. Walker Brothers (Wigan), Limited, Wigan, who will supply the transmissions.

THE INSTITUTION OF MECHANICAL ENGINEERS.

At the meeting of the Institution of Mechanical Engineers held on Friday, November 7, Mr. N. G. Dennis, M.A., A.M.I.Mech.E., reviewed the subject of water-turbine governors. He presented a general picture of closed-sequence system controls of hydro-electric plants, covering the relation between water-turbine governors and water level, power, frequency and tie-line controls. The paper was well received, particularly as the existing literature of the subject is regarded as meagre. The author made special reference to the difficulty of governing which is created by the inertia of the water in the pipe-line. He first described the principles of operation and the various types of governor, and then gave analytical descriptions of the numerous devices which form parts of water-turbine governors; for example, centrifugal devices and their drives, hydraulic and mechanical addition and subtraction, pilot relays, distributing valves and servo-motors, temporary-return motion and acceleration-sensitive devices. Mr. Dennis described the simultaneous control of guide vanes and runner vanes, or guide vanes and relief valve, or spear and diffusor or deflector, and referred also to various arrangements for supplying pressure oil for small governors, and for very large governors in which 300,000 ft.-lb. of energy could be released in a single stroke. He concluded with a description of an actual governor, and in an appendix he gave a brief theoretical analysis of the behaviour of a water-turbine governor. In the discussion which followed the presentation of the paper, one of the speakers, Mr. H. G. Conway, M.A., made a suggestion, based on his experience of hydraulic systems for aircraft, that if, instead of using pressures of 200 lb. or 300 lb. per square inch, pressures of 1,500 lb. per square inch or more were used for water-turbine governors, it would be possible to halve the weight and size of the governor. Since cost was in some degree proportional to size, presumably it, too, would be reduced considerably.

THE UNITED KINGDOM GAS INDUSTRY.

In the third year of nationalisation, namely, the twelve months ended March 31, 1952, the gas industry showed a net surplus of 1,440,916*l*. Ten of the twelve Area Gas Boards had a surplus on the year's working, and two—the North-Western and the North-Eastern, a deficit. The surplus for the previous year was 1,492,784*l*., and the cumulative surplus for the period since vesting date, 3,404,443*l*. These figures are drawn from the third report and statement of accounts of the Gas Council and, in commenting on the report at a Press conference held in London on November 11, Colonel Harold C. Smith, C.B.E., D.L., M.I.C.E., the chairman of the Council, emphasised that progress in the extension of manufacturing and storage plant had been seriously delayed by the shortage of steel. Nevertheless, Colonel Smith continued, there had been a net addition to the total plant capacity of the industry of 5·5 per cent. since the beginning of 1951. On March 31, 1952, the plant capacity was approximately 11 million therms, or 2,300 million cub. ft. a day. There had been general improvements in the efficiency of gas production, and the average yield of gas, per ton of coal carbonised, had increased from 71·62 therms in the previous year, to 72·77 therms this year. But for this increased efficiency of production, 440,000 tons more coal would have been required, at a gross cost of 1,590,000*l*. The interlinking of gasworks by "grid" schemes was an important part of the planning of all the Boards, and in spite of restricted supplies of cast-iron and steel pipes, 47 small works had been closed during the year, making a total of 106 since the vesting date. Expenditure on research by the Council totalled 137,555*l*. during the year, an increase of 86,971*l*. over that for the previous year. The Council's second research station (the first is in London) had been opened at Nechells Gasworks, Birmingham, under the direction of Dr. F. J. Dent and the administrative control of the West Midlands Gas Board. Its major task, at present, was the extension of research into complete gasification processes. The coal carbonised during the year totalled 27,421,800 tons, compared with 26,368,700 tons in the previous year. The production of water-gas had been reduced by 8·5 per cent. On account of its expanding requirements and the limited amount of the better carburising coals available, the industry still had to receive an increasing quantity of inferior coals from the gas-making point of view. A matter of interest was that increasing quantities of methane might become available from coal mines and a joint committee of the Gas Council and the National Coal Board were examining the possible uses of this gas in the national interest.

ELECTRICITY SUPPLY IN SOUTH AFRICA.

Shortage of electricity-generating plant is common to many countries. In Great Britain it is to a considerable extent due to the growth of the domestic load and might be attributed to the inhabitants attempting to consume more than they are producing; alternatively, it may be explained as the result of a Government financial policy hampering an activity which is at the basis of industrial prosperity. South Africa is one of the countries which has experienced power cuts due to shortage of generating capacity, but as far, at least as plant is concerned, the shortage is not due to shortfall on the part of domestic manufacturers; all generating plant is imported. The reports of the Electricity Supply Commission have in recent years regularly reported delays due to late deliveries. The latest report, which deals with the year ended December 31, 1951, is less insistent on this particular matter but in connection with more than one of the separate undertakings refers to difficulty caused by coal shortages; in the Cape Western Undertaking "there were times when coal reserves were almost nil" and in the Cape Northern Undertaking shut-down was only prevented "by a timely loan of four trucks of coal" from the De Beers Company. Demand, both by the mines and industry, is continually increasing and the units sold in 1951 were 7·9 per cent. greater than in 1950. The aggregate installed capacity of the Commission's power stations at the end of 1951 was 1,594,580 kW, this showing an increase of 80,605 kW over the corresponding figure for 1950. Plant under erection or on order will bring the total up to 2,637,580 kW. The situation is being dealt with with foresight and energy and eight new power stations are under construction. Hex River Station of the Cape Western System will have an initial capacity of 60,000 kW and Salt River No. 2 Station of the same system 180,000 kW; Swartkops Station, to serve Port Elizabeth, will have a capacity of 40,000 kW; Taaibos, which will serve the goldfields in the Orange Free State, will contain six 60,000-kW generating sets; Umgeni Station, which will supply Durban, will ultimately have a capacity of 180,000 kW; Vierfontein Station, which will also supply power to the Orange Free State goldfields, is planned for an ultimate capacity of 210,000 kW; West Bank No. 2, at East London, is designed for 90,000 kW of generating plant; and Wilge Station in the Transvaal will have a capacity of 180,000 kW. Messrs. Merz and McLellan are responsible for the design of the Salt River No. 2, Umgeni and West Bank No. 2 Stations, the others are designed by the engineering staff of the Commission.

THE INSTITUTION OF GAS ENGINEERS.

The forthcoming autumn research meeting of the Institution of Gas Engineers will include the presentation of a paper on the "Application of the Gas Turbine for Recovery of Waste Heat," by Captain (E) W. Gregson, R.N.R., M.Sc.(Eng.), one on "The Gasification Programme of the Birmingham Research Station," by Dr. F. J. Dent, and another on "Thermal Efficiency in Gas Production and Utilisation," by Mr. J. E. Davis. The titles of the other papers are: "Manufacture of Butane-enriched Blue Water Gas on Small Undertakings," "Effect of Load Variation on Costs," "Influence of Preheating the Air and Steam Supplies on the Performance of a Blue Water Gas Plant," "Some Effects of Traces of Iron Carbonyl in Town Gas," "Sampling and Quality Control," and "Performance of Oxide Purifiers." The meeting will also include discussions on the report of the chairmen's technical committee, the report of the gas education committee, and the report of the joint refractories committee. It is to be held at Church House, Westminster, London, S.W.1, on Tuesday and Wednesday, November 25 and 26. Further particulars may be obtained from the secretary of the Institution at 17, Grosvenor-crescent, London, S.W.1.

FARADAY HOUSE OLD STUDENTS' ASSOCIATION.

The annual dinner of the Faraday House Old Students' Association was held at the Savoy Hotel, London, on Thursday, October 30, the President (Mr. D. E. Bird) being in the chair. In proposing the toast of "Faraday House," the President of the Institution of Electrical Engineers (Colonel B. H. Leeson) said that during the last 50 years the British electrical industry had made great progress and had contributed not a little to the national well-being. It was now organised in two

sections, the one dealing with supply being nationalised, while the other, which was concerned with manufacturing, was still in private hands. The partnership between the two was close, however, and both were operating in the best interests of the country. The engineering manufacturing industry was the third largest exporter and contributed about 40 per cent. of the resources required to keep us alive. These resources would, however, have to be increased and a great deal of "wattless" work eliminated if it was to continue to play its proper part. In attaining this aim, Faraday House would have its role and he hoped that present students would maintain the standards that had been set by their forerunners. The Principal (Dr. W. R. C. Coode-Adams), in reply, compared the hardships under which our ancestors had suffered, in such fields as artificial lighting, with the amenities enjoyed to-day. On the other hand, the moderns had to endure such disabilities as crowded tube trains, which they had escaped, so that progress was not unaccompanied by disadvantages. A great deal had lately been heard about technological universities, but in taking part in discussions on this subject it must be remembered that the principal function of these institutions should be to make the students think logically, as the technical details could be added later. In replying to the toast of "The Guests," proposed by Mr. J. C. Thompson, the Quartermaster-General (General Sir Ouvry Roberts) stressed the need of the Army for electrical engineers, in both peace and war. Any electrical engineer, he said, who joined the Army would gain useful experience with many types of equipment.

LETTERS TO THE EDITOR.

HUMAN RELATIONS.

To the Editor of Engineering.

Sir,—I was very grateful for the generous notice of my recent book, *Industrial Leadership and Joint Consultation*, which was embodied in the article on "Human Relations" of page 474 of your issue of October 10. There is a great need at the present time for a closer understanding of each other's work on the part of the engineer and the administrator (or manager), if only because of the increasing tendency for both engineers and those with little experience in the natural sciences (e.g., arts graduates) to assume managerial positions in industry. Any endeavour, therefore, to make the engineer more aware of the nature and problems of the administrative process—or, conversely, to give the administrator a fuller appreciation of the impact of technological factors on his work—is to be welcomed, particularly when, as in the case of your article, some of the more important considerations are so lucidly stated.

I would, however, like to draw attention to what appeared to be a slight inaccuracy in the concluding paragraph of your article, where you discuss the difficulties of the employee representative. You say, "He is faced with conflicting loyalties, one to his union, the other to his workmates." While I would not deny that union policy and the demands of the shop floor may often be at variance, and that these discrepancies do make the task of the employee representative a more difficult one, the position appears to me to be rather different in several important respects from your impression of it. I endeavoured to emphasise in my book that the representative's basic problem arises from his need to reconcile the new demands for co-operation within the factory with his traditional combative role on behalf of his constituents. If I may quote from the text (pages 126-127): "The foreman has been revealed as the 'master and victim of double talk,' the custodian of the uncertain frontier between 'management' and 'workers.' The employee representative vies with the foreman for this unenviable distinction, and the development of joint consultation, with its emphasis on co-operation rather than conflict, has increased his difficulties. So long as his role was simply one of opposition, his status, in the eyes of both management and workpeople, and his relationships, were more clearly defined. . . . Now he gains only a limited acceptance from management, yet is seldom the natural leader of a well-knit group of employees. He is neither the 'boss's man' whom some employees consider him to be, nor the 'regular fellow' whom others would like him to be. As a steward in Firm B remarked, 'The shop steward to-day needs to be a schizophrenic, representing management as better than they are when addressing his workmates, and his workmates as angels when addressing the management.' He 'gets the kicks from both sides,' as others commented." The broader implications of this problem are also dealt with in the concluding chapter (pages 151-152).

Yours faithfully,
W. H. Scott.

The University of Liverpool,
Department of Social Science,
19, Abercromby-square,
Liverpool, 7.
October 30, 1952.

WORMGEAR RATIOS.

To the Editor of Engineering.

Sir,—As a draughtsman who has to refer to wormgear manufacturers' catalogues from time to time, I would like to put in a plea for accuracy in stating the ratios of wormgears. They are often wrongly given in the makers' catalogues for many of the sizes, and I have even found this wrong ratio stamped on the gear itself. For instance, a 10 : 1 wormgear is really 9·66 : 1 for sizes 3 in. and 4 in.; 9·75 for 5 in., 6 in., 7 in., 8 in., and 10 in.; and 9·8 for sizes 12 in. and 14 in. Again, the ratio $12\frac{1}{2}$: 1 is correct for 3 in. only; for sizes 4 in., 5 in., and 6 in. it is 12·75 : 1. A 15 : 1 gear is never this ratio, but 14·5 : 1 for 3 in., 4 in., and 5 in., 14·66 for 7 in., 8 in., 10 in. and 12 in., and 14·75 for 14 in. Ratios 20, 25 and 30 to 1 will also be found to be correct for certain centres only.

Surely it is just as easy to state the ratio correctly as incorrectly? Also, I would like to suggest that a better way to state wormgear ratios would be 2/25 for 12·5 : 1, 3/29 for 9·66 : 1, and 4/51 for 12·75 : 1.

Yours faithfully,
T. G. Castle.

Kodak Works,
Wealdstone, Middlesex.
November 3, 1952.

WATER HAMMER IN PIPE-LINES.

To the Editor of Engineering.

Sir,—It appears that Mr. Linton and I disagree on fundamentals. I agree that the latest form of my formula for water hammer (page 380 of your issue of September 19) differs markedly from accepted theory, but I cannot agree that the new formula is incapable of representing observed facts. The reason for the somewhat staggering change in the appearance of the theoretical result has already been given, namely, the omission of the term in the energy equation which accounts for "pressure energy" of the fluid flow. This quantity is, in fact, of primary importance to the balance of energy, and I must add that I was astounded to realise that, for over 50 years, its effect appears to have been ignored.

I am amazed at Mr. Linton's refusal to accept the principle of energy conservation for the purpose of the flow of an "elastic" fluid. Whether the flow be steady or unsteady is immaterial, provided one takes account of the work done on, or by, the fluid. I am in complete agreement with him when he states that the kinetic energy of the water column is not wholly expended in straining the pipe. The question of losses is, unfortunately, always with us.

I hope to ventilate my new treatment of water hammer in a paper to one of the professional institutions, and I repeat the promise already given to Mr. Linton that I shall request the Institution to send him an advance copy.

Yours faithfully,
L. E. Adams.

11, Milner-road,
Kingston-on-Thames.
November 10, 1952.

OBITUARY.

MR. B. A. DUNCAN, O.B.E., WH.EX.

With regret we record the death of Mr. B. A. Duncan, O.B.E., Wh.Ex., which occurred on November 5 at Cheltenham, after a short illness, Bernard Arthur Duncan, who was production director of Dowty Equipment, Limited, Cheltenham, was born at Liverpool on February 21, 1894. He was educated at Caldy Grange grammar school, West Kirby, and after leaving school was apprenticed to Elder, Dempster and Company, Limited. During his apprenticeship he attended the City of Liverpool Toxteth Branch Technical School and the Central Technical School, Liverpool, and in 1913 he won the Sir Edward Harland Scholarship and the City of Liverpool Senior Technical Scholarship. He then entered the University of Liverpool as an engineering student, and in 1914 he became a Whitworth Exhibitioner. During the first World War, he was commissioned in the Royal Engineers, and served in France and Belgium. He was wounded in 1917, and in 1918 was invalided out of the Service. He took his engineering degree at Liverpool University in the summer of 1918. He was then appointed as a technical officer in the experimental and materials section of the Department of Aircraft Production of the Ministry of Munitions. In 1919, he was transferred to the Directorate of Research, Air Ministry. Subsequently, he became assistant designer to A. V. Roe and Company, Limited, Manchester, assistant designer and experimental works manager, Blackburn Aircraft, Limited, Brough; and manager of the experimental department of the Weybridge branch of Vickers-Armstrongs, Limited. In 1942, he was appointed manager of the Chester works of Vickers-Armstrongs, Limited, where he was largely responsible for the high output of Wellington and Lancaster bomber aircraft for the Royal Air Force. He received an O.B.E. for services in the production of military aircraft. He joined Dowty Equipment, Limited, as a director in 1948. He was an associate member of the Institution of Civil Engineers, an associate member of the Institution of Mechanical Engineers, and a Fellow of the Royal Aeronautical Society.

Deferment of North Wales Hydro-Electric Schemes.—The British Electricity Authority announce that, in view of recent restrictions on capital investment, they have decided for the time being to defer the promotion of legislation which would enable them to carry out further hydro-electric development in North Wales. The Maentwrog and Dolgarrog schemes, which were authorised by the North Wales Hydro-Electric Power Act, 1952, however, will not be effected.

Oil Prospecting in the South China Sea.—By the end of this year, the first major submarine oil-drilling operation in the British Commonwealth, from a platform fixed to the sea bed, will be in hand in the South China Sea, about a mile from the coast of British Borneo. Initiated by the Shell oil interests, the plan is to drill wells into the sea bed in an endeavour to find extensions of the Seria oilfield, at present producing 5,000,000 tons of crude oil annually. So far, the under-water extensions of the field have been explored by deviated wells drilled from the land and from platforms erected in shallow water. In the new project, four separate submarine wells will be drilled from a single fixed platform. The foundation of the platform consists of a tubular steel jacket; this was prefabricated in harbour and carried out to a selected location, where it was secured to the sea bed. The technique of drilling four wells from a single platform has been developed to obviate the necessity of building a platform at each separate location. One will be vertical and the other three will be deviated according to requirements, thus enabling a large area of the underlying formations to be tested. To give access to the platform regardless of the state of the sea, an aerial ropeway, linking the drilling platform to the shore, has been constructed. Lifts up to five tons can be carried by the ropeway and a transporter car for personnel has been provided. British Ropeways, Ltd., designed and supplied the ropeway and it was erected at Seria by George Wimpey & Co., Ltd., under the supervision of Shell local staff. The drilling platform, derrick, etc., are in position and it is expected that drilling will soon commence. An Ideal 50 drilling rig, supplied by the Oilwell Equipment Co., will be used.

THE INSTITUTION OF NAVAL ARCHITECTS' AUTUMN MEETING.

(*Continued from page* 605.)

WE continue herewith our report of the autumn meeting of the Institution of Naval Architects, held in Italy from September 25 to October 2, in collaboration with the Associazione di Tecnica Navale. The previous instalment dealt with the second of the five papers presented and discussed in Genoa. The third paper was by Professor E. V. Telfer, Ph.D., on the subject of "Ship-Model Correlation." Professor A. M. Robb occupied the chair.

SHIP-MODEL CORRELATION.

The problem of ship-model correlation, said Dr. Telfer, was a real anxiety to the shipbuilder and the experimenter alike. The introduction of the fully-turbulent model had coincided not only with the widespread adoption of the smooth welded hull, but also with an increasing preference for Diesel-engine propulsion and its associated use of propellers of low pitch-ratio. The smooth hull had "destroyed the fortuitous validity of the Froude frictional coefficients," and the scale effect of the propeller of low pitch-ratio had caused ship propulsive coefficients to be appreciably greater than those previously predicted from the model values. The effect was to produce some rather extraordinary errors in power prediction, and over-estimates of the order of 30 per cent. were not unknown. Such errors were disturbing, and with some British shipbuilders the model experiment had lost caste. To revise the model prediction methods required a correct knowledge of ship and model resistance, and a corresponding knowledge of ship and model shaft horse-power. The first part of the correlation problem arose from the fact that the smooth ship specific resistance was smaller than that of the model at the same Froude number, and involved the correlation of resistance at low and high viscosities; it could be assumed that there did exist some function of the relative viscosity which would linearise the consequent variation of specific frictional resistance. On that basis, Dr. Telfer constructed a relative-velocity extrapolation diagram which reduced "to a single straight line the apparently complex relation existing between a structurally rough ship and its technically smooth model . . . without any separate knowledge of the extrapolator or the viscous roughness."

The second part of the problem, he continued, concerned the comparison of propulsive coefficients. The model had a wide range of propulsive coefficient, depending upon the convention used to interpret it. Current practice at the Teddington tank was to tow the model by the relative differences between the model and the ship resistances and then to determine the propulsive coefficient at the ship point of self-propulsion; but that completely neglected the propulsive scale effect. The major issue was, whether the ship propulsive coefficient should be correlated with the model at the self-propulsion point of the model or of the ship. A useful guide was provided by Dr. van Lammeren's work on geometrically similar models, to various scales, of the Simon Bolivar, as communicated by him to the 1939-40 session of the North East Coast Institution. He showed that, the larger the "geosim," the less was the shaft horse-power required for a given relative effective horse-power. What convention must be adopted to predict the actual shaft horse-power of the full-size ship? Dr. Telfer argued that extrapolation must be through the model point of self-propulsion of each geosim, since only then would the changing conditions of effective horse-power and wake be truly simulated; and it seemed preferable that the extrapolation should be made to the smooth ship, allowance being made later for the roughness and for appendage resistan ce.

DISCUSSION.

Mr. R. W. L. Gawn, O.B.E., who opened the discussion, observed that models were generally tested in a flat calm and still air. Allowance must be made for any departure of the sea and weather conditions on ship trial from those of the laboratory experiment. Despite all the intricacies involved, the propulsive coefficient deduced from model experiments was, in Admiralty practice, about 90 per cent. of that of the ship. General De Vito's paper gave information which led to substantially the same result for liners. The comparatively small difference of 10 per cent. was attributable to the effect of wind and weather on ship trials, together with the uncertainties in predictions for the other items named. The late Sir Amos Ayre, in his paper, presented in 1951, said that a large measure of success had been achieved in predictions for merchant ships, except in a few recent cases. The ensuing discussion showed that there was still much to be learned regarding the effect of artificial turbulence stimulation on the model, and that time would be needed for the necessary correction factors to be evolved. Professor Telfer had painted a picture which seemed more serious than it really was. He referred to over-estimates of the order of 30 per cent. of the ship power. It would be of interest to have confirmation or otherwise of that abnormal discrepancy, and to know the number and type of ships involved.

The method of extrapolation was empirical rather than physical, and therefore the proposals, like other methods of correlation, could be judged only in the light of results. Considerable attention was being devoted in a number of countries to the correlation of ship and model results, and the intensive investigations encouraged the hope that further refinements in methods of prediction, with better understanding of the fundamental physics of the problem, would emerge. Dr. Telfer looked forward to the publication of the results of the Lucy Ashton series of models in this connection; that attitude, of reserving judgment pending the availability of facts, was commendable. Meanwhile, there was the expression which he had called "pseudo-thrust deduction." Perhaps he would advise on whether the resistance term included appendages, and would comment on the fact that the expression would have a significant negative value for some classes of ship, even if the appendage resistance were neglected. His proposal to average the thrust deduction factor over the speed range would appear to be a detraction from accuracy, since, contrary to his statement, model experiments usually indicated a significant change with speed, consistent with theory.

Professor Ing. A. di Bella contended that Dr. Telfer's general expression for a Froude number contour did not satisfy the Nunan-Stokes equations. If, from the three component functions of Nunan and Stokes, the resultant were derived, it was seen that the specific elementary resistance was compounded of wave resistance, frictional resistance, and a third resistance which differed from both. It was impossible to imagine any integration of Dr. Telfer's expression which would affect that, for the integration of a differential equation did not destroy the physical concepts embodied in it. He might assume that the specific eddy resistance was negligible or that it remained the same for the ship as for the model; but was the appendage resistance (which was largely eddy resistance) a negligible quantity? Was not the conviction general that the appendage resistance of the model was proportionately different from that of the ship? Dr. Telfer's equation, in effect, was an application of the formula of Stanton and Pannell for the resistance of water in pipes; but the frictional resistance of a ship differed greatly from that of water in a pipe. Froude's method might be "in the melting pot," but what method should be substituted for it? If it were desired to get rid of an empirical method, it was necessary to have available some method that was founded, in the first place, on a solid theoretical basis, and not merely to pass from one empiricism to another. In spite of that criticism, however, Professor di Bella admitted that Professor Telfer's method was very suggestive and deserved to be studied. Dr. van Lammeren had already undertaken extensive experiments in order to apply it, and it would be a good thing if other tank superintendents were to follow his example.

Dr. J. F. Allan thought that the opening paragraph of the paper was misleading; there was no question of any sudden development having destroyed the validity of the Froude method of calculating frictional resistance, but rather of an increasing appreciation of the true meaning and the shortcomings of the use of that method. Neither was there any question of tank predictions of power being 30 per cent. high; so far as he was concerned, the predictions for all riveted shells were substantially the same as they always had been. Flush construction of the shell reduced the resistance of a ship, but it was only comparatively recently, and on data not yet published, that the full extent of the reduction was becoming evident. Recent carefully measured performances of similar ships showed variations over a wide range, which made it all the more difficult to compare accurately the tank predictions with actual performance. That variation in the performance of ships had been noted in the United States as well as in Britain, and he submitted that Dr. Telfer's statement of 30 per cent. error was more harmful to the general understanding of those matters than helpful to his particular argument. The suggestion that propellers of low pitch ratio influenced ship efficiency because of their greater scale effect raised a point which did not appear to be of great significance; most propellers were still of quite normal pitch ratio. The author had developed his method of ship-model correlation in a series of papers, starting in 1927. The important question was, did it give a true interpretation of the distribution of the various forces involved in ship resistance? Dr. Allan thought not: it was still an empirical analysis. International discussions had indicated a general agreement that departure from existing methods of ship-model prediction could be justified only if a new method gave a good approach to final truth. From the practical point of view, the Froude, Schoenherr and Telfer methods could all be made to yield satisfactory results, but it was not proved that the last method was clearly superior.

When Professor Telfer applied his method to the propulsion problem he was certainly being logical; but he proposed a complete change of approach, and that required justification. Although the solutions proposed appeared to be delightfully simple in use, they were based, as in the case of the resistance analysis, on assumptions and extrapolations which might or might not be justified when more data were obtained. The scale effects in propeller and propulsion factors were small and subject to erratic change, for several reasons; for instance, at the National Physical Laboratory some evidence had been obtained of laminar flow on model propellers in recent research. Another factor was the change of the point of separation of flow in the after body of the model and the ship, and yet another was the roughness effect on the ship and on the ship's screw. It would be very surprising if a simple extrapolation were completely satisfactory in accounting for those complicated factors. The author referred to "the old Teddington practice" of allowing the models to be entirely self-propelled, and argued that it had something natural about it. He also described as "brutal" the method of running the model at a loading corresponding approximately to the ship loading and applying the data obtained to the ship condition. There was just as much "brutality" in the extrapolation method proposed in the paper. It required to be set against carefully measured data, of which the paper contained very few, and for the lack of which the author could not be blamed. Experiments were in progress, however, in several countries.

Dr. Ir. W. P. van Lammeren did not share Professor Telfer's view that the rather extraordinary errors in power prediction recently found were due to the adoption of the smooth welded hull and to the favourable efficiency scale effect of the low pitch-ratio propeller which was associated with Diesel propulsion. There was evidence that most of the ships having smooth welded hulls showed a somewhat smaller, but still normal, allowance on the tank test results. Cases of under-estimation of the actual power had come to his own knowledge. Over-estimates of the order of 30 per cent. had never been found by the Wageningen model basin, the maximum discrepancy being of the order of 15 per cent. That difference might be explained by the fact that, at Wageningen, turbulence-producing devices had been employed as standard for the past 15 years. Another factor which influenced the allowances on tank-test

results was that due to wind and sea. The results of recent tests with a 70-ft. model of a Victory ship (scale 1 : 6) at widely different wind speeds had shown that the effect of wind and steering was of much more importance than was generally accepted. Extra allowances of 10 to 15 per cent. were found, due to relative wind speeds of 8 m. a second, which might explain the discrepancies found in the Netherlands on trials of some ships having smooth welded hulls. In all cases of under-estimation of the power, the weather on trial was extremely good, there being no wind and the sea being absolutely smooth. He agreed with Professor Telfer that it was necessary to overhaul model prediction methods and to start with the examination of the first part of the correlation problem, the scale effect in resistance and self-propulsion factors. The remaining parts of the problem—effects of roughness and of wind and sea—could not be tackled seriously before the problem of scale effect had been solved. He was not sure, however, that the discrepancies in power predictions which had been found on trials were due only to the application of Froude's method; the influence of wind and sea, and consequently of steering, might be of greater importance than that of scale effect.

Although he admired the way in which the author had developed his method for extrapolating the various propulsion components, and could agree with the general expression of his extrapolator, Dr. van Lammeren did not think that the results obtained would be better than those arrived at with other extrapolators so long as the function X has not been fixed. That could be done only with the help of extensive experimental work. The results of the Bolivar geosims were not sufficient and it was hoped, therefore, that, besides the Victory geosim tests now in progress, more geosim tests would be carried out in the near future. Professor Telfer had said that there was definite experimental evidence from geosim research to suggest that the assumption of an equal thrust-deduction factor for ship and model was invalid and that the ship value would be less than that of the model. If that statement were right, as Dr. van Lammeren feared it was, the estimation of the resistance of the ship from the measured propeller thrust would become very complicated. He could not see the general truth of the author's statement that it was a gross assumption to believe that, if a model A of a certain ship type were better than a model B of the same type, the corresponding ships would show the same comparison. It might be so in some particular cases, i.e., when comparing a model having struts with a model having bossings, or when comparing propellers having circular-back sections with propellers having aerofoil sections, which were acting in the sub-critical zone; but, on the other hand, there was a lot of evidence with existing ships that improvements arrived at by model tests were fully realised.

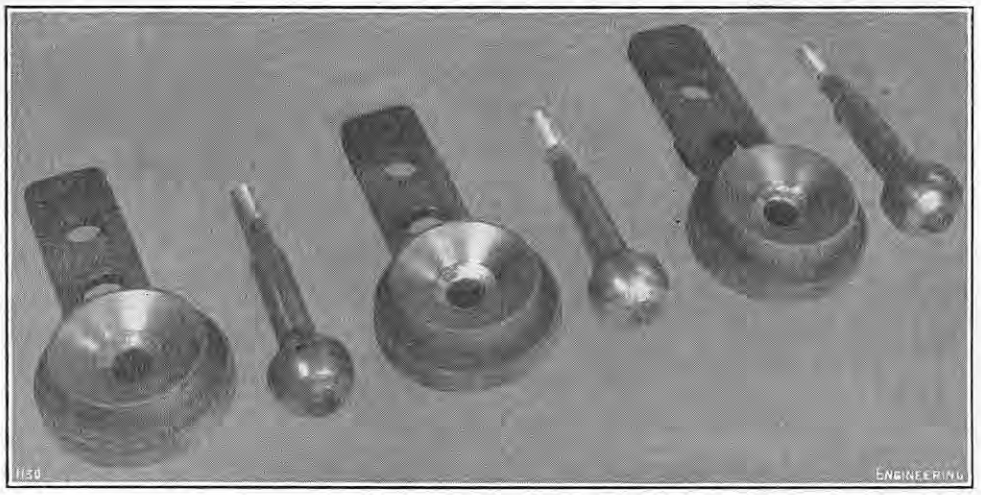
Dr. Ing. G. Castagneto said that, in spite of the dramatic introduction of the paper, he could not believe that Professor Telfer really thought the experimental tank had failed. At the Rome tank, they never had predictions 30 per cent. above the ship results. Thrusts, revolutions and powers were determined from the model experiments to the ship-propulsion stage. The frictional coefficients were Froude's, and there was no allowance for roughness, air resistance, etc.; the estimation of allowances was left to the experience of the builder, and the Italian builders were satisfied with their estimates based on the figures from the model tank. For the same ship on the same trial they might get differences of 5 per cent., and a greater power increase between one double run and another; and for sister ships the differences between the averaged results might exceed 20 per cent. Model-ship correlation was meaningless when confined to a single case; it had to be referred at least to the mean value of all the sister ships. Dr. Telfer reduced the model-ship resistance relationship to a single figure which included also the roughness effect. No simpler result could have been reached, and he asked whether it was possible to fuse into a single figure the two (resistance and propulsive efficiency) extrapolators, since they were based on the same radical scale. It would be interesting to have a direct correlation between model and ship shaft horse-power.

If it were asserted that the extrapolator might differ from hull to hull and that it had to be established in each single case by experimenting with two geosims, no progress had been made. In normal work, no one would test two similar models; neither could the problem be solved even with two geosims of dimensions suitable for experiment in any existing tanks. When the trial results were available by means of such geosims, one could find out all about the extrapolator values and the exponents of Reynolds number that was to be known; it was merely a question of determining by subtraction small differences in large figures. To extrapolate from model to ship the geosims of a size suitable for tank experiments might furnish a lead, but they did not seem sufficient to give the final spot. For that purpose, accurate tests were needed on full-size ships; but to arrive at the results might take a long time.

Dr. Telfer, replying to the discussion, said that most of his experimental friends saw something harmful in the empirics; but the whole of their life's work was purely empirical, and logical empiricism was better than the chaotic empiricism that they were trying to retain. It was merely a question of the adjustment of experience and knowledge in the light of all possible sources of information. He considered that no existing system explained as many facts as simply as did the extrapolator system. It was useless to deny that the errors might be as high as 30 per cent. Some shipbuilders had complained publicly that they had been misled to the extent of having to increase the size of their engines, after the order for them had been placed, because tank experimenters said there was not sufficient power; and then the builders had found that they had much more margin than they expected. He was not considering air resistance; that was easily obtained on trials. Methods of measuring the wind speed and of making a full and correct allowance were available, and there was no need to confuse what was obtainable with that which was not obtainable. In his latest paper to the North East Coast Institution, he had shown that there was a real advantage in having two speed and power trials of a ship, one against the weather and one with it. The model correlation was best done with the weather, because then the disturbances due to possible wind influence were reduced to a minimum. Those general remarks applied to most of the contributions to the discussion. While they might appear to differ on many things, he felt that they did not differ fundamentally. There were difficulties, and they must be faced. He had given one way of doing it and was quite sure that that way would not be entirely disproved. His professional work had obliged him to devote most of his investigations to ships, and he could claim to have a much more comprehensive knowledge of ship behaviour and service performance than the majority of experimenters. He felt sure that the explanation of the differences which he had given would prove eventually to be not only qualitatively, but quantitatively, correct.

(To be continued.)

CIRCUIT-BREAKERS FOR FURNACE CONTROL.



AIR-BLAST CIRCUIT-BREAKERS FOR ARC-FURNACE CONTROL.

Experience with the large number of arc furnaces, built during the war for the production of special steels, showed that the standard oil circuit-breaker was often unsuitable for controlling the high-tension supply under conditions which involved some 500 breaking operations per week, with currents ranging from those required for magnetising the transformers to those due to fairly heavy faults. To overcome this drawback, certain equipments were provided with strengthened bearings and moving parts and others with special oil filters. Careful weekly maintenance, including changing or filtering the oil and dressing the contacts, was also adopted. On the other hand, experience indicated that the air-blast circuit-breaker would be more suitable for this heavy duty, owing to the fact that the arc is drawn in air (a fresh supply of which is provided for each break operation) and that pneumatic control offers the advantages of flexibility and light moving parts.

These points may be supported by reference to the results obtained with an air-blast circuit-breaker, installed by the English Electric Company, Limited, Queens House, Kingsway, London, W.C.2, during the war at the Brymbo steel works, near Wrexham. This circuit-breaker, which had a rupturing capacity of 150 MVA at 6·6 kV, was put into commission early in 1940 and, except for minor initial troubles, has operated without trouble since, although it was out of commission for about two years when the furnace was shut down. After being in continuous use for 13 months, during which time it was operated about 26,000 times, it has recently been stripped down and, as shown in the accompanying illustration, the wear on the contacts was so slight that they have been re-fitted for further use. The pneumatic equipment, including the control and blast valves and the compressor, were also in order and have been returned to service. It may be added that, apart from the weekly external inspection and draining the water from the reservoir of the compressor, no maintenance has been carried out.

Phosphate Coating of Automobile Components.—Leyland Motors, Ltd., have announced that they are making more extensive use of a special phosphate-coating process which, it is claimed, decreases wear of the bearing surfaces of chassis components having precision finishes. The treatment produces a non-metallic absorptive phosphate coating on the components which is hard and yet retains oil for long periods, thus reducing the likelihood of scuffing taking place. Additional components to be treated by the process include gearbox layshafts and the steel pads which take the king-pin thrust in front axles of passenger vehicles and the Comet "90" range of trucks. Operations in the treatment comprise degreasing, a hot-water rinse, submersion in a chemical bath, a further hot rinse and, finally, immersion in oil. The new surface brought about by chemical reaction varies in thickness from 0·0002 in. to 0·0003 in.

TRAINING FOR THE SHIPBUILDING INDUSTRY.*

By Lt.-Col. T. Eustace Smith, T.D.

A very serious position is apparent at the moment in the lack of suitable younger personnel to take up the higher executive positions in our industries. We say that this is due to the result of two major wars and the slump of 1929, but, while this may be true to a large extent, I suggest that it is also due to our not making the possibilities of a career attractive enough to encourage young people of the right sort and with a broad enough education to enter our industries. While some very brilliant leaders have been brought in from the Services to take over some of our major concerns, it seems wrong that we should not be able to fill these positions from within our own ranks. The present apprentice schemes of training may, in many instances, be satisfactory for the training of technicians, but I do suggest that there is room for, and a great necessity for, a higher grade of training. We must be prepared to take on a certain number of specially selected young men, drawn from public schools of good standing, and to give them special attention. To make this attractive, it will be necessary to pay them more than the normal rates of wages during their training. The offering of scholarships for the universities might be of advantage, and the definite promise of adequate pensions would certainly be an added attraction. While the early stages of training may be on similar lines to our existing basis of training, a further period of experience in other yards, and especially in foreign travel, I feel to be essential. There are many good men found through the ordinary courses of training, but as businesses get bigger and more complicated, it is essential to have leaders specially trained, with a broad outlook and wide knowledge which can only be obtained by special training and education. No future slump should be allowed to interfere in our resolve.

There have been many developments in the training of apprentices in the last few years, but I believe there is still much room for improvement. Many of the bigger firms have established their own training schools, some even going so far as to provide their own educational training. Whatever form these schools take, one of the first essentials, I believe, is to give a boy the opportunity of changing his ideas as to what trade he is ultimately going to follow, during this period of training. By carefully watching and analysing the reactions of boys during their early training, provided that it covers all the various trades that are employed in our industry, it can be ascertained very often that a boy may have special aptitudes for some trade entirely different from his first ideas. During the three or four years that we have been running our school, quite a large proportion of boys have changed their ideas after their six months training, and the importance of a boy's starting his career in a trade to which he is most adapted cannot be over-emphasised. Some schools run for six months continuously, some for one day a week for twelve months; again, on the Continent, you will find schools in which apprentices spend their whole training period of three to four years. The intensive training given there enables the apprenticeship period to be cut to three years in many instances. There are many advantages to be obtained from cutting the years of apprenticeship, provided efficiency is maintained. The old idea of cheap labour is over and in many cases five years of apprenticeship is no longer necessary.

We are still experimenting on the best methods of training craftsmen and I would not like to dogmatise on the best methods, but I believe that a great deal more thought and study is necessary if we are going to make this important subject both efficient and attractive to the youths we want to enter our industries. There are two aspects which, I think, also need careful thought. The law is that a boy should be released one day a week for technical training; this has not yet been enforced, but it has been tried by some firms on a voluntary basis. I am not at all satisfied from our own experience that the way this is working at the present time is in the best interests either of industry or of the boys themselves. From an industry point of view, it is upsetting to production to have anyone absent one day a week, whether apprentice, labourer or craftsman, and from the boys' point of view, a day in a different atmosphere and doing something different from the normal is apt to be looked upon as a holiday. One of the greatest difficulties encountered by young boys is the need for concentration and any variation in routine is so easily interpreted as an excuse for not concentrating. Certainly, in our limited experience, the number of failures in day release work is much too great.

It may be that some form of "sanctions" against the boys who will not work might be beneficial, and possibly an improvement in the type of lectures given would help. We must endeavour to find means of making this work better before the law is enforced; otherwise it will be too late. On the other hand, the pre-apprenticeship training colleges set up by the Ministry of Education for boys from 13 to 16 years of age have great possibilities for raising the standard of apprenticeship. At the age of 13, an industrial tendency in a boy's education can be very helpful, and from 15 to 16 I am certain that a boy is much better employed in receiving technical and practical experience, however elementary, than acting as office boy or messenger. These schools are something new and only deal with certain trades, but when fully developed and if guided properly by industrialists, should be of very great value.

One of our greatest difficulties with apprentices at the present time is the need of military service. Even if deferment is accepted and apprenticeship completed, by no means all of these young men return to the industry after their military service. Quite a lot go to sea and may eventually return to us when the desire for a shore job develops, but even then they are lost to the industry for the time being. Other boys decide to join up at 18 and many of these never return to complete their apprenticeship. I hope that eventually some amended form of military service will be evolved—one that may satisfy military demands, and at the same time not interfere so materially with the training of our future craftsmen. It may be possible, when tension in the world lessens or the need for so many men in the armed forces is not so vital, for a boy to spend his first four years in the Territorial Army and then, say, one year or 18 months only with the Regular Army. In this way, from industry's point of view, the boy's apprenticeship could be completed concurrently with his Territorial training, his period of national service could be reduced, and the whole period of military service would thus be completed by the age of 23 to 24. Under the present arrangement, if deferment is granted, he does not complete his national service until he is 27 years old. From the Army point of view, the elements of military training could be taught by the Territorial Army in the first four years and it should be possible to reduce the time of service with the Regular Army without seriously affecting the efficiency of our armed forces.

Another aspect of training schools which we should study is the training schools within the works for adults. In Holland, for instance, any man taken on from outside the industry goes through a school for six months before being put on to his particular job. Not only are shipyard methods taught, but the environment and special conditions for the carrying out of his work, which may vary considerably in a shipyard compared with other industries, are taught him. This school also deals with men who may change from one trade to another and so save them from becoming redundant through changes of practice or variation in the types of ships built. In this country, of course, this would raise big questions with trades-union membership, but the flexibility of labour thus obtained must be of very great value.

We have had a long run of full employment—something that we all desire; but if, with increasing competition (which we are bound to be faced with, if we are to continue with full employment), we must be able to produce at increasingly competitive prices. A lot can be done by modernisation of plant and a good deal has been done, so far as heavy taxation, controls and licences permit. Much can be done by more individual effort, but a lot of this is automatically offset by the desire for shorter hours and longer holidays. Surely there is one aspect which is not being fully explored, and that is the flexibility of labour. The more the demand for labour, the more flexible it must be, and fundamentally it must be wrong that two men should be needed to do the work of one. Unlike other countries, we are far too inclined to stick to old customs and practices and to endeavour to secure work to individual trades, instead of making labour more flexible and carrying out the work with the fewest men and therefore in the most efficient manner. As a nation we are most adaptable and in times of stress, as during the last two wars, we have proved that we are more so than any other nation. In our struggle for better times and full employment and improved standards of living, we should use this flexibility to the full.

* Excerpt from the presidential address to the North-East Coast Institution of Engineers and Shipbuilders, delivered in Newcastle-on-Tyne on October 17, 1952.

GAS-TURBINE OPERATING EXPERIENCE IN THE TANKER "AURIS."

The tanker Auris, which is owned by the Anglo-Saxon Petroleum Company, Limited, Great St. Helen's, London, E.C.3, and is the first merchant vessel in the world to be fitted with a gas turbine, has now completed a year of service with this unit in operation. The Auris, it will be recalled, was built by Messrs. R. and W. Hawthorn, Leslie and Company, Limited, at Hebburn-on-Tyne, and commissioned in 1948. The designer was Mr. John Lamb, O.B.E., head of the Shell Marine Research and Development Department, who envisaged her as an experimental ship in which new developments would be tried out at sea. Such developments included the use of a gas turbine as a propulsion unit. To begin with, therefore, she was fitted with four Diesel engines driving alternators, which were synchronised and supplied current to a single motor driving the propeller. The engine room was designed, however, so that one of the Diesel sets could be replaced by a 1,200-h.p. gas-turbine alternator set, at that time under development by the British Thomson-Houston Company, Limited, Rugby. After some three years of normal service using her Diesel engines, the Auris returned to Hebburn-on-Tyne in August, 1951, for the installation of the gas-turbine unit, which, by that time, had been developed at Rugby and had successfully completed long and arduous trials. Details of the design of the gas turbine and the trials to which it were subjected were given in the issue of Engineering of February 23, 1951 (vol. 171, page 209), and we published a description of the further work carried out at Hebburn-on-Tyne in our issue of January 25, 1952 (vol. 173, page 119).

The Auris left the Tyne for Port Arthur, Texas, U.S.A., immediately after the modifications had been completed, arriving there in November, 1951; the gas turbine was running throughout the voyage, which took 22 days. The vessel has since been employed on normal routine voyages, totalling 52,898 nautical miles. In spite of the fact that the nominal power of the turbine is only slightly more than a quarter of that of the total installed horse-power, it has consistently produced nearly 40 per cent. of the total power delivered to the propeller motor. In March of this year, the vessel made the westward crossing of the Atlantic using the gas-turbine alone, and during this trip ordinary boiler fuel, having a viscosity of 1,500 seconds Redwood at 100 deg. F., was used. The average speed was 7·35 knots and a noticeable feature was the absence of vibration. The turbine has, in fact, proved extraordinarily reliable, there having been no need to carry out any sort of maintenance work while at sea, and in port this work has been limited to comparatively easy operations, such as washing the compressor blading and heat-exchanger surfaces.

During the first four months of service, the high-

pressure turbine casing was lifted three times for routine inspection of the blading, but since March of this year none of the major units has been opened up for any purpose. The consumption of lubricating oil has averaged less than half a gallon per 24 hours operation and the fuel consumption has proved to be about the same as that of a steam turbine. At present, the vessel is out of service for routine overhaul of the engines and hull, and apart from calibration of the instruments it has not been necessary to carry out any repairs to the turbine. If the ship had been propelled by a gas turbine, or gas turbines, alone, all overhauls would have been completed in three days; as it is, it will take three weeks to overhaul the Diesel engines.

The gas turbine installed on the Auris is, as stated, a pioneer unit and much still remains to be learnt. Among the problems still to be solved, for example, are the ultimate life of the turbine blading and the effect of still heavier fuels on the rate at which blade deposits build up. So far, however, the performance of the set gives every indication that the basic marine requirements of reliability and low running and maintenance costs will be met by a unit of this type. There seems to be little doubt that when turbines of greater power are built they will possess the further advantages of lightness and compactness allied with improved economies in fuel consumption. Meanwhile, the basic design of a new type of 18,000 tons deadweight tanker is being prepared. She will be propelled by twin gas turbines developing 8,300 brake horse-power. These will drive alternators, and part of the power generated will be used in port for discharging the cargo and for all auxiliary services.

SUBSTITUTES FOR NICKEL PLATING.

Tests on the resistance to atmospheric corrosion of various substitutes for nickel plating, which is normally used under chromium plating, are being conducted by the British Non-Ferrous Metals Research Association, and the results are expected to be available in a few months time. Owing to the shortage of nickel, it is often difficult, if not impossible, to produce a nickel deposit sufficiently thick to give sound protection. There is therefore intense interest in alternatives to a heavy coating of nickel as an undercoat to chromium plating for ordinary decorative and protective purposes. A number of substitute undercoats have been suggested and many claims have been made for them. For example, white brass (80 per cent. zinc, 20 per cent. copper) and tin bronze (90 per cent. copper, 10 per cent. tin) have been suggested, and satisfactory results have been claimed by chromium plating either directly on a copper deposit or on a heavy copper deposit followed by a thin coating of nickel. Although some of these methods are being used in service, there appears to be little reliable comparative information as to their performance. It is obviously desirable to obtain as soon as possible a sound indication of how these coatings will withstand atmospheric corrosion in service. Unfortunately, because accelerated corrosion tests are unreliable, the only acceptable method is to place a large number of samples in several atmospheric corrosion sites and to average the results.

The British Non-Ferrous Metals Research Association has accordingly instigated a large-scale investigation. Over a thousand sample steel stampings have been plated by various processes by member firms and others. The samples are being exposed at three atmospheric exposure sites, representing marine conditions and two types of industrial area, mild and severe. A further set is being subjected to an accelerated corrosion test for comparison purposes. The thicknesses of plating applied are being checked by means of micro-sections, and the results of the exposure tests will be assessed on a quantitative basis. Each type of plating has been duplicated by two different plating shops, and four samples of the work of each are exposed on every site. Both standard and proprietary solutions have been used. Half the specimens will be regularly cleaned; the remainder will be left untouched. When the results become available they will be communicated to member firms of the Association.

LABOUR NOTES.

Engineering trade-union leaders agreed last Friday to accept the wage offer of 7*s*. 4*d*. a week, equal to an advance of 2*d*. an hour, put forward by the Engineering and Allied Employers' National Federation on October 21. This decision was made at a meeting of the executive council of the Confederation of Shipbuilding and Engineering Unions in London, on Friday, by a majority of thirteen votes to eight. The same resolution also covered the acceptance of the increase of 7*s*. 6*d*. a week offered by the Shipbuilding Employers' Federation for employees in the shipbuilding industry. It is estimated that, in all, some two-and-a-half to three million employees will benefit by these increases, at a cost to the industries concerned of about 40 million pounds a year. They will come into operation immediately. The Confederation originally asked for an increase of 40*s*. a week for all adult male manual employees in the engineering industry and for a "substantial" advance for adult male employees in the shipbuilding and ship-repairing industries. Had these demands been accepted in full, the cost would have been in the region of 300 million pounds per annum.

It is believed that the decision to accept the employers' proposals was only reached after some considerable discussion had taken place, and after the representatives of the more extreme unions had moved the rejection of the offers and the revival of proposals to ban overtime and restrict piecework. It was by the acceptance of an amendment to this motion, put forward by an official of the National Union of General and Municipal Workers, that the final decision to take up the offers was reached. It may be noted that this union, which caters, in the main, for the lowest-paid grades of employees in the industries concerned, has counselled moderation throughout the whole dispute. No doubt the present position of the industries, the increase in international competition, the firmness of the employers, and the view that resort to arbitration would be hardly likely to obtain any advance, played their part in leading the executive council to consider that acceptance of the employers' offers was a wise course.

The meeting of the Confederation's executive council took place immediately after a joint meeting between council representatives and officials of the Shipbuilding Employers' Federation, at which the latter made it clear that no better offer than the 7*s*. 6*d*. a week, previously suggested, would be forthcoming. On the previous day, November 6, there was a joint meeting between leaders of the Confederation and representatives of the Engineering and Allied Employers' National Federation, at which the trade-union leaders sought to secure improvements in the engineering offer of 7*s*. 4*d*. a week. They are understood to have pressed upon the employers the importance of the decisions made at the special delegate conference of the Confederation held in London on the preceding week, when the offers of both sets of employers were considered to be "inadequate," and to have submitted that the engineering offer should be increased to at least 9*s*. 2*d*. a week. The engineering employers' representatives, however, after a short meeting in private, informed the union leaders that the offer could not be increased further.

Wage increases for some 500,000 civil servants are being sought by the staff side of the Civil Service National Whitley Council and a meeting between representatives of the staff side and Treasury officials took place on Wednesday. The leaders of the various civil service unions decided last year to act in concert with respect to any pay claims they might decide to present. They base their present demands on the rise of five points in the Ministry of Labour index of wage rates which occurred during the nine months ended September 30 last. That index measures the movement of wages in occupations outside the Civil Service. It was announced after the joint meeting on Wednesday that the representations of the staff side would be considered and that the decision of the Treasury on the claim would be made known at an early date.

In January this year, civil servants earning a basic salary of up to 500*l*. a year were awarded an increase of 10 per cent. in recognition of a 12 point rise in the official index of wage rates during 1951. Officials in the higher-paid grades of the service were also given increases, but on a lower scale. This concession was estimated to add about 30 million pounds per annum to the Government's wage bill. The staff side of the National Whitley Council anticipates that, as the negotiations proceed, later figures of the index of wage rates will become available and strengthen the case for an increase. It was announced on November 6 that the civil service unions would renew their agitation for equal pay for men and women members of the service. They have, however, declined the suggestion of the Chancellor of the Exchequer that they should discuss with the Treasury the means by which equal pay might be brought about. The staff side of the Council considers that such discussions could have little practical value, in view of the Chancellor's statement that the Government could not be bound by any decisions arrived at as a result of such talks.

A special conference of the National Union of Mineworkers, attended by some 200 delegates from all coalfields in Great Britain, assembled in London on November 7 to discuss wage problems in the industry. It approved the action of the union's national executive committee in accepting the award of the industry's National Reference Tribunal, presided over by Lord Porter, which rejected outright the union's claim for an all-round increase of 30*s*. a week. At the same time, the delegates decided that a new pay claim should be presented to the National Coal Board in respect of the 400,000 day-wage men employed in the industry. This claim was considered at a meeting of the executive committee yesterday and it is probable that it will go before the Board to-day.

The resolution passed by the delegates to the special conference stated that, having regard to the position that revisions in local piece rates become permissible as from November 22, the conference instructed the national executive committee to review the situation, with a view to seeking an increase in wages for all day-wage men, such increase to date from October 27. No decision appears to have been taken as to what increase should be claimed for miners engaged on a time basis. So far as employees on piecework are concerned, it may be recalled that the wage agreement reached at the end of 1951 stipulated that piece rates in the industry were to remain in operation unaltered for a period of twelve months. This terminates on November 22, and it is considered that piecework employees will then be able, in general, to secure new rates of pay by means of their local negotiating machinery.

It was reported at the special delegate conference that some concessions had been made by the National Coal Board regarding payment for the bonus shift, as a result of representations by the union. Under existing arrangements, miners who work five complete shifts in one week are paid for six, but, to earn the bonus, men must work all five, and it has been argued for some time that it was unfair for men to lose the whole of the bonus, as well as a day's pay, when they are prevented from working by unavoidable causes. Under the new arrangements, miners who are absent from work owing to illness, accident, bereavement, or local-government activities will be entitled to a proportion of the bonus-shift payment.

Figures issued by the National Coal Board on Monday last show that the voluntary Saturday shift was not worked at 22 collieries in South Wales and at 49 in Scotland on November 8. The Board also reported that, even at those Scottish pits where the voluntary shift was worked, absenteeism was well above the average. This action was taken by the miners as a protest at the rejection of their recent wage claim and against union advice.

RECONSTRUCTION OF BARRY GRAVING DOCK.

Fig. 1. Partly-Reconstructed Dock in Use.

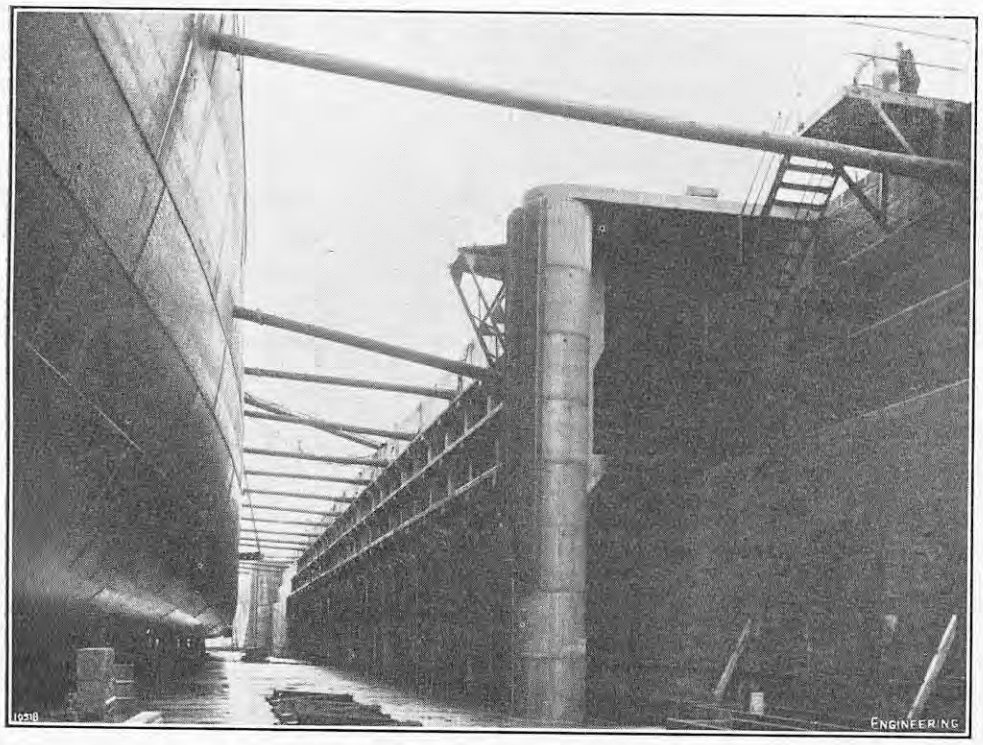


Fig. 2. Ship with Side Shores off the Skeleton Wall.

BARRY COMMERCIAL DRY DOCK.

Barry Docks, South Wales, were constructed in the late 1880's by Mr. (afterwards Sir) John Wolfe Barry, and the port quickly developed a coal export trade second only to that of Cardiff, some seven miles farther east along the Bristol Channel. Three graving docks were provided for the colliers and other shipping using Barry, the third and last to be constructed, completed in February, 1893, being the largest. The renovations made to this dock during 1951 are the subject of the following article, but before describing them it is necessary to give a few notes on the original construction of the dock.

The Dock Prior to 1950.

The graving dock in question was originally built and owned by the Barry Railway Company and lay at the south-eastern corner of the area and close to the lock entrance of the main No. 1 dock. Its construction had been contemplated during the building of the main dock, and a suitable entrance, then temporarily closed by a concrete wall, was left in the main dock wall. The graving dock, when originally constructed, was designed to accommodate four vessels, two side by side in each of the two parts of the dock that were separated by a central gateway which, like the entrance, could be closed by a floating caisson. The floor of the dock was provided with a double line of keel blocks and vessels were docked with a list towards the nearer wall and shored by timber props off that wall only; if necessary, as an additional precaution, bilge props were put in place after the dock had been emptied. Alternatively, one particularly long, narrow vessel could be docked alongside the north-eastern wall by keeping the central gateway open. Access to the inner part was only possible through the outer part of the dock and major repairs were therefore undertaken in the inner section, work in the outer section being restricted to hull cleaning. A dotted outline of the original dock, which had an overall length of 725 ft. and was 113 ft. wide at cope (100 ft. at the floor), is shown in the plan, Fig. 3, on page 642. The main dock at Barry was not tidal, being protected by a lock, and the water was held up to a level of 21 ft. 6 in. above the cill of the graving dock, a facility which has not been affected by the new work. The utility of the dock has been greatly restricted in recent years by the narrowness of the entrance and the gateway, which were only 60 ft. wide at the cope. Both the entrance and the gateway were closed by interchangeable caissons of box-section made from wrought-iron with greenheart meeting faces that bedded on to finely axed granite stones. The top deck of the caissons was planked for traffic and the second, or working deck with the pumps and sluice controls, was iron-plated. Below the second deck the caissons were divided into six compartments into which water could be admitted or discharged by the pump and valve system, and the bottoms of the caissons were packed with cast-iron kentledge.

The construction employed for the dock was typical of its period and the engineers and contractors responsible for the new works have reported that all the old work was still in excellent condition. Excavation had been chiefly in red marl which, when first exposed, seemed suitable for constructional purposes but experience showed that it weathered badly, and the spoil was therefore used only for roadmaking and as filling for embankments elsewhere in the area. Nevertheless, it had been found sufficiently stable for deep trenches to be cut without timbering. The red marl contained many joints and fissures through which salt water issued, and suitable drainage arrangements had therefore to be incorporated under the floor of the dock. The floor was paved with 6 to 1 Portland cement concrete, 2 ft. thick, overlaid with a single course of brickwork, which, after sixty years, showed little sign of deterioration. The inverts of both the entrances were formed by inverted brick arches laid in cement mortar and topped with two courses of Staffordshire blues.

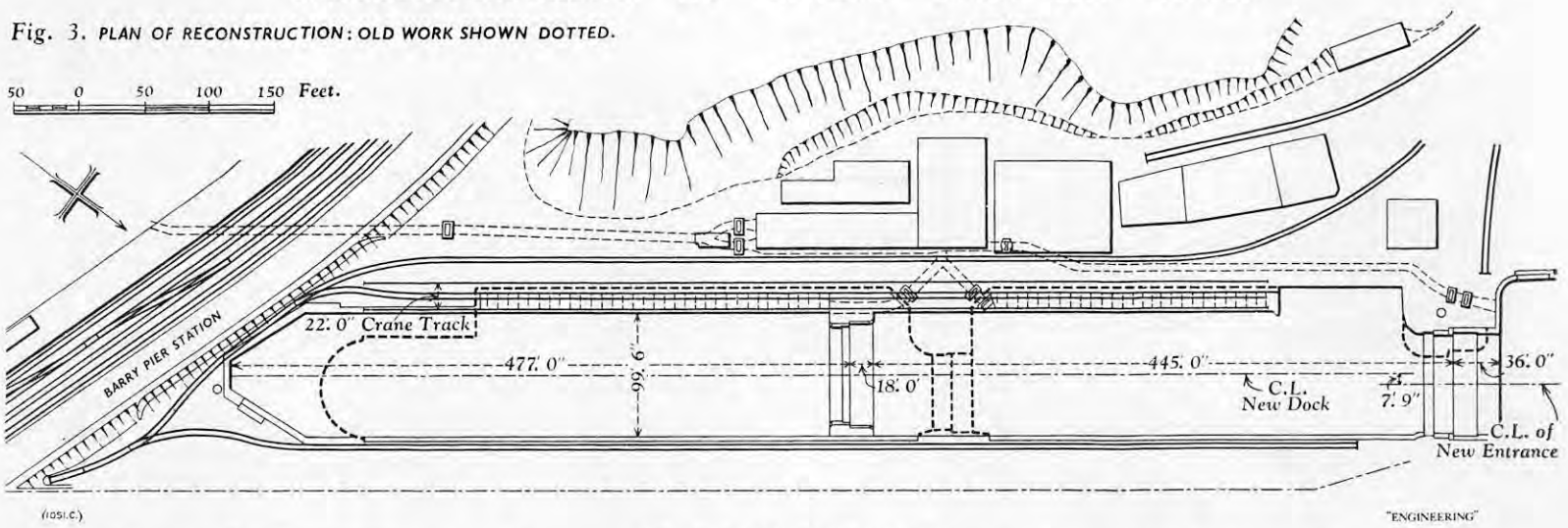
The walls of the dock were built of mountain limestone from the Alps Quarry, some five miles away. The roughly-dressed face-stones were squared, but were not laid in courses, although they were laid with close beds and joints for 6 in., lipped with Portland cement mortar for 3 in. in from the face. The remainder of the wall stones were set in blue-lias lime mortar with 3½ ft. long headers laid through from back to front. Granite cope and altar stones, each 2 ft. by 9 in. in cross-section, completed the construction of the walls, which were 32½ ft. high from floor to cope. Despite this massive section, the walls were not intended to resist water pressure from behind, due to seawater seeping through the fissured marl; they were therefore provided with wrought-iron drainage pipes, originally fitted with brass flap-valves at the face, that prevented back-flow when the dock was full.

At some date after the original construction of the graving-dock, the inner section was extended a further 120 ft. and completed by a circular end wall of rather fine appearance. The back of this circular end wall butted against an older masonry cross-wall that had apparently been built as a dam to exclude the sea-water from the site of the original graving dock.

When the graving dock was taken over by the British Transport Commission under the Transport Act of 1947, the Docks and Inland Waterways Executive, who were responsible to the Commission for the operation of the dock, gave immediate consideration to the work required to bring it up to date. In 1950, therefore, the dock was leased to the old-established firm of C. H. Bailey, Limited, ship repairers, of Barry, Cardiff and Newport, on condition that they put in hand the necessary renovations. This has been done and, in future, the dock will be known as Bailey's Dry Dock, Barry. A general view of the dock is given in Fig. 8, Plate L. Immediate use was made of the new facilities, the first vessel being docked before the quay installations were complete, as may be seen in Fig. 1, on this page.

RECONSTRUCTION OF BARRY GRAVING DOCK.

Fig. 3. PLAN OF RECONSTRUCTION: OLD WORK SHOWN DOTTED.



Work of Reconstruction.

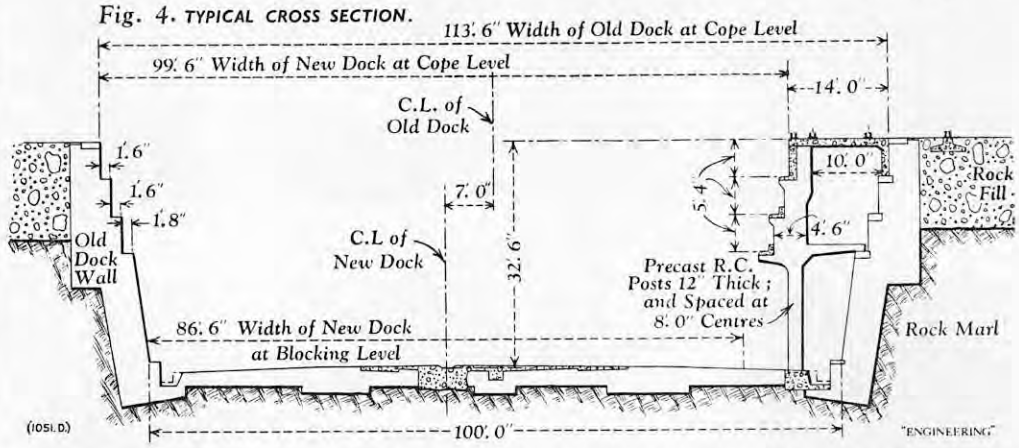
The object of the work of reconstruction was to alter the dock so that it could conveniently accommodate two modern cargo vessels at the same time, or, by using the two divisions of the dock as one, to take the largest vessel that is able to use the port. The principal alterations consisted of widening the entrance of the dock to 78 ft. 6 in., re-siting and widening the inner gateway to a like width, and lengthening the dock to 940 ft., as shown in Fig. 3. Simultaneously, the overall width of the dock has been reduced to 99 ft. 6 in. at cope level, by the erection of a reinforced-concrete skeleton framework which saved the expense of considerable filling that would otherwise have been required, as shown in the cross-section, Fig. 4. The widening of the entrance and middle gateway has meant the construction of two new floating caissons, and the fairly extensive re-location of the original culverts. In addition, the dock has been fully equipped with modern ship-repairing appliances, and new workshops and offices have been erected alongside. In order to undertake the work of remodelling the entrance, shown in progress in Fig. 9, on Plate L, a floating dam, sufficiently wide to seal-off the dry dock during this phase of the reconstruction, was lent to the contractors by the Docks and Inland Waterways Executive. The mouth of the re-located discharge culvert was constructed in the basin wall behind a specially-designed limpet dam. Two aspects of the work of renovation are worthy of particular note; the reinforced-concrete framework used to reduce the width of the dock, and the new floating caissons.

Reinforced-Concrete Skeleton Framework.

In order to reduce the excessive width of the dock, originally intended for two vessels to be berthed side by side, to a figure more convenient for a single modern ship, a reinforced-concrete skeleton framework was erected along the greater part of the length of the south-west wall of the existing dock. The basis of the framework was the large reinforced-concrete altar posts, sited at 8 ft. centres. The back-tie was anchored to the lowest altar of the existing wall and the front laps of the posts received the pre-cast reinforced-concrete beams that serve as altars in the new dock. Some of the posts already in position and ready to receive the altar beams are shown in the photograph reproduced in Fig. 6, opposite.

This method of reconstruction had many advantages over the alternative of solid masonry: it was erected more quickly and cheaply than would have otherwise been the case and at the same time space was left behind the framework for cables, services, stairways and the widened drainage channels. The posts, which weighed nearly seven tons each, were cast in stacks on the floor of the dock, as shown in Fig. 5, while the work of reconstruction was in progress. The framework is surmounted by a heavy reinforced-concrete slab which supports the rails for a 5-ton crane intended for light service and transport. The outer twin rail for a 25-ton monotower crane (built by Butters Brothers, Limited, Glasgow) is located over the centre line of the posts, while the other rail is mounted on a foundation beam constructed behind the old wall. The headroom under the portal of the larger crane is sufficient for the small crane, with lowered jib, to pass through, so that both cranes may work along the length of the dock without interfering with each other. A ship with side shores in position off the new skeleton wall is shown in Fig. 2, page 641.

Fig. 4. TYPICAL CROSS SECTION.



New Caissons.

The new caissons also showed some marked differences from usual practice. Many of the difficulties associated with conventional design were avoided by the expedients adopted, which, in particular, permitted the erection of the caissons to be undertaken in the graving dock by the general civil engineering contractor while the other work proceeded alongside, as may be seen in Fig. 5, opposite.

The new caissons, each weighing about 660 tons, are composite assemblies having an outer skin of structural steelwork, decks and vertical corner beams of reinforced concrete, with pig-iron kentledge in the concrete base. Greenheart is used for the timber meeting faces, elm for the fenders, and the top decks are planked with oak. A typical cross-section is shown in Fig. 7, opposite. The overall dimensions are 81 ft. 2 in. long, 16 ft. wide, and height, to the top of the kerbs, 35 ft. 6 in. The walls of the caisson are built from 12 in. by 3½ in. by 26·37 lb. rolled-steel channels pre-fabricated into panels, each 6 ft. wide by 34 ft. 9 in. high, by Messrs. Redpath, Brown and Company, Limited, Glasgow; the flanges of adjacent channels were riveted together with their webs reversed, so that the panels resemble steel trough flooring. Fig. 10, Plate L, shows one of the caissons during erection. The vertical joints between successive panels were made by site-bolted connections with a waterproofing insertion between the flanges. To ease the difficulties of manœuvring the caissons into their working position, the leading edges of the end walls are set out-of-plumb, and the end walls themselves, although vertical, are set at an angle to the back and front walls. The corner junction at the leading edge has therefore been made from a ½-in. mild-steel plate of about 7 ft. girth, bent to the required profile and bolted to the adjacent pre-fabricated panels. The base slab, as shown in Fig. 7, is of reinforced concrete, 2 ft. 6 in. thick, and two further reinforced-concrete decks, working as beams, serve to further strengthen the box-shape of the caisson. Angle tie frames in the flooding chamber maintain the top of the box in true shape. The top deck is supported by 12 in. by 6 in. rolled-steel cross-beams at 3-ft. centres and is planked with oak.

Scuttle tanks are provided in the lower compartment of the caissons of sufficient capacity, when filled, to cause the caissons to float approximately one foot lower in the water, thus submerging the ports of the flooding chambers, through which water enters, causing the caissons to sink until they land upon the bearer stones across the entrance. These open ports in the upper flooding chamber enable the water to rise and fall inside the caisson with changes in water level behind the gate. Two sluice trunks, of ½-in. mild-steel plate and of 3 ft. 1 in. by 2 ft. 3 in. clear section, through the lower half of the caisson, provide the means for flooding the dock.

The design and supervision of the constructional work were carried out by Messrs. Maunsell, Posford and Pavry, as consulting engineers to the lessees, C. H. Bailey, Limited. The civil-engineering contractors for the whole of the remodelling work, including the construction of the new caissons, were John Howard and Company, Limited, Buckingham Gate, London, S.W.1; McLeod and Company, Limited, Cornish granite masters, undertook the masonry work on behalf of the main contractors.

Chemical Engineering Scholarships.—The Anglo-Saxon Petroleum Company have informed University College, London, that they intend to give the College 2,700*l.* annually for the provision of scholarships in chemical engineering and of apparatus for use in the study of chemical engineering in the Ramsay Memorial Laboratory.

RECONSTRUCTION OF BARRY GRAVING DOCK.

(*For Description, see Page* 641.)

FIG. 8. DOCK IN USE.

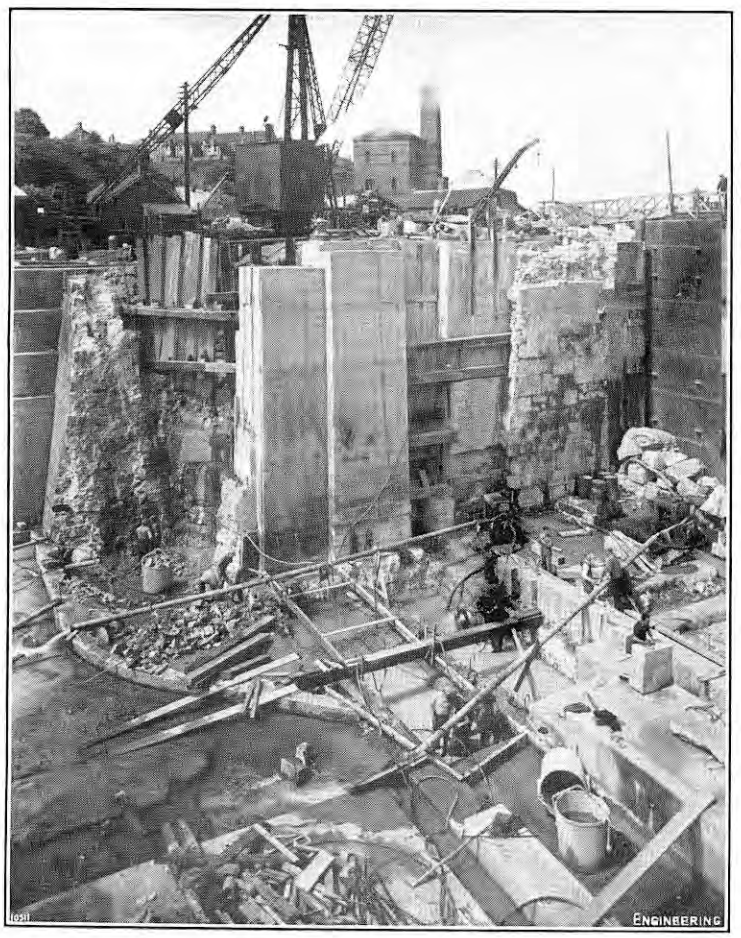


FIG. 9. REMODELLING ENTRANCE.

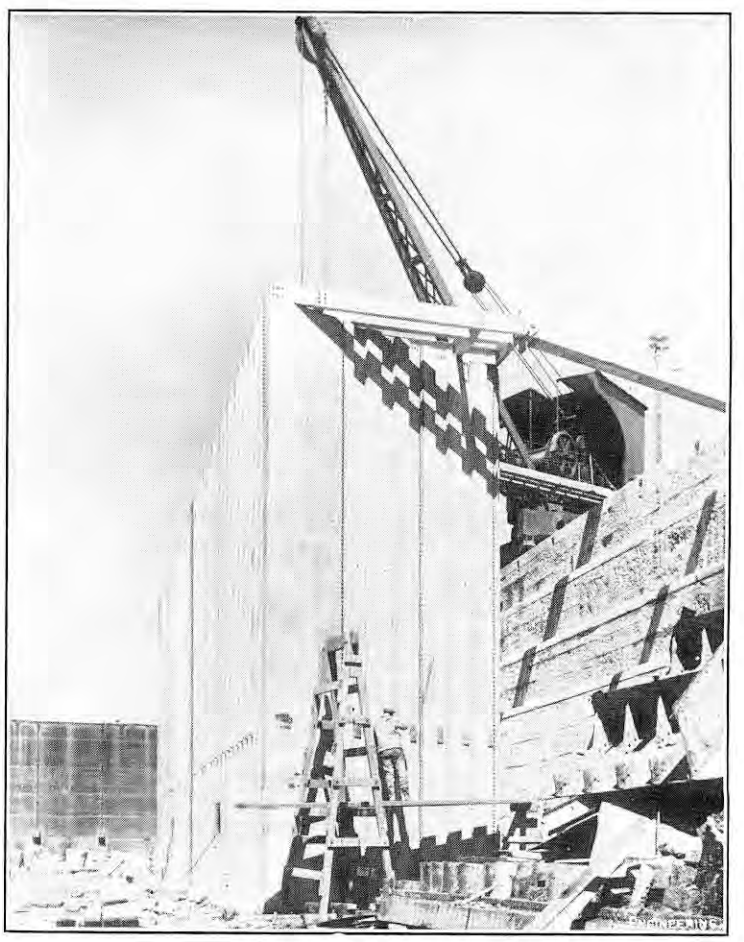


FIG. 10. CONSTRUCTION OF NEW CAISSON.

RECONSTRUCTION OF BARRY GRAVING DOCK.

(*For Description, see Opposite Page.*)

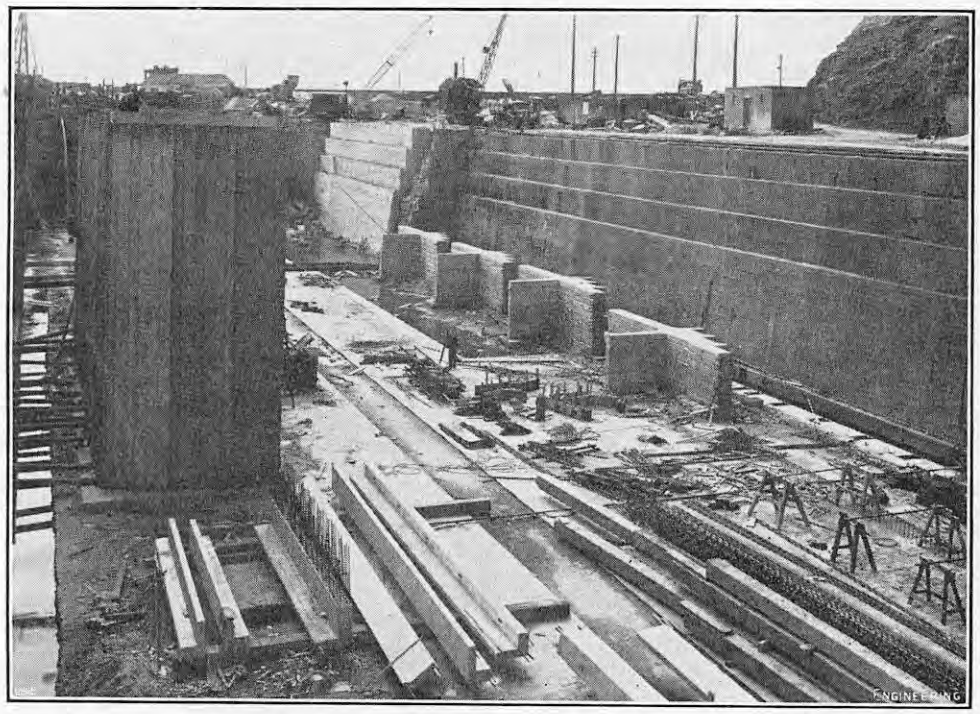


FIG. 5. INTERIOR OF DOCK DURING RECONSTRUCTION.

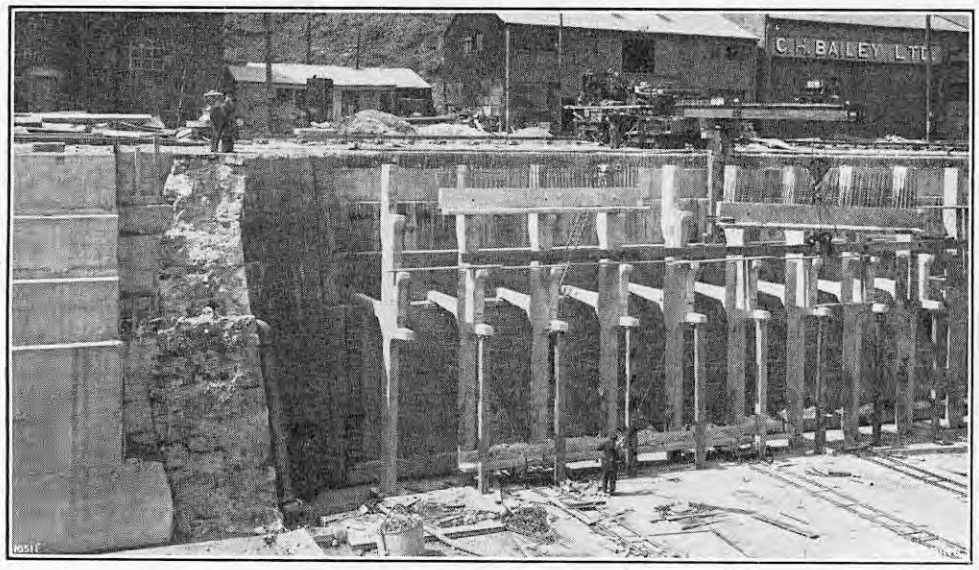
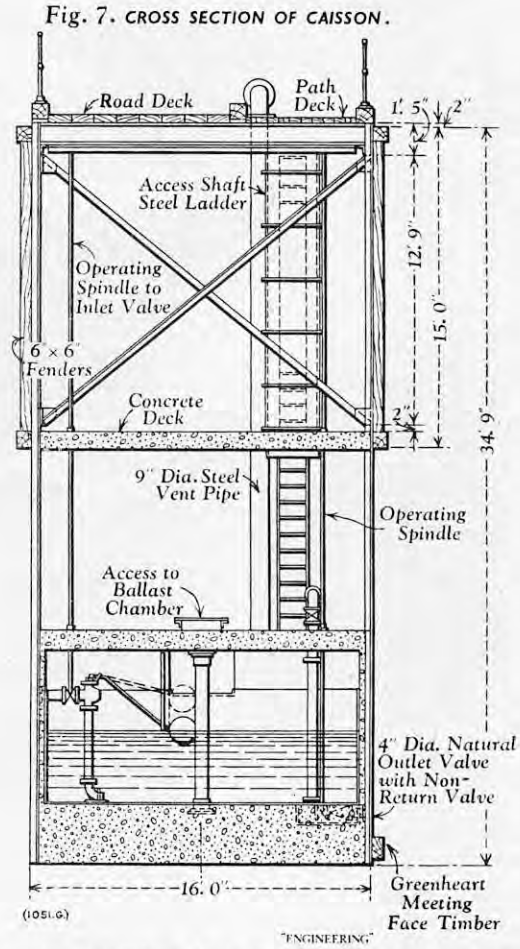


FIG. 6. ERECTING SKELETON WALL.

Fig. 7. CROSS SECTION OF CAISSON.



RESEARCH ON CAST IRON.

WORK on the production of nodular cast irons in the laboratories and shops of the British Cast Iron Research Association, at Alvechurch, Birmingham, is now mainly concerned with such matters as the study of the influence of various elements on the nodulising process and improvements in manufacturing technique. The use of cerium for the production of nodular structures in cast irons, in the as-cast condition, was originated some five or six years ago by the Association and the material so produced, which possesses greatly enhanced mechanical properties, is covered by a series of British and foreign patents. It is stated in the Association's annual report for the year ended June 30, 1952, that the harmful effects of titanium, lead, antimony, bismuth, aluminium and copper in irons in which additions of magnesium have been made to produce a nodular structure have been studied. It may be mentioned, in passing, that the process for the production of nodular cast irons by making additions of magnesium to the molten metal, shortly before casting, was the subject of a United States patent application by Messrs. K. D. Millis, A. P. Gagnebin, and N. B. Pilling in October, 1949. The report states that it has been found that titanium and the other metals enumerated above can partly or completely prevent the addition of magnesium from having the desired nodulising effect. As the result of work carried out at Alvechurch, however, it has been shown that the "subversive" effects of these elements can be completely neutralised by the addition of approximately 0·005 per cent. of cerium. The study of the influence of other interfering elements and the neutralisation of the effects of subversive elements by other rare earths is in hand. Moreover, to meet the requirements of the work on nodular cast irons, chemical methods for the determination of very small amounts of lead, antimony and bismuth in cast iron have been developed.

Work on the determination of gaseous elements, and their influence in cast iron has been continued. A satisfactory molten-metal sampling technique, for subsequent vacuum-fusion determination, has been developed. Field tests carried out in industrial foundries have shown that the oxygen and nitrogen contents of irons vary considerably from plant to plant. Some preliminary data on the influence of nitrogen in cast iron have been obtained and the factors influencing the solubility of oxygen in cast iron have been studied.

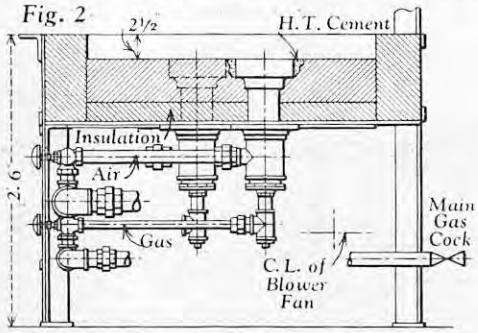
For work on mechanical properties, six fatigue testing machines have been constructed in the Association's workshop and are now in use to study the influence of silicon content on the notch-sensitivity of nodular cast iron. An extensive investigation of the impact properties of various types of cast iron is also in hand. During the twelve months covered by the report a new sand laboratory has been built and occupied. Work on the standardisation of a shatter test for foundry-sand control is proceeding, and further investigations have been carried out on synthetic bonding resins. New resins have been tested for strength, gas content and stripping qualities and the brittleness of cores bonded with synthetic resins has also been studied. An investigation has been conducted on a new method for the rapid mechanical analysis of sand. Further work on the Association's research programme relates to studies of factors influencing chill depth and soundness in iron castings, the nature and character of dust in foundry atmospheres, and other matters.

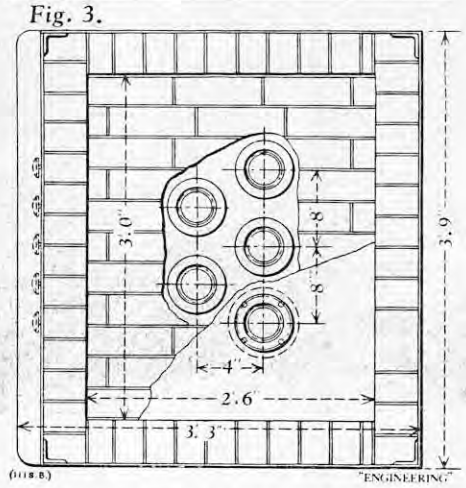
DIESEL FUEL FOR NAVAL AIRCRAFT.—In a recent issue of the *Weekly News Letter* from the Society of British Aircraft Constructors, it is announced that successful flying trials have been carried out, without modification, on the Fairey Gannet anti-submarine aircraft using ship's Diesel fuel, as used by the Royal Navy for driving generating plant and auxiliary engines on aircraft carriers. The Gannet, it may be recalled, is powered by a Double Mamba propeller-turbine engine constructed by Armstrong-Siddeley Motors Ltd., Coventry. It is believed that this is the first time that a British military aircraft has flown on Diesel fuel.

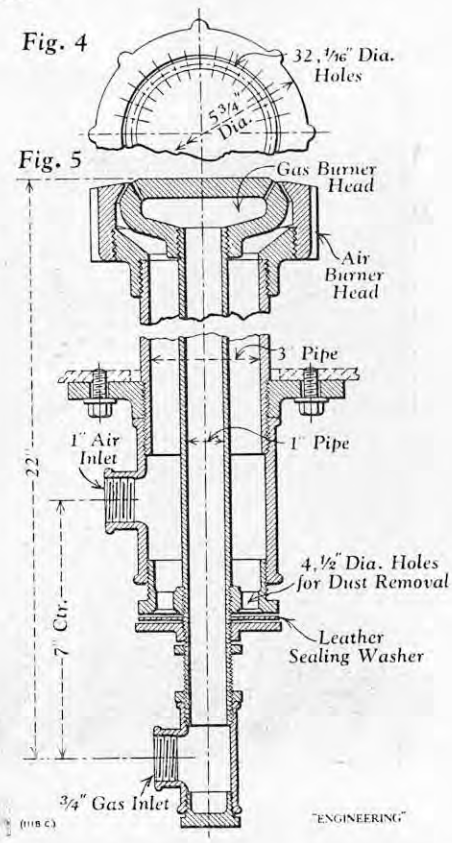
OFFICE EQUIPMENT.—Office equipment with some ingenious features of design is displayed in a small exhibition at the showrooms of Randall Products Metal Shelving (Industrial), Ltd., 106, Victoria-street, London, S.W.1. The range of filing cabinets includes one for the personal use of senior staff which opens by means of a lid at the top, revealing groups of suspended files of quarto or foolscap size or both. A cupboard with shelves and sliding doors is provided underneath. The full range of equipment covers filing, storage, library and sound-recording needs, as well as fittings for holding record cards. The various equipments are built largely of a number of standard units.

GAS-FIRED PIPE-BENDING HEARTH.

Fig. 1.







GAS-FIRED PIPE-BENDING HEARTH.

THE gas-fired pipe-bending hearth shown in Fig. 1 has been designed by the Industrial Department of the Liverpool Undertaking of the North Western Gas Board, and constructed by the Dowson and Mason Gas Plant Company, Limited, Manchester, for the workshops opened recently by the Liverpool Education Authority at the city's College of Building. It is suitable for bending pipes up to 4 in. in diameter. Hitherto, coke-fired hearths have been used for pipe-bending, but since there was no storage space available for solid fuel in the new building, and in order to avoid the handling problems involved, the Education Authority decided that a gas-fired hearth, simulating the conditions that would be encountered in practice in a coke-fired hearth, would be more suitable.

It was decided that the hearth should consist of a bed of broken refractory heated by a number of burners. The primary requirements were, firstly, to produce a temperature equivalent to that obtained in a coke-fired hearth of similar size; secondly, to provide an even heat distribution throughout the bed of refractory; and thirdly, to provide an adequate area of heated bed. Experiments showed that the only type of burner that would satisfy the conditions was one in which gas from a ring of jets directed outwards and upwards at an angle of about 45 deg. was surrounded by a larger diameter ring of air jets facing inwards and upwards. The gas and air streams meet in the refractory bed about ¼ in. above the burner head. A burner head of this type was designed with a gas rate of 200 to 220 cub. ft. per hour per burner, with air at a pressure of 6-in. water gauge, and tests were carried out to determine the area of refractory bed heated by one burner. From these tests, it was concluded that five such burners would be required for the hearth, arranged as in Figs. 2 and 3. The laboratory tests were carried out on broken firebrick, but broken "Aloxite" refractory was selected for the hearth, since it would be less likely to fuse in the presence of scale, and would also withstand raking.

When the hearth was first put into operation, it was found that the time taken to heat up the Aloxite bed was much longer, and it was not evenly heated. The trouble was cured by using larger burner heads, of heat-resisting cast iron, shown in Figs. 4 and 5. In this burner, gas is supplied to the centre mushroom head, which is centralised by ribs in the outer casting, forming an annulus through which air is supplied. The burner head is turned and screwed in one setting of the lathe, to ensure a concentric annulus giving an even flow of air and an undistorted flame.

As may be seen in Fig. 1, all the gas and air controls are grouped on a panel at the front of the hearth. The fan and all the connections are housed under the hearth. The burners are set in the well of the hearth with refractory cement and they are arranged, as shown in Fig. 3, so that any number can be operated, to suit the size and shape of the pipe to be bent. The gas and air pipes to the burner heads are provided with arrangements for removing small particles of refractory falling through the ports. The well is constructed of firebrick, supported on an angle-iron frame and backed by insulating material. It is enclosed in a strong mild-steel casing with removable side panels, and is filled to a depth of 6 in. to 7 in. with Aloxite lumps.

The blower fan, which delivers 100 cub. ft. of air per minute at a pressure of 5-in. water gauge at the burners, is driven by a ½-h.p. electric motor. The air and gas supplies to the burners are controlled by radiator-type globe valves. A shut-off cock and a back-pressure valve are provided in the gas inlet line; no governor is fitted. The products of combustion are extracted through 12-in. diameter trunking by an electrically-driven fan with a capacity of 2,350 cub. ft. per minute, giving an upward velocity of about 110 ft. per minute at the underside of the hood.

Some of the results of performance tests on the hearth are as follows. It required 53 minutes to reach working temperature when starting from cold, and in doing so consumed 470 cub. ft. of gas, at an average rate of 530 cub. ft. per hour. During heating up and standby periods, a ¼-in. plate is laid on top of the refractory to minimise heat losses. After warming up, a 2-in. diameter sand-filled pipe required 12 minutes to reach bending temperature and a hollow 2-in. diameter pipe attained bending temperature in 6 minutes. The corresponding periods for 1-in. diameter pipes were 5 and 3½ minutes. Several pipes can be heated simultaneously, if required. The length of straight pipe raised to bending temperature is 10 in. to 12 in. on the rear row of burners, and 5 in. to 6 in. on the front row.

This description of the hearth is based on report No. 512/52 of the Industrial Gas Development Committee of the Gas Council, compiled from information supplied by the Liverpool Group of the North Western Gas Board.

LAUNCHES AND TRIAL TRIPS.

S.S. "BOHEME."—Single-screw cargo vessel, with accommodation for three passengers, built by Bartram and Sons, Ltd., Sunderland, for Rederi A/B Wallenco, Stockholm, Sweden. First vessel of two. Main dimensions: 445 ft. between perpendiculars by 62 ft. by 40 ft. 2 in.; deadweight capacity, about 10,300 tons on a draught of 27 ft. Triple-expansion reheat reciprocating steam engine, developing 3,900 i.h.p. in service, and three multitubular oil-burning boilers, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Sunderland. Speed, 12½ knots. Launch, September 3.

M.S. "CORBRAE."—Single-screw collier, built by the Burntisland Shipbuilding Co., Ltd., Burntisland, Fife, for William Cory and Son, Ltd., London, E.C.3. Main dimensions: 271 ft. 6 in. overall by 39 ft. 3 in. by 18 ft. 11 in.; deadweight capacity, 2,760 tons on a draught of 17 ft. 6½ in.; gross tonnage, 2,002. Eight-cylinder Diesel engine, developing 1,050 b.h.p., constructed by British Polar Engines, Ltd., Glasgow. Speed, 11 knots. Trial trip, September 22.

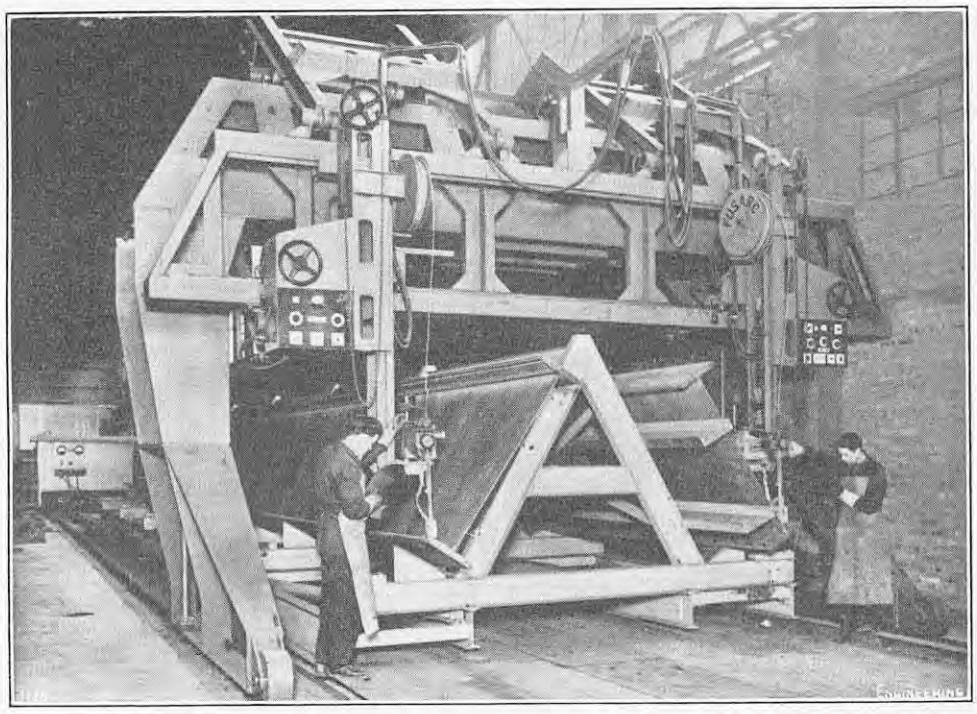
M.S. "WINDSOR."—Single-screw cargo vessel, built and engined by Barclay, Curle & Co., Ltd., Whiteinch, Glasgow, for the Britain Steamship Co. Ltd. (Managers: Watts, Watts & Co., Ltd.), London, E.C.2. Main dimensions: 465 ft. overall by 58 ft. 6 in. by 38 ft.; gross tonnage, 7,530; deadweight capacity, about 9,950 tons on a mean draught of 27 ft. Barclay Curle-Doxford four-cylinder airless-injection heavy-oil engine, developing 4,400 b.h.p. at 115 r.p.m. in service. Speed, 13 knots. Trial trip, September 25.

M.S. "MERCHANT KNIGHT."—Single-screw oil tanker, built by Sir James Laing & Sons, Ltd., Sunderland, for the Drake Shipping Co., Ltd., London, E.C.3. Main dimensions: 475 ft. between perpendiculars by 67 ft. 4½ in. by 37 ft. 4 in.; deadweight capacity, about 15,330 tons on a summer draught of 29 ft. 1 in. Hawthorn-Doxford four-cylinder opposed-piston oil engine, constructed by R. and W. Hawthorn, Leslie & Co., Ltd., Newcastle-upon-Tyne, and installed by William Doxford & Sons, Ltd., Sunderland. Service speed, 12½ knots. Trial trip, September 25 and 26.

M.S. "MARICOPA."—Single-screw oil tanker, built by Sir James Laing and Sons, Ltd., Sunderland, for Thorvald Berg, Tonsberg, Norway. Main dimensions: 490 ft. between perpendiculars by 69 ft. 6 in. by 40 ft. 6 in.; deadweight capacity, about 17,400 tons on a summer draught of 30 ft. 11 in. Five-cylinder opposed-piston oil engine, constructed by William Doxford and Sons, Ltd., Sunderland. Speed, 13¾ knots. Launch, October 20.

ARC-WELDING MACHINE FOR STEEL GIRDERS.

FUSARC, LIMITED, GATESHEAD-ON-TYNE.



ARC-WELDING MACHINE FOR STEEL GIRDERS.

The portal type automatic arc-welding machine shown in the accompanying illustration was built by Fusarc, Limited, Team Valley, Gateshead-on-Tyne, 11, and has been installed in the Motherwell works of Messrs. Alexander Findlay and Company, Limited. It has been designed for welding prefabricated H-type and box-section girders up to 100 ft. in length, and is used for the production of girders of this type that are required for the construction of several new power stations. The work shown in the machine illustrated is a 60-ft. girder which has been fabricated from two doubler sections. These sections comprise two $\frac{3}{4}$-in. plates $14\frac{1}{2}$ in. and $12\frac{1}{2}$ in. wide and fillet-welded, the web being of 5 ft. by $\frac{1}{2}$ in. section. The welding current used was 580 amperes, the $\frac{3}{8}$-in. doubler fillets being treated at 12 in. per minute, and the $\frac{5}{16}$ in. web fillets at 14 in. per minute.

The machine carries two welding heads, which can be operated independently and are supported on vertical slides so that adjustments can be made. These slides are fitted on carriages which can be traversed by hand over the whole width of the supporting booms, a distance of 14 ft. This traverse could also be operated electrically at speeds ranging from 7 in. to 28 in. per minute. The height of the boom supporting the cross-traverse is adjustable, the necessary operation being effected by an electric motor. In this way, a vertical operating height of between 1 ft. and 11 ft. is obtainable in conjunction with the head slides. The main structure can also be traversed longitudinally, the electric drive for this purpose giving speeds of 16 ft. per minute for locating, and of between 7 in. and 28 in. per minute for welding. Within this range, the speed is infinitely variable.

Although the machine has been designed for any straight-line or rectangular work within the present limits of 100 ft. by 14 ft. floor space, the range could be extended by lengthening the supporting rails and adding roller bases or tilting turntables.

Completion of H.M. Destroyer "Duchess."—The third of the Daring class of destroyers, H.M.S. Duchess, has now been completed and is expected to join the Home Fleet. She was built by John I. Thornycroft & Co., Ltd., Woolston, Southampton, who also constructed the geared steam turbines by which she is propelled. The vessel, which was launched on April 9, has an overall length of 390 ft., a beam of 43 ft., and a maximum draught of 12 ft. 6 in. Her armament comprises six 4·5-in. guns, six smaller guns, and two "pentad" torpedo tubes mounted on deck.

UTILISATION OF SOLAR ENERGY.*

(*Continued from page* 608.)

Power.

Owing to the intermittency of the supply, the direct use of solar energy for driving engines need not be considered for large power plants. There is, however, a number of purposes for which intermittent power as low as 1 kW would be useful. In particular, the economy of the Indian village might be profoundly affected by the availability of such prime movers for water pumping. Their use for driving the small looms employed in cottage industries has been suggested, but the intermittency of the supply makes it doubtful if they would be acceptable for this purpose.

As a basis of calculation we assume that 1 kW of power is required during the hot weather in India. The optimum temperature for running a small steam, vapour or hot-air engine would probably be about 200 deg. C. A temperature higher than this would reduce the efficiency of collection and a lower temperature would reduce the efficiency of the engine. The efficiency of collection at such a temperature would not exceed 50 per cent., and to attain this figure at 200 deg. C. a mirror collector would be required. The limit of efficiency set by the laws of thermodynamics for an engine working between 20 deg. and 200 deg. C. would be 38 per cent. Mechanical and irreversible thermal losses would reduce this to about 14 per cent. With these efficiencies (Table II) an average of 0·056 kW of useful power per square metre during the part of the day when the sun was shining brightly would be obtained. For a power of 1 kW the area required would be 18 sq. m. The efficiencies assumed are somewhat optimistic, but even so the area of mirror required is so large as to make the scheme too expensive for use in peasant agriculture. This conclusion might be modified if a suitable flat-plate collector could be developed, though it would then be necessary to work at a lower temperature with a corresponding loss in engine efficiency and increase in area.

Table II.—*Production of Power.*

—	Per Cent.	kW Per Square Metre.
Solar constant	100	1·3
At earth's surface (average for bright sunlight in tropics)	62	0·80
Heat collected	31	0·40
Converted to mechanical energy	4·3	0·056

The pumping of water from bores requires more power than the pumping of water from canals or rivers. The average connected load for over 2,000 State-operated wells in the United Provinces is 10 kW per well, and this load is used to about 40 per cent. of capacity.[12] The use of solar engines to supply this would require impracticably large collectors. We are thus regretfully forced to the conclusion that orthodox heat engines driven directly by solar power are not an immediate practicable proposition. We have also considered the possibilities of the direct generation of electricity by solar power without first converting it to mechanical energy. There are three known ways of doing this: by the thermoelectric effect, by a photovoltaic cell and by the photogalvanic effect.

The thermoelectric effect has been discussed by G. Geiling[13] and by D. Gabor.[14] With existing materials the efficiency of the conversion of absorbed heat into electric power is about a quarter of the thermodynamic efficiency, or rather less than that of a small steam engine working between the same temperatures. This might be raised somewhat by the production of improved thermoelectric materials, but it seems unlikely that the scheme could be made substantially more efficient than the steam engine. It has other disadvantages. With a temperature difference of 200 deg. C., and the very high thermoelectric power of 4×10^{-4} volts per degree C., 250 junctions would be required to produce 20 volts, of which only 10 volts would appear in the external circuit. If a power of 1 kW is required, these 250 junctions must have a resistance of less than 0·1 ohm. The equipment will clearly be of considerable complexity and a large bulk of relatively expensive materials will be needed. A serious practical difficulty would be the disposal of the large amount of unused heat.

The efficiency of photovoltaic cells is determined by the quantum yield, i.e., the number of electrons liberated per quantum absorbed, and by the fraction of the energy of the quantum which is converted into energy of the electron. Both these can be quite high in certain parts of the spectrum. Selenium is the most favourable of known materials and gives a quantum yield of up to 75 per cent.[15] The fraction of the energy of the quantum converted may be as high as 15 per cent. Of the power produced, only about 36 per cent. appears in the external circuit when the conditions are adjusted to give the highest efficiency. These figures give an efficiency of 4·1 per cent. at the most favourable region of the spectrum (in the green). The use of sunlight instead of green light reduces the efficiency to 0·53 per cent. This figure gives 1·1 watts per square metre for an average incident energy of 0·2 kW per square metre, and a peak of 6 watts per square metre. This very low figure can only be improved by extending the spectral range of the cell into the infra-red without sacrificing its other properties. We do not consider that it is necessary to give any special encouragement to the improvement of photovoltaic cells for power production from solar energy. There is, for other reasons, a strong incentive for their improvement, and the prospects of their useful employment for power production do not seem good enough to justify extra effort in that direction.

It is, in principle, possible to construct a photogalvanic cell in which a chemical change is stimulated by sunlight and which, in consequence, produces electrical power. The little that is known about these systems makes it appear most unlikely that they could be developed into an efficient source of power.

Production of Fuel.

The use of solar energy to produce fuel which is subsequently used in an engine is attractive, as it

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

avoids the consequences of the intermittency of sunlight and allows the energy to be used in applications requiring the continuous production of power.

Photosynthesis in non-living systems.—Most photochemical reactions lead to a release and not to a storage of chemical energy. The basic reason for this is that if the primary action of light is to break a chemical bond, either the same bond, or one energetically more stable, is formed. The photochemical combination of hydrogen and chlorine is an example of the latter process. It is only in very special and complicated systems that photosynthesis of compounds with more energy than the raw materials is possible. In fact, no suitable non-living systems are known, and in the present state of photochemistry there is little chance of finding any in the near future. Research on photosynthesis is of great importance for many reasons, but we do not believe that at present any attempt should be made to divert workers in this field to the study of potential fuel-producing systems.

Use of plants to produce fuel.—The efficiency of the utilisation of sunlight by growing plants is remarkable. *Eucalyptus globulus* in India gives 2·4 kilograms of wood per square metre (9·4 tons per acre per year). The wood has a calorific value of $2{\cdot}1 \times 10^4$ joules per gramme (5,000 calories per gramme). The rate of storage of energy in the wood of an Indian eucalyptus forest is therefore 1·6 watts per square metre, or 0·8 per cent. of the energy reaching the ground. The yield from annual plants is of the same order. For example, H. A. Spoehr[16] states that the annual yield of sugar cane is 3·8 kg. per square metre (15 tons per acre). With a calorific value of $1{\cdot}7 \times 10^4$ joules per gramme (4,000 calories per gramme) this would give 2 watts per square metre.

If the wood of a eucalyptus forest is burnt and used in a steam engine with a boiler efficiency of 70 per cent. and an engine efficiency of 14 per cent. (this is higher than has yet been achieved in small commercial engines, which give about 5 per cent.) it would yield 0·15 watts per square metre of forest. The alternative of fermenting vegetable matter to alcohol and using this in an internal-combustion engine yields less power, in consequence of the small proportion of the plant that can be converted to alcohol. For example, according to Spoehr a kilogram of sugar cane yields only 60 gm. of alcohol.[16] With a calorific value of $3{\cdot}1 \times 10^4$ joules per gramme (7,400 calories per gramme) this would give 1,860 joules per gramme of sugar cane or 0·22 watts per square metre. With an engine efficiency of 30 per cent. the useful power obtained would be 0·07 watts per square metre. It seems unlikely that it would be worth-while growing plants for fermentation, though in favourable circumstances the use of waste material may be profitable.

As an alternative to fermentation to alcohol, an anaerobic fermentation to methane is possible for some kinds of vegetable matter. M. Ruheman, W. A. Immerwahr, D. A. Theedam and D. G. Arnott have shown that in this way, using the water hyacinth (*Eichhornia crassipes*), 400 joules (95 calories) can be obtained from one gramme of the green plant; this is equivalent to 2,400 joules (460 calories) per gramme of dry material. This is of the same order as the heat obtained by burning the alcohol from cane sugar, but is so much less than the calorific value of any vegetable matter that the process seems unlikely to be economic unless large quantities of a material incapable of direct burning were available. The figure of 0·15 watts per square metre is much less than that for the production of power directly from solar energy, but the area is of forest, not equipment.

(*To be continued.*)

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[14] D. Gabor, unpublished note to National Research Development Corporation, 1950.

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DISCUSSION ON THE CORROSION OF STEEL.

A MEETING organised by the Iron and Steel Institute in conjunction with the British Iron and Steel Research Association, to discuss papers on the corrosion of steel under phosphate coatings and protective finishes, and also the "Second Report of the Methods of Testing (Corrosion) Sub-Committee," was held in London in the afternoon of October 28. Mr. H. T. Shirley, chairman of the Corrosion Committee of the Research Association, presided and the first half of the meeting was devoted to the presentation and joint discussion of three papers, namely, "Phosphate Coatings as a Basis for Painting Steel," by the Phosphate Coatings (Drafting) Panel of the British Standards Institution; "Corrosion by Retained Treatment Chemicals on Phosphated Steel Surfaces," by Drs. S. G. Clarke and E. E. Longhurst; and "Tentative Analytical Tests for Phosphate Coatings on Steel," by Mr. R. St.J. Preston, Mr. R. H. Settle, and Mr. J. B. L. Worthington.

Corrosion of Steel Under Phosphate Coatings.

Dr. J. C. Hudson, chairman of the phosphate Coatings Panel of the British Standards Institution, presented the first paper. In this, the Panel stated that the Institution had considered for some time the possibility of drafting standard specifications for phosphate coatings, with particular reference to their use as a basis for painting steel. Consequently, the suitability of various analytical and performance tests for standardisation purposes had been discussed. In several phosphating processes, the phosphated article was given a hot-water rinse between its withdrawal from the phosphating bath and its transfer to the drying oven. Often chromic acid or a soluble chromate was added to the rinsing water. The effects of these chromic-acid rinses on the protective properties of the phosphate coatings had been investigated. The addition of small amounts, of the order of about 0·1 per cent., of chromic acid to the rinsing water had been found to improve the protective properties of the phosphate coating, but high concentrations, i.e., those greater than approximately 0·5 per cent., were injurious because the coating was dissolved. The conclusion of the Panel was that, in spite of the wide range of industrial phosphating processes, it might be possible to draw up specifications for individual processes, if each specification were strictly limited to the particular process concerned, and if the criteria of acceptance were suitably related to the purpose for which the phosphate coating was required. Such specifications might be based on a performance test for a specimen phosphated by the process concerned, and provided with a standard organic finish of oil, lacquer, or paint, which specimen would be required to show a specified performance in a standard laboratory corrosion test. Experimental work to explore this possibility was in progress.

The second paper, on "Corrosion by Retained Treatment Chemicals on Phosphated Steel Surfaces," was presented by Dr. Longhurst. The authors stated that their investigation had been carried out using sheet-steel specimens having a dent in the flat surface to receive drops of the phosphating solution, and also overlaps under which the solution might be trapped. Three different phosphating processes had been tested; these were claimed to be quite satisfactory without rinsing off residues of the treatment solution after the coating had been formed. For comparison, one process requiring after-rinsing, had been tested. As a result of the work, it had been concluded that the risk of corrosion from phosphating solution trapped in crevices or folds varied with the type of phosphating solution. In general, the risk was much less with the plain metal phosphate-phosphoric acid type of bath than with accelerated phosphating solutions containing other constituents more active in stimulating corrosion. With the plain-type bath, the washing parts of simple shape, from which the solution could drain off freely, was probably not essential, but, to avoid the risk of corrosion, it was desirable to wash creviced parts after phosphating. With phosphating solutions containing other active constituents, washing was generally essential to remove residual corrosion solution, particular attention being necessary where crevices were present.

The third paper, on "Tentative Analytical Tests for Phosphate Coatings on Steel," was presented by Mr. Preston. The paper gave details of laboratory tests intended for the determination of the nature and uniformity of phosphate coatings. The proposed tests, which have been drawn up by the Phosphate Coatings Sub-Committee of the British Standards Institution, comprise the determination of the moisture content or loss in weight at 105 deg. C., the absorption value, the coating weight, its hygroscopicity, and the phosphate and chromate contents of the coating.

The discussion was opened by Mr. R. J. Brown who described how ring blistering of motor-car body finishes had been caused by water spots dropping on to the clean body surfaces from overhead condensation points after phosphating and before painting. Even after continuous processing equipment had been introduced, trouble had been encountered in the form of "snail trails," which were lines of fine blisters at the interface of the phosphate coating and the priming paint. Much work had been done to correct the trouble but the final step had been taken on the advice of the Chemical Research Laboratory. This consisted of the application of the chromic-acid rinse, without heating, and the prevention of the rotation of the car bodies between the rinse and the forced drying. Uniform drying over the entire body surface was then possible without the formation of the corrosion trails. The next speaker, Mr. R. F. Drysdale, stated that in work conducted on light-weight coatings applied both by accelerated and non-accelerated processes, he had obtained the best results from specimens treated by non-accelerated processes which had been dried unwashed. There was little to choose between those washed with water, chromic acid or soluble chromate solutions.

Mr. A. Nicholson also spoke on the question of rinsing. He stated that even with unaccelerated processes, rinsing was advisable. A final rinse with zinc phosphate might be advantageous in certain circumstances and he believed that there was a German patent on this subject. The last speaker, Mr. E. I. Brimelow, considered that there were dangers in assessing phosphate coatings by accelerated corrosion tests, particularly to determine the most useful concentration of chromic acid in the rinsing solution. In his reply to the discussion, Dr. Hudson agreed with Mr. Brimelow that caution was necessary in such cases and re-emphasised that the optimum chromic-acid concentration varied for different phosphating processes. In the course of his reply to the discussion, Dr. Longhurst agreed that it appeared that small concentrations of phosphoric-acid residues were not necessarily dangerous. He added, however, that in industrial practice it was difficult to avoid major concentrations of phosphoric acid, owing to seepage from crevices or inefficient drainage in the case of awkwardly-shaped components. Minor defects would occur where such concentrations existed and, generally, he was in favour of a quick rinse even in the most favourable circumstances.

Report on Methods of Corrosion Testing.

The "Second Report of the Methods of Testing (Corrosion) Sub-Committee," which contained further details of investigations referred to in the first report of 1948, was presented by the chairman of the Sub-Committee, Dr. J. C. Hudson. In doing so, he stated that, in brief, the main result of the Sub-Committee's work, to date, had been to standardise laboratory tests for evaluating the resistance of a metal to corrosion. These had been adopted by the British Standards Institution and would be shortly published as specification B.S. No. 1391 : 1952. The first of these tests, in which specimens were sprayed with a solution of original sea water and stored under cover between spraying, rested on a method originally devised by the Armament Research Establishment, Woolwich. In a second test, specimens were suspended over a very dilute solution of sulphur dioxide and intermittent

DUSTPROOF SIFTING MACHINE.

HENRY SIMON, LIMITED, STOCKPORT.

condensation was induced on them by means of a cooling device. This test had originated in work by Mr. R. St. J. Preston and his colleagues at the Chemical Research Laboratory. The development and standardisation of these tests had involved collaborative work in many different laboratories and, in some respects, the reproducibility of the tests was not all that could have been desired, but it might be concluded that it was generally as good as was to be expected in this type of experiment. It should be pointed out, however, that there was no such thing as a single fixed order of merit of a number of protective schemes. The order varied not only according to the conditions of exposure or the type of service but also according to the criterion on which failure was assessed.

It was doubtful whether a laboratory test would ever be devised that would give a hard and fast correlation with the results of service. In general, however, laboratory tests were of great value in weeding out unsatisfactory protective schemes, but they became fallible when it was a case of distinguishing between several good or excellent protective schemes. The differences arising from different definitions of the criterion of failure were evident in another form in the report, in the sections dealing with the effects of mechanical damage on the result. There was probably some tendency to exaggerate the effects of damage on the performance of protective schemes. Often, although failure occurred at a damaged area, the rusting remained localised and might even become stifled. It was thought desirable, therefore, in the new B.S. No. 1391 : 1952, to make optional the infliction of damage before testing.

In the course of the discussion which followed the presentation of the report, Mr. R. F. Drysdale considered that wide publicity should be given to the contents of the report. He added that perhaps the best method of accomplishing this would be to publish a single concise article on its main findings. Such a course would be welcomed by busy executive officers. In his reply, Dr. Hudson agreed that, ultimately, the publication of such an article would be a measure to be recommended and he stated that the matter would be examined by the Sub-Committee.

INDUSTRIAL PRODUCTS OF WOLVERHAMPTON.—The Municipal Art Gallery and Museum at Wolverhampton is holding a series of displays of industrial products made in the town. An exhibition of aeronautical equipment has just been replaced by ball bearings made by the Fischer Bearings Co., Ltd. The present display will remain on view until the end of November, when it is hoped that an exhibition of gun locks will be held.

SIFTING MACHINE.

A SMALL flexible dustproof sifting machine for screening and grading powdered and finely granulated materials has been introduced recently by Henry Simon, Limited, Cheadle Heath, Stockport. Known as the Junior Sifter, it has a capacity of up to 3 tons per hour, and is normally driven by a ¼-h.p. motor. A photograph of the Junior Sifter is reproduced in the accompanying illustration. It consists of eight removable sieves, totally enclosed in a metal case suspended from a metal frame by canes. The sieve case is driven through an eccentric mechanism mounted on the frame under the case. The sieve trays are of non-corroding aluminium alloy, and are provided with sifting covers of wire, nylon or silk bolting cloth attached to interchangeable wooden frames. The manufacturers recommend the use of St. Martins nylon bolting cloth, which has a long life and sifts as freely as the best silk. The sieve trays can be arranged in three ways, to give one inlet with two or three outlets, or two inlets and four outlets, as desired. Cleaners are provided in the trays to keep the mesh open. The machine, being totally enclosed, is dustproof, but, if necessary, an exhaust can be fitted at the inlets, rendering the machine completely free from dust and removing moist air from the sifting surfaces.

AERIAL SPRAYING OF LOCUSTS.—One of the worst locust plagues in living memory was overcome earlier this year in Iraq by the prompt application of combative measures which included aerial spraying. The swarms originated in Ethiopia and Somalia at the beginning of the year and by the end of February had spread over southern Iraq and Iran. Control operations were started at once; these were of two kinds, namely, ground control and spraying from the air. Ground control was initiated by the Iraqi local governments, who called on all available men to lay down poisoned bait. In some places, however, it proved most difficult to use this method, and in such areas Aldrin, a petroleum-derived insecticide manufactured by the Shell Group, was sprayed from the air for which purpose two Piper Cub aircraft were employed. The aircraft and the pilots were supplied by the United States Government. The insecticide and the method of distribution proved most effective and outstanding results were obtained. It should be emphasised, however, that aerial spraying formed only a part of the combative measures and that the main instrument of control was the use of poisoned bait. Nevertheless, the results obtained by aerial spraying were most encouraging and suggest that this method will prove useful in the future, especially in areas where traditional methods cannot be employed.

ULTRASONIC SOLDERING IN THE FOUNDRY.

IT is now widely known that the difficulty of soft soldering aluminium and its alloys can be overcome by the use of the ultrasonic soldering iron made by Mullard, Limited, Century House, Shaftesbury-avenue, London, W.C.2. With this tool the film of oxide which forms on the surface of the metal, and renders it impossible to employ the normal methods of the tinsmith, is broken up mechanically and continuously by causing the copper bit to vibrate at a very high frequency while the solder is being applied for tinning; no flux is used for the operation. The vibrations, which are of very small amplitude, considerably less than a thousandth of an inch, are produced by a magneto-striction transducer to which the bit is secured, the bit being heated by low-frequency energy as in the case of an ordinary electric soldering iron. The methods of using the ultrasonic iron in sheet-metal work are fairly obvious. The parts to be joined are both tinned, placed in contact and heated until the solder melts, more solder being supplied if required to fill the joint.

Our attention has recently been called to a less obvious application of the ultrasonic soldering iron in the foundry for the surface treatment of faulty light-alloy castings and for alterations and repairs to aluminium patterns now extensively used in the foundry instead of wooden patterns. Light-alloy castings are not infrequently rejected on account of surface cavities and other superficial blemishes which, while not materially affecting the strength or utility of the casting, do detract from its appearance. Surface cavities and cracks can, however, be easily filled and made good by means of the ultrasonic soldering iron using a tin-zinc solder with a texture and colour so similar to those of the aluminium-alloy casting that, after machining, the repair is practically indistinguishable from the parent metal. It is not suggested that cracks should be repaired in this way in any part of the casting which will be subjected to heavy working stresses, because the strength of the zinc-base solder is not equal to that of the alloy casting. If used with reasonable judgment, however, many castings which otherwise would have to be scrapped can be saved.

To fill a cavity in the surface of a casting the latter is first preheated to the melting point of the solder which is then run in to fill the hole. The bit of the ultrasonic soldering iron, which for this purpose is tapered, is then applied so that the oxide film on the bottom and sides of the cavity is removed and the surfaces are effectively tinned. When the work has cooled, and the solder has solidified, the casting can be machined. If necessary, further solder can be added before machining. For the treatment of comparatively large surface blemishes a flat chisel-shaped bit is used in the soldering iron. For the alteration and repair of aluminium foundry patterns, the necessary area can be tinned with the ultrasonic soldering iron and solder built up as required to restore or modify the shape. It is also possible to make up light-metal patterns *ab initio* by using aluminium-alloy sheets bent to shape and soldered together, instead of joining the various parts by drilling, screwing or riveting. Considerable economy is claimed for the use of soft soldering in the production and use of light-metal patterns.

POWER-PRODUCTION POSTERS.—The Education and Training Department of the British Electricity Authority have produced four coloured lithographs on various aspects of power production which they suggest may be of value for teaching purposes. The posters, which are oblique projections in part section, measure 30 in. by 40 in., and three illustrate the coal and ash-handling plant, the boiler house and the turbo-alternator, respectively. The fourth is a composite poster, entitled "Power to the Grid," and shows the inside of a power station and the equipment of an outdoor grid substation. Single copies can be obtained on cartridge paper or linen backed at prices of 7*s.* and 9*s.*, respectively; or in sets of four at 22*s.* 6*d.* or 31*s.* 6*d.*, on application to Mr. L. J. Luffingham, Public Relations Officer, British Electricity House, Winsley-street, London, W.1.

ANNUALS AND REFERENCE BOOKS.

Directory of Board of Trade Departments and Their Work.

H.M. Stationery Office, Kingsway, London, W.C.2. [Price 9*d.* net.]

This directory has been issued by the Board of Trade as a guide for those in industry or business who have to deal with Government departments on commercial matters. The Directory is divided into three sections, the first of which gives the addresses and telephone numbers of the various departments and regional offices of the Board of Trade, together with a brief description of their functions. In the second section, all the matters dealt with by the Board of Trade are listed alphabetically, and the appropriate department and telephone number is given against each entry. In the third section are given the main production departments—i.e., the Admiralty, the Board of Trade, and the Ministries of Agriculture and Fisheries, Food, Fuel and Power, Health, Materials, Pensions, Supply, Transport and Works—together with a list of the affairs, arranged alphabetically, for which they are responsible.

The Architects', Builders', Civil and Highway Engineers' Reference Book.

Fourth edition. George Newnes, Limited, Tower House, Southampton-street, London, W.C.2. [Price 105*s.* net.]

Not infrequently, books of this kind tend to become little more than catalogues of proprietory products, but one of the most notable features of this work is that it is genuinely a technical compendium—containing, of course, a large number of what are classed as "manufacturers' announcements," but providing also a variety of technical and scientific articles of high quality, written by experts in their respective spheres. These are much too numerous to list individually, but it may be said that they cover adequately the very wide field indicated by the title of the book; the text is divided, in fact, into 25 sections, including as one the three introductory articles dealing with the trends of development in school building, British water resources, and highway legislation. The general editor is Mr. E. Molloy, who has been assisted by an editorial panel consisting of Mr. Evelyn Drury, B.A., A.R.I.B.A., Mr. A. C. Pallot, B.Sc., M.I.C.E., and Mr. Edward Stead, A.M.I.C.E. The concluding section comprises a directory of manufacturers, an index to advertisers, and a technical index.

Scientific Research in British Universities, 1951-52.

H.M. Stationery Office, York House, Kingsway, London, W.C.2. [Price 8*s.* 6*d.* net.]

The first list of research work in progress at British universities was prepared in 1946 for the Royal Society's Empire Scientific Conference; there had been some previous co-ordination in this field between the universities themselves and the professional engineering institutions, but it was far from being comprehensive and, in any case, the information was not publicly available. The British Council produced the first issue of their *Scientific Research in Britain* in 1948, but this was intended for their own use only, and the subsequent editions of 1949-50 and 1950-51 also were not generally available. Under the auspices of the Department of Scientific and Industrial Research, however, the work has been put upon a different footing, with the result that all who are interested in research, in any branch of science covered by the British universities and university colleges, can have at hand a complete survey of the research work in progress and can identify it with the colleges concerned and the individuals who are conducting it. The arrangement is by universities, etc., in alphabetical order, and by their departments. There is a complete index of names, but none of subjects.

Handbook for Constructional Engineers.

Dorman, Long and Company, Limited, Middlesbrough.

For many years, the handbooks of rolled sections and structural steelwork prepared by Messrs. Dorman, Long and Company have been regarded as some of the most valuable reference works available to steel users engaged in constructional work. The 1952 edition, recently to hand, does more than merely maintain that standard, having been considerably enlarged by the addition of new tables, etc. Moreover, it has been extensively re-arranged, to aid convenient reference. The greater part of the book is devoted to the firm's products, the properties of the various rolled sections, singly and in combination as compound girders and stanchions, beam formulæ, etc.; but there is also a section of the book dealing with welded constructional steelwork, another on colliery arches and cambered joists, and extensive extracts from the relevant British Standard Specifications and the regulations of the roads department of the Ministry of Transport relating to highway bridges. The book is not on sale, however, to the engineering public in general, and the firm inform us that, as only a limited number have been printed, distribution must perforce be restricted.

The Practical Electrician's Pocket Book, 1953.

Edited by R. C. Norris. Electrical Radio and Training, 189, High Holborn, London, W.C.1. [Price 5*s.* net.]

The 55th edition of this well-known publication contains a great deal of new material. This includes new chapters on "Switches and Control Circuits," "Time Switches" and "Power Factor," while several pages are, for the first time, devoted to "Fibre-glass Insulation." Notes on hydro-electric plant have been added and fresh information is given on such subjects as refrigeration, water heating and the suppression of radio and television interference. The section on wiring installations has been re-arranged.

FLUORESCENT MAGNETIC FLAW-DETECTION INK.

The photograph reproduced in Fig. 1, below shows specimens of steel plate in which grinding cracks have been revealed by the application of a new fluorescent magnetic flaw-detection ink known as Lumor, developed by the Physics Research Group of the Manchester Oil Refinery, Limited, Twining-road, Trafford Park, Manchester, 17.

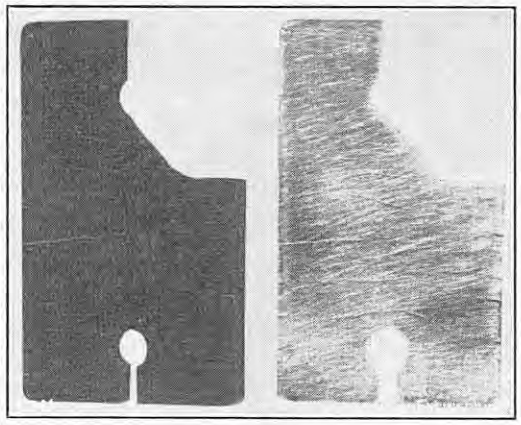

Fig. 1.

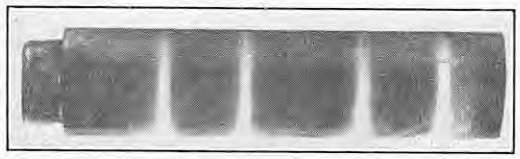

Fig. 2.

The plate on the left is under ultra-violet illumination, whereas that on the right shows that the cracks are still visible, although less clear, in daylight. In Fig. 2 can be seen cooling cracks in the interior of a steel bar, revealed by the same process.

The Manchester Oil Refinery, it may be recalled, have also developed recently a non-magnetic fluorescent ink—Glomor—for the non-destructive testing of surface cracks in plastics and non-magnetic metals, described in Engineering, on page 727 of our 173rd volume (June 6, 1952). For detecting cracks in magnetic materials, the Lumor method is simpler and speedier, since there is no need to remove surplus ink from the specimen. Lumor ink is a non-caking suspension of fluorescent magnetic material in a liquid medium—either with a petroleum base (Lumor K) or an odourless non-petroleum base (Lumor S) that can be safely used on rubber-bonded steel or cast iron. After prolonged standing, it requires only a slight agitation before applying to the test-piece—by pouring, brushing, spraying, or dipping. The test-piece is magnetised either by passing current through it, supplied by a low-voltage high-current transformer, or by the magnetic-flux method, using a permanent magnet, an electro-magnet or a magnetising coil. An ultra-violet light source, with a black glass filter, is required for viewing the specimen. The smallest cracks or internal flaws are revealed immediately in a brilliant green fluorescent pattern.

BOOKS RECEIVED.

Ministry of Housing and Local Government. The Cost of House-Building. Third Report of the Committee of Inquiry. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s.* 3*d.* net.]

An International Bibliography on Atomic Energy. Vol. 2. *Scientific Aspects.* Supplement No. 1. Prepared by the Atomic Energy Section, Department of Security Council Affairs, United Nations Sales and Circulation Section, United Nations, New York, U.S.A. [Price 3·50 dols.]; and H.M. Stationery Office, Kingsway, London, W.C.2. [Price 25*s.*]

Atomic Energy Research Establishment. Report No. R/L 5. *Lecture Notes on Pile Theory.* By C. A. Rennie. [Price 5*s.*] No. R/R 922. *A Quantitative Study of Uranium-Graphite Lattices.* By E. A. Guggenheim and M. H. L. Pryce. [Price 6*s.*] H.M. Stationery Office, Kingsway, London, W.C.2.

Report of the Radio Research Board, with the Report of the Director for Radio Research for the Year 1951. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s.* 6*d.* net.]

The Fight Against Rust. The Work of the Corrosion Committee of the British Iron and Steel Research Association. Offices of the Association, 11, Park-lane, London, W.1. [Price 2*s.* 6*d.*]

Fortuna Domus. A Series of Lectures Delivered in the University of Glasgow in Commemoration of the Fifth Centenary of its Foundation. The University, Glasgow, W.2. [Price 15*s.*]

Who's Who in the Motor Industry. Compiled and edited by Roland C. Bellamy and Cyrus Andrews. Roland C. Bellamy Publications, St. Mary's Gate, Grimsby. [Price 27*s.* 6*d.*]

Metallurgy for Engineers. Casting, Welding and Working. By Professors John Wulff, Howard F. Taylor and Amos J. Shaler. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 6.75 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 54*s.* net.]

Handbook on Mechanical Stokers for Shell Boilers. The National Coal Board, Production Department, Hobart House, Grosvenor-place, London, S.W.1. [Price 15*s.*; reduced rate for educational establishments and students, 11*s.* 6*d.*]

CONTRACTS.

The Railway Executive have placed orders for 57,490 all-steel 16-ton mineral wagons with the following firms: the Birmingham Railway Carriage and Wagon Co., Ltd., Birmingham, 10,000 wagons; the Butterley Co., Ltd., Codnor Park, Nottinghamshire, 5,000 wagons; the Cambrian Wagon and Engineering Co., Ltd., Cardiff, 10,500 wagons; the Derbyshire Carriage and Wagon Co., Ltd., Chesterfield, 4,600 wagons; P. and W. MacLellan Co., Ltd., Glasgow, 4,550 wagons; the Metropolitan-Cammell Carriage and Wagon Co., Ltd., Birmingham, 13,000 wagons; and the Tees Side Bridge and Engineering Works, Ltd., Middlesbrough, 9,840 wagons. Further contracts are pending.

During September, the British Electricity Authority placed contracts for equipment for power stations, transforming stations and transmission lines, amounting, in the aggregate, to 6,468,387*l.* The principal orders include: for Brunswick Wharf power station, London, one 320,000-lb. per hour boiler, with John Brown & Co., Ltd.; for Marchwood power station, near Southampton, civil engineering works, with Sir Robert McAlpine & Son, Ltd.; for Tilbury power station, 3,300-volt and 415-volt auxiliary switchgear, etc., with the English Electric Co., Ltd., and ash-handling and dust-handling plant, with Babcock & Wilcox, Ltd.; for Drakelow power station, Burton-on-Trent, 132-kV 3,500-MVA switchgear, with A. Reyrolle & Co., Ltd.; for Nottingham power station, condensing and feed-heating plant for one 60,000-kW turbo-generator, with Metropolitan-Vickers Electrical Co., Ltd.; for Hams Hall "C" power station, near Birmingham, initial site works, with Sir Robert McAlpine & Sons (Midlands), Ltd.; for Southport power station, one 85,000-lb. per hour oil-fired boiler, with Yarrow & Co., Ltd.; for Stella South power station, near Newcastle-upon-Tyne, 132-kV transformers, with C. A. Parsons & Co., Ltd.; for Three Bridges substation, Sussex, site and foundation works, with Thomas Lowe & Sons, Ltd.; for Staythorpe substation, Newark, 132-kV 2,500-MVA switchgear, with the General Electric Co., Ltd.; for Stella substation, 275-kV isolators and connections, with A. Reyrolle & Co., Ltd.; for Stella South substation, 132-kV and multicore cables, with British Insulated Callendar's Cables, Ltd.; and for Carrington substation, near Manchester, 132-kV 3,500 MVA switchgear and 275-kV isolators, 'bus-bars and connections, with Metropolitan-Vickers Electrical Co., Ltd.