THE MANDI HYDRO-ELECTRIC SCHEME; NORTHERN INDIA.

By C. F. STRICKLAND.

THE important scheme of the Punjab Government for the development of hydro-electric power in the Himalayas has recently been re-examined by a special committee, appointed at the request of the Punjab Legislative Council, and, despite the hostile criticism to which it had been submitted in certain quarters, has been unanimously endorsed, and is to to be continued to its completion. Electric light and power have hitherto been supplied to the towns and factories of North West India from small plants, municipal or private, which produce their current at a cost varying from $\frac{3}{4}d.$ to $2d.$ per unit. The development of industry has been hampered by this high figure, and the Industrial Commission recommended the undertaking of power production by the agency of Government on a much larger scale.

A thorough examination of the sites available in the nearer Himalayan ranges led to the selection of a point on the Uhl River, a confluent of the Beas in Mandi State, 100 miles above railhead in the north of the Punjab. A plan of the area is given in Fig. 1. After consultation with Dr. H. E. Grüner, of Bâle, Switzerland, an estimate of 3,500,000*l.* was drawn up, and construction was begun in April, 1926, under the supervision of Colonel Battye, R.E., Chief Hydro-Electric Engineer to Government. According to the project, the water of the Uhl will be drawn off at a barrage at an elevation of 6,000 ft., passed through a tunnel 9 ft. 3 in. in diameter and $2\frac{1}{2}$ miles long, shown in Fig. 6, page 816, in the ridge which here divides that river from the Beas. It will fall 2,000 ft. to a power-house at an elevation of 4,000 ft. at Shanan or Jogindarnagar. From here current will be distributed by trunk lines to a network covering the Punjab, Delhi, and part of the United Provinces. Fig. 2 is a plan of this network. The spot chosen for the headworks, shown in Figs. 3 and 4, page 816, is, however, inaccessible by road, the Mandi State being an imperfectly developed and a rugged tract of country. It was, therefore, necessary first to build a haulage way from the southern side of the range to the 8,000 ft. level, thence round the crest and down again to 6,000 ft. on the northern slope. These works, which are illustrated in Figs. 5 and 7, page 816, were carried out with considerable difficulty amid the heavy snows of winter and the torrential rains of the hot season, at a distance of 100 miles from railhead, occupied 33 months in place of the 24 months originally anticipated, but have now been successfully completed. The tunnel, which was next undertaken, presented new and unexpected obstacles. It was clearly impossible for an engineer, when preparing an estimate, to foresee the nature of the rock or other material in the centre of a $2\frac{1}{2}$-mile tunnel, 3,000 ft. below the crest of the mountain. The actual progress through a thick stratum of slimy clay and another of crumbling stone, which were encountered at a considerable depth, was disappointingly slow, amounting for a time to no more than 100 ft. per mensem. After passing this stage, the advance has been from 400 ft. to 500 ft. per mensem, as originally estimated. The delay, however, has been expensive, chiefly in cost of labour and supervision.

The revision of the estimate, resulting from this misfortune and from the late delivery of certain machinery for construction, enhances the total to 4,675,000*l.*, a figure accepted by the committee of inquiry, and if no other mishap occurs, the work should be finished in the winter of 1932–33, and current should be available in the spring of the latter year. The scheme will thus have required $6\frac{1}{2}$ years to construct, instead of the 4 years which were estimated. Nevertheless, it has every prospect of success. The first part of the project, as above described, will generate nominally 36,000 kw., and, after allowance for loss in transmission and for the diversity factor, the current available for distribution will be 38,250 kw., and the cost of production 109*l.* per kilowatt. This may be compared with the Shannon station in Ireland, which produces 42,000 kw. at a cost of 6,000,000*l.*, or 142*l.* per kilowatt, and with the Perak River scheme in Malaya, for which no final estimates are yet published, though the kilowatt is likely to cost about 125*l.* or 130*l.* The Shannon works, moreover, have also exceeded the earlier estimate of cost (5,210,000*l.* in December, 1927), in consequence of difficulties, such as the subsidence of a bank and certain miscalculations, closely resembling those of Mandi, and may be quoted to show the impossibility of an exact forecast. The Punjab consumers of electric power, both manufacturers and local authorities, have been canvassed with regard to their requirements and their willingness to accept a supply over the new lines. The consumption in the province is, at present, 20,000 kw., and, at the existing rate of progress, should be 40,000 by the spring of 1933. Consumers of 17,000 kw. have already promised to take current at a rate lower than that of the small plants now in use, and there should be no lack of demand for the 38,250 kw. when available at an economic price. The hydro-electric staff have, in fact, already arranged temporary installations for several towns, including the busy centre of Amritsar, with a view to their permanent supply at a later date.

The production cost, according to the first estimate, was to be $\frac{1}{4}d.$ per unit on the high-tension line and slightly over $\frac{1}{2}d.$ as delivered to the local plant. These figures must now, on the revised estimate, be raised to approximately $\frac{5}{16}d.$ and $\frac{5}{8}d.$ The Shannon figure for production is $\frac{9}{10}d.$, and the Punjab engineers may pride themselves on a fine achievement if they are able, in a region of greater natural obstacles and far from the sources of machinery, finally to produce more cheaply than Messrs. Siemens-Schuckert, under much easier conditions. The Punjab project is, however, to be further developed. The network of lines, shown in the plan Fig. 2, will at first run from the foothills to Amritsar and Lahore, throwing off branches towards Jullundur and Ludhiana in the east, Lyallpur and the Chenab canal area in the west, and Ferozpur to the south. By constructing a dam on the Uhl river and making use of an increased head of water, an extension will be rendered possible by a new trunk line to Simla, Ambala and the Patiala State, and the supply available to the consumer will then be about 70,000 kw. Again, it is proposed, by means of a further 3-mile channel and a fall of 1,200 ft. to a power house at Kun, shown in Fig. 1, to bring up the capacity to 120,000 kw., and feed the southern districts of the Punjab, Delhi itself, and the western towns of the United Provinces. The price to the consumer (factory or local plant) will then be reduced to $0{\cdot}52d.$ at the second and $0{\cdot}44d.$ at the final stages.

The ability of North West India to absorb so great a supply has been questioned, and one of the objections urged against the Mandi scheme before the committee of investigation was based on such a doubt. It is, perhaps, relevant to mention that some of the critics were advocates of a rival site for generating hydro-electric energy, and their argument with regard to the inadequacy of demand would have equal force against every site. There is, however, no ground for alarm. The estimate as now revised provides only for the first stage of 38,250 kw., and reasons have been given above for believing that this will be taken up. Cheap energy will lead to the growth of new industries. Cotton, tanning, wool, paper and flour mills are operating in Delhi and the Punjab; coal is known to exist in the Mandi State and in other submontane tracts, while the field of electrical power in the development of small rural undertakings—cane-crushing,

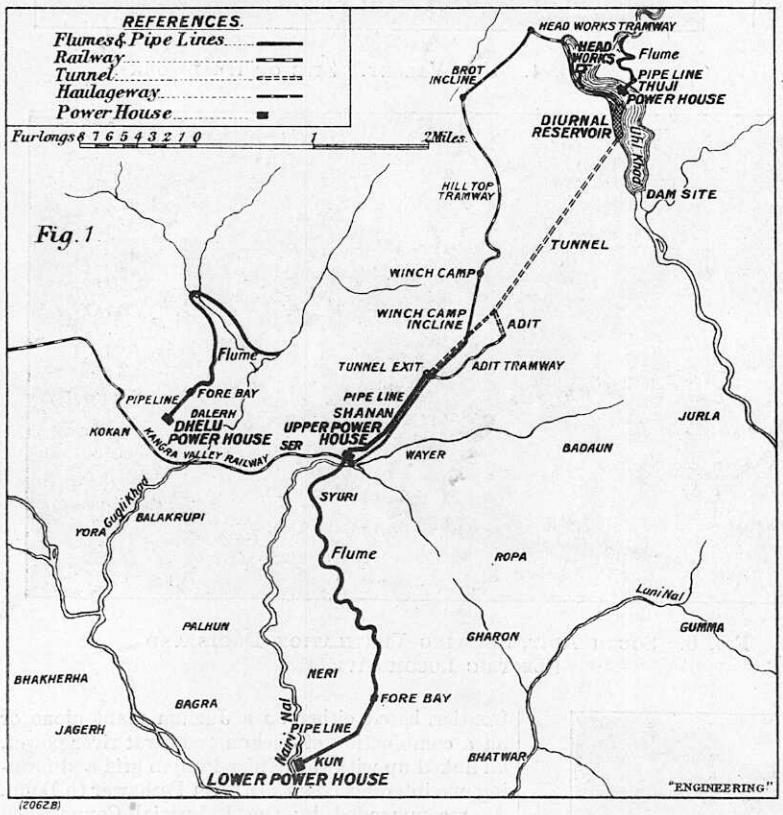


Fig. 1.

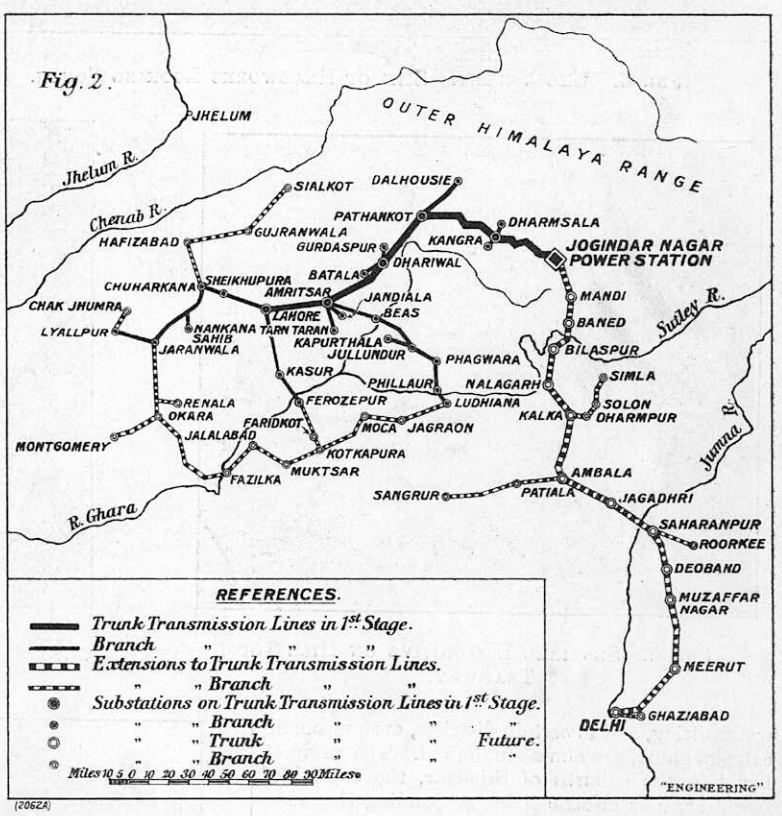


Fig. 2.

THE MANDI HYDRO-ELECTRIC SCHEME; NORTHERN INDIA.

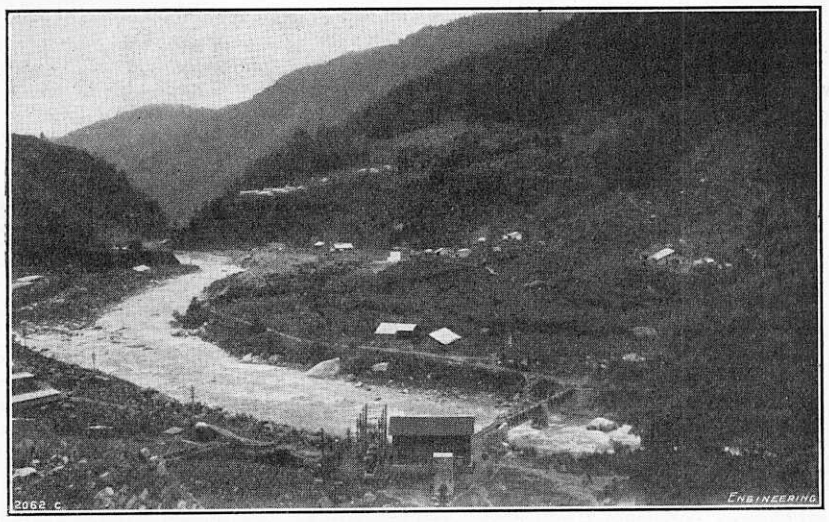


FIG. 3. UHL VALLEY. SITE OF HEADWORKS LOOKING SOUTH.

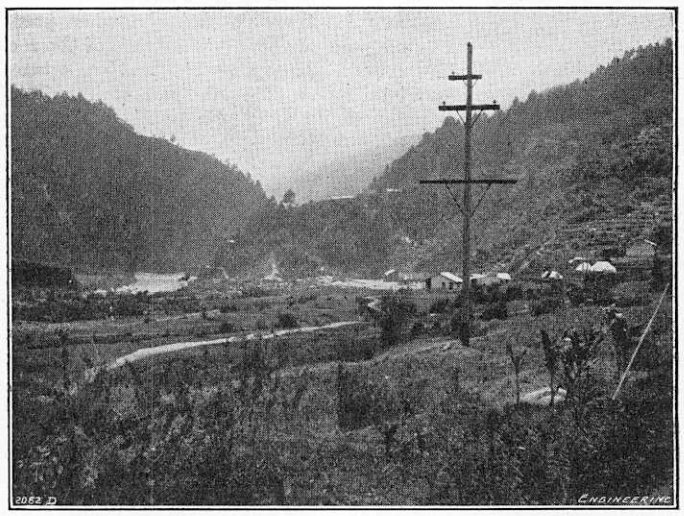


FIG. 4. UHL VALLEY. SITE OF HEADWORKS.



FIG. 5. SENTINEL LOCOMOTIVE ON HILL TOP TRAMWAY.

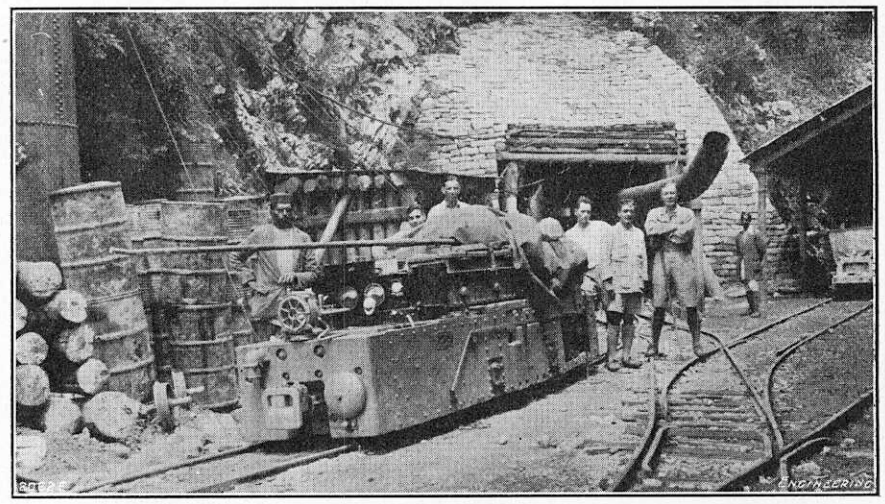


FIG. 6. SOUTH ADIT, SHOWING VENTILATION DUCTS AND ELECTRIC LOCOMOTIVE.

water-lifting, and in certain districts, even mechanical ploughing, are almost unlimited. The meanest hovel in the suburbs of Srinagar, the capital of Kashmir, uses electric light, suspending the wires and bulbs precariously from crumbling beams or the branch of a neighbouring tree, and the Punjabi peasant is not less appreciative of such comforts if they are placed cheaply within his reach.

The committee of inquiry has, however, prudently advised that a halt be called and the whole plan of future expansion be reconsidered, when the first stage is in working order. The Back Bay disaster in Bombay has rendered the Indian public apprehensive of financial losses in engineering, and it is, no doubt, wise to hasten slowly. It is even possible that, as the rate of interest on Government loans is falling, a reduction in the estimates for the later parts of the work may be effected. Some of the extra cost incurred in the first section has already been recouped in this way. On the other hand, time will show whether the earthquakes, which are frequent and occasionally violent in the Kangra district and the Mandi State, are a serious danger to the tunnel or the power houses. It was forcibly urged before the committee that the collapse of a generating plant, from which the entire province derived its light and power, would cause grave loss to the economic life of the people. Meanwhile, the urban producer, perhaps also the farmer, will become familiar with electrical possibilities, and if the working of the earlier part of the scheme is successful, the future demand will not fail to grow.

The Shanan power house will not be the last to be erected in the Himalayas; the rivers which issue from the steep valleys of that range offer an inexhaustible source of power, and will all, in turn, be harnessed. The Punjab network, as now designed, will not cross the Jhelum river or utilise the waters of that great stream. There will hereafter be a network between the Jhelum and the Afghan frontier, based either on a Jhelum plant alone or on a combination of Jhelum and Swat river power, all linked up with the earlier Punjab grid and forming one interdependent net from Peshawar to Delhi. As recommended by the Industrial Commission, the task must remain in the hands of Government. No firm yet exists in India which can execute a work of this magnitude; neither is it desirable in that country to hand over to private control an undertaking of general public utility. Indian public opinion is insistently demanding the resumption of the leased railways by the State, and action is being taken accordingly as the leases fall in; the canals (with rare exceptions) belong to Government, and the great majority of the urban utilities (water, tramways, &c.) are managed and owned by the municipal authorities. It is inconceivable that India should vary this policy with regard to hydro-electric power, and the Mandi scheme, conferring benefits on a population of at least 30 millions, and bringing in valuable revenues to the Government, will confirm the opinion of those who favour a central and national control.

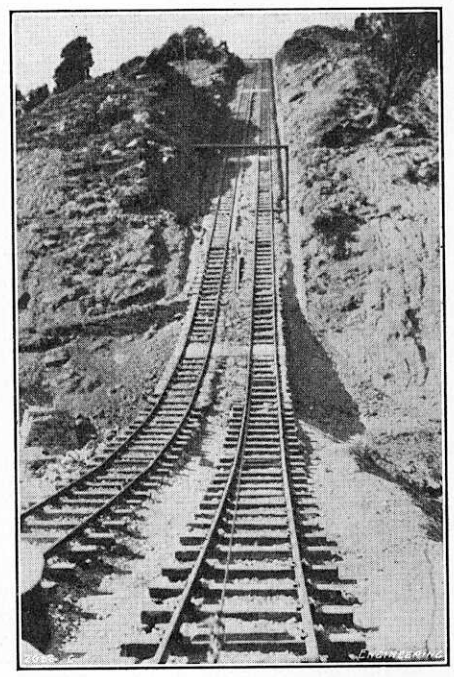


FIG. 7. HAULAGE WAYS ON SHANAN SPUR.

PLATINUM METALS IN CANADA.—Platinum is recovered in the treatment of the nickel-copper ores of the Sudbury district, and this constitutes the chief source of Canada's platinum. The increased production of these ores, consequent upon the present extensive development programme, which is being carried out in the Sudbury area, indicates that Canada's output of platinum metals is likely to increase. The 1929 production of platinum from Canadian mattes and residues, treated by Canadian, British and United States refineries, together with a small proportion of the metal recovered from alluvial sands, totalled 12,839 oz., valued at 741,790 dols. The 1929 output of palladium, rhodium and other metals was 13,717 oz., worth 319,881 dols.

LITERATURE.

Pioneers of Electrical Communication. By ROLLO APPLEYARD. London: Macmillan and Company, Limited. [Price 21*s.* net.].

THE story of electrical communication carries us back two centuries, and to the seclusion of the Charterhouse in the City of London, where Stephen Gray experimented with silk and feathers, glass and ivory, grouping substances into electrics and non-electrics, conductors and non-conductors. He it was who first found that a charge of electricity communicated to one end of a long wire produced effects at the other end. For his investigations he received the historic Copley Medal of the Royal Society, his name being at the head of a long roll of distinguished men of science who have followed in his footsteps. Hawksbee, Desaguliers, Dufay, Boze, and Kleist were among Gray's contemporaries, and through their work came the electrical machine, the condenser and other familiar apparatus of the eighteenth century. Again and again the passage of electricity along wires was demonstrated, and in the early part of last century various practical forms of telegraphs using frictional electricity were devised. But telegraphy, as we think of it to-day, made no important strides until after the invention of Volta and the work of Oersted, Ampère, Arago, Sturgeon and Ohm. These were the experimentalists who gave us the battery and by whom the fundamental truths of electro-magnetism were discovered, and it is with them and their successors that Mr. Appleyard is concerned.

Altogether there are ten sketches, beginning with an account of the life of Maxwell and ending with that of Ronalds. The other chapters are on Ampère, Volta, Wheatstone, Hertz, Oersted, Ohm, Heaviside and Chappe. It would have been an improvement had they been arranged in chronological order, while many readers would have appreciated a slight sketch showing how the work of each grew out of that of his predecessors. Much interesting matter is given besides that relating to electrical communication, but the outstanding events referred to are Volta's letter of 1800 to Sir Joseph Banks describing the voltaic pile and battery; Oersted's discovery, in 1820, of electro-magnetism, "one of those lucky throws that come not twice in a thousand years"; Ampère's memorable papers of 1820 and 1822; the foundation of electrical formulæ by Ohm, "whose life is lost sight of in a law"; Wheatstone and Cooke's patent of the first practical telegraph in 1837; Maxwell's "Dynamical Theory of an Electro-magnetic Field," of 1864; Hertz's epoch-making demonstrations of twenty years later and Heaviside's contribution to electrical science which were made in the 'eighties and 'nineties.

By the inclusion of Ronalds among the pioneers we are given a sketch of one who devised a telegraph as early as 1816, and who, for more than half a century, maintained touch with the advance of communication, while by the chapter on Claude Chappe (1763–1805) the author is enabled to give an interesting account of the modes of signalling in use prior to the electric telegraph. The semaphores of Chappe were found all over Europe, and meteorologists interested in visibility and atmospheric pollution will find that, in the three years 1839–42, the Admiralty semaphores between Whitehall and Portsmouth were not available by reason of the state of the atmosphere for 323 days in London, 142 at Putney, and 65 at Portsmouth.

Well-illustrated throughout, with photographs of the pioneers and their homes and haunts, their apparatus and their handwriting, skilful use has been made, in some instances, of correspondence. Mr. Appleyard's travels took him to Lyons, Cologne, Munich, Bonn, Como, Rome, Paris, Amsterdam, and other places, and he acknowledges the friendliness which allowed a stranger to wander among the treasures of their laboratories, homes and libraries. Some of the riches he gathered are here displayed for us; but we are not confined to these pioneers, for great names meet us on every page. We learn that it was Fourier who first appreciated Ampère's work; that it was Fourier's essay to which Ohm turned when studying conductivity; while an investigation by Heaviside of a Fourier's series was found written on the back of a bill for a copy of *Love's Old Sweet Song*. The account of Heaviside will be found by some readers the freshest of all, as it is also the longest. Not many sketches of that great investigator have been written, and this should materially help to correct some conceptions that may possibly have been erroneous.

If editors found Heaviside as perplexing a correspondent as others did the poet Francis Thompson, it was not for the want of good advice, and Hertz on one occasion wrote to him, "If you would only take a good form, a book of yours on the theory of electricity would have a great success in England and abroad. But I fear you have some pride in this, not to yield to the understanding of others. I think this is a false pride; you certainly are not aware how very difficult your papers are to understand to others, and it is old wisdom that the many will expect you to come to them, and not come up to you, be your merits ever so great." That was written in 1890 when Hertz was 33 and Heaviside was 40. The latter lived thirty-five years longer, but he never took the advice. The isolation in which Heaviside lived was largely of his own making, but it is pleasant to read that there was neither destitution nor desperate poverty as has sometimes been asserted.

Aufgaben aus dem Wasserbau Angewandte Hydraulik. By DR.-ING. OTTO STRECK. Berlin: Julius Springer. [Price 12 marks.]

IT frequently happens that an engineer mainly engaged upon a specialised branch of work finds it necessary to undertake the solution of problems in other branches, when he would greatly value a book which, not being a mere collection of data or purely a text-book, would show him the short-cuts of the specialist in these other branches. Dr. Streck's book is one of this class in the branch of hydraulic engineering, presuming only such knowledge of fundamentals as are possessed by most keen engineers.

In all, the author takes 40 widely varying and numerically specified problems and works them out in detail, as would be done in practice, giving only the brief technical exposition necessary to freshen the reader's memory of student times.

The first section deals with hydrostatic problems, such as cofferdams, caissons, sluice-gates, &c., and is followed by practical cases of uniform flow through open channels, dealing very well with the "section of maximum efficiency." To show the practical limits of calculation, the same problem is frequently solved by a number of alternative methods, and the results are compared with each other to emphasise the unfortunate truth that this is not yet an exact science.

In the next section, dealing with closed conduits, we are rather disappointed to find that the author, like every author of hydraulics texts we have ever read, omits to point out a limit, the neglect of which has frequently led to unsatisfactory results from pipe lines. It is always stated that, if the open end of a uniform pipe lies H ft. below the free surface, the theoretical velocity of efflux is $\sqrt{2\,g\,H}$, whereas it is evident, but often forgotten, that, if the depth of submergence of the inlet is h ft., and the water barometer stands at b ft., it is utterly impossible for the velocity in the pipe running full to exceed $\sqrt{2\,g\,(h+b)}$. This is a minor point sometimes, but at others vital.

In dealing with pipe lines, the author goes slightly outside his province and briefly discusses stresses in pipes and anchorages, which is possibly a pity, in view of the greater utility of the true aims of the book. The section on variable flow, after evolving the differential equation of the free surface from the fundamental conception of the "Energy-line," works out a number of "backwater" and "drop-down" problems by the step-by-step method, and by the approximations of Rühlmann and Tolkmitt, and concludes by discussing the outlets of (we believe) the Isar plant in what we can honestly call the clearest and most comprehensive study of the type of discharge in which a syphon, basin, bell-mouth, and pipe-line are employed that we have yet had the pleasure of reading.

With the thoroughness for which his countrymen are famed, the author deals also with surge chambers, drowned weirs, submerged orifices, rainfall and run-off, transport of debris, storage reservoirs, and water supply in general.

Here he very wisely refers the reader to specialist treatises, but when one considers that his avowed aim is merely to show competent but specialised men how to apply the knowledge which they already possess but rarely need to use, and not to impart that knowledge *ab initio*, one is bound to confess that, even where his text is highly condensed, he has omitted none of the essentials.

In aim and performance the book is a very welcome addition, and we can only repeat our regret that this branch of engineering appears in danger of becoming a German preserve.

Disrupted Strata. By M. H. HADDOCK. London: Crosby Lockwood and Son. [Price 16*s.* net.]

AMONG the many problems with which the mining engineer is liable to be confronted, are those connected with faulting of the seam or vein. Not infrequently, much valuable time is lost in searching for the faulted portion of a mineral deposit through insufficient knowledge of the natural laws governing the disruption of strata and inability to follow up, in a logical manner, those indications which are certain to be available in a greater or lesser degree. In the past, cases have been known where the search for a faulted portion has even led to the abandonment of a mine, the high expenditure on dead work, persistently continued on a falsely-reasoned theory, having exhausted the funds available. Although, it may be objected, such cases are rare, mention of them serves to emphasise the importance of a correct appreciation of faulting by those responsible for the technical side of mine operations. In practice, this usually comes within the scope of the mine surveyor.

The author of the above work, who is Principal of Coalville Mining and Technical Institute, deals with the practical side of the subject from the surveyor's point of view, purposely avoiding that aspect which treats with the dynamics and causes of faulting. The result is a conveniently-sized volume which deals with the problems of faulting in a thorough and practical manner, and should certainly find a place on the bookshelf of every mine surveyor.

It is unfortunate that, in a subject which is already sufficiently intricate, the nomenclature of faulting should be so unsatisfactory, as it undoubtedly is. The author suggests, in his preface, that this is probably due to the common practice of "portraying any kind of fault in simple end-views normal to the fault dip." As this method gives no information regarding the strike of the fault and disrupted strata, such end views are often misleading. In calculating fault data, the strike is the most important direction to be obtained.

The first chapter deals with definitions and primary considerations, and here it is made clear that three times as many dimensions are necessary as the usual hade, heave and throw which have hitherto been deemed sufficient. To the beginner, this will, perhaps, prove disconcerting, accompanied as it is with a rather long list of definitions. Yet these are essential to a correct appreciation of the actual characteristics of faults, and to enable the problems they involve to be solved mathematically.

Information regarding the dip and strike of faults or of strata is often obtained by means of boreholes. The second chapter deals with this important subject, showing how various problems in this connection may be solved. Strike angles, face angles and intersection lines assume definite aspects and magnitudes for each type of faulting, and hence afford important information in the location of dislocated portions of veins or seams. The author devotes a chapter to these features. Another chapter, which should be found particularly useful to the surveyor and mining engineer, is that entitled Locating the Disrupted Member. Other chapters are devoted to fundamental formulæ; rotational faulting; and to drifting or driving of headings in certain directions with the object of connecting two or more points known or assumed. The presence of faulting on a large scale would influence not only the direction, but also the inclination or height co-ordinates

of such drifts, and thus the surveyor would have to deal with three dimensions for which methods of space analysis or spherical trigonometry may become necessary.

THICK-WALLED TUBES AND CYLINDERS UNDER HIGH PRESSURE AND TEMPERATURE.

By R. W. BAILEY, A.M.I.Mech.E.

(*Concluded from page* 786.)

Thick Cylinder under Internal Pressure with Heat Transmission through the Wall.—The case of a thick cylinder under internal pressure and with heat transmission through the wall may be reduced to the case of uniform wall temperature by a modification of the stress-log . creep or log . stress-log . creep diagram, in the way shown by the author in the paper already referred to. Two cases arise, namely, (*a*) the one common in engineering practice where heat is transmitted from the outside to the inside of the cylinder or tube, and the other (*b*) where the heat flow is in the reverse direction, as, for example, occurs in a chemical, reaction chamber when an exothermic reaction is involved. Both may be dealt with in the same manner.

Case (*a*). *Heat Transmission from Outside to Inside of Cylinder.*

Let K = coefficient of thermal conductivity of the metal.
H = heat flow inwards across unit length of cylinder in unit time.
θ = temperature of wall at radius r.
θ_1 = temperature of inside wall.
θ_2 = temperature of outside wall.

The differential equation for heat flow is :—

$$2 \pi r K \frac{d\theta}{dr} = H,$$

which, upon integration, gives :—

$$\theta_2 - \theta = \frac{H}{2 \pi K} \log_e \frac{r_2}{r} \quad . \quad . \quad (39)$$

But from equations (1) and (4)

$$\log_e \frac{r_2}{r} = \frac{1}{2} \log_e \frac{C}{C_2} = \frac{1}{2} \log_e \frac{\phi}{\phi_2}.$$

Consequently

$$\theta_2 - \theta = \frac{2 \cdot 303 H}{4 \pi K} \log_{10} \frac{\phi}{\phi_2} \quad . \quad (40)$$

Equation (40) represents a linear relation between the temperature θ and $\log \phi$, and appears as a straight line EF in Fig. 7 at a slope γ (due account being taken of scales) given by the relation :—

$$\tan \gamma = \frac{2 \cdot 303 H}{4 \pi K}. \quad . \quad . \quad (41)$$

By means of the line E F, the case under consideration may be reduced to one of uniform temperature, as will now be shown.

Referring to Fig. 7, the curves marked $\bar{\theta}_1$, $\bar{\theta}_2$ and $\bar{\theta}_3$ represent the relation between f and $\log \phi$ obtained by shear creep tests at the temperatures $\bar{\theta}_1$, $\bar{\theta}_2$ and $\bar{\theta}_3$. The ordinate G E is drawn at the permissible value of $\log \phi_2$, where, of course, $\phi_2 = 2 C_2$.

The point E corresponds with the wall temperature θ_2 at the outside of the cylinder, and E F is drawn at the slope indicated by equation (41), a suitable temperature scale being chosen as shown at the right-hand side of the diagram. The line E F connects temperature with $\log \frac{\phi}{\phi_2}$ and indirectly with $\frac{r}{r_2}$, thereby determining the temperature distribution through the wall of the cylinder. The resistance of the metal to creep, depends upon the temperature, and it will be apparent that the point I, for example, determines the stress f and corresponding $\log \phi$, where the temperature is $\bar{\theta}_2$. Similarly, the point H determines the corresponding values of f and $\log \phi$ for a temperature $\bar{\theta}_3$. The curve G I H gives the relation between f and $\log \phi$ taking into account the influence of temperature distribution, and it may be employed exactly as a relation between f and ϕ for constant temperature would be used in the case where there is no heat transmission. In practice, the range of $\log \phi$ concerned in any problem will be such that the curvature of GIH over this range is negligible, and the corresponding value of n may be obtained and employed in the formulæ derived for the case where there is no heat transmission.

The case where a linear relation between $\log f$ and $\log \phi$ may be assumed is dealt with in exactly the same way as in Fig. 7.

Case (*b*). *Heat Transmission from Inside to Outside of Cylinder.*

Employing the same symbols as in case (*a*) the same relations are obtained, except that H must be taken as negative. In effect, this change can be made in Fig. 7, by reversing the temperature scale, E, as before, representing the wall temperature at the outside (in this case the lowest temperature) and equal to, say, $\bar{\theta}_3$, and the other temperature θ_2 and θ_1 being read below $\bar{\theta}_3$. Having made this change, the procedure remains as before, and the curve LIJ is obtained which represents the relation between f and $\log \phi$, taking into account

Fig.7

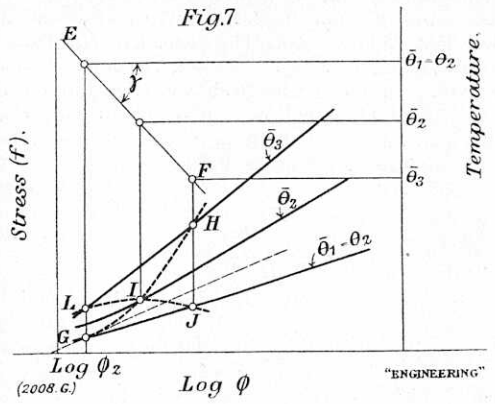
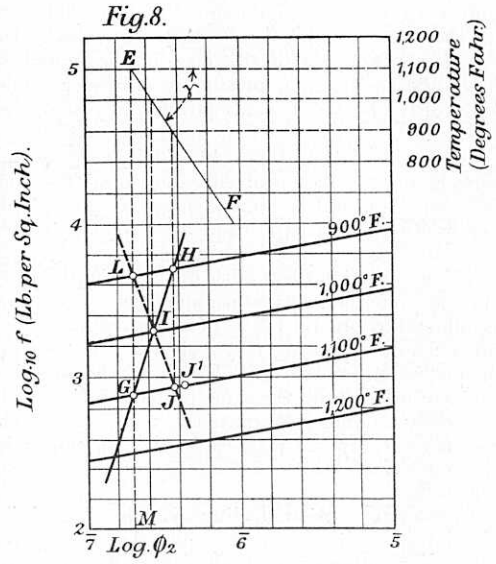


Fig.8.



heat transmission from the inside to the outside of the cylinder. It will be observed that, with heavy rates of heat transmission, the slope of LIJ may become negative, and thereby give rise to negative values of n for use in the expressions derived for the case where there is no heat transfer, when employed for the present case.

As in case (*a*), it will be evident that the same procedure would be followed when the relations between $\log f$ and $\log \phi$ is linear. It may be added, however, that it is possible to show that the relations between $\log f$ and $\log \phi$ derived to meet the case of heat transmission may be expected to be approximately linear. In the following, data obtained by Mr. F. H. Norton in his tensile-creep tests (*The Creep of Steel at High Temperatures*) is utilised in an example to illustrate the application of the preceding.

Example.—An example will illustrate the case where there is heat flow, a linear relation being taken to connect $\log f$ and $\log \phi$. Utilising as a basis tensile-creep test data given by Norton for an 0·42 and an 0·45 per cent. carbon steel, Fig. 8, probably represents roughly the relation between $\log f$ and $\log \phi$ for the temperatures 900, 1,000, 1,100 and 1,200 deg. F. It is required to determine the outside diameter of a cylinder of 20-in. bore for a working pressure of 2,000 lb. per square inch, given maximum metal temperature 1,100 deg. F.; permissible diametral creep rate at outside of cylinder 10^{-7} strain per hour; heat transmission through wall 20,000 B.Th.U. per foot square per hour at bore surface; and thermal conductivity of metal $K = 6 \times 10^{-4}$ $\frac{\text{B.Th.U.}}{\text{deg. F. inch sec.}}$ units. The two cases of heat flow, *i.e.*, in the direction towards and away from the cylinder axis, are to be considered.

Case (*a*). *Heat Transmission Towards Axis.*

H = heat transmitted per inch length of cylinder

$$= \frac{\pi \times 20 \times 20{,}000}{144 \times 3{,}600} = 2 \cdot 42 \text{ B.Th.U. per sec.}$$

From equation (41)

$$\tan \gamma = \frac{2 \cdot 303 \times 2 \cdot 42 \times 10^4}{4 \pi \times 6} = 738 \text{ deg. F.}$$

From equation (1) $\phi_2 = 2 \times 10^{-7}$.

Referring to Fig. 8, ordinate ME is drawn at $\log \phi_2$ and EF is inclined at γ (= $\tan^{-1} 738$) to the horizontal, due account being taken of the $\log \phi$ and temperature scales. The point E corresponds with the maximum temperature, which will occur, in this case, at the outside of the cylinder, *i.e.*, at $\log \phi_2$. Intersection of EM with the $\log f \times \log \phi$ line for 1,100 deg. F. marks a point G on the equivalent relation required which takes into account heat transmission. Similarly, projecting across from the temperature scale on to EF and down on to the $\log f \times \log \phi$ lines for the same temperatures determine points I and H, and results in the equivalent $\log f \times \log \phi$ graph GIH.

Referring to equation (38) the value of b^1 for GIH is 3. The value of f_2 represented by point G is 760 lb. per square inch. Introducing $p = 2{,}000$.

$$\frac{r_2}{r_1} = \left(1 + \frac{2{,}000 \times 3}{760}\right)^{\frac{1}{6}} = 1 \cdot 44,$$

or outside diameter of cylinder = 29 in., say, and

Temperature drop through wall = $738 \times 2 \log 1 \cdot 45$
= 238 deg. F.

Case (*b*) *Heat Transmission Away from Axis.*

Since the temperature of the cylinder is only known for the inside surface, *i.e.*, 1,100 deg. F., it is necessary to proceed by means of equation (36), putting $2 f_1 = x_1 + y_1$. Then

$$f_1 = p \frac{b^1}{1 - \left(\frac{r_1}{r_2}\right)^{2 b^1}}$$

which gives :

$$\frac{r_2}{r_1} = \left(1 - \frac{p\, b^1}{f_1}\right)^{-\frac{1}{2 b^1}}$$

Referring to Fig. 8, owing to the parallelism or substantially parallel character of the $\log f \times \log \phi$ lines for different temperatures, the values of b^1 for the derived line GIH is not affected in any practical case by the value of $\log \phi$ employed to fix the positions of E. Similarly, the value of b^1 for JIL, which, from what has been said, will be seen to represent the present case, will not be affected by the positions of E.

In the present case (line JIL) b^1 has the value $-2 \cdot 7$. As a first approximation, let it be assumed that $\phi_1 = 2 \times 10^{-7}$ (*i.e.*, the permissible value of ϕ_2) in which case G represents f_1, *i.e.*, 760 lb. per square inch. Introducing values

$$\frac{r_2}{r_1} = \left(1 + \frac{2{,}000 \times 2 \cdot 7}{760}\right)^{\frac{1}{5 \cdot 4}} = 1 \cdot 473.$$

From equation (5)

$$\frac{C_1}{C_2} = \frac{\phi_1}{\phi_2} = 1 \cdot 473^2 = 2 \cdot 17.$$

As a small adjustment of the value of $\frac{r_2}{r_1}$ will not greatly alter the ratio of C_1 to C_2, it is now possible to estimate an approximate value of ϕ_1.

Taking $\phi_1 = 2 \times 10^{-7} \times 2 \cdot 17$, the point I in Fig. 8 marks the corresponding position of $f_1 = 890$ lb. per square inch.

Recalculating $\frac{r_2}{r_1}$:

$$\frac{r_2}{r_1} = \left(1 + \frac{2{,}000 \times 2 \cdot 7}{890}\right)^{\frac{1}{5 \cdot 4}} = 1 \cdot 437.$$

Recalculation with $\frac{r_2}{r_1} = 1 \cdot 437$ gives $\frac{r_2}{r_1} = 1 \cdot 438$ as in the first case.

Required outside diameter of cylinders = 29 in.

Procedure in Experiment.—It has already been stated that there are very little data available upon

the creep of metals under pure shear, few tests having been made in torsion either upon thin-walled tubular or solid cylindrical specimens. Nevertheless, the author hopes that he has demonstrated that such tests form the basis of a rational treatment of the creep of tubes or cylinders under internal pressure with or without heat transmission through the wall. When the creep of metals under complex stress is fully understood, it may be possible to base all cases upon the results of tensile-creep tests, which, on account of their simplicity in execution, is desirable. Until this time is reached, the most direct and reliable course appears to be via the torsion-creep test. It is expected, therefore, that torsional-creep tests will become the immediate means of dealing with the design and behaviour of these important parts, and the first question that arises is what form the specimen should take.

In the case of tubes of sufficiently small dimensions, there is no reason why the tube itself should not be employed as a test piece; indeed, it is desirable that it should be used. A suitable delicate torsionmeter would be attached to register the twist over a gauge length in order to eliminate errors due to possible slip or irregularities at the grip. In the case of larger parts, it will be necessary to cut test pieces, and, in view of the difficulty in preparing accurate tubular specimens, they should be avoided if possible. This can be done and equally good results can be obtained from solid cylindrical specimens. It is necessary, however, to interpret from the test results the correct relations between f and ϕ as would be given by tests upon thin-walled tubes. Such an interpretation is readily made.

The author's tests upon thin tubes indicate that a solid cylindrical test piece should behave as if composed of a number of elementary concentric tubes undergoing rates of creep in shear proportional to their radii. Taking a linear relation to connect f and log ϕ, *i.e.*, equation (6) or (8), and equating the applied torque T to the moment of resistance gives

$$T = 2\pi \int_0^{\frac{d}{2}=r_2} r^2 (a + n \log_e \phi)\, d\, r$$

d = diameter of specimen.

But

$$\phi = \frac{r}{r_2}\phi_2$$

$$T = 2\pi \int_0^{\frac{d}{2}} r^2 \left[a + n \left(\log_e \phi_2 + \log_e \frac{r}{r_2} \right) \right] d\, r$$

$$= 2\pi \int_0^{\frac{d}{2}} r^2 \left(f_2 + n \log_e \frac{r}{r_2} \right) d\, r.$$

Integrating:

$$T = 2\pi \left[\frac{r^3}{3} \left(f_2 + n \log_e \frac{r}{r_2} - \frac{n}{3} \right) \right]_0^{\frac{d}{2}=r_2}$$

$$= \frac{\pi}{12} d^3 \left(f_2 - \frac{n}{3} \right) \quad . \quad . \quad (42)$$

If the stress were uniform over the cross section at a value f^1, the moment of resistance would be $\frac{\pi}{12} d^3 f^1$. Putting f in place of f_2 to represent a general case in which ϕ is the shear-creep rate corresponding, it is seen from equation (42) that

$$f = f^1 + \frac{n}{3} = \frac{12\,T}{\pi d^3} + \frac{n}{3} \quad . \quad . \quad (43)$$

The shear-creep rate ϕ is, of course, given by $\frac{d}{2}\alpha$ (see equation (1)).

A series of tests at the same temperature but at different stresses f^1 will give a relation between f^1 and log ϕ from which n may be determined, and therefrom the required relation between f and log ϕ is obtained.

If a linear relation between log f and log ϕ is taken as represented by equation (7) it will be found that

$$f = \left(1 + \frac{b^1}{3} \right) f^1 = \left(1 + \frac{b^1}{3} \right) \frac{12\,T}{\pi\, d^3} \quad . \quad (44)$$

or

$$\log f = \log \left(1 + \frac{b^1}{3} \right) + \log f^1.$$

In this case, therefore, the true line between log f and log ϕ is parallel to that between log f^1 and log ϕ, and displaced in the direction of log f by $\log \left(1 + \frac{b^1}{3} \right)$. The relation between log f^1 and log ϕ determines b^1 and consequently the required relation between log f and log ϕ is provided.

Thus, test pieces of solid circular cross section under torsion-creep tests can provide the information that would be obtained from tubular specimens. Solid test pieces will generally be of cylindrical form, but cases may arise, when approximation is permissible, where it is desirable to employ wire or rod of small cross section loaded as a spring.

Conclusion.—In the foregoing, the strength and creep of thick cylinders and tubes under internal pressure has been shown to have a rational connection with creep of the material in shear, and it has been shown that, given the requisite-creep test data from torsion tests, practical cases may be readily dealt with. One or two comments, however, are desirable.

Referring to the actual behaviour of tubes, Fig. 1, *a* and *b*, page 773 *ante*, indicates how a tube under torsion is similar, from a creep point of view, to a tube under internal pressure, but an isotropic material is implied. If there is marked difference in the characteristics of the material with direction, the different orientation of the corresponding stress systems of Fig. 1, *a* and *b*, in the tube wall may result in a difference in the actual behaviour of tubes under torsion and the corresponding internal pressure. While the author does not suspect that the directional differences, of material characteristics found in good quality solid-drawn steel tubes, *e.g.*, superheater elements, are sufficient to affect to a practical extent the correspondence of tubes under torsion and internal pressure, it is desirable for this point to be investigated by experiment. In cases where surface treatment is applied, *e.g.*, calorising, whereby concentric zones of modified metal are produced, the circumstances are such that disturbance of the correspondence of the behaviour of such tubes under torsion and internal pressure is not expected. In the case of castings and forgings where test pieces would be employed the question of difference does not arise.

Reference may be made to the character of the creep of metals under constant stress and temperature. In the foregoing it is taken that, for any particular stress and temperature, the creep rate is constant, and that throughout a cylinder wall steady conditions are attained. For all practical purposes, this will be the case after a time, but as in a creep test there will be an initial period during which important changes in the creep rate will occur, the analysis given must be taken to apply when something like steady creep rates have been attained.

The author is indebted to the directors of Messrs. Metropolitan-Vickers Electrical Company, Limited, for permission to publish the matter of this article.

THE INTERNATIONAL RAILWAY CONGRESS, MADRID.

(*Concluded from page* 790.)

WE conclude our account of the Railway Congress by dealing with the reports and discussion on the question of staff training, following this by a brief summary of the proceedings at the plenary and final sessions and a few notes on the visits, excursions and social functions.

TRAINING OF STAFF.

At a meeting held on May 12, Question XVI, covering methods followed in training staff of the professional, technical and ordinary working grades, was discussed by Section IV. Four reports, of which we give abstracts below, were prepared on this subject, and these reports were summarised in a special report prepared by Mr. Barth.

The first report, covering America, the British Empire, China and Japan, by Mr. L. C. Fritch, of the Chicago, Rock Island, and Pacific Railway, dealt, in separate sections, with the United States, Great Britain and Northern Ireland, New South Wales, New Zealand, India, South Africa, Nigeria, Japan, China (*i.e.*, the South Manchurian Railway), Egypt (limited to the Sudan Government railways and steamers), and the Federated Malay States. Stress was laid upon the facilities for training offered by the companies, and sick funds and libraries were among the features noticed. As regards the United States railways, Mr. Fritch outlined the organisations, comprising boards of directors elected by the shareholders, subject to the approval of the Interstate Commerce Commission, and, under them, the executive, legal, financial, accounting, operating, traffic and purchase departments, discussing their requirements separately. The Indian railways (Ceylon, Madras, Great Indian Peninsula, East Indian, South Indian, North-Western, Bombay, Baroda and Central India, Eastern Bengal and Bengal-Nagpur), supplied fuller information than others. The reports referred particularly to the training of apprentices.

The report for Belgium, France, Holland, Italy, Portugal, Spain and their Colonies, by Mr. Barth, of the French Est Railway, reviewed replies received from Belgian, French and Spanish lines. The oral and correspondence courses of the Ecole des Travaux Publics at Paris and the review on railway work issued every other month, since January, 1929, by the Paris-Lyon-Mediterranean Railway, were commended.

The report by Mr. Mereutza, of the Roumanian State Railways, was intended to deal with all the remaining countries (except Germany), but was actually limited to Bulgaria, Denmark, Sweden, Norway, Finland, Greece, Czechoslovakia, Yugoslavia, Poland, Roumania, Switzerland and Luxemburg. As regards the bulk of the employees, most of these railways were obliged to take on workers from outside as the need arose, after a preparatory period; only the higher grades were filled by promotion. The examination was largely restricted to an inspection of testimonials and to practical testing, after which appointments were confirmed. Psycho-technical tests were being introduced. Apprentices were almost certain to be appointed to permanent positions, but this was not guaranteed. The policy in Switzerland of subsidising schools not entirely dependent upon the railways had been abandoned.

Dr. Ing. Bruno Schwarze, of the central administration of the Reichsbahn, had an easier task than his colleagues in preparing the report for Germany, inasmuch as the main regulations are the same for the whole German railway system. There is, however, much diversity, and voluntary education in the schools of the Association of Reichsbahn technical schools is still assisted by the loan of class rooms and apparatus and by grants of free fares for students. The Reich spent, in 1928, about 7,000,000 marks on the training of some 700,000 officials and men, this total being less than the sum paid annually for cotton waste alone.

In the matter of pay and training, the staff was classified in seventeen categories. The highest administrators and officials, such as engineers, surveyors and chemists, must have academic training. The special training was provided for the middle class and lower classes. The examination of applicants might include psycho-analysis in the case of signalmen, but not in the case of stokers. Theoretical instruction was given in service schools for beginners and for managers, by lectures and practical work; attendance at these was compulsory. Railway cars were fitted up as travelling schools with maps, models, dummy apparatus, signals, &c. The central schools took the form of boarding schools for up to 100 employees. Debates on traffic disorganisation, time-table adjustments, emergencies, &c., were encouraged. There was a good deal of co-operation with other educational organisations.

In his special report, Mr. Barth divided the subject into three subheadings, viz., the selection of candidates, preliminary instruction, and instruction given to men already in the service. He stated, in connection with the first division, that most administrations examined the candidates, and the latter, in certain cases, were required to produce diplomas. Psycho-technical tests had been adopted, with good results, by the Société des Transports en Commun, of Paris, and also by the Czechoslovakian and German State Railways. With regard to instruction given before entering the railway service, it appeared that railways which had subsidised private educational institutions were dropping this arrangement, since it seemed better

that direct instruction should be given by the railways themselves. The training of the staff was of very great importance from the points of view of output and safety. On many systems men received instruction in the subjects they required to study at stations, depots, &c., or in schools provided for the purpose. Noteworthy schools of this class existed in France, Germany, Sweden, Denmark, India, Australia, &c.

In the subsequent discussion on this question, Mr. Poirel submitted a proposition that the inquiry should be pursued, and recommended that in countries where military service was obligatory, ex-apprentices, on the conclusion of their military service, should be given employment in their respective trades by the railways on which they had previously served. Mr. Barth supported this proposition with the provisos that the apprentices should have given satisfaction, and that vacancies existed. Several other speakers supported this proposition, and Mr. Cramp referred to the necessity for giving adequate instruction to men who had to work alone. He also emphasised the need for practical instruction in the steps to be taken in the event of accidents or other emergencies. Dr. Bruno Schwarze referred to the successful development in Germany of the psycho-technical system of tests, mentioning that over 120,000 of these examinations had been made with satisfactory results, and Mr. J. Hondl stated that these tests had been used successfully in Czechoslovakia since 1923. Mr. R. Honold referred to the necessity for giving theoretical instruction as well as practical training, also expressing the opinion that each employee should receive instruction for a certain number of hours over a fixed period, his attendance for such instruction being duly checked. Mr. W. T. Biscoe was in agreement with Mr. Honold, and mentioned the difficulties experienced with Indian native railwaymen to whom all instructions had to be conveyed orally.

After some further discussion, the following summary was adopted by the Section :—

(1) Railway administrations should take particular care to select candidates possessing the necessary qualifications for the posts to be filled. To this end, candidates should be required to pass an examination in general knowledge, or furnish a school certificate. Special examinations, including psycho-technical tests, should, however, be instituted if necessary. Several administrations have made use of such tests with very satisfactory results ; their extension is recommended.

(2) Preliminary instructions should be given before the selected candidates commence work. This instruction will, of course, vary in character and duration for ordinary workmen, artisans and clerks. Most administrations have made arrangements of this kind, particularly as regards apprenticeship. It is recommended that Administrations should take care to give their manual workers at least as good a training as that afforded by other industries in their respective countries. It is also recommended that all railway administrations, in countries where military service is obligatory, should give priority to their ex-apprentices who, on the termination of their military service, submit applications for employment in any posts that may be vacant.

(3) In view of the information furnished by the various Administrations and the trials already carried out, it is recommended that employees should be given regular and methodical instruction in regard to new regulations, new developments in their respective spheres of work, and be taught to carry out their work economically (*i.e.*, obviating waste of time or materials) punctually, and with safety to themselves, the public, the rolling stock, &c. The employees should be required to serve probationary periods, either in technical schools, or by instruction at the stations, depots, &c., using instruction cars (*wagons-écoles*), optical lanterns, and the kinematograph. Good results have been obtained from instructional kinematographs, and their use is recommended. It is strongly recommended that men who work alone should receive careful instruction, and further that practical training should be given as regards the steps to be taken in the event of accidents or other emergencies. Furthermore, it is necessary to test the men from time to time, to see that they have assimilated the knowledge imparted to them, and are making good use of it.

(4) It is also recommended that support should be given, as far as possible, to private institutions which provide tuition for the men, and attention is drawn to the methods of teaching by correspondence, which have been successfully adopted by some Administrations.

(5) Finally, men of particular merit should have an opportunity of being tested in regard to their powers of judgment and ability to command, with a view to promotion to the higher grades.

It was finally recommended that Question XV, on the Co-operation of the Staff towards Increased Efficiency and Participation in the Profits, should be included on the agenda for the next Congress, in addition to the two following questions :—The systematic organisation of railway work, and competition between systems of combined transportation (*i.e.*, railways and aeroplanes, and railways and motor cars) from the technical, commercial and legal points of view.

Plenary and Final Meetings.

The general meetings, at which the findings of the various sections are considered by the delegates as a whole, were held on May 10, 14, and 15. At the first of these, Sir Henry Fowler proposed that the term "summaries" should be used to designate the findings arrived at by the sections, instead of the term "conclusions" and, after some discussion, this suggestion was adopted. In most cases, the sectional summaries were adopted without alteration, or with only slight verbal modifications. In connection with Question XIII, Road-Transport Competition, however, Sir Josiah Stamp expressed the view, with regard to the granting of concessions to railway companies for the organisation of motor road services, that the companies should not obtain such concessions unless they were prepared to make use of them. This alteration and other slight modifications having been agreed upon, the amended summaries were duly adopted. We should, perhaps, mention that, at a joint meeting of Sections III, IV, and V, held on May 9, the summaries on this question were also modified to some extent, but the alterations did not materially affect the main points in the abbreviated form in which they were given on page 709, *ante*. Another point raised at the plenary meeting held on May 10 had reference to Question XV, Co-operation of Staff. Mr. Marin del Campo mentioned that the words *traitement du personnel* in the French text had been translated by "staff remuneration" and he wished it to be made clear that the point involved not merely the remuneration but also the general treatment of the staff. It was found, on examination, that the German text was sufficiently explicit, and a proposition by Sir Josiah Stamp that "treatment" should be substituted for "staff remuneration" in the English text was agreed to. Modifications were also made in the summaries of Section I with regard to Question II, Wear and Breakage of Rails, mentioned on page 708 *ante*. These were to the effect that rails obtained from the heads of ingots should be used in those parts of the line which were least heavily stressed and that, in addition to the development of lubricating appliances for preventing the lateral wear of rails on curves, special steel or heat-treated steel rails should be used.

At the plenary session held on May 14, Mr. M. Liebrand proposed, with regard to Question XX, Rail Motor Vehicles, that the conclusion reached with regard to the use of rail motor coaches with steam or internal-combustion engines (see page 758 *ante*) should be modified to include accumulator vehicles, and this suggestion was adopted after some discussion. No important alteration to the sectional summaries was made on the plenary session held on May 15, but other matters dealt with included the admission of Bulgaria, Turkey, Colombia, Austria and Hungary to the Association. The election and re-election of a number of members to the Permanent Commission was confirmed and the decision to hold future Congresses at intervals of three years was approved. The meeting then considered the question of the venue for the next Congress, the General Secretary, Mr. P. Ghilain, explaining that, as a result of negotiations, the Permanent Commission wished to propose Egypt for this. The meeting having expressed approval of this proposition, Dr. S. Matsunawa proposed that the Congress should be held in Tokyo in 1936, but Mr. D. C. Coleman, of the Canadian Pacific Railway, asked that this question should be deferred, as Canada desired to receive the Congress in 1936. The President, after thanking the Japanese and Canadian delegates for their invitations, explained that a definite decision as to the venue for the 1936 Congress could only be made at the 1933 Congress, but the suggestions made by Dr. Matsunawa and Mr. Coleman would be carefully considered. Mostafa Bey Hamdy El Kattan, of the Egyptian State Railways, then assured the assembly of a cordial welcome in Cairo in 1933.

The last plenary session was followed by the closing ceremony, at which the chair was taken by H.R.H. the Prince of the Asturias. Señor Don José Gaytan de Ayala, President of the Congress, after expressing thanks to His Royal Highness for his attendance at the meeting, briefly referred to the work of the Congress, which, he said, marked a further stage in the progress of the science of transportation. He also expressed appreciation of the services of the officers of the Congress, and thanked the Spanish Railway Companies and the International Sleeping Car Company for the contributions they had made to its success. Mr. E. Foulon, President of the Permanent Commission, who also spoke, first thanked H.M. The King of Spain and the Royal Family for the interest they had shown in the work of the Congress, and then referred in appreciative terms to the efforts of the Spanish Government, particularly of the Minister of Public Works, to make the Congress the success it had been. Special thanks, he said, were due to Señor Gaytan de Ayala for presiding over the Congress and to Messrs. Krahe and Garcia-Lomas for the part they had taken in its organisation.

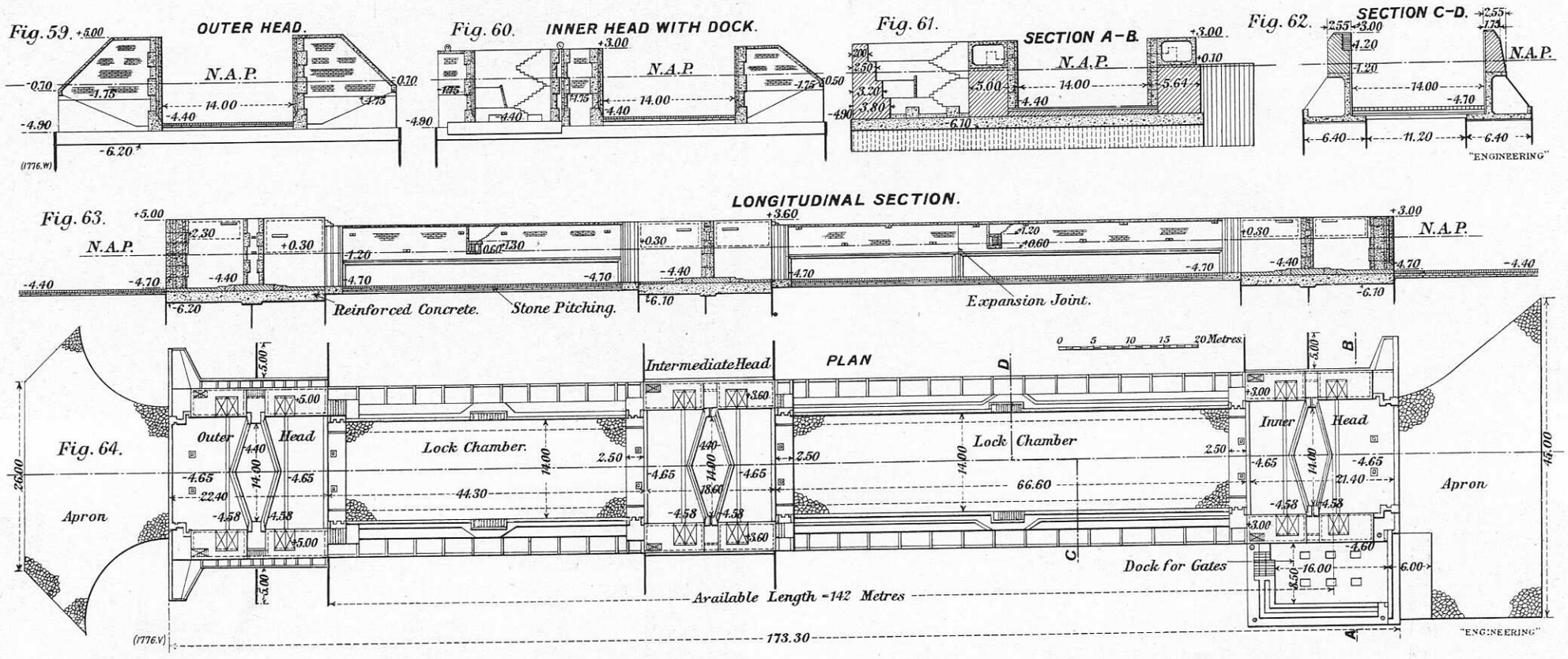
Visits, Excursions, &c.

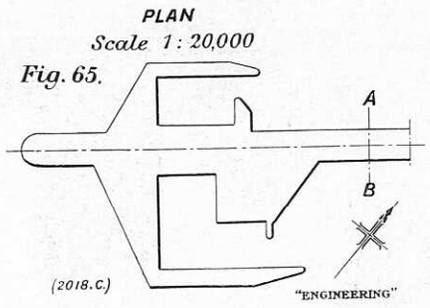
Throughout the Congress, a most attractive programme of visits, excursions and social events was provided by the Spanish Local Commission, who are to be congratulated on the manner in which these were invariably carried out. The events included a reception by the City Corporation of Madrid in the Retiro Park during the afternoon of May 6, and a pelota match at the Jai-Alai Frontón in the evening of the same day. On the following day, visits were paid to the workshops and stores of the Madrid, Saragossa and Alicante Railway Company at Villaverde Bajo, about 4 miles from Madrid, and to the repair shops and depots of the Madrid Tramway Company, in Madrid. Another party, on the same day, attended the inauguration of the Railwaymen's Orphan's College by H.M. The King of Spain. In the evening of May 8, a concert of Spanish music was given in the Teatro Gran Metropolitano, and this was honoured by the presence of Their Majesties, The King and Queen and members of the Royal Family. The concert was followed by a *fête* and dance.

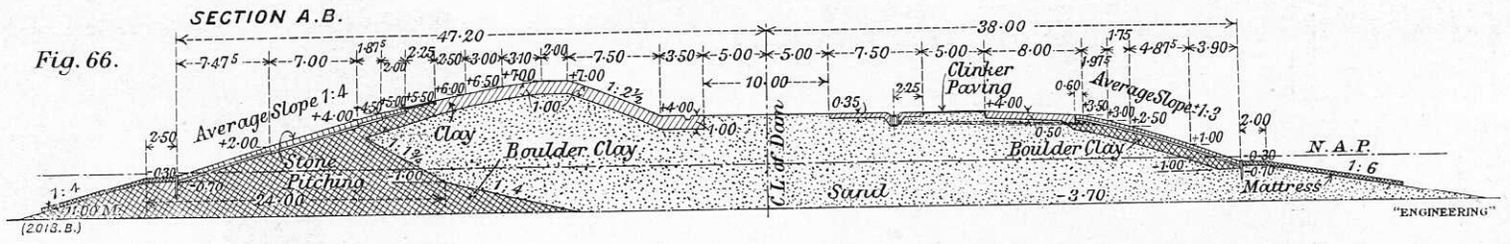
A particularly enjoyable event was the banquet given to the delegates by the Local Commission at the Palace Hotel on the evening of May 9. After this, the Acting President of the Congress, Señor Don José Gaytan de Ayala, in a brief but felicitous speech, thanked the delegates for their attendance, and expressed his appreciation of the work of the Association. Responding in a similar manner, M. E. Foulon, Chairman of the Association, thanked Señor Gaytan de Ayala for the manner in which the delegates had been received, and referred to the effect of improvements in means of transport on international relationships and on the economic positions of countries. He also mentioned that, in order to follow the evolution in means of transport more closely, it was proposed to shorten the interval between the congresses, which would in future be held once in three years. M. Foulon also referred in appreciative terms to the interest taken by H.M. The King of Spain in the work of the Congress, and, after thanking the Spanish Government, the railway companies, and the members of the Local Commission for having contributed so largely to its success, concluded by proposing the loyal toast, which was enthusiastically received.

ZUYDER ZEE RECLAMATION WORKS: LOCK AND SLUICES IN MAIN EMBANKMENT.

(*For Description, see Page* 821.)







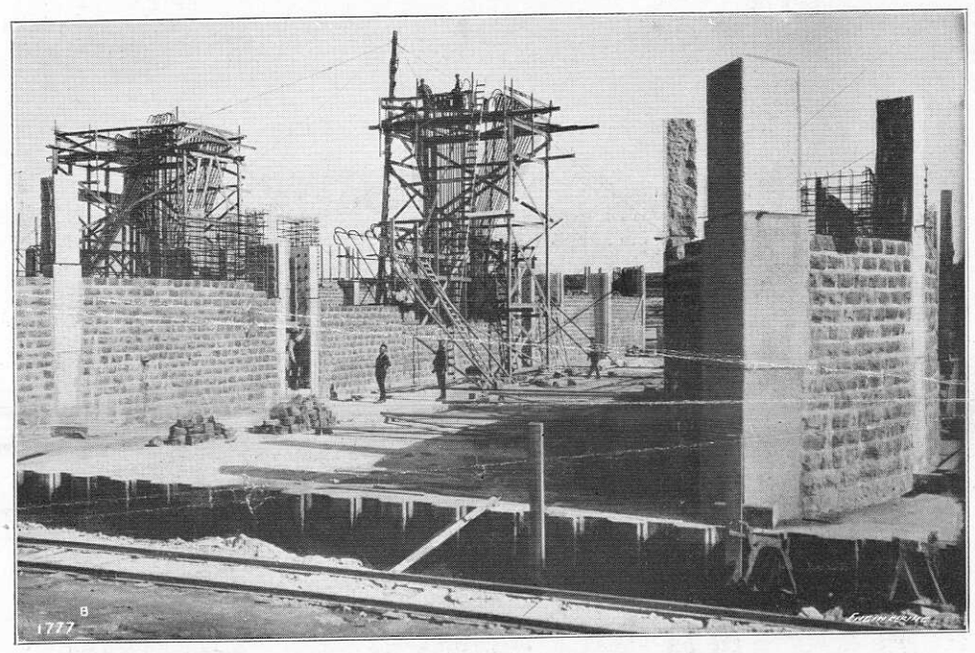


Fig. 67. Sluice Walls under Construction.

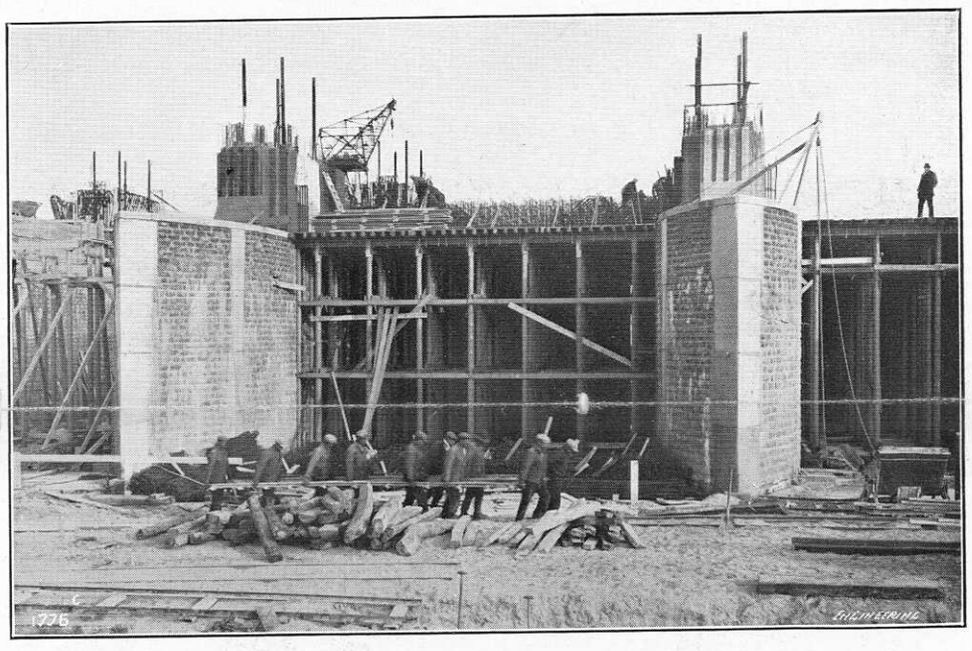


Fig. 68. Shuttering for Railway Bridge.

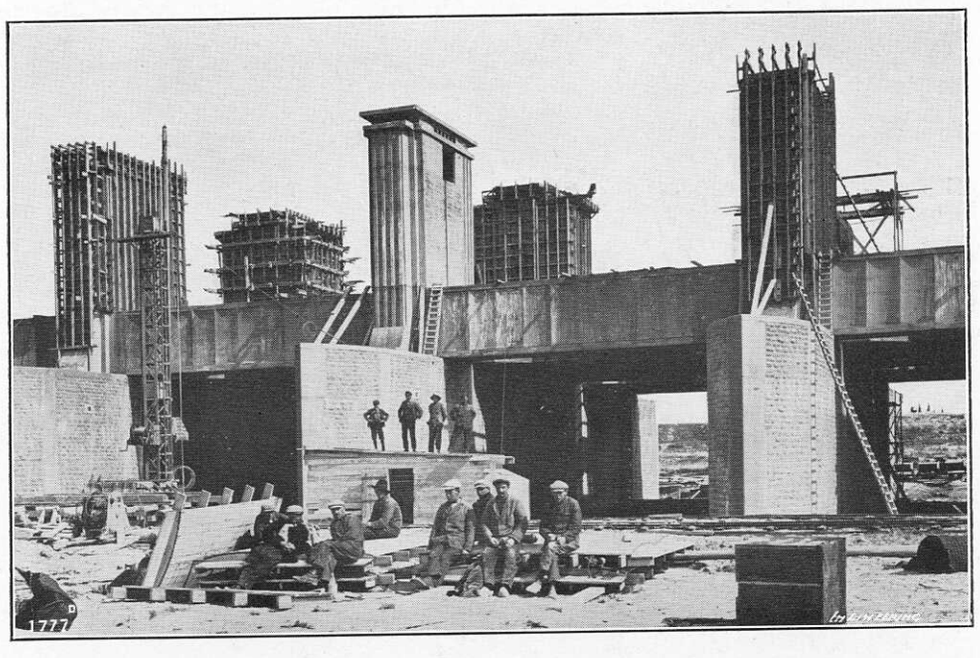


Fig. 69. Outlet Side of Sluices with Gate-Operating Towers.

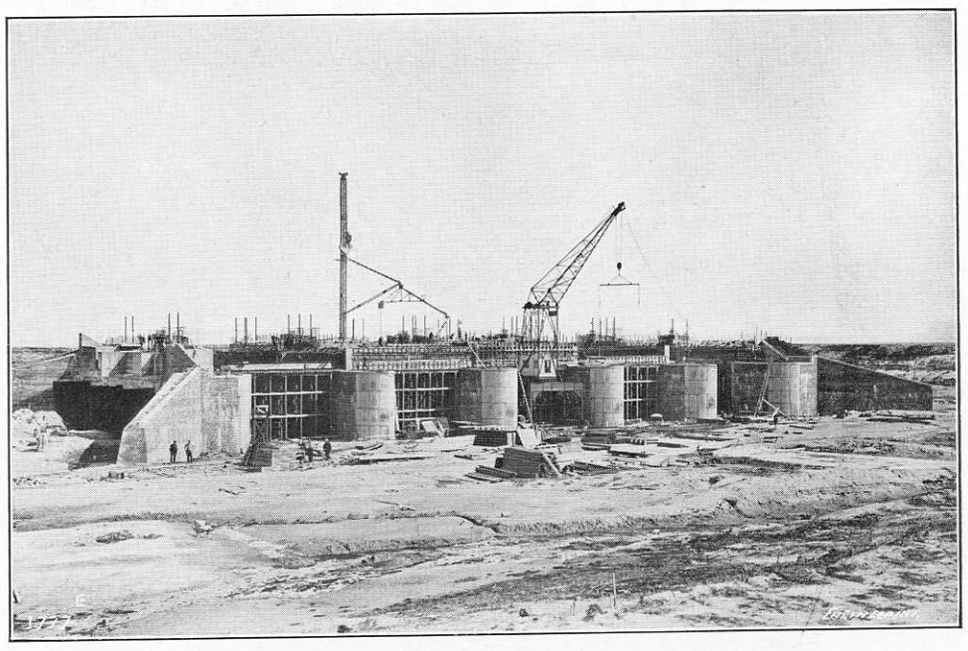


Fig. 70. Inlet Side of Eastern Set of Sluices.



Fig. 71. Construction of Sluices and Locks, Kornwerderzand, September, 1928.

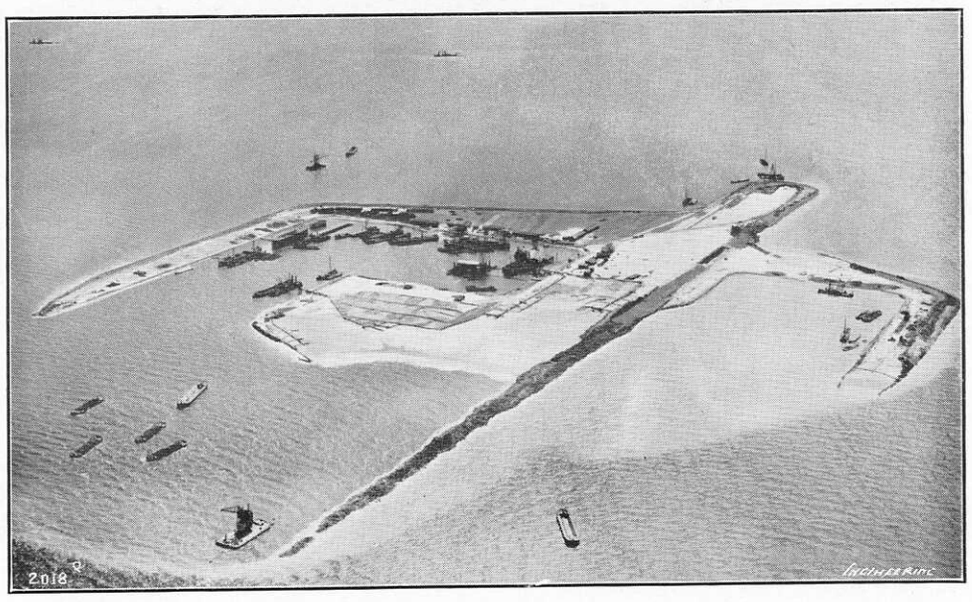


Fig. 72. Harbours and Portion of Main Embankment at Breezand.

On Saturday, May 10, the delegates visited the power station and car shops of the Madrid Metropolitan Railway. The line, the first section of which was opened in 1919, now runs in a north-south direction from Tetuan to Vallecas, and in an east-west direction from Ventas to the Norte railway station, the total length at present open for traffic amounting to about 11 miles. The tunnels are of concrete, located generally just below the road surface. Three-phase current is supplied at 15,000 volts by three companies, viz., the Unión Eléctrica, the Hidráulica Santilla, and the Hidroeléctrica Española, this current being transformed in three substations into direct current at 600 volts, at which pressure it is supplied to overhead lines in the tunnels. Two of the substations are equipped with motor-generator sets, but in the most recently constructed substation, viz., that at Quevedo, three mercury-vapour rectifiers, two of 800-kw., and one of 2,100-kw. capacity, are installed. To provide against a possible failure in the supply, a stand-by power station has been erected in the Pacifico district, this station being equipped with three Diesel-engine driven sets, each of 1,000-kw. capacity, generating three-phase current at 15,000 volts. The company owns 66 motor cars and 64 trailers of all-steel construction, the former being fitted with specially designed trolley type collectors taking current from overhead wires supported from the top of the tunnels. We understand that these trolley collectors have proved greatly superior to the pantograph collectors first employed. That the operation of the line is entirely satisfactory may be gathered from the fact that, in 1929, the passengers carried numbered 80,000,000 although the population of Madrid is only about 1,000,000.

On Sunday, May 11, and Tuesday May 13, excursions were arranged to places of interest within easy reach of Madrid such as Toledo, Salamanca, Segovia-La Granja, El Escorial, Avila and Aranjuez, and on Wednesday, May 14, the delegates were received by H.M. The King at the Palace. As already mentioned, the final session of the Congress, was held at the Senado on the morning of Thursday, May 15, and on the following Friday and Saturday, the delegates left for Seville or Barcelona, those travelling to Seville visiting Cordoba *en route*. At Seville, the Spanish-American Exhibition was in progress, while the National Exhibition was being held in Barcelona. At both cities, an attractive programme of visits and excursions was provided by the Local Commission, concluding on May 20 at Barcelona and on May 21 at Seville.

ZUYDER ZEE RECLAMATION WORKS; MAIN ENCLOSING EMBANKMENT AND SLUICES.

By J. W. THIERRY.

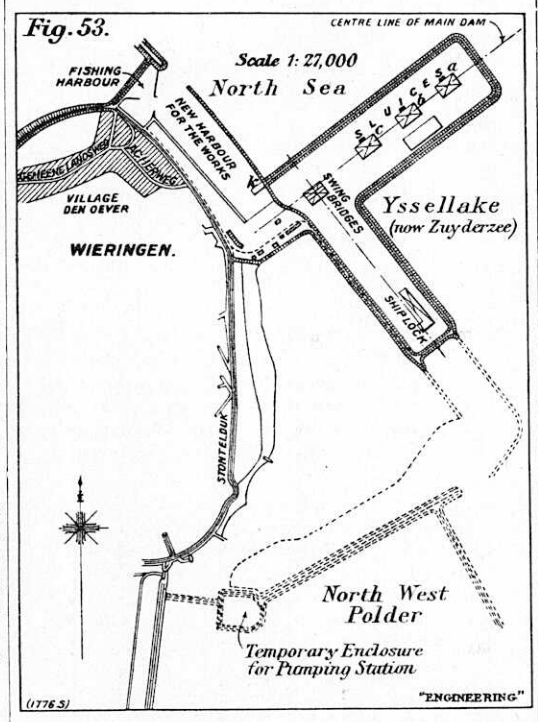
(*Concluded from page* 762.)

ALTHOUGH the two previous articles dealt with the only part of the whole of the Zuyder Zee scheme completed up till the time of writing, some account is nevertheless necessary of the work in progress for the enclosing and subsequent draining of the Zuyder Zee in order to obtain a rational idea of what still remains to be done. As already explained, the enclosure of the North West Polder was undertaken in the open Zuyder Zee from reasons of economic pressure, and the next operation, in order of urgency, is that of completing the embankment from Wieringen to the Friesland coast, thus converting a tidal sea into an inland lake. The area of this tidal sea is then to be very considerably reduced by the reclamation of three polders, all much larger than that in the north-west.

The site of the main enclosing embankment is indicated in Fig. 33, page 759 *ante*. It extends in a straight line almost to the Frisian coast, where there is some divergence to obtain more suitable soundings. The west end of the embankment is situated at Den Oever, on the east end of Wieringen, where, in the figure, an L-shaped outline indicates the site of 15 sluices and a lock, for evacuating the surplus water of the Yssellake to the North Sea, and for affording a means of passing vessels between these two bodies of water. Off the Frisian Coast, near Kornwerd, a similar outline indicates the position of 10 sluices and a lock, together with a somewhat smaller lock. Near the centre of the embankment, in the shallows of Breezand, will be seen a trident-shaped outline. This denotes a completed portion of the embankment, with projecting wings forming harbours of refuge both for the vessels engaged in construction, and for fishing craft after completion. The heavy plain and dotted lines indicate, respectively, completed portions of the embankment, and portions crossing deep channels, which have not yet reached the water level. This part of the account is illustrated by Figs. 53 to 75, on this and the following pages, page 830, and on Plate LXX.

The position of the partly-constructed sluices and lock at Den Oever is shown in Fig. 74, page 830. This is an aeroplane view taken looking south, but has a tendency to be misleading when first examined, inasmuch as the embankment round the L-shaped area appears to be a permanent structure. It is, of course, really temporary, and will disappear when the main enclosing embankment is finished, but it should be realised that the area had to be thus enclosed and the water pumped out of it before any other work could be done, an operation of a not inconsiderable magnitude in itself. The main embankment will stretch from the land at the right, and leftwards to the other coast, being interrupted by the lock and sluices shown. The harbour in front of the village, at the right hand of the figure, has been constructed for the dredgers and other craft employed on the works. The small triangular portion, however, represents the old fishing harbour. The right-angled structure at the top right-hand corner of the figure shows the end of the embankment reaching from Medemblik, and its connection with Wieringen, in course of construction. The 15 sluices are arranged in three groups of five each, the relative position of the three groups being easily seen in this figure, as well as in the key plan of Fig. 53, above.

Fig. 53.



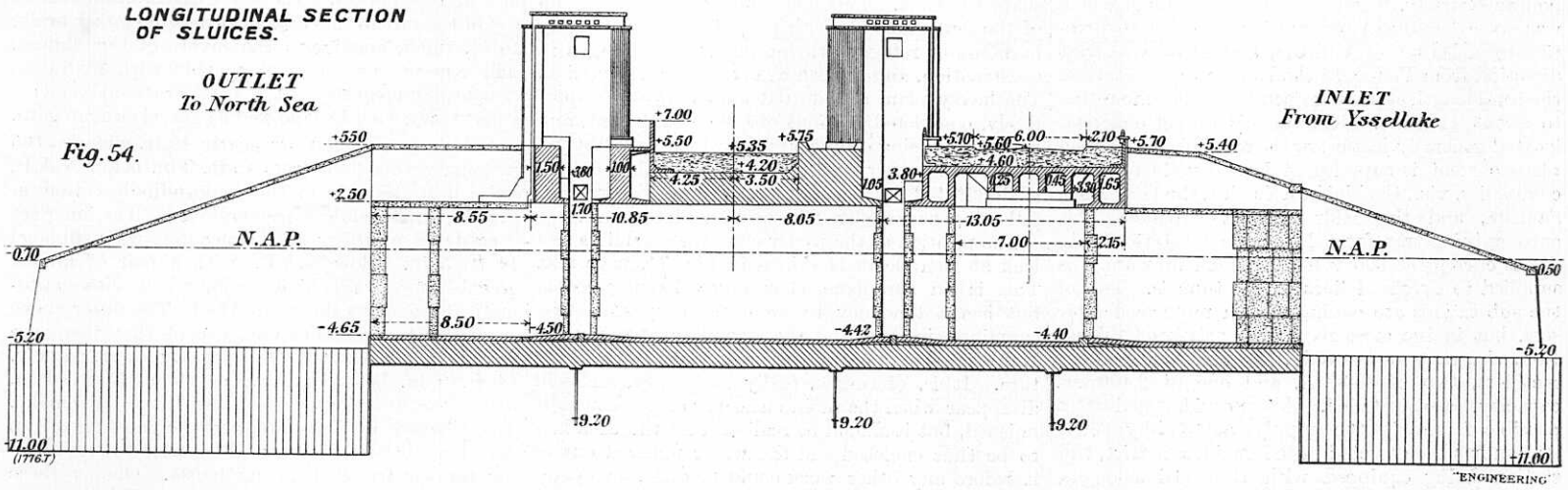
Each group of five sluices rests upon a continuous raft of reinforced concrete, measuring 289 ft. by 164 ft., with a distance between adjacent rafts of 289 ft. The rafts are 4 ft. 7 in. thick, and are enclosed by steel sheet piling, the top of which is flush with the upper surface of the raft while the bottom edge is about 16 ft. 5 in. below its lower surface. A view of one of these rafts under construction is shown in Fig. 75, page 830, the enclosing piling, which is of the Larssen type, section No. 2, being visible both in the foreground and the middle distance. In the background is seen a portion of the temporary enclosing dam. The disposition of the piling is well shown in Fig. 54, page 822, from which it is evident that, apart from the enclosing sheeting there are three transverse cut-offs under the raft. These are 9 ft. 10 in. deep and are provided not as supports to the raft, which rests directly upon the subsoil, but to prevent seepage and consequent scour, as already described when dealing with the lock at De Haukes. The layer of material seen on top of the raft in this figure consists of clinker brick, 10 in. thick, and forms the invert of the sluices. The concrete of the raft is made with hydraulic cement, and consists of 1 part Portland cement, $\frac{1}{4}$ part trass, with $1\frac{1}{2}$ sand and $2\frac{1}{2}$ gravel as aggregate.

The sluice channels are nearly 40 ft. wide by 165 ft. long, with a floor level 15 ft. 3 in. below N.A.P. As will be seen from the longitudinal section in Fig. 54, double sluices are employed. The inner set consists of a lifting steel sluice gate with sill level 14 ft. 5 in. below N.A.P., with a pair of hinged greenheart gates behind them, which close automatically against the rising tide. The outer sluice is similar to the inner one, except that there are no tidal gates, and the sill is slightly lower, namely, 14 ft. 9 in. below N.A.P., or about 13 ft. 6 in. below the average level of the future Yssellake. The sills are of a granite, and the gates travel up and down between reinforced concrete towers housing the electrical operating hoists. One of these towers is shown in Fig. 55, page 822. The channels can be isolated for inspection or repairs by caissons at each end of a type similar to those used for graving docks. The dividing walls between the channels are of mass concrete, of 1 : 2 : 3 mixture. These are 13 ft. 2 in. thick, except in the way of the tidal gates, the recesses for which reduce them to 8 ft. 5 in. They are provided at both ends with a curved cutwater, that on the inlet side having radii equal to the thickness of the wall and that on the outlet side being struck with radii of twice the thickness. These features are seen in Fig. 58, page 822. The walls are faced with basalt, in order to resist the impact of ice during discharge in winter. As the Yssellake will ultimately contain fresh water and will not be tidal, the formation of ice will be more extensive than before enclosure. Granite is used on the cutwaters and on all projecting corners. It is interesting to note that the contour of the cutwaters was determined experimentally in order to reduce the formation of eddies as much as possible, and in addition to effecting this it has also increased the discharge capacity of the sluice channels.

The sluices are crossed by two reinforced concrete bridges built with concrete of a mixture of 1 : $1\frac{1}{2}$: $2\frac{1}{2}$, with the addition of $\frac{1}{6}$ trass. One of these bridges is to carry the railway already mentioned as running along the Yssellake enclosing embankment. It is situated between the sluice gate towers and, as will be seen in Fig. 54, is very solidly constructed. It has a width of about 25 ft. 6 in. to carry two tracks, the sleepers of which are bedded in ballast. The other bridge, on the southward side of the towers, is of cellular construction and is situated over the tidal gates. It accommodates a roadway paved with concrete and 19 ft. 8 in. wide, on either side of which are a raised footpath and a bicycle track each 6 ft. 6 in. wide. Both rail and road bridges are flat, as will be evident from Figs. 56 and 57, page 822. Photographs showing the sluices in various stages of construction are reproduced in Figs. 67, 68 69, and 70, on Plate LXX. The enclosing piling of the foundation is seen in the foreground of Fig. 67, while the distribution of the granite and basalt facing is also well shown. Fig. 70 is noticeable as showing a set of five sluices. This view is taken from the inlet side, the area in the foreground being ultimately covered by the Yssellake.

Referring to Fig. 53, it will be seen that the connection for navigation between the Yssellake and the North Sea at Den Oever is by means of a lock situated to the south-west of the sluices. At this point a brief reference to the eventual state of what is now the Zuyder Zee may be made. The three polders yet to be reclaimed are those in the north east, the south west and the south east. The embankment enclosing the first of these will begin at the point south of Stavoren on the Frisian Coast at the point marked X in Fig. 33, page 759 *ante*, and will continue in a roughly semi-circular manner to the province of Overyssel in the extreme east of the Zuyder Zee. The embankment for the south-west polder will start at Enkhuizen, and will run in a straight line in a south-westerly direction for some 13 miles. At this point a straight embankment will run for a

ZUYDER ZEE RECLAMATION WORKS; SLUICES AT DEN OEVER.



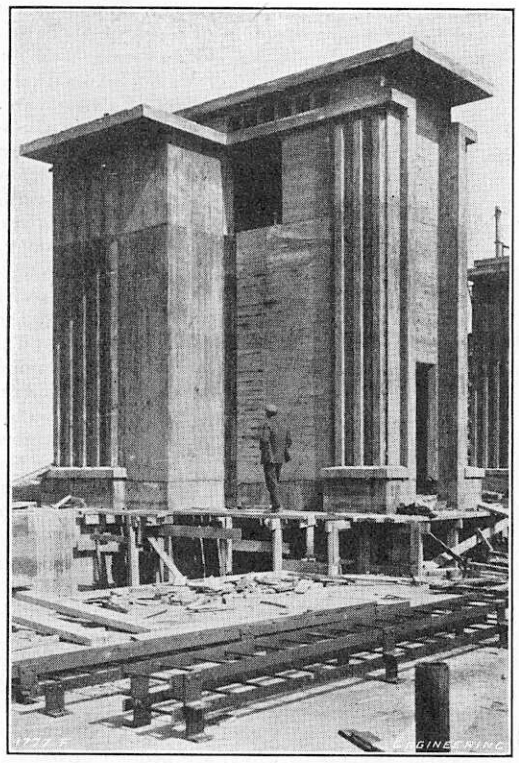
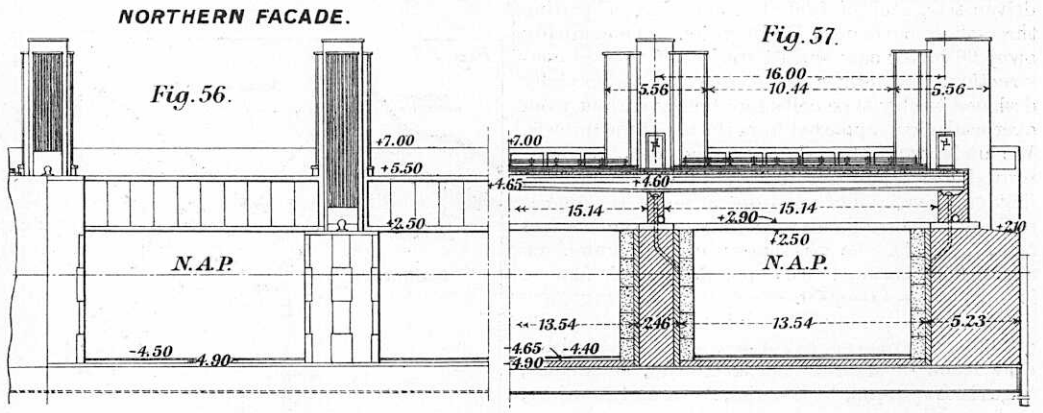
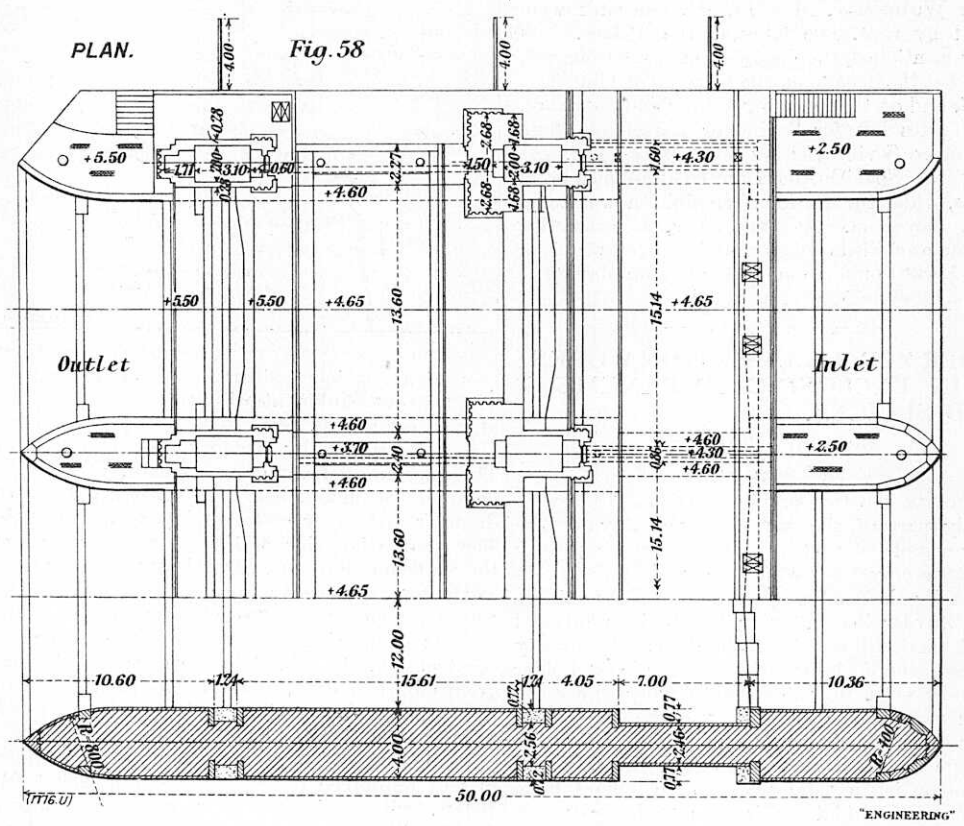


FIG. 55. SLUICE-GATE OPERATING TOWER.





similar distance due east and west to Overyssel, a small natural portion of the land at which will form the termination of the Yssellake. The River Yssel, a branch of the Lower Rhine, here discharges near the town of Kampen, and the Yssellake, of about 270,000 acres in extent, will regulate its overflow to the North Sea, as already mentioned. The south-west and south-east polders, however, though their main embankments join each other, are not otherwise connected, as they are separated by a wide ship canal running in a south-westerly direction from the point of intersection of the outer embankments to a group of three small lakes left along the old coast line in the south west. The largest of these, the Y-lake, will form a basin for the port of Amsterdam, the one to the south of it will receive the discharge of the River Eem, while that to the north of it, the Gouw Lake, will have on one side the well-known island of Marken, which will be merged in the south-west polder. The island of Urk will similarly lose its identity in the north-east polder. The old coast lines around the new polders will be faced by the internal enclosing embankments to form catch-water areas for the original drainage systems.

From the above it will be realised that Amsterdam will still be in communication with the northern part of the Zuyder Zee outside the main enclosing dam, and, in consequence, the lock at Den Oever has to be large enough to accommodate ships of fairly considerable size. It has accordingly been designed for vessels up to 2,000 metrical tons, together with a tug. The total available length is 465 ft., and the width is 46 ft. It can, however, be divided, by an additional set of gates, into two compartments of 185 ft. and 255 ft. long, respectively, when passing smaller vessels. The sills are 14 ft. 5 in. below N.A.P., that is, 13 ft. 2 in. below the normal level of the Yssellake. Its general construction is shown in Figs. 59 to 64, Plate LXX. These need no further comment than the statement that the foundation and also the walls up to 4 ft. below N.A.P are built of reinforced concrete. Above this level the walls are made of mass concrete. The railway and road, mentioned in connection with the sluices are carried over the lock approach on the seaward side by two swing bridges, and the approach on the Yssellake side is effected through a channel having an opening near the end of the Medemblik-Den Oever embankment, as indicated by the dotted lines in Fig. 53.

The other end of the main embankment will now be considered. This is situated on a shoal called the Kornwerderzand, near Kornwerd, as indicated in Fig. 33 *ante*. Two views of the construction of the sluice and lock pits, are given in Fig. 71, Plate LXX, and Fig. 73, page 823. This site is about 2½ miles from the coast, and has now been connected to it by a section of the main enclosing embankment. As in the construction of the sluice pits at Den

ZUYDER ZEE RECLAMATION WORKS.

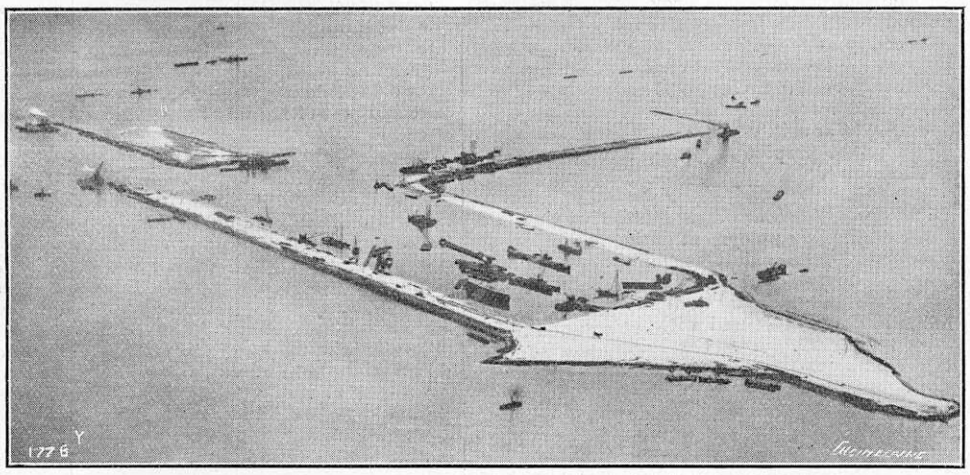


FIG. 73. SITE OF SLUICE AND LOCKS AT KORNWERDERZAND, JULY, 1927.

Oever, the preliminary work consisted of enclosing the necessary space by a temporary dam and then draining it. Fig. 73 shows an early stage with the temporary dam in process of formation, while in Fig. 71 it has been completed, and excavation for the sluices and locks commenced. In this figure, the portion in the bottom left-hand corner is the beginning of the main embankment on the west side. In line with it are seen the pits for the sluices, which latter are in two sets of five, and exactly similar to those at Den Oever, with the exception that here the foundation slab rests on a pile foundation, the subsoil consisting of alternate layers of alluvial sand, clay, and peat. The transverse area will contain two locks on the south side of the embankment. On the north side, that is, the left-hand of the figure, is the approach from the North Sea, the water on the right-hand side being that of the future Yssellake. The curved portion, extending to the coast line in the background, is part of the main embankment. The big lock at Kornwerderzand is of the same dimensions as that at Den Oever, which can accommodate vessels up to 465 ft. in length, but it has no intermediate gates. The smaller lock is intended for vessels not above 230 ft. long. It has accordingly a width of 29 ft. 6 in., and a depth of sills of 14 ft. 5 in. below N.A.P.

The photograph reproduced in Fig. 72, Plate LXX, shows the construction of the harbours of refuge on the shallows of Breezand, situated about midway between the Kornwerderzand and Den Oever sluices. This necessitated the formation of a small island, on which has been constructed a section of the main embankment, 1,650 ft. long, with two projecting arms forming the harbours, and a sand platform, the general outline being as shown in Fig. 65, Plate LXX. After the photograph was taken another section of 1,650 feet was completed before the winter set in and further work is in progress. As the site is 6 miles from the nearest of the other works, it was necessary to provide accommodation for the workmen and storage room for stone, brushwood and other materials upon it. The disposition of these is apparent from Fig. 72. The rounded end at the right-hand side of the figure is a section of the main embankment of the correct width. This will be continued to Den Oever. The longer ridge in the centre is a portion of the main embankment being continued to Kornwerderzand. Extension is now being carried on from both ends, 4 miles having to be completed in this central portion before it can be joined up to the lengths being built out from the main land on each side. The construction of the three isolated portions indicated in Fig. 33 *ante* has already been referred to.

A section across the main bank is given in Fig. 65, Plate LXX. It has a core of boulder clay backed by sand. The outside, which has an average slope of 1 in 4 is faced with stone pitching on rubble, extending to 3 ft. 5 in. above the storm-tide level on the seaward side. The stone employed is basalt from the Rhine and limestone from the Meuse. The thickness of the facing varies from 8 in. to 16 in, Above the stone facing is brick paving 6 ft. wide and the remainder is merely turfed. The outer toe, 8 ft. in width and lying at low-water level, is covered with a mattress of brushwood weighted with rip-rap. The sand at the back of the boulder clay core is covered with a layer of clay, 3 ft. 3 in. thick. The height of the crest of the embankment varies from 20 ft. 4 in. to 24 ft. 8 in. above N.A.P. It is 6 ft. 6 in. wide. A berm, 13 ft. 2 in. above N.A.P., so as to be out of the way of waves in the Yssellake during storms, carries the railway and road along the inner side of the embankment. The inner slope has a batter of 1 in 3, and is faced by stone pitching up to a height of 11 ft. 6 in. above N.A.P. Below the water line the slopes on both sides of the embankment are protected against scour from the back wash of the waves by mattresses of brushwood weighted with riprap. The depth of the sea bottom along the embankment averages 10 ft. below low water level, but in the deep channels referred to above as being closed by sill dams, the depth in one case is 26 ft. and in another 40 ft.

It should be mentioned that of the photographs reproduced in Figs. 71 to 74, the copyright is the property of Messrs. Koninklijke Luchtvaart Maatschappij, and in the case of Figs. 55, 67, 68, 69 and 70 of Mr. W. Verkerk.

THE ROYAL SOCIETY CONVERSAZIONE.

THE second annual conversazione of the Royal Society, generally referred to as the Ladies' Night, was held at Burlington House, on Wednesday last. Several of the exhibits were, of course, of a biological or botanical character and others were referred to in our columns on pages 643 and 675 *ante*, when we dealt with the exhibits at the first conversazione. Of the remainder, that of Sir Robert Hadfield, F.R.S., was probably of most direct interest to engineers. His exhibit of castings and forgings of "Era C.R." high tenacity non-corrodible steel used in connection with the work of restoration of St. Paul's Cathedral was singularly appropriate, since the re-opening ceremony by H.M. the King took place on the day of the conversazione. The material referred to was used in the form of cast-wall plates measuring 3 ft. by 1 ft. 6 in. connected by machined rods 3 in. or 4 in. in diameter, the rods being made in three parts joined by screwed sleeve couplings to enable them to be placed in position. The new material, which has a tensile strength of 45 tons to 50 tons per square inch, with a 40 per cent. elongation and a 50 per cent. reduction in area, takes the place of the original wrought-iron bars used by Sir Christopher Wren, many of which were found to be in a badly corroded condition. Sir Christopher Wren, it may be mentioned, was himself a Fellow of the Royal Society.

Sir Robert also showed an interesting exhibit to illustrate the difference in the effect of mechanical deformation on manganese steel and steel containing high percentages of nickel and chromium. Both these steels are non-magnetic in their ordinary condition, and the magnetic properties of the former are not affected by cold work, but a specimen of the nickel-chromium steel, after having been hammered to about two-thirds of its original thickness, was strongly magnetic. In both cases, the effect of the cold work appears to be merely to distort the grains, and the reason for the change in magnetic properties has not yet been explained.

Another metallurgical exhibit was that of Prof. Sir Harold Carpenter, F.R.S., who showed examples of single-crystal bars and also the forms assumed by such bars when subjected to plastic deformation. A particularly interesting exhibit was a single-crystal sphere of copper about 2 in. in diameter, which was produced in the form of a bar from molten copper by controlled solidification from a particular point, the sphere then being machined from the bar. The cube faces of the crystal were rendered visible by etching with ammonium persulphate, but by using another reagent it would be possible to show the octahedral faces.

Mr. George H. Gabb showed an interesting collection of hydrometers to illustrate the evolution of that instrument for fiscal purposes in England. The earliest instruments dated from early in the 18th Century and were of turned ivory made hollow, and are excellent examples of hand lathe work. The metal hydrometer was invented by John Clarke in 1725, and several examples of Clarke's instruments were included in the collection, together with early and modern examples of the Sike's hydrometer, which is the standard instrument at present in use for spirit assay by H.M. Customs.

Messrs. The Gramophone Company, Limited, showed equipment for recording talking films and a magnetically controlled mercury-vapour relay. To demonstrate the latter, one of the relays was placed so that a permanent magnet attached to the extremity of a pendulum passed over the relay as the pendulum swung. In doing so, it permitted a current impulse to pass, which was utilised to maintain the motion of the pendulum. Another interesting exhibit by the company was the stroboscopic examination of the vibrations of the cone diaphragms of moving-coil type loud speakers. Simple cone diaphragms, it was shown, behave as rigid pistons only at low frequencies of the order of 50 cycles per second, breaking up into characteristic nodes of one, two, or more nodal diameters at higher frequencies. Large cones stiffened by corrugations behave as rigid pistons up to about 200 cycles per second.

Optical apparatus for recording and reproducing talking films is now being manufactured by Messrs. R. and J. Beck, Limited, and their exhibit showed the principles involved by means of diagrams and models, together with actual parts of the apparatus. Both the slit, or variable density, and the graph, or variable-area, methods were illustrated. In the former, the sound record takes the form of a series of parallel lines resembling a complex spectrum, the distance between the lines representing the pitch and the degree of opacity of the film the amplitude. In the other method, there is no variation in the density of the deposit, the sound record being in the form of an irregular line on one side of which the film is solid black and on the other side quite clear. In this case, the height of the peaks in the line determines the amplitude of the sound and the distance between them the pitch. Both types of sound record are, of course, produced on the edge of the same film as that on which the pictures are recorded, and apparently only occupy a width of about $\frac{1}{8}$ in.

The only other exibit to which we can refer on this occasion is that of Messrs. Marconi's Wireless Telegraph Company, Limited, who showed the apparatus employed for the facsimile telegraphic transmission of diagrams and script. Examples of such transmissions received in England from America showed the various types of signal distortion occurring in the upper regions of the atmosphere, and can thus be used for studying the properties of the Heaviside layer.

LABOUR NOTES.

AN emergency resolution on the subject of rationalisation, passed last week by the annual conference of the National Federation of Building Trades Operatives, demanded (1) a 40-hour working week without reduction of the total weekly wage, (2) minimum annual holidays of two weeks and all statutory holidays with pay, (3) pensions at 60 sufficient to maintain persons with dependents in comfort without their having to struggle for a livelihood in industry, and (4) the raising of the age of entrants to the building industry to 15. The resolution expressed great concern at the changes that had been, and were being, effected in the practical working of the building industry. It pointed out that, while building employers were taking the utmost advantage of the discoveries of science and profiting by them, no consideration was being given to the effect these had of lowering the operative's status, nor was there any concern for those displaced by the new machinery and methods.

Writing in the *Monthly Report* of the Boiler Makers and Iron and Steel Shipbuilders' Society, Mr. John Hill, the general secretary of the organisation, gives details of one of the schemes which a committee of the Trades Union Congress is considering to find employment for shipyard and engine shop men displaced as a result of the Naval Treaty and disarmament. It is to scrap old ships. "At present," he says, "most of our old British merchantmen are sold abroad, and these old ships continue in competition for the world's commerce. You will readily understand that so long as plenty of these old ships are floating about there will be no demand for new ships. We estimate that there is about 2,000,000 tons of shipping afloat over twenty years old. The average difference in the price of a twenty-year-old ship sold for service and sold for scrapping is about 2*l.* per gross ton. Our scheme is to get agreement among all parties concerned for the formation of a pool into which shipowners and the Government would contribute, and out of this pool this difference would be paid, if we could secure agreement for compulsory breaking up of old ships. Our first object is to clear the market for new shipping, and thus give employment in British shipyards. If old ships were broken up, we would bring our merchant fleet up to date. Already we have fallen behind Germany, for, as you will remember, Germany had to build a new fleet of merchantmen to replace the German shipping which we took from her as part of the war indemnity."

Mr. Hill goes on to say that since the committee, of which he is, of course, a member, took the question up, its scheme has received widespread support. "Only a few days ago," he proceeds, "at an international conference of shipowners, the chairman, who is a British shipowner, said:—'To my mind, the proposal which is the soundest is the elimination of old and inefficient tonnage, say, exceeding twenty-five years old. Such a step would be in line with modern procedure of rationalisation. The scrapping of old vessels would, therefore, be of great advantage to both the shipping and shipbuilding industries.'" Mr. Hill reckons that if the Government would make a contribution of 1,000,000*l.* per year for five years shipowners and shipbuilders would contribute their quota and the scheme would be set in operation. "This 1,000,000*l.* from Government funds would be," he says, "a sound investment. It would find employment for tens of thousands of shipbuilding and engineering workers. It would relieve the unemployment funds and the local rates of more than 1,000,000*l.* per year in 'doles.' It would give the raw material in scrap which is required for the prosperity of our steel industry, and would give an impetus to all the heavy industries which are now most seriously affected by unemployment."

At the end of May, 11,582 members of the Boiler Makers and Iron and Steel Shipbuilders' Society were "signing the books," as compared with 11,006 at the end of April. The number in receipt of superannuation benefit was 4,575, as compared with 4,619, and the number in receipt of sick benefit 1,362, as compared with 2,508. The expenses for May, which month had to bear five weeks' outlays, were 10,801*l.*; in April the total expenditure was 9,005*l.*

The writer of the editorial notes in the Electrical Trades Union's *Journal* says that members engaged in electricity generation and distribution in station and sub-station have been busy in May calculating how much advantage has accrued to them as a result of the recent wages settlement. "Already," he remarks, "one or two murmurs have reached us that the results are only a tithe of what was anticipated. This is to be expected. Others are very well satisfied with the results. It may be possible next month to give some further details, but at the moment it is wise to say nothing further, except that it is a positive relief to the officials to get a rest from the three years' work which has been put into this single case. The 'rest' mentioned would be better described as a transference of the work to other sections in the electricity supply industry rather than a general cessation, as, whatever may have happened to those special sections, there is an ever-growing demand that the other sections, especially those employed as shift workers, shall have their wages reviewed for the purpose of getting some advance on the present rates."

The Ministry of Labour Gazette states that there was a further decline of employment during May. Among workpeople insured against unemployment in Great Britain and Northern Ireland, the percentage unemployed in all industries taken together was 15·3 at May 26, 1930, as compared with 14·6 at April 28, and 9·7 at May 27, 1929. For males alone the percentage at May 26 was 15·5, and for females 15·0. At April 28, 1930, the corresponding percentages were 14·9 and 13·8. It is estimated that on May 26, 1930, there were approximately 9,724,000 insured persons aged 16 to 64 in work in Great Britain. This was 75,000 less than a month before, and 536,000 less than a year before.

Excluding persons normally in casual employment, there were, on May 26, 1930, 1,164,468 persons on the registers of Employment Exchanges in Great Britain, who were out of a situation. This was 6,359 more than a month before and 384,783 more than a year before. The total on May 26, 1930, included 847,097 men, 34,016 boys, 250,018 women, and 33,337 girls. It was made up approximately of 772,000 insured persons who had paid at least 30 contributions during the receding two years, and therefore satisfied the full contribution condition for the receipt of unemployment benefit; 320,000 insured persons who had paid less than 30 contributions during the preceding two years; and 72,350 uninsured persons. The claimants for benefit, numbering 1,053,016, included 190,178 men, 4,400 boys, 42,982 women, and 2,250 girls who had been on the register for less than one month. At May 26, 1930, there were registered as unemployed in Great Britain 321,129 men, 10,647 boys 167,351 women, and 10,494 girls who were on short time, or were otherwise suspended from work on the definite understanding that they were shortly to return to their former employment. The total of 509,621 was 62,377 more than a month before, and 236,152 more than a year before.

At May 26, 1930, there were on the registers in Great Britain 93,414 men, 179 boys, 2,340 women, and 29 girls who normally seek a livelihood by means of jobs of short duration. These are mainly employed in dock, harbour, river and canal service. The total of 95,962 was 2,929 more than a month before, and 16,835 more than a year before.

A substantial increase in the numbers unemployed occurred during the past month in coal mining, shipbuilding and marine engineering, motor vehicle manufacture, the cotton, linen, and lace industries, textile bleaching, dyeing and finishing, slate quarrying, and dock and harbour service. On the other hand, there was improvement in the building, public works contracting, general ironfounding, silk and artificial silk, hosiery, boot and shoe, and clothing industries.

In the industries for which statistics are regularly compiled by the Ministry of Labour, the changes in rates of wages reported to have come into operation during May resulted in an increase of about 43,300*l.* in the weekly full-time wages of 550,000 workpeople, and in a decrease of 13,600*l.* in those of 150,000 workpeople. The most important change in wages during the month applied to railway employees, including those employed in railway engineering shops, whose earnings ceased to be subject to the deduction of 2½ per cent., which had been in operation since 1928. Other workpeople whose wages were increased during the month included blastfurnace workers in Cumberland and Scotland, and workpeople employed in the tinplate industry in South Wales and Monmouthshire. The workpeople whose wages were reduced included coal miners in Northumberland and Warwickshire, electrical cable makers, and a considerable number of workpeople, in the wool textile industry in Yorkshire, who returned to work during May after having stopped work in April in consequence of the dispute.

The number of trade disputes involving stoppages of work, reported to the Ministry of Labour as beginning in May was 35. In addition, 20 disputes which began before May were still in progress at the beginning of the month. The number of workpeople involved in all disputes in May (including workpeople thrown out of work at the establishments where the disputes occurred, but not themselves parties to the disputes) was about 87,600, and the aggregate duration of all disputes during May was about 1,600,000 working days. The principal dispute in progress was that in the wool textile industry in the West Riding of Yorkshire and part of Lancashire, which began in April.

The workers' representatives in the metal and engineering industry in Central Germany, comprising the districts of Halle, Magdeburg, Anhalt and Thale am Harz, terminated, on April 30, the working hours agreement under which provision was made for the normal weekly working time to be extended from 48 to 52 hours. The workers demanded a 46-hour week. Conciliation proceedings failed to secure agreement between the demands of the employers and workers, and an arbitration award was accordingly issued towards the middle of May providing that the working week may be extended by not more than 3 hours a week. The award was rejected by the workers, and, so far as is at present known, has not been declared binding.

Notice has been given by the workers of their intention to terminate, at July 31 next, the general agreement regulating working conditions in undertakings in the Berlin metal and engineering industry. The demands of the workers, numbering some 180,000, include a claim for the reduction of the working week from 48 to 42 hours, with a 7-hour working day. In Saxony, the employers have given notice of their intention to terminate, on June 30, the general agreement for the metal and engineering industry, comprising some 150,000 workers in the Dresden, Leipzig, Chemnitz, Zwickau and Bautzen districts.

As a means of relieving unemployment among members of their trade union, the lath-workers in the city of St. Louis, Mo., U.S.A., have decided to work only six hours a day. It is calculated that one additional man to every three now working will find employment as a result.

On June 16, 1930, the numbers of persons on the registers of Employment Exchanges in Great Britain were 1,173,800 wholly unemployed, 617,500 temporarily stopped, and 94,000 normally in casual employment, making a total of 1,885,300. This was 110,193 more than on June 2, 1930, and 762,587 more than a year before. The increase as compared with June 2 was almost wholly among persons "temporarily stopped," and included 80,000 in Lancashire and Cheshire, and 20,000 in the Midland Counties, arising in the main from extended holiday stoppages of a temporary nature. The total on June 16, 1930, comprised 1,336,300 men, 44,400 boys, 462,200 women, and 42,400 girls. Figures are not available in respect of Whit Monday, June 9, 1930, as a count was not taken on that day.

Discussing the prospects of the Trade Disputes and Trade Unions Bill, the *Industrial Review*, an official organ of the Trades Union Congress General Council, says that the reassurance given by the Government on the subject is welcomed by trade unionists. "The trade unions recognise fully," the writer goes on to remark, "the difficulties confronting the Government in dealing with this question, especially in view of the fact that as a minority Government the Parliamentary time-table is not wholly under the control of Ministers, and having regard to the hostilities which a measure of this kind will necessarily incur from both sections of the Opposition. There is now every hope that the Bill, in a form satisfactory to the trade union movement, is speedily to be introduced, and that the Government intends to make a vigorous effort to get it on the Statute Book at the earliest possible moment. From the trade union point of view, it is a matter of real urgency. Nobody doubts the goodwill of the Government, or discredits its intention to deal with the question in accordance with the pledges given at the General Election."

The Unemployment Grants Committee, Lord St. Davids in the chair, has approved for Government grant a number of schemes of work submitted by local authorities and other statutory bodies for the relief of unemployment. The estimated cost of the schemes so approved was 913,000*l.*, to provide employment for approximately 3,200 men. Schemes before the committee for approval, which are now the subject of inquiry, number 718, and are estimated to cost 12,723,000*l.*

AIR-SEPARATION COAL-PULVERISING PLANT.

CONSTRUCTED BY MESSRS. THE BRITISH REMA MANUFACTURING COMPANY, LIMITED, ENGINEERS, HALIFAX.

(*For Description, see Page* 826.)

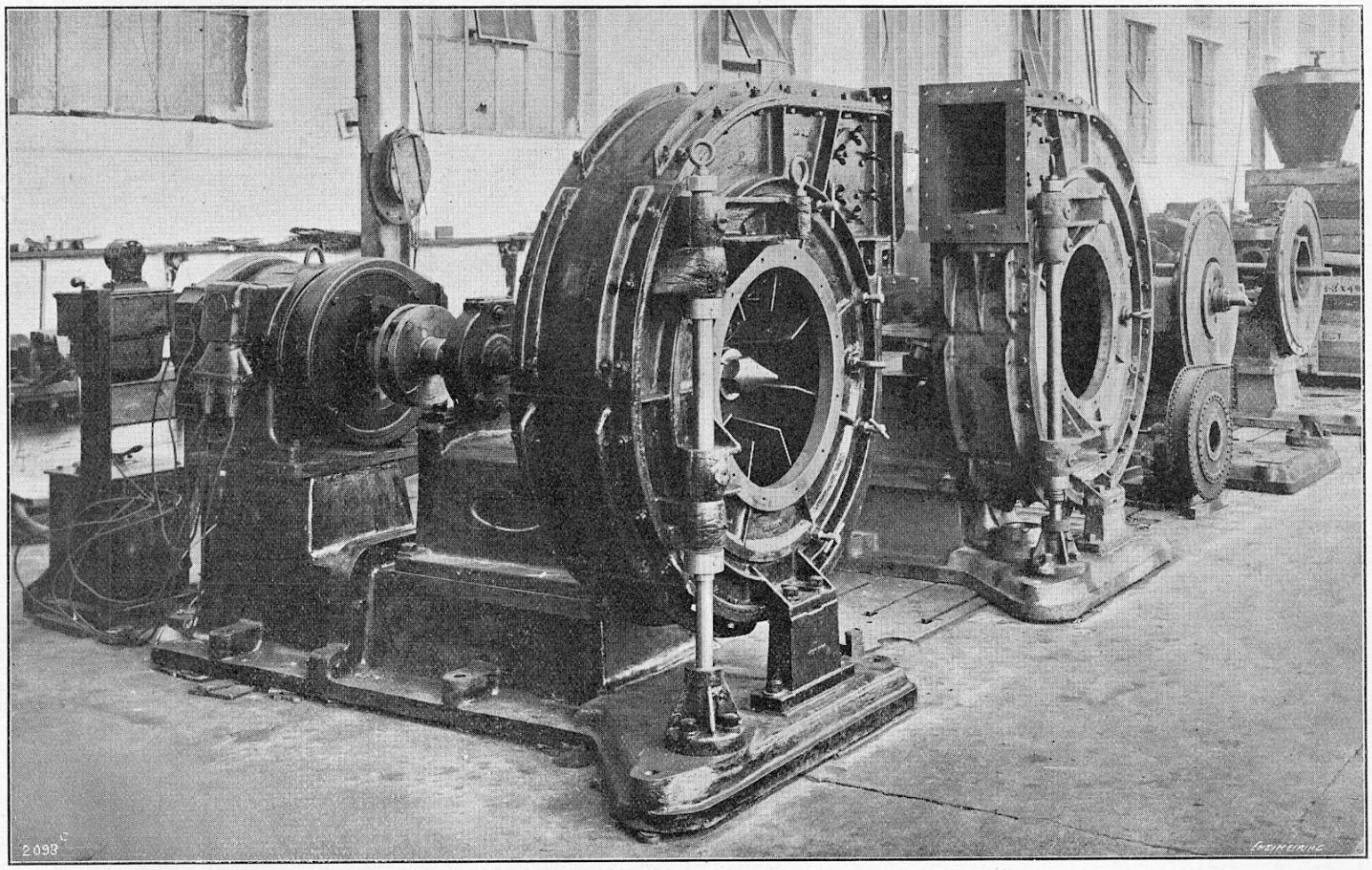


FIG. 1. ELECTRICALLY-DRIVEN FANS.

ATMOSPHERIC POLLUTION.

FOR many years, the Meteorological Office organised systematic observation by authorities in various parts of the country on the amount and nature of the impurities deposited from the atmosphere within their areas. For some time past, however, it has been felt that, in order to obtain practical results from observations of this kind, it was necessary both to study the effects and their collated results and to obtain information as to the presence of suspended as well as deposited impurities. It was therefore determined that, from April, 1927, the organisation of such observations should be undertaken by the Department of Scientific and Industrial Research, with the co-operation of a number of local authorities, and of certain supply undertakings and industrial concerns who, between them, were to contribute at least half the cost. The first report presented by the Department, which is the 14th of the entire series, has now been published.*

For the time being, the search for accurate recording instruments to measure atmospheric pollution is still in progress, and even a representative plan of distributing those gauges that are available over the country has not been instituted. At present, therefore, it is not possible to draw general conclusions applicable to the whole of the country, but attention may be drawn to some particular results which are interesting, if not gratifying. The practice in the tables of general deposits is to compare the figures of the year for each station with the average of the previous five years for the station in question. On this basis, the condition of the atmosphere of London for the year under notice showed a distinct falling off. Its contents in sulphates and tar had increased in seven out of the eight available stations, and for the country as a whole the stations for which five-year averages are available show results that are scarcely better. Of the 23 such stations, the tar is higher than the general average in 11, and the sulphates in 22. When, again, the stations are divided into groups according to the amounts of solid impurities in their respective atmospheres, very similar results are obtained. It appears, therefore, as the report remarks, that the purification of the air has not made such rapid advances as many people imagine.

What curious problems may have to be solved before the results which have been accumulated are understood may be illustrated by referring to the experience of London and Glasgow. In both these cities there was a considerable improvement in the atmosphere between the years 1915–16 and 1921–22. In London, the total deposit fell during that period from 415 tons per square mile to about 300 tons, and the deposit of sulphates from 72 tons to 25 tons, while in Glasgow it fell from 422 tons of total solids to 255 tons, and from 92 tons of sulphates to 34 tons. From that date onwards, however, the fall ceased, and was indeed replaced in each city by a slight advance. For 1927–28, the London figures were 316 tons per square mile for total solids and 40 tons for sulphates, while for Glasgow they were 320 tons and 50 tons, respectively. There is at present nothing to show what can have caused this simultaneous variation in the atmospheres of two cities so far distant from each other. It is possible that, as the report suggests, it may be connected with variations in the extent to which gas and electric heaters have replaced coal fires, but in the absence of figures on the point no conclusion to this effect can be drawn.

In addition to observations of deposited impurities, measurements are now being made in some stations of the suspended impurity, as shown by an automatic filter devised by the Superintendent of Observation, Dr. J. S. Owens. In this apparatus, a succession of dark spots is produced on standard filter paper at regular intervals by passing a standard volume of air through the paper. It is worked by a constant flow of water, and the only attention it requires is to change the disc on which the dark spots are produced, which is done once in 24 hours. The extent of impurity is measured by the degree of greyness of the dark spots, which has been calibrated against the weight of suspended impurities in a given volume of atmosphere (milligrammes per cubic metre). The varying depth of tint can be divided into two standard shades, the difference between which can be recognised accurately.

Another method about to be introduced is the microscopic examination of Dr. Owens, in which particles of dust and smoke are caught and displayed on a microscope slide. At the present time, the Research Committee is engaged on considering revised methods for measuring the sulphur content of the atmosphere. There are present 81 deposit gauges, maintained by 33 authorities, and, in addition, 12 automatic filters.

* *The Investigation of Atmospheric Pollution*: Report on Observations in the year ended March 31, 1928. H.M. Stationery Office. [Price 3*s*. 6*d*. net.]

THE INSTITUTION OF ELECTRICAL ENGINEERS.

The annual conversazione of the Institution of Electrical Engineers, which was held at the Natural History Museum, South Kensington, on Thursday, June 12, was made the occasion for the presentation to Colonel R. E. Crompton, C.B., of a congratulatory address on his attainment of the age of 85. The wording of the address was as follows; The President and Council of the Institution of Electrical Engineers desire to convey their heartiest congratulations to its esteemed Past-President, Colonel Evelyn Bell Crompton, on the occasion of his eighty-fifth birthday on May 31, 1930, and cordially wish him *ad multos annos*. His pioneer work in the advancement of Electrical Science and Engineering and their applications, which is universally recognised, entitles him in the fullest degree to the respect and admiration of Electrical Engineers. As a mark of appreciation of the great services rendered by Colonel Crompton to the Electrical Engineering Profession during his 50 years' membership of the Institution, he was elected one of its Honorary Members in 1923, and was awarded its Faraday Medal in 1926." Over 1,600 members and guests attended the conversazione, and were received by the President, Colonel Sir Thomas F. Purves and Lady Purves, and the Council of the Institution.

AIR-SEPARATION COAL-PULVERISING PLANT.

CONSTRUCTED BY MESSRS. THE BRITISH REMA MANUFACTURING COMPANY, LIMITED, ENGINEERS, HALIFAX.

Fig. 2.

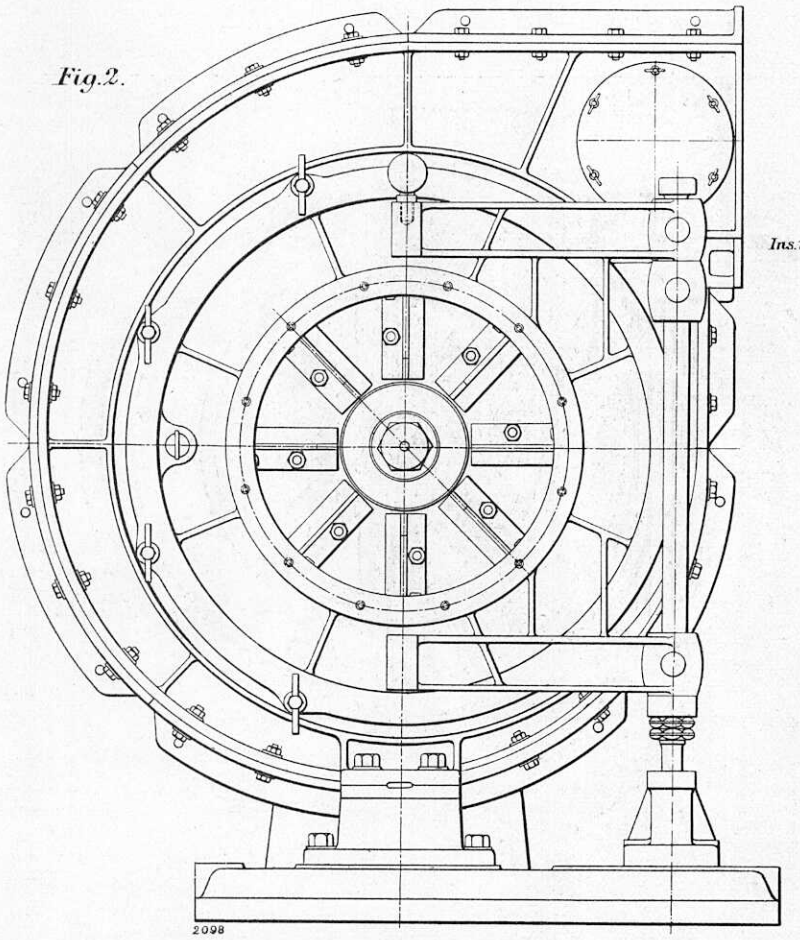
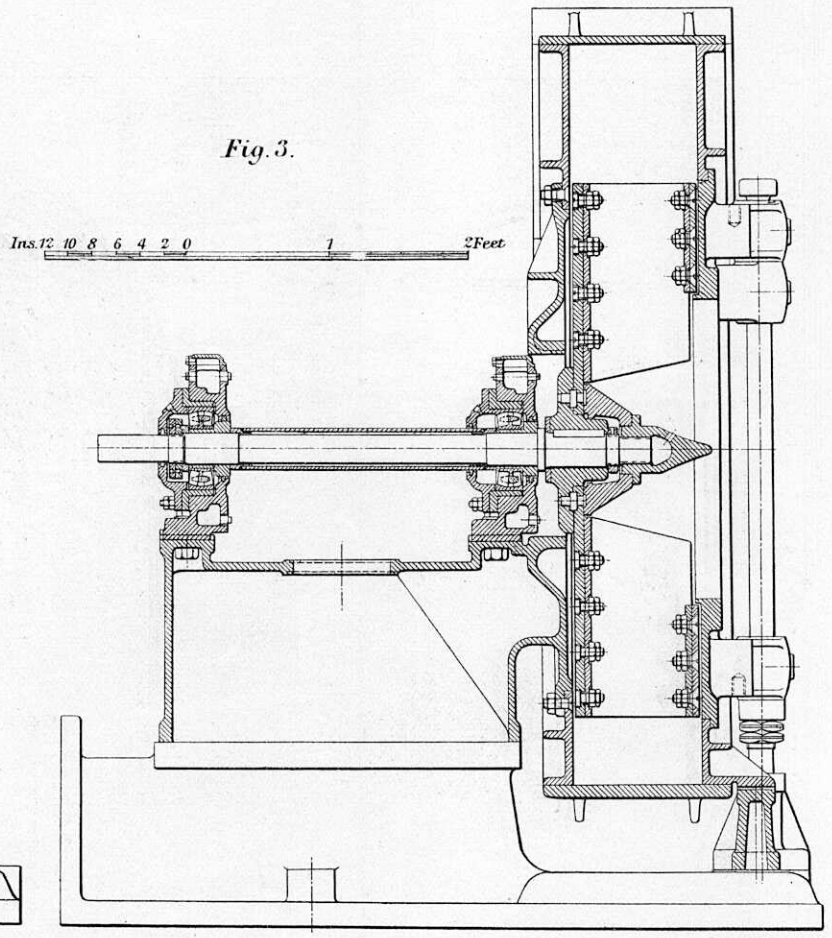


Fig. 3.



THE LATE MR. PERCY ALLAN.

WE regret to note the sudden death, at the age of 68, on May 7 last, at his home at Darlinghurst, N.S.W., Australia, of Mr. Percy Allan, formerly Chief Engineer of the New South Wales Public Works Department. The son of the late Mr. Maxwell Rennie Allan, who was Principal Under-Secretary for New South Wales, and a grandson of Mr. David Allan, who came to Australia in 1808 and subsequently, from 1818 to 1823, served as Deputy Commissary-General, Mr. Percy Allan received his general education at Calder House School, Sydney, and entered upon an engineering career in 1878 when 16 years of age. In that year, he was appointed a cadet in the Public Works Department, and, after some three years of preliminary training, was given a post in the drawing office. In 1886 he was promoted to the rank of chief draughtsman, and continued in that capacity until 1893, when he was given charge of the designing of all highway bridges in New South Wales. During the next six years he was responsible for the design of over 450 bridges of all types, perhaps the most important of which were the Glebe Island and Pyrmont bridges, both in the neighbourhood of Sydney.

In 1900, Mr. Allan became surpervising engineer, and was subsequently appointed principal assistant engineer, for the rivers, water supply, and drainage section of the Public Works Department. While in this capacity he superintended the completion of the low-level sewerage system of Sydney. From 1904 to 1907, Mr. Allan was engaged on various works connected with water conservation and artesian-well boring, and in April, 1908, he was appointed district engineer at Newcastle and president of the Hunter District Water Supply and Sewerage Board. During his four years' tenure of office at Newcastle, he organised and directed the operations for the deepening of the harbour bar from 19 ft. to 23 ft. 6 in. In October, 1912, Mr. Allan was recalled to Sydney to take up the appointment of assistant to the newly-created Director-General of Public Works in New South Wales. Some four years later, however, the position of Director-General was abolished, and Mr. Allan was appointed Chief Engineer for National and Local Government Works. During the next few years he again devoted his attention to bridge design, finally retiring in 1928. Mr. Allan became an associate member of the Institution of Civil Engineers on May 20, 1890, and was transferred to full membership on December 19, 1900. He was awarded a Telford Premium for his paper, "Port Improvements at Newcastle, New South Wales," presented to the Institution on February 22, 1921. He was also a member of the American Society of Civil Engineers.

AIR-SEPARATION COAL-PULVERISING PLANT.

THE pulverising plant for the unit system of pulverised coal firing which we illustrate by Figs. 1 to 5, on page 825 and on this and the opposite pages, embodies several novel features which have been added subsequently to the original development of the mill itself on the Continent. Messrs. The British "Rema" Manufacturing Company, Limited, Halifax have introduced these improvements since they acquired the sole licence rights for the British Empire, some three years ago, the outstanding feature being the firm's air-separating system, which eliminates the necessity for any preliminary drying of the fuel and provides a definite discharging action of the ground coal into the separating system, though the mill is not air swept in the accepted sense of the term. As the action of an exhausting fan creates the vacuum which gives the name to the system, it is perhaps only logical to commence our brief description by some account of this fan. The group of fans shown in Fig. 1 illustrates very well a distinctive feature in the hinging of one entire side, so that complete accessibility to the impeller is provided by simply breaking the joint of the suction pipe and swinging out this side. This accessibility makes possible the changing of an impeller in the short time of, approximately, 15 minutes, while inspection or repair to a fan is a correspondingly shorter operation.

The fan, as is evident from the figure, is driven by a direct-coupled motor, and is normally designed to pass the correct volume of air when the plant is working with zero resistance on the pipe leading to the mill inlet, and with a resistance not exceeding $1\frac{1}{2}$ in. of water at the fan outlet. The volume delivered is about 4 lb. of air per lb. of coal on full load. The fans, however, can be individually designed for the particular job, as different types of burner vary in the air volume required while the pressure may also range from 1 in. to 15 in. of water at the outlet. The constructional details of the fan are more clearly shown in Figs. 2 and 3. The side casings are made throughout of cast iron, but the periphery is usually formed of segmental castings of semi-steel bolted to the sides through external flanges. This arrangement ensures maximum life particularly as any part wearing more rapidly than the others can be replaced without disturbing less worn parts, the heaviest wear usually taking place near the outlet.

The impeller consists of a driving disc, to which are bolted renewable rolled-steel blades of heavy section, a feature again conducing to long life. The driving plate and shrouding ring are first dynamically balanced during manufacture, and the complete impeller is again balanced after the renewable blades are fitted. Every subsequent set of spare blades is also balanced before leaving the works, so that when a new set of blades is fitted, the balance, possibly upset by worn blading, is again restored. This practical feature ensures smooth and vibrationless running after a change without the necessity for re-balancing on the site. In this connection, it may be noted that cases are on record in which fans have handled 10,000 tons of coal before it was necessary to re-blade the impeller, while the wear is so evenly distributed, that a worn 48-in. impeller before re-blading, on being checked for balance on a Schenck machine, was found to be only 3 oz. out, and ran without a tremor. The fan shaft is of special alloy steel supported on two roller bearings a considerable distance apart and protected from dust by a sleeve.

The general arrangement of the system may now be described by a reference to Figs. 4 and 5. The mill shown in these is a shaft driven type ball mill, but it may be mentioned that the firm manufactures tube mills and ring roll mills with the vacuum separating system, having, in fact, constructed what is believed to be the largest single-unit mill of this latter type extant. This mill, working at Dresden, has an output of 20 tons of pulverised coal per hour, and is used for firing water-tube boilers. Beater and pinned-cage mills are also fitted with the system. Returning to a consideration of Fig. 4, it must first be premised that the end of the vertical pipe just showing in the upper part of the conical chamber above the mill is the bottom of the suction, or ascension, pipe of the fan. This is directly in line with the vertical leg of the right-angle air-supply pipe below it which passes under the mill, and the end of which is connected to a hot-air supply, or alternately to a mixture of hot air and waste gases, in cases where coal having a moisture content of about 15 per cent. is to be handled. This supply pipe has two connections in its length, viz. a Venturi pipe from the mill, on the horizontal leg, and a coal-supply pipe from the feeding device on the vertical leg. The small triangular attachment at the bend is a pocket for arresting tramp iron, &c., there being no magnetic separator.

AIR-SEPARATION COAL-PULVERISING PLANT.

CONSTRUCTED BY MESSRS. THE BRITISH REMA MANUFACTURING COMPANY, LIMITED, ENGINEERS, HALIFAX.

Fig. 4.

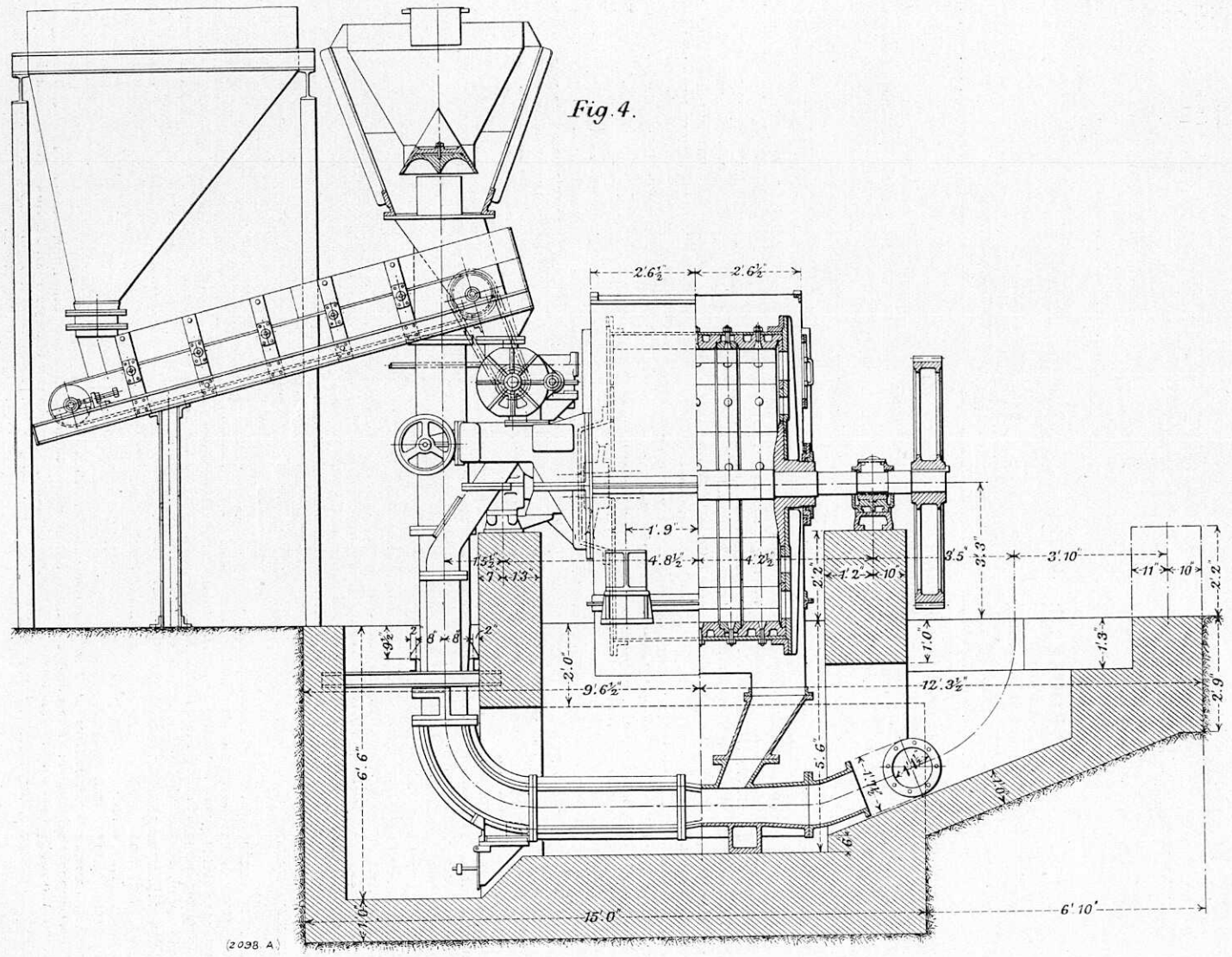
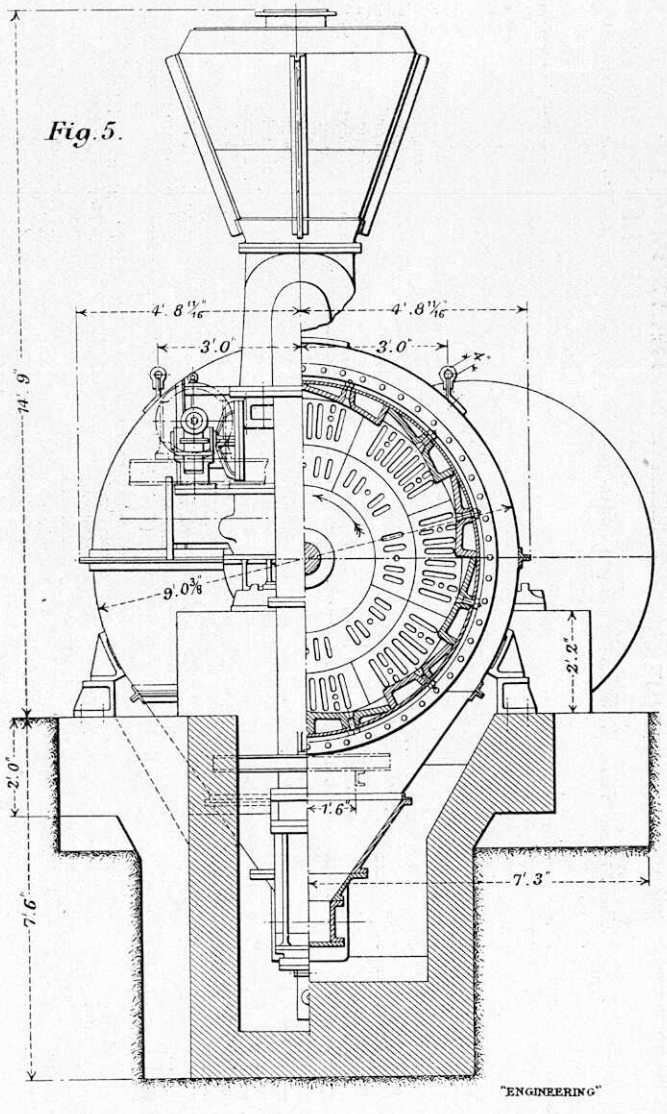


Fig. 5.



It is important to grasp the fact that the hot-air supply does not pass through the mill; neither is the coal fed directly into the mill. The raw coal, previously crushed to 1¼ in. cube, is supplied to a feeder containing a rotating valve, driven either from the mill shaft or independently, as is most convenient, and is thence delivered into the ascension pipe. The conveyor shown in the figure between the raw-coal hopper and the feeder is not an essential part of the system and may be passed over without further comment. The coal on entering the ascension pipe meets an ascending current of hot air which carries it up into the conical chamber containing deflecting cones and screens. Any coal fine enough to pass through the screens, which are normally adjustable to give a fineness of 70 per cent. through either 100 mesh or 200 mesh, is taken on by the fan, but the oversize falls into an inclined chute, and is delivered into the mill. There it is pulverised, and in this state passes through the slots in the diaphragm plate of the mill and down the Venturi pipe into the hot-air supply to be carried up into the chamber and again classified.

There is, of course, a circulation of some hot air through the mill due to the injector effect of the main supply past the end of the Venturi pipe. This air circulation is really only a by-pass, the main stream going round the mill and not through it. The handwheel seen near the coal feeder in Fig. 4 is the feed control, but a mechanical remote control is sometimes adopted. The plant is very flexible in operation and responds to a change of feed in less than one minute. The mills are stated to work quietly between full load and one-sixth of full load. For very variable loads, divided ascension and conveying pipes may be fitted, which device enables the air to be throttled down when the load is reduced. In this case, two or more fans may be used if necessary, thus permitting a very wide range of control over the primary air.

The system is deliberately designed to pass the material through quickly, and to produce only 20 per cent. to 45 per cent. of material fine enough to get through the classifier. It is claimed that this prevents any crushing or clogging, and is thus more effective than when the material is ground to the finished fineness in one pass. The power consumption is low, being approximately 10 kw. per ton when grinding hard coal. The drying is also stated to be very effective, owing to the fact that every particle of coal is enveloped by the hot air stream as it is conveyed to the classifier. A recent test has shown that 5 per cent. of moisture can be extracted in 0·25 of a second with an air temperature of 250 deg. F. Other tests on very wet coal have demonstrated that temperatures of over 600 deg. F. can be used for drying, when handling coal containing 20 per cent. of moisture, without driving off any volatile constituents.

As the main object of this account is to indicate the general features of the system we do not propose to discuss in detail the construction of the mills themselves. A word, however, may be added on the subject of the life of ball, short tube, or ring roller mills which are slow running. The designs of these are based on the minimum requirement that the plant shall work without it being necessary to replace any wearing parts more than once in 3,000 hours' running. As a matter of

fact, in a recent installation for cement kilns we understand that the liner plates of the mills, when grinding hard Northumberland coal containing iron pyrites, are estimated to last over two years with continuous night and day operation, and that the machines will handle coal containing up to 16 per cent. of moisture without difficulty or reduction in output.

LAUNCHES AND TRIAL TRIPS.

"HOLMSIDE."—Single-screw steamer; propelling machinery supplied by Messrs. North-Eastern Marine Engineering Company, Limited, Wallsend-on-Tyne. Launch, June 11. Main dimensions, 350 ft. by 48 ft. by 25 ft. 6 in. Built by Messrs. Cowpen Dry Docks and Shipbuilding Company, Limited, Blyth, for Messrs. Burnett Steamship Company, Limited, Newcastle-upon-Tyne.

"MATAI."—Twin-screw lighthouse and general service steamer; triple-expansion engines. Launch, June 11. Main dimensions: length 228 ft., beam 35 ft. Built by Messrs. R. and W. Hawthorn, Leslie and Company, Limited, Hebburn-on-Tyne, for the Government of New Zealand.

"FOYLEBANK."—Twin-screw cargo motorship; eight-cylinder, airless-injection Harland-B. and W. oil engines. Launch, June 12. Main dimensions, 425 ft. by 57 ft. by 38 ft. 7 in. Built by Messrs. Harland and Wolff, Limited, Belfast, for Messrs. Andrew Weir and Company, London.

"LOSSIEBANK."—Twin-screw cargo motorship; five-cylinder Sulzer-type Diesel engines. Trial trip, June 12. Main dimensions, 440 ft. by 57 ft. by 38 ft. 7 in. Built by Messrs. Workman Clark (1928), Limited, Belfast, for Messrs. Andrew Weir and Company, London.

"INNISFALLEN."—Twin-screw passenger motorship; 10-cylinder, airless-injection Harland -B. & W. oil engines. Trial trip, June 14. Main dimensions, 320 ft. by 45 ft. 6 in. by 19 ft. Built by Messrs. Harland and Wolff, Limited, Belfast, for the City of Cork Steam Packet Company, Limited, Cork.

"HAVSTEN."—Single-screw oil-tank motorship; four-cylinder, two-cycle, opposed-piston Barclay Curle-Doxford airless-injection engine. Launch, June 17. Main dimensions, 420 ft. by 58 ft. 6 in. by 31 ft. 3 in. Built by Messrs. Barclay, Curle and Company, Limited, Glasgow for Messrs. Rafen and Loennechen, a Norwegian firm.

"PAVON."—Single-screw cargo steamer; triple-expansion engine supplied by Messrs. J. G. Kincaid and Company, Limited, Greenock. Launch, June 18. Main dimensions, 395 ft. by 53 ft. by 34 ft. Built by Messrs. Napier and Miller, Limited, Old Kilpatrick, to the order of La Compagnie de Navigation d'Orbigny, Paris.

"SILVERCYPRESS."—Twin-screw cargo motorship; six-cylinder, single-acting Harland-B. and W. Diesel engines. Trial trip, June 18. Main dimensions, 455 ft. by 61 ft. 9 in. by 40 ft. Built by Messrs. Harland and Wolff, Limited, Belfast, to the order of Messrs. Stanley and John Thompson, Limited, London, for the Silver Line, Limited.

"PLATANO."—Turbo-electric passenger and fruit-carrying steamer; electric propulsion equipment supplied by Messrs. The British Thomson-Houston Company, Limited. Trial trip, June 20. Main dimensions 415 ft. by 56 ft. by 34 ft. Built by Messrs. Cammell Laird and Company, Limited, Birkenhead, for Messrs. Elders and Fyffes, Limited, London.

"FJORDHEIM."—Single-screw timber-carrying steamer; triple-expansion engine supplied by Messrs North Eastern Marine Engineering Company, Limited, Sunderland, Bauer-Wach turbine installed by the builders of the ship. Trial trip June 24. Main dimensions, 384 ft. by 51 ft. 6 in. by 26 ft. Built by Messrs. Swan, Hunter, and Wigham Richardson, Limited, Sunderland, for Mr. Nils Rogenaes, Haugesund, Norway.

PERSONAL.—Messrs. F. W. Bridges and Sons, Limited, have transferred their offices from Avenue Chambers, Southampton-row, to Grand Buildings, Trafalgar-square, London, W.C.2.—Messrs. Oxley and Company (Machinery), Limited, Central Works, Savile-street, Sheffield, have opened out an additional department for metals.—Mr. D. E. Grant is relinquishing his position at the Elswick works of Messrs. English Steel Corporation, Limited, to take up the appointment of managing director of Messrs. Dixon and Corbitt and R. S. Newall and Company, Limited, Gateshead-on-Tyne.—Messrs. Celite Products Corporation, Windsor House, 46, Victoria-street, London, S.W.1, have changed their name, and will henceforth trade under the style of Messrs. Johns-Manville Company, Limited.—The firm of Messrs. The Tangent Tool Engineering Company, Limited, Tangent Works, Keynsham, Bristol, has been taken over by Mr. H. E. F. Brecknell, who is continuing the business under the style of Messrs. H. Brecknell and Sons.—Mr. H. Hoover has joined the Philadelphia branch of Messrs. Wagner Electric Corporation, Saint Louis, U.S.A.—Messrs. Guest, Keen and Nettlefolds, Limited, Bolt and Nut Section, Atlas Works, Darlaston, announce that their representative, Mr. C. C. Parson, will in future operate from their London office, 66, Cannon-street, E.C.4. The London office of their associated company, Messrs. John Garrington and Sons, Limited, is also at 66, Cannon-street.—Messrs. T. W. Ward, Limited, Albion Works, Savile-street, Sheffield, have acquired the undertaking and assets of Messrs. The Midland Coal, Coke and Iron Company, Limited, Apedale, Staffordshire.

TENDERS.

WE have received from the Department of Overseas Trade, 35, Old Queen-street, London, S.W.1, particulars of tenders invited by various bodies in the British possessions and in foreign countries. The closing date of each tender is stated below. Details may be obtained on application to the Department at the above address, the reference number given being quoted in each case.

Centrifugal Pumps.—The supply and installation of two electric motor-driven 24,000,000-gallon centrifugal pumps and two 10,000,000-gallon centrifugal pumps. The City of Toronto Department of Works, Canada; July 29. (Ref. No. A.X. 9754.)

Sewage Distribution.—The supply and delivery of four 100-ft. revolving spray-driven sewage distributors and two low-draught dosing syphons. Stores Department, City of Johannesburg, South Africa; July 21. (Ref. No. A.X. 9764.)

Portal Jib Crane.—The supply and delivery of one 15-ton electrically-driven portal jib crane for South Side (New Basin) South Arm Widening, Table Bay Harbour. The South African Railways and Harbours Board, Johannesburg; August 11. (Ref. No. A.X. 9765.)

Bridgework.—The supply of structural steel bridgework for six bridges. The South African Railways and Harbours Board, Johannesburg; July 28. (Ref. No. A.X. 9766.)

Bridge Superstructures.—The supply of superstructures for steel railway bridges. The Royal State Railways of Siam, Bangkok; November 8. (Ref. No. A.X. 9769.)

Steam Wagons and Road Roller.—The supply of four 6-ton steam wagons, four 4-ton trailers, and one 10-ton, three-wheel, steam or oil-driven road roller. The City Council of Johannesburg, South Africa; July 19. (Ref. No. A.X. 9773.)

Discharge Valves and Crest Gates.—The supply and delivery of a discharge valve, or valves, capable of a discharge of 550 cusecs, for the Mahinerangi Dam; August 20. The supply and delivery of automatic crest gates to be capable of a discharge of 16,000 cusecs; September 3. The City Council of Dunedin, New Zealand. (Ref. No. A.X. 9783.)

BOOKS RECEIVED.

The Railway Year Book, 1930. London: The Railway Publishing Company, Limited. [Price 5*s.* net.]

United States Public Health Service. Reprint No. 1328. *Experimental Studies of Natural Purification in Polluted Waters.* II. *Development of a Suitable Dilute Medium.* By C. T. BUTTERFIELD. Washington: Government Printing Office. [Price 5 cents.]

The Law Relating to the Compulsory Taking of Land by Public Companies and Local Authorities. By THOMAS WAGHORN, revised by E. BORREGAARD. Third and enlarged edition. London: Effingham Wilson. [Price 5*s.* net.]

Engineering Materials. Vol. III. *Theory and Testing.* By ARTHUR W. JUDGE. London: Sir Isaac Pitman and Sons, Limited. [Price 21*s.* net.]

Canada. Department of Mines. Mines Branch No. 699. *Abrasives.* Part IV. *Artificial Abrasives and Manufactured Abrasive Products and their Uses.* By V. L. EARDLEY-WILMOT. Ottawa: Department of Mines, Mines Branch. [Price 20 cents.]

American Civil Engineers' Handbook. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 40*s.* net.]

Canada. Dominion Water Power and Reclamation Service. Annual Report 1927—1928. *Irrigation Series* Bulletin No. 7. *Irrigation Practice and Water Requirements for Crops in Alberta.* Ottawa: Dominion Water Power and Reclamation Service.

Aeronautical Research Committee. Reports and Memoranda. No. 1275. *The Interference of a Wind Tunnel on a Symmetrical Body.* By C. N. H. LOCK. [Price 1*s.* net.] No. 1277. *Stability Derivatives of the Bristol Fighter.* By A. S. HALLIDAY. [Price 1*s.* net.] No. 1281. *"Cornering" at High Speeds.* By W. C. JENNINGS. [Price 9*d.* net.] No. 1284. *Pressure Plotting a Streamline Body with Tractor Airscrew Running.* Part II. *Airscrew in Rear Position* By C. N. H. LOCK and F. C. JOHANSEN. [Price 1*s.* net.] No. 1285. *Mechanical Properties of Pure Magnesium and certain Magnesium Alloys in the Wrought Condition (continued). Mechanical Properties of "Electron" Alloy.* By H. J. TAPSELL, S. L. ARCHBUTT and J. W. JENKIN. [Price 9*d.* net.] No. 1289. *The Determination of the Water Resistance of Seaplanes.* By H. M. GARNER and L. P. COOMBES. [Price 9*d.* net.] No. 1291. *Some Generalised Curves for the Accelerated Motion of an Aeroplane.* By H. GLAUERT. [Price 9*d.* net.] No. 1293. *Exploration of the Flow near the Screw proposed for the N.P.L. Compressed-Air Tunnel.* By C. N. H. LOCK and A. R. COLLAR. [Price 9*d.* net.] No. 1294. *Centre of Pressure Travel of Symmetrical Section at Small Incidence.* By F. B. BRADFIELD. [Price 9*d.* net.] No. 1295. *Maximum Lift Coefficient of "Starling" with Clark Y.H. Wings.* By R. P. ALSTON. [Price 3*d.* net.] No. 1301. *Experimental Comparison between a Series of Turns of Different Diameter on a Gloster IV Seaplane.* By J. K. HARDY. [Price 6*d.* net.] London: His Majesty's Stationery Office.

Everyday Uses of Portland Cement. Fifth edition. London: The Cement Marketing Company, Limited. [Price 10*s.* 6*d.* net.]

Transactions of the Institution of Water Engineers. Vol. XXXIV. 1929. Edited by A. T. HOBBS. London: Offices of the Institution.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Restricted output of Cleveland pig iron continues to be in excess of current needs, and there seems no likelihood of early material expansion of demand. Ironmasters have as much Cleveland pig stored as they care to carry, but stocks can hardly be described as inconveniently large, and are increasing little. Makers are still taking up a large proportion of the production for their own consuming departments. A little direct business with local and other home consumers is passing, but export sales are very few and small. Second hands are disposing of odd parcels to customers abroad, and are doing a little home and export trade in Midland iron. Their holdings of Cleveland pig are light, and they have not a free hand as to the disposal of that commodity to home users. Ironmasters adhere to their fixed figures for ordinary business, but are understood to have made substantial price concessions to secure trade with firms in Scotland. Recognised market rates remain: No. 1 grade of Cleveland, 70*s.*; No. 3 g.m.b., 67*s.* 6*d.*; No. 4 foundry, 66*s.* 6*d.*; and No. 4 forge, 66*s.*

Hematite.—In their anxiety to keep furnaces in operation, producers of hematite iron are now naming low rates at which they are prepared to book orders, but customers are not tempted by the offers, and fear is expressed that further curtailment of output will have to be made in the very near future. Merchants have not much iron on hand, but are underselling makers. Home demand is very quiet, and export business is difficult to arrange in face of the comparatively cheap Continental hematite. Makers offer ordinary East Coast brands at 71*s.* 6*d.*, and have accepted less, though cost of output is well over 75*s.* No. 1 quality is on sale at 72*s.*

Foreign Ore.—There is no new feature in the foreign ore trade. Sellers realise the futility of attempting to renew contracts just now, and business is virtually at a standstill. Consumers are carrying large stocks, and are heavily bought abroad.

Blast-furnace Coke.—Durham blast-furnace coke is plentiful, and buyers are little in evidence. For early delivery, good average qualities are on sale at 16*s.* 6*d.*, but consumers cannot buy far ahead at that unprofitable figure.

Manufactured Iron and Steel.—Business in manufactured iron and steel matures very slowly. Some surprise was expressed at the decision not to alter fixed steel prices. Among the principal market quotations are: Common iron bars, 10*l.* 15*s.*; best bars, 11*l.* 5*s.*; double best bars, 11*l.* 15*s.*; treble best bars, 12*l.* 5*s.*; iron rivets, 11*l.* 10*s.*; packing (parallel), 8*l.*; packing (tapered), 10*l.*; steel billets (soft), 6*l.* 15*s.*; steel billets (medium) 7*l.* 12*s.* 6*d.*; steel billets (hard), 8*l.* 2*s.* 6*d.*; steel rivets, 11*l.* 5*s.*; steel ship plates, 8*l.* 15*s.*; steel angles, 8*l.* 7*s.* 6*d.*; steel joists,, 8*l.* 10*s.*; heavy sections of steel rails, 8*l.* 10*s.* for parcels of 500 tons and over, and 9*l.* for smaller lots; fish-plates 12*l.* 10*s.*; black sheets (No. 24 gauge), 9*l.* 15*s.*, and galvanised corrugated sheets (No. 24 gauge), 11*l.* 17*s.* 6*d.*

THE WORLD ENGINEERING CONGRESS, TOKYO.—A pamphlet has just reached us containing particulars regarding the publication of the proceedings of the World Engineering Congress, held at Tokyo, Japan, from October 29 to November 7, 1929. The proceedings, which will be ready in the autumn, will contain 812 papers in English, French, German, and various other languages, and will comprise 16,500 pages. Two editions are being prepared, namely, the standard edition, comprising 20 volumes bound in cloth and sold by the set only, and the popular edition, consisting of 39 paper-backed volumes, single volumes of which are obtainable. The price of the standard edition, if ordered on or before September 30 next, is 20*l.* net per set; if ordered after this date, the price is 25*l.* net per set. In the case of the popular edition, the regular prices of the volumes vary from 8*s.* to 14*s.* If, however, orders are placed before September 30, a rebate of 2*s.* is allowed on the price of each volume. Orders and correspondence should be addressed to the World Engineering Congress, Nihon Kogyo Club Building, Marunouchi, Tokyo, Japan.

CHEMICAL ENGINEERING AND CHEMICAL CATALOGUE.—Described as a catalogue of heavy and fine chemicals, raw material, machinery, plant and equipment applicable to production industries, the sixth edition of the *Chemical Engineering and Chemical Catalogue* has made its appearance. The volume is in effect a directory, and is intended for the use of engineers and works managers charged with the specification and purchase of the plant, equipment, and material utilised in the manufacture mainly of consumable products. The book is divided into five main sections, namely, a catalogue of chemical products; a catalogue of plant, equipment, and chemical engineering; alphabetical and classified indexes, one of which is in the Spanish language; physical and chemical data and tables; and a list of technical and scientific books. A useful feature is that the division of the various sections is shown by thumb indentations. The data and tables section, we are informed, has been doubled, many of the tables having been specially compiled for the catalogue. The book contains many illustrations and diagrams and is free from purely advertising matter. In place of this, precise data and really useful information are furnished. The volume is edited by Dr. D. M. Newitt and is published by Messrs. Leonard Hill, Limited, 231-232, Strand, London, W.C.2. The annual subscription is 10*s.* 6*d.*, but single copies may be obtained at the price of 15*s.* net.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Strong exception is taken by prominent manufacturers in the local steel and engineering trades to the circulation of pessimistic reports. It is pointed out that these often bear the impress of ignorance of actual working conditions, and frequently appear to be based on conscious misrepresentation. Trade organisers stress the damage done to connections, particularly in foreign markets, where rivals are only too glad of the opportunity to exploit such reports for their own ends. The actual facts are that many more thousands of operatives are employed here than before the war, despite the substantial loss of armament and related work; that the quality of Sheffield steel and steel products is incomparably higher than at any preceding period; and that Sheffield is turning out 50 per cent. more steel and products thereof than in the best of pre-war years. Current conditions are somewhat disappointing. Buying is mainly of a hand-to-mouth character, and, though there are exceptions, the bulk of departments are working well within productive capacity. Further advance has been made with the manufacture of hollow-forged high-pressure steel drums for oil refining, aircraft testing, and steam-pressure services. In other directions work at rolling mills, forges, and presses is needed to maintain output at its recent level. There is also a good deal of idle capacity at open-hearth steel furnaces. Prices are surprisingly firm considering the unevenness of the demand. They are as follows: Siemens acid-steel billets, 9*l.* 10*s.*; hard basic-steel billets, 9*l.* 2*s.* 6*d.* to 9*l.* 12*s.* 6*d.*; medium hard basic, 7*l.* 12*s.* 6*d.* to 8*l.* 2*s.* 6*d.*; soft basic, 6*l.* 10*s.*; Lincolnshire foundry pig iron, 75*s.* 6*d.*; Derbyshire foundry pig iron, 73*s.* 6*d.*; Derbyshire forge, 69*s.* 6*d.*; crown iron bars, 11*l.*; iron hoops, 12*l.*; steel hoops, 9*l.* 10*s.* to 10*l.*; basic-steel scrap, 50*s.* Large supplies of steel are being taken for the manufacture of electrical machinery and appliances. A healthier tone is shown in the production of axles, tyres and other railway steel. Heavy demands are still being made on Sheffield works for automobile steel. There is a fair call for agricultural iron and steel and garden tools. Improved business in harvesting machinery is anticipated from the crop prospects. Hacksaw production is being placed on a wider basis. Fair sales of twist drills and cutters are reported.

South Yorkshire Coal Trade.—Business is labouring under the existence of heavy stocks, resulting from a generally quiet demand. Little movement is shown in house coal. Benefit may result from efforts to induce consumers to stock for the winter earlier than usual. Collieries and depots have substantial supplies for which there are comparatively few buyers. There are weak spots in the industrial demand quite apart from the shortage of export business. Some speculative buying is reported in smalls. Quotations: Best branch hand-picked, 25*s.* to 26*s.* 6*d.*; Derbyshire best brights, 20*s.* to 22*s.*; Derbyshire best house, 19*s.* to 20*s.*; screened house coal, 17*s.* to 19*s.*; screened house nuts, 15*s.* to 17*s.*; Yorkshire hards, 14*s.* to 15*s.* 6*d.*; Derbyshire hards, 14*s.* to 15*s.* 6*d.*; rough slacks, 8*s.* 6*d.* to 9*s.*; nutty slacks, 7*s.* to 8*s.*; smalls, 3*s.* to 5*s.*

CANADA AND BRITISH STEEL.—The Executive Committee of the National Federation of Iron and Steel Manufacturers, at its meeting held on June 19, expressed high appreciation of the recent action of the Dominion of Canada in according increased preferences to the products of the British iron and steel industry.

DIRECTORY OF PAPER MAKERS.—The 1930, and 54th annual edition of that useful work, *Directory of Paper Makers of Great Britain and Ireland*, was published recently by Messrs. Marchant Singer and Company, 47, St. Mary Axe, London, E.C.3. As was the case with earlier issues, the book contains alphabetical lists of paper and millboard makers in Great Britain and Ireland and lists of paper enamellers and surfacers, of paper makers' representatives and agents, of London wholesale stationers, and of watermarks and trade names used by paper makers and wholesale stationers. Alphabetical and geographical directories of individual paper mills are also given, several maps being included, and the volume closes with sections dealing with such matters as standard names and sizes of papers and boards, paper-trade customs, and paper-trade publications. The volume, which comprises upwards of 270 pages, is well printed and neatly bound, and the price is 5*s.* net, or post free in the United Kingdom, 5*s.* 6*d.*

THE ALUMINIUM PAVILION, LIÉGE EXHIBITION.—The international aluminium pavilion was inaugurated recently at the Liége International Exhibition. The Bureau International de l'Aluminium, which is responsible for the arrangement and organisation of the pavilion, is receiving the co-operation of the prominent aluminium producers in Great Britain and the Continent, and each country is well represented at the various stands. The exterior of the building is picked out in polished or fluted aluminium strip, the window frames are of Duralumin, and the roof is composed of aluminium sheet. The ground floor is occupied by stands, on which the more massive applications of the light-metal industry are exhibited. There is also, on this floor, a cinema in which films illustrating the production and working of aluminium and its alloys are shown continuously. On the upper floor, the stands have been grouped under various industries, the chemical, electrical, wireless, mechanical, motor-car, and textile industries each exhibiting a representative selection of aluminium articles. On the roof of the pavilion is placed an all-metal aeroplane of Duralumin, while welding and other processes are demonstrated in the basement.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Little change has taken place in the Scottish steel trade during the week, but a more hopeful feeling prevails as the prospects of the shipbuilding industry are somewhat brighter. One or two good contracts have lately been secured, and there is a probability of some more orders coming along in the near future. Meanwhile, the steel makers are having difficulty in keeping their plant running on account of the scarcity of specifications, both on home and export account. The internal trouble in India and the tariff revision in Australia have curtailed our overseas trade to a very considerable extent. These, with the general home trade in such a poor state, have brought outputs to a very low level. It is expected that business will show a better face after the summer holiday vacation next month. In the black steel sheet trade the demand for the lighter gauges is keeping up wonderfully well, and makers have quite satisfactory order books, but the heavier gauges are very slow all round. Galvanised sheets are in very poor request and makers find difficulty in securing a sufficient tonnage to keep plant in operation. Prices are nominally unchanged and are as follow:—Boiler plates, 10*l.* 10*s.* per ton; ship plates, 8*l.* 15*s.* per ton; sections, 8*l.* 7*s.* 6*d.* per ton; black steel sheets, $\frac{1}{8}$ in., 9*l.* per ton; and galvanised corrugated sheets (No. 24 gauge), 12*l.* 15*s.* per ton, all delivered at Glasgow stations.

Malleable-Iron Trade.—There is still a great scarcity of fresh business in the West of Scotland malleable-iron trade, and the works are only operating in a hand-to-mouth manner. The industry has been suffering very badly during recent months and there is little sign of any betterment on the horizon. The re-rollers of steel bars are also finding things very stiff at present as specifications are extremely scarce. Prices are without change and are as follow:—"Crown" bars, 10*l.* 5*s.* per ton for home delivery, and 9*l.* 15*s.* per ton for export; and re-rolled steel bars are 7*l.* 12*s.* 6*d.* per ton for home delivery and for export.

Scottish Pig-iron Trade.—A very quiet tone continues to prevail in the Scottish pig-iron trade and the demand has not improved in the slightest degree. The current rate of production is more than equal to all calls, and stocks are increasing. When the holiday season arrives next month it is fully expected that the blast furnaces will be damped down for a lengthened period unless there is a considerable improvement in business. In the hope of reviving the demand, prices have been reduced by 1*s.* 6*d* per ton, and the following are now the current quotations:—Hematite, 79*s.* 6*d.* per ton delivered at the steel works; foundry iron, No. 1, 79*s.* per ton, and No. 3, 76*s.* 6*d.* per ton, both on trucks at makers' yards. Forge iron is now 76*s* 6*d.* delivered at consumer's works. There are at present 15 furnaces producing ordinary iron and 10 producing hematite.

Scottish Pig-Iron Shipments.—The shipment of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, June 21, was one of the smallest on record, and only amounted to 50 tons. Of that total 40 tons went overseas and 10 tons coastwise. During the corresponding week of last year the figures were 688 tons overseas and 48 tons coastwise, making a total shipment of 736 tons.

HYDRO-ELECTRIC POWER DEVELOPMENTS IN BRITISH COLUMBIA.—The East Kootenay Power Company intends to apply to the Provincial Water Controller at Victoria, British Columbia, Canada, for the right to dam the Elk river at a point about 10 miles below the town of Elko, and to erect a water-power plant having a capacity of between 15,000 and 20,000 h.p. The main feature of the scheme is the construction of a dam across the river at Phillip's Canyon. The East Kootenay Power Company already operates two hydro-electric power plants, the one on the Elk river and the other on the Bull river, as well as a steam-driven plant at Sentinel in Southern Alberta. These plants have a total installed capacity of 37,200 h.p., and power is supplied to a number of collieries, to the large Sullivan silver-lead-zinc mine, and to a number of townships, including Crambrook and Fernie.

SKILLED EMPLOYMENT AND APPRENTICESHIP ASSOCIATION.—As we have previously stated in our columns, the main object of the Skilled Employment and Apprenticeship Association is to promote the welfare of boys and girls by encouraging and assisting them to enter skilled trades, and to continue this encouragement and advice after they have entered such trades. The 24th annual report of the Association shows that it is steadily continuing its useful work, for, during 1929, 673 boys and 548 girls were placed in trades and occupations either as apprentices or as learners. It is a gratifying indication of the careful work of the committees that only about 10 per cent. of the children, for whom openings were found, proved unsuitable after trial. The East London Apprenticeship Fund continued its good work under the ægis of the Association during the year under review. Premiums amounting to 290*l.* have been granted in 13 cases. Those boys who have completed their apprenticeships during the year are doing well, and satisfactory reports are received of the 59 still on the books. Mr. H. Glanfield is now the honorary secretary of the Association, Mr. Horne having resigned the joint honorary secretaryship and Mr. F. Coston Taylor having finally relinquished that office after 10 years, to become honorary treasurer. The Association invites subscriptions to enable it to extend its work. The central office of the organisation is at 75, Denison House, 296, Vauxhall Bridge-road, London, S.W.1.

NOTICE OF MEETING.

INSTITUTION OF MECHANICAL ENGINEERS.—Summer Meeting, Monday, June 30, to Friday, July 4, The University, Bristol. Tuesday, July 1, 10 a.m. "Air-cooled Aero-Engines; a Review of Developments in the past Ten Years," by Mr. A. H. R. Fedden. At 2 p.m. Various visits to works. Wednesday, July 2. Whole-day visits to works. At 7.30 p.m. Institution Dinner, Grand Hotel, Bristol. Thursday, July 3, and Friday, July 4. Whole-day excursions and visits to works.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The opposition of the House of Lords to the Coal Mines' Bill has created hopes amongst coal market operators that the Bill will either be dropped, or so modified as not to increase costs of production or unnecessarily interfere with the working of the collieries. Operators feel that what is wanted is less restriction and fewer handicaps to the conduct of business so that they can estimate, with some degree of certainty, the cost of coal, and confine their attentions to the selling of the mineral rather than be compelled to spend time in studying what they can and cannot do as a result of the mass of restrictions which have been placed on the industry from time to time. Meanwhile conditions show no change of note, and, though shipments have expanded during the last week, the demand continues insufficient to clear current production, despite the fact that collieries have been compelled to work irregularly owing to the general slackness of trade. In the circumstances prices remain on the basis of the schedule based on 20*s.* per ton f.o.b. for best Admiralty large, and 13*s.* 6*d.* for best steam smalls. For prompt loading, sized coals too are obtainable round the schedule, but for shipment ahead, tentative inquiries are more numerous, and business is being quietly booked up at anything from 3*d.* to 2*s.* per ton above the schedule. In the past week exports of foreign coal totalled 475,000 tons, which was 147,000 tons more than in the previous week, but still considerably below the rate of clearances in the first quarter of the year.

500,000 *Tons Contract.*—A contract which caused considerable interest during the week was that of the Buenos Ayres Electricity Works, which has placed an order with Messrs. Gueret, Llewellyn and Merrett Limited of Cardiff, for 500,000 tons of sized coal, to be delivered at Buenos Ayres and Rosario over 1931 and 1932, and for 50,000 tons to be shipped to Lisbon (Portugal) over 1931. The importance of the business is the fact that it was secured, in keen competition with Germany, by the margin of 1*d.* per ton. The order has been taken on a c.i.f. basis, which means that the successful tenders are taking a big risk with the freight. Though a half-million ton contract is a substantial order, spread over two years, it does not mean much as it represents only 5,000 tons a week or a day's output of a good-sized colliery.

Iron and Steel.—Shipments of iron and steel goods last week amounted to 18,750 tons, which was more than treble the quantity despatched in the preceding week. Clearances of tin-plates and terne-plates were raised from 4,642 tons to 15,019 tons, of black plates and sheets, from 149 tons to 1,015 tons, of galvanised sheets, from 141 tons to 1,473 tons, and of other iron and steel goods from 300 tons to 1,243 tons.

MOTOR SHOW, MILAN.—A report on the motor show, held in connection with the Milan Fair, from April 12 to 27 last, has been furnished to the Department of Overseas Trade by H.M. Vice-Consul at Milan. United Kingdom firms desirous of receiving a copy of the document should communicate with the Department, at 35, Old Queen-street, London, S.W.1, quoting Reference No. A.X. 9665.

SOOT, ASH, AND GRIT FROM POWER STATION CHIMNEYS.—The Electricity Commissioners have appointed a committee, under the chairmanship of Mr. C. D. Taite, and with Mr. C. S. Jenkins as secretary, to consider and report upon the measures which have been taken both in this and other countries, to obviate the emission of soot, ash, and gritty particles from the chimneys of electric power stations. The Committee includes Messrs. M. H. Adams, J. Bruce, A. N. East, W. Innes, A. B. Owles, Dr. S. L. Pearce, Messrs. T. Roles, W. C. P. Tapper, E. R. Wilkinson and H. K. Beale, Bailie A. Holmes, and Alderman W. Walker. The Committee held its first meeting on June 2.

CONTRACTS.—Messrs. Robert Stephenson and Company, Limited, 25, Victoria-street, London, S.W.1, have received an order from the Buenos Ayres and Pacific Railway Company for fifteen 0-8-0 type tank locomotives, the approximate full weight of which being 65 tons, and the light weight, 53 tons.—H.M. Office of Works has accepted the tender of Messrs. The British Thomson-Houston Company, Limited, Crown House, Aldwych, London, W.C.2, for Mazda gas-filled and vacuum lamps to be supplied during the period ending May 31, 1931.—Messrs. The British Rema Manufacturing Company, Limited, Halifax, are building, for the North Metropolitan Power Station Company, Limited, London, for installation in their Brimsdown power station, one British Rema ring-roll type pulverising mill, fitted with their vacuum system of classification. The plant is stated to be the largest of its type in this country; it will have a guaranteed output of 12 tons per hour.

ZUYDER ZEE RECLAMATION WORKS; SLUICES AND LOCK AT DEN OEVER.

(*For Description, see Page* 821.)

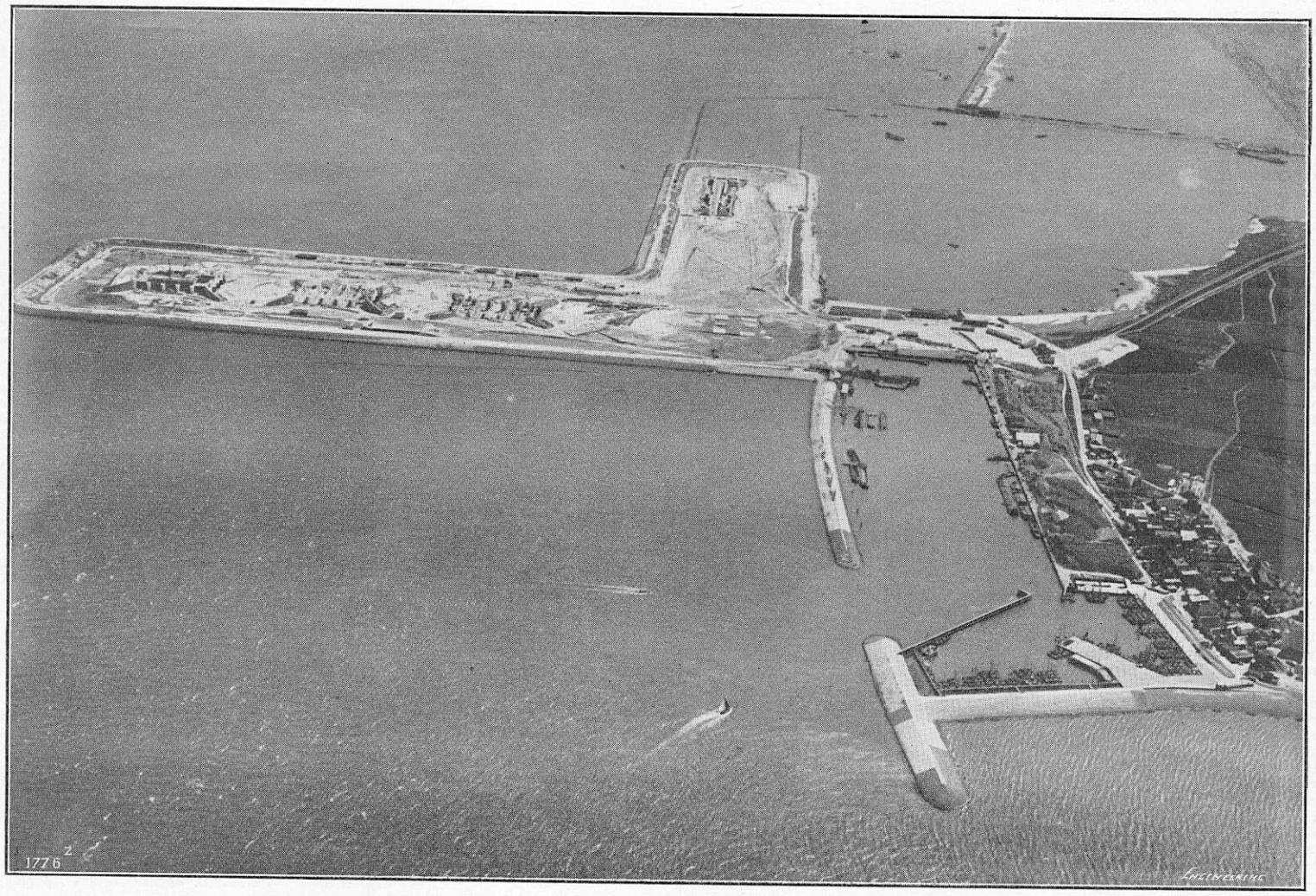


FIG. 74. TEMPORARY DAM ENCLOSING SLUICES AND LOCK UNDER CONSTRUCTION.

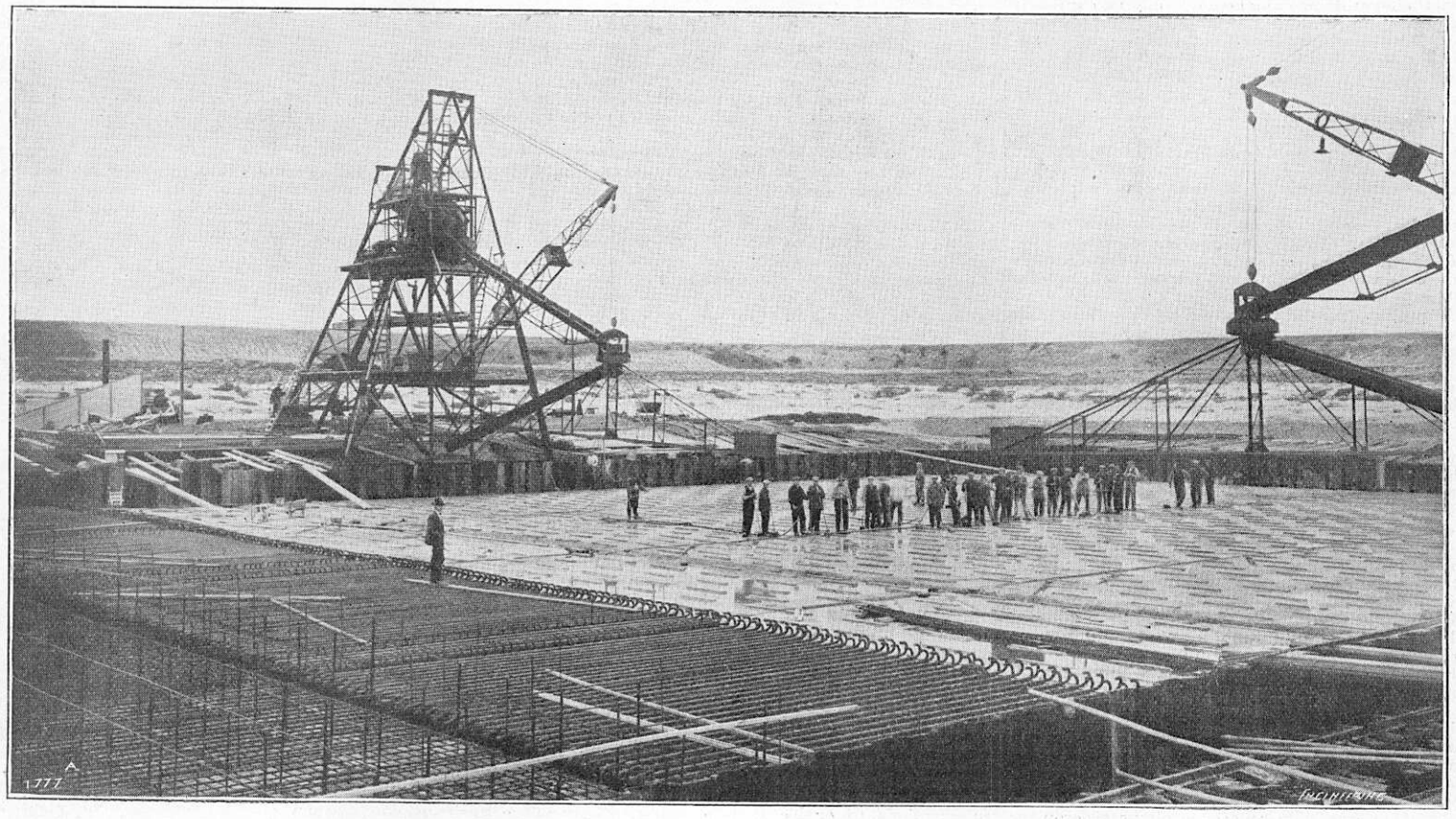


FIG. 75. CONSTRUCTION OF REINFORCED CONCRETE FOUNDATION FOR SLUICES.

ENGINEERING.

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ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines, or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received 10 days previous to the day of publication.

All accounts are payable to "ENGINEERING," Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

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CANADA, Toronto, 2, Ont. : Wm. Dawson Subscription Service Limited, 91-93, Queen-street, East.

DENMARK, Copenhagen : Kaat-Jensen and Company, Vester Farimagsgade 22.

EDINBURGH : John Menzies and Company, Limited, Rose-street.

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CONTENTS.

	PAGE
The Mandi Hydro-Electric Scheme ; Northern India (*Illus.*)	815
Literature—Pioneers of Electrical Communication. Aufgaben aus dem Wasserbau Angewandte Hydraulik. Disrupted Strata	817
Thick-walled Tubes and Cylinders under High-Pressure and Temperature (*Illus.*)	818
The International Railway Congress, Madrid	819
Zuyder Zee Reclamation Works ; Main Enclosing Embankment and Sluices (*Illus*)	821
The Royal Society Conversazione	823
Labour Notes	824
Atmospheric Pollution	825
The Institution of Electrical Engineers	825
The Late Mr. Percy Allan	826
Air-Separation Coal-Pulverising Plant (*Illus.*)	826
Launches and Trial Trips	828
Tenders	828
Books Received	828
Notes from Cleveland and the Northern Counties	828
Notes from South Yorkshire	828
Notes from the North	829
Notice of Meeting	829
Notes from the South-West	829
The Re-Opening of St. Paul's Cathedral	831
The Assessment of Compensation Water	832
Notes	833
The Second World Power Conference	833
The White Star Motor Liner "Britannic" (*Illus.*)	836
Letters to the Editor—The Design of Submarines. The Supercharging and Compounding of Aero-Engines	838
The Selection and Operation of Pumping Machinery for Waterworks	839
Automatic Gas-Pressure Controller (*Illus.*)	841
The Airport at St. Hubert, Montreal, Quebec (*Illus.*)	842

One Two-Page Plate—ZUYDER ZEE RECLAMATION WORKS ; MAIN ENCLOSING EMBANKMENT AND SLUICES.

ENGINEERING

FRIDAY, JUNE 27, 1930.

VOL. CXXIX. No. 3363.

THE RE-OPENING OF ST. PAUL'S CATHEDRAL.

ST. PAUL'S CATHEDRAL has been re-opened this week in the presence of Their Majesties the King and Queen with the solemnity due to an historical and unprecedented occasion. For five years only the nave of the building has been available for public worship, and the whole area under the dome has been shut off, with the transepts and choir extending to the east. This drastic measure was found necessary not for the purpose of avoiding immediate danger to the public, but in order to allow work which had been found essential to the preservation of the structure to be carried on without interruption. Those who have been associated with these works are to be congratulated on having at last attained the substantial purpose in view. The event has shown further that the preservative measures were planned with considerable foresight. Little alteration has been found necessary in them as the work has progressed, disclosing the state of the building more completely than it could have been known when the plans for its amendment were made. They have been carried out, moreover, in less time than was expected originally, an unusual experience in protracted operations under difficult and initially uncertain conditions. The engineering interest of the work does not lie in its mere size. First and last it has extended over 17 years and has cost less than 400,000*l.*—figures not exceptional in large constructional operations. The experience gained has been interesting and instructive and when, in addition, the unique value of the Cathedral is considered, not to be expressed in any economic units, it may be desirable to call attention to the grave warning it gives as to what may be necessary in the future.

When the Cathedral was built, the usual extent of sub-surface works and of traffic was, of course, incomparably smaller than it is now, and if he could have foreseen how they were to be developed, it is hardly likely that Wren would have erected so weighty a structure as his dome on such shallow foundations. They extend, in fact, only 4½ ft. below the level of the crypt floor, and a deep bed of sand and gravel separates them from the firm bed of solid blue London clay. Even during the 40 years over which the building of the Cathedral extended, settlements occurred which Wren himself had to make good, and in 1831 the whole edifice was threatened with destruction through great quantities of sand being pumped out from beneath it in attempting to lay a sewer in its immediate neighbourhood, a calamity which seems to have been averted only by the intervention of Rennie and Brunel. The problem which the structure has always presented arises from the great weight of the dome and its supports, amounting to about 70,000 tons, in relation to the outside diameter of about 140 ft., and to the depth and nature of the foundations. Signs appeared many years ago of the need for the utmost precaution in avoiding any interference with the foundations. Even in 1890 further burials in the Cathedral were forbidden absolutely in the nave part of the crypt, and allowed only in very exceptional cases elsewhere. Even at that time, however, the true situation of the structure was far from being appreciated accurately. As recently as 1907, a special committee of eminent architects reported after careful enquiry that the Cathedral required no large scheme of repairs. A very few years later, however, when the proposal to construct an underground tunnel near the building in connection with the suggested St. Paul's Bridge was examined by Sir Francis Fox and others, it became apparent that substantial preservative operations were already necessary.

There was a small fabric fund at St. Paul's, barely adequate for current repairs, and quite insufficient for any emergency work on the required scale. Accordingly, in 1914, a public appeal for 70,000*l.* was made to provide for certain work, recommended by two distinguished architects, one of them the Surveyor of the Cathedral. In consequence of observations made in the course of this work, a Commission was appointed in the autumn of 1921 to examine the building and advise what methods should be adopted for its preservation. This Commission included, in addition to two architects (Sir Aston Webb and Mr. Mervyn Macartney, the Cathedral Surveyor), three civil engineers, Mr. (now Sir) Basil Mott, Mr. E. F. C. Trench, and Mr. (now Sir) G. W. Humphreys, and on its advice in an interim report, an appeal for a further sum of 100,000*l.* was made for work that was evidently and immediately necessary. A large part of this sum was subscribed promptly, and during the next three years the Commission made a minute examination of the condition of the structure under and composing the dome, instituting also a series of measures, including a system of reference points embedded in the masonry, by which any movement in the structure could be controlled more amply and accurately than had been possible up till then. In the light of the results so obtained the works now being completed were planned, and a further appeal for 140,000*l.* was made to enable them to be carried out, an amount which was quickly raised, being considerably oversubscribed. In substance the measures undertaken were essentially of three kinds. The piers on which the dome is carried were consolidated by grouting under pressure through bore-holes, the piers being strengthened temporarily during the process by steel and timber casing, and being left permanently reinforced by metal rods embedded in the bore-holes. The drums of the dome were encircled by metal hoopings, to prevent a possible cumulative increase in their circumference. Arrangements were made for repeating the levelling and similar observations of the structure at regular intervals, so as to keep constant account of any change which might occur. It was recommended also that precautions should be taken against the danger that might arise from building operations near and below the level of the foundations of the Cathedral.

The observations which have been made during the progress of the work show that for the time being no movements are occurring in the foundations, and no cumulative movements in the structure. Small periodic movements, indeed, appear to occur owing to temperature changes, but these could neither be controlled without the fear of dangerous concentration of stresses on

some part of the surface, nor are of serious consequence so long as they are not cumulative. With the amendments that have now been made in the superstructure, there appears, in fact, to be no reason at all to expect further cause for anxiety in regard to the structure, so long as the circumstances of the foundations remain unchanged. The weakness of the position appears to be that it discloses no sufficient assurance against such a change. The tendency of practice in commercial districts, such as that in which St. Paul's is placed, is not only to construct higher buildings with more storeys but also to open out deeper basements. The construction of tunnels, such as those of tube railways, or of other underground structures, such as modern drainage and other subways, may under given circumstances have a considerable effect on the foundations of neighbouring structures, and those of the Cathedral would certainly be sensitive to such effects. Experience seems to show, moreover, that increased volume, weight, and velocity of traffic may produce consequences below the surface which as yet are imperfectly ascertained, and certainly the effects of the vibrations so produced cannot be predicted with the accuracy that is necessary when dealing with an irreplaceable structure such as St. Paul's Cathedral. Engineers who have had occasion to travel in the Dominions, and even in the United States, have observed the keen interest with which the recent fortunes of the Cathedral have been followed in those countries. Canon Alexander, the Treasurer of the Cathedral, has described its relation to the Empire in a singularly graphic phrase, having termed it "The Parish Church of the Empire," and in a preface to a second edition of his little work on *The Safety of St. Paul's*, he has repeated a suggestion made many years ago that special measures should be taken to restrict excavations in the area surrounding it to such as would be without danger to the Cathedral. There would be obvious objections from the point of view of owners to restricting the use to which they may turn their property. Nothing, however, is better settled in the law as well as the justice of the community than that a man may not use his property so as to injure that of his neighbour. When the neighbouring property is also a national and imperial possession, the maxim seems at least as applicable as when it is that of a private person. Doubtless there is a correlative obligation on the owner of the threatened property to use all reasonable means to protect it against injury. If further experience confirms the present impression of the effect which has been produced by the recent works, the Cathedral authorities have discharged that obligation. It remains now to define what limitations should be put on excavations and other operations in the neighbourhood of the Cathedral, to what area such restrictions should extend, by what technical authority they should be prescribed, and by what mechanism applied.

THE ASSESSMENT OF COMPENSATION WATER.

WHEN a community grows up on the banks of a river and becomes dependent upon it for many vital interests, and when some other party, often at a considerable distance, takes supplies of water from it, it has long been felt essential that an adequate flow should be left for the first community. Any regulation of water supplies, moreover, should make such provision as is possible for preventing them from being wasted. Not only may waste in the form of floods become a nuisance or even a danger to the neighbourhood, but the duty of husbanding all water supplies so as to avoid shortage is now well recognised. When it comes, however, to applying these principles, the fundamental difficulty arises of ascertaining how much water is available for control. In many parts of the country, indeed, observations have been made in recent years on rainfall and run-off from which much more accurate estimates of supplies can be made than were possible some 70 years ago, when the present method of assessing compensation water was prescribed, and although these records can still be amplified, the data now available appear to be sufficient to call for a reconsideration of the present method of assessment. This view has been taken by the Advisory Committee on Water set up by the Ministry of Health, as indeed it was stated in the final report of the Water Power Resources Committee in 1921, and the Ministry has now published a report on the subject by a Technical Sub-Committee of the Advisory Committee on Water (H.M. Stationery Office; Price 9*d*. net). The Sub-Committee, a small body of eminent water engineers under the chairmanship of Mr. Sandford Fawcett, has produced a series of definite recommendations, in which the main Committee, itself an essentially practical body, has expressed its concurrence. These recommendations, if they receive legislative sanction, will make a substantial difference in the basis on which water undertakers will be required to discharge compensation water.

The present method is based exclusively on the average annual rainfall over the catchment area for as long a period of years as possible. A deduction of one-fifth or one-sixth from the amount thus determined was made in order to arrive at the rainfall that might be relied upon during a period of three consecutive dry years, and a flat deduction of a number of inches of rain, usually 14 in., was made from the remainder to cover the losses due to evaporation and absorption. The remainder, which was called the reliable or the available yield, was then divided between the requirements of the public water supply and the river in certain definite proportions, very commonly two to one, or sometimes three to one. The latter, regarded as compensation water, became a first charge on the storage reservoirs in which the water flowing from the catchment area might be impounded. The application of this method, therefore, made no provision for the very varied requirements of different rivers as regards compensation allowance, these varying naturally with the industrial uses to which the river may be put, and made no allowance at all for the considerable extent to which river interests may be benefited by the construction of large impounding reservoirs on their head stream. For purposes of power or trade, the value of a natural river of variable flow is, obviously, increased to the extent to which its available flow is regularised, and impounding reservoirs not only provide this advantage, but also to a considerable extent conserve the flood waters which run off rapidly from the catchment area in times of heavy rain. This reduces the serious damage to property which may occur from time to time with the river left in its natural condition. The power derivable by the control of the flow from the reservoir and, for example, delivering it to industries during working hours, enables the supply to be used with greater economy. To some extent, indeed, flood waters from upland areas may produce scour in the channel of an estuary, with beneficial results to its sanitary purification, but, on the other hand, the quantity of head water impounded at the level necessary for gravitation supplies will usually be small compared with the volume of flood water in a river at or near its estuary derived from other parts of the river basin, and such advantage as may be ascribed to scour effect is likely to be more than offset by the increased flow in dry periods which results from the discharge of compensation water.

The Sub-Committee has had the opportunity of working not only on records of rainfall much more extensive and accurate than those which were available when the present practice was adopted, but also of obtaining confidentially, from various parts of the country, records of continuous gaugings of the daily flows of a number of the more important rivers used for water-supply purposes, extending over periods of some 4 to 19 years. Their investigation of these records reveal certain obvious defects in the present method. In many cases the deduction made for the loss due to evaporation and absorption, now taken as a flat rule-of-thumb allowance, is found to be inadequate. It makes, moreover, no allowance at all for the widely varying character of the flows in the different streams. A mountain stream, for instance, carrying the water from a steep impervious area, with a high annual rainfall, will in its natural state pass down the bulk of its total annual flow in short periods of heavy flood, and yield a low dry-weather flow of little use to the riparian owner, whereas its value is considerably increased when it is fed regularly with compensation water from a reservoir. On the other hand, a stream fed from a less steep gathering ground on a more pervious foundation, possibly also supplied from springs, and with a lower average rainfall, will have a more regular rate of flow. In confirmation of the view of the Water Power Resources Committee, the present report is definitely in favour of assessing compensation water with due regard to the nature of such variations. It is held to be eminently desirable also that account should be taken of the extent to which riparian owners lower down the stream make use of the river water for industrial or other purposes.

After much investigation into other possible alternatives, the Committee recommends that the basis of estimated rainfall over three dry years, calculated by deducting 20 per cent. from the long-period average rainfall, should be retained, the records now available being in its opinion, reasonably accurate for the purpose. In place, however, of a flat-rate reduction for evaporation and absorption, it is proposed to use the difference between the rainfall and the run-off as ascertained by stream gaugings corrected for three dry-year periods. It has found, in fact, that there is a sufficiently close relationship between rainfall and run-off, and consequently between rainfall and loss, to enable a suitable formula for the loss to be constructed. To define the character of the flow in such a form as will yield the most serviceable distinction for the purpose in view, it proposes the use of a characteristic consisting of the ratio between the average daily flow on the days when the flow did not exceed the mean of the whole gauging period and the mean daily flow during that period. This figure, estimated for a three-consecutive-dry-year period, after correcting for loss by evaporation or absorption, is to be the "assessable" flow on which Parliament should base the amount of the compensation water. This amount finally is to be corrected by a "user" factor, which will apply a coefficient varying from 0·35 to 0·70, according to the extent to which the stream is classed as industrial. It is contemplated that in appropriate cases, such, for example, as when the water is used as a source of power, a money compensation might be arranged instead of compensation water; and that in other instances, such, for instance, as the supply of compensation water for fishery purposes, it may be of mutual advantage that the compensation water should be supplied at special seasons of the year instead of continuously. In all cases water undertakers empowered to abstract supplies from rivers should be required to maintain stream gauges giving accurate measurements of the flood as well as of the dry-weather flows, and to keep continuous records of their readings. On a point not included in the reference to the Sub-Committee the Advisory Committee is, further, of opinion that the allowance of compensation water should take account of the extent to which the requirements of the river are satisfied by any tributaries that are not impounded. It is proposed that general legislation should define the principles on which compensation water is to be assessed, and that Parliament should apply them to future private bills. Should the water undertakers find ground for claiming a revision of the amount of compensation water awarded, either before or after the passing of the contemplated Act, it is held that they should be allowed at any time after the lapse of three years from the date of an award, to make application to the Minister, who may make an order modifying the award in accordance with the principles laid down in the general legislation.

There can be little doubt that the general effect of these modifications will be to produce assessments fairer to the parties and, a matter of still more consequence, to promote the control of flood water and the economical use of supplies. It may be questionable, however, whether, even if the Minister is accepted as the proper authority for deciding on modifications, the right of appeal should not be extended to other interested parties besides the water undertakers. Without underrating the importance and costliness of water supplies, it is clear

that cases may arise in which change of circumstances may produce an urgent demand for an increased river flow, which may be of no less general public importance than the provision of a water supply. Increase of population, for example, or even a rapid growth of a particular industry, may create a situation in which the public interest may need an increase in the amount of compensation water. The present suggestion that riparian communities should be treated in closer accordance with their existing circumstances than has been usual is perfectly fair, and should be in the public interest. It seems, however, that when such restrictions are imposed on them, provision should be made for such alterations as may be expedient if the circumstances on which their rating was determined should alter. The question is certainly a difficult one, but ought not to be lost sight of.

NOTES.

THE FARADAY CENTENARY CELEBRATIONS, 1931.

THE diary of Michael Faraday shows that the first experiment which led to the discovery of electro-magnetic induction, was made by him on August 29, 1831. This date constitutes, therefore, the starting point of the utilisation of electric power for the purposes of man, and August 29, 1931, marks the centenary of what is undoubtedly the greatest event in the history of electrical engineering. The Royal Institution, in which Faraday spent practically the whole of his active life, is taking a leading part in the organisation of the centenary celebrations of Faraday's discovery, and has joined forces with the Institution of Electrical Engineers in drawing up the arrangements for a great commemorative meeting to be held in 1931. Two conferences on the subject have been held, the first at the Royal Institution on February 5, and the second at the Institution of Electrical Engineers on April 17. In each case a large number of technical institutions and societies were invited to send representatives. As the result of these conferences two committees were formed, one by the Royal Institution, and the other by the Institution of Electrical Engineers, and these have acted jointly in the preparation of a draft programme. As now arranged, the meeting will open on the afternoon of Monday, September 21, 1931, when a reception of foreign and other delegates will be held at the Royal Institution. In the evening a commemorative meeting will be held in the Queen's Hall, at which discourses will be given on Faraday's work. On the morning of September 22 an electrical conference will commence, of the members of the Institution of Electrical Engineers, and those of all other associations connected with the electrical industry. An important feature of the celebrations will be the Faraday Exhibition, held in the Royal Albert Hall, which will be open to the public for about 10 days, namely from September 23 to October 3. This will contain reproductions and illustrations of Faraday's actual experiments and a display of historic apparatus. In addition, the development of electrical and chemical science and industry in all branches which have their origin in Faraday's work will be shown by means of special exhibits.

THE ENGINEERING SECTION OF THE BRITISH ASSOCIATION.

The British Association is holding its annual meeting this year in Bristol from Wednesday, September 3, to Wednesday, September 10, inclusive, under the presidency of Professor F. O. Bower, D.Sc., F.R.S., the sectional proceedings commencing on September 4. Sir Ernest W. Moir, Bart., is this year President of Section G (Engineering), and the other officers of that section are as follows: Vice-Presidents, Professor F. C. Lea, Mr. T. A. Peace, Mr. H. Faraday Proctor, Professor Andrew Robertson, and Mr. W. A. Stanier; Recorder, Mr. J. S. Wilson, 49-50, Parliament-street, London, S.W.1.; Secretary, Mr. S. J. Davis; and Local Secretary, Professor A. J. S. Pippard. The meetings will be held in the main buildings of the University. Two papers on internal-combustion engines will be read on Thursday, September 4, one on "The Influence of Turbulence upon Highest Useful Compression Ratios," by Messrs. T. F. Hurley and R. Cook, and the other on "Some Recent Progress in Air-Cooled Aero-Engine Development," by Mr. C. F. Abell. On Friday, September 5, Sir Ernest Moir will deliver his presidential address, and this will be followed by a joint discussion with Section I (Physiology) on "Air-Pressure Variations Encountered in Engineering Works and Their Physiological Effects." The discussion will take place in the meeting room of Section G. The meeting, on Monday, September 8, will be devoted to the question of airship construction, papers on this subject being contributed by Lieut.-Col. V. C. Richmond, who will deal with "The Development of Rigid Airship Construction," and by Mr. B. N. Wallis, who will describe the design and construction of the airship R 100. On Monday afternoon a series of kinematograph films of the airships R 100, R 101 and of the *Graf Zeppelin* will be shown in the Great Hall of the Merchant Venturers' Technical College. Three papers on the economical production of power will be dealt with on Tuesday, September 9. One of them, entitled "The Use of High Pressures and Temperatures in the Generation of Power," is by Mr. George A. Orrok of New York. Of the other two papers, one is by Sir Henry Fowler on "The Question of Fuel Consumption in Locomotive-Practice," and the other by Messrs. A. Lennox Stanton and Theodore Stevens on "Obscured Fundamentals in the Development of Integrated Electricity Supply." The final meeting on Wednesday, September 10, will be devoted to the subject of structural work and to the reports of various committees. Mr. J. S. Wilson will read a paper on "Structural Steel Design and Regulations," and Mr. J. Stuart Lewis one on "Standardisation of Design for Structural Steelwork." Another paper will be read by Professor Cyril Batho. The committee reports taken will be those on Electrical Terms and Definitions, Earth Pressures, and Stresses in Overhead Materials. The works to be visited during the course of the meeting include the Portishead Power Station, Avonmouth Docks, the Bristol Aeroplane and Engine Works at Filton, Messrs. Stothert & Pitt's works at Bath, the Swindon locomotive works, the works of the Bristol Waterworks Company at Chelvey, Cheddar and Blagdon, Messrs. Petters Oil Engine Works and the Westland Aircraft Works at Yeovil, and the works of Messrs. R. A. Lister and Company at Dursley. Advance proofs of the papers will as usual in this Section be available at the meeting. Further information may be contained from the Secretary of the British Association, Burlington House, London, W.1.

THE SECOND WORLD POWER CONFERENCE.

(*Continued from page* 805.)

BEFORE continuing our account of the proceedings at the World Power Conference in Berlin, which concluded on Wednesday, June 25, it may be interesting to say a few words regarding the arrangements which were made for interpreting the remarks of the various speakers who took part in the discussions into the three official languages—German, English and French. In each of the three halls in which the meetings were held, the speaker's rostrum was equipped with a microphone, which was connected to a number of head telephone sets on an interpreters' table. The latter instruments were combined with a microphone, which was fitted with a soft-rubber mouthpiece, so that the interpreters were able to carry out their duties without disturbing either the speaker or the audience. Each seat in the auditorium was also equipped with a head set and change-over and volume-control switches, so that any of the three languages, including that which the speaker himself was employing, could be heard. The entire installation was provided by Messrs. Siemens und Halske A.-G., of Berlin.

A further useful, though not altogether necessary, refinement was the provision of illuminated panels behind the chairman, on which the names of the languages which were being transmitted were exhibited, while the subject under discussion was illustrated symbolically in the same way. In addition, there was a system of signalling lights, which indicated to the speaker that the microphone was energised and that the time allotted to him had expired.

The success of such an arrangement must obviously depend on the restraint of the speakers and the skill of the interpreters in about equal proportions. The former must speak clearly and slowly, if the time lag between him and his interpreter is not to be excessive. The latter must be able to appreciate the meaning of what is being said without delay, and to translate it intelligibly and concisely. On the whole, it may be said that the system worked well and, as the large majority of the speakers were German or used that language, British participants were able to follow the proceedings with an ease that might not otherwise have been possible.

Three technical sessions were held on the morning of Tuesday, June 16. In Section II, which was presided over by Mr. Robert Sibley, the subject for discussion was "Electricity in Crafts and Industry," the General Report being presented by Dr.-Ing. R. Bingel. In the electrochemical industry, it was stated, the endeavours that were being made to increase the output and to obtain a lower specific power consumption could be illustrated by calling attention to the introduction of large cells for water electrolysis. and by the increase in the current intensity of the furnaces used in the aluminium and carbide industries. Direct-current intensities up to 40,000 amperes were being employed in separate furnaces. The output of direct-current generators could not exceed 20,000 kw., owing to transport difficulties. The maximum output of three-phase furnace transformers was 32,000 kv.-a., the current exceeding 100,000 amperes, though there were no insuperable technical difficulties to an increase above these figures.

New developments in the use of electricity were the production of spongy iron by gas reduction, and *ciment fondu*. The arc furnace was being increasingly employed for the manufacture of high-grade steel alloys and grey cast iron. Induction furnaces predominated for the melting of copper alloys, while the use of high-frequency furnaces was becoming more general. Resistance furnaces were being largely adopted for the heat treatment of metals, while equipment in which a protective gas was used to prevent the formation of scale and to enable copper-hydrogen soldering to be performed was coming into use.

Any increase in the power demands for electrochemical and electro-thermal purposes pre-supposed a very low charge for current, since both the base load and the load factor were increased. In turn, these improvements would tend to a reduction in the cost and assist in increasing the use of electricity in these industries. As regards electric welding, arc was generally preferred to resistance welding and was making good progress. The aim must be to improve the efficiency of the seam and to render it independent of the accidents which would occasionally occur in hand operation. Everyone interested should endeavour to extend the use of the new methods of lighting, so that their effect on work of the most different descriptions could be ascertained with the ultimate idea of increasing the quality and quantity of the output.

Considerable progressive development could be recorded in the use of electrical precipitation plants, whether for the recovery of material, for purifying useful gases, or for dealing with smoke and waste gases. The generation of the high-tension direct-current necessary for this equipment was being effected by hot-cathode valves, and more recently by copper-oxide rectifiers in place of the ordinary mechanical rectifier.

In the application of electricity to power, the efficiency of the motor itself was not the primary consideration, as an improvement in the quality of the product or an increase in its quantity depended mainly on the reliability, accessibility and simplicity of the drive. Since the early days, the movement had been from the central drive to the group drive and then to the individual drive by single motors. The extended application of the last method to the most varied types of machines had resulted in the

production of open, protected, enclosed and built-in motors, as well as to the use of roller bearings, to combinations of motors and lay shafts, and to constant and variable-speed units. There had also been developments in the starting and regulating equipment, in the protective devices, and in remote and automatic control systems. The sub-division of the power transmission on the machines themselves, and the distribution of the load between several motors mounted on the working shaft or tool, had been greatly assisted by the application of sound electrical principles in the design of the individual motors. It had led to the direct coupling of the motors to the machines as, for instance, on spinning frames and centrifuges, where speeds of from 10,000 to 30,000 r.p.m. were required. It had also necessitated an investigation into the internal mechanical transmission on machines where the accurate automatic control of the individual parts in relation to one another was essential. For instance, on paper-making machines the use of the multi-motor drive had overcome the drawbacks of mechanical transmission and had resulted in an increase both in the quality and quantity of the product. Similar problems occurred on rolling mills, where an automatic, rapid and accurate control of the individually-driven rolls was essential. Endeavours were, in fact, being made to eliminate gearing as the final intermediate mechanical drive. This necessitated separate synchronous drives for the top and bottom rolls.

A lengthy discussion took place on this report, in which it was pointed out by more than one speaker that there were considerable openings for electric heating among small power consumers and that its use on such equipment as soldering irons would favourably affect the efficiency of the various processes. Mr. Mörtzsch said that in Germany the number of large electric ranges in use had increased from 25 to 250 in five years, and that heat storage formed a load profitable both to the undertaking and the consumer. Referring to electrical precipitation for gas cleaning, Mr. Schmidt said that more than 1,000 equipments working on the Lodge-Cottrell principle were in use in the United States, the aggregate capacity of which was 100,000,000 cub. m. of gas per hour. The largest installation could deal with 5,000,000 cub. m. per hour. Dr. H. Lund referred to the increasing use of the double-wound squirrel-cage motor in Germany. It had almost entirely replaced the slip-ring motor, owing to the ease with which it could be started without disturbing the network. More than 20,000 such motors were in use.

Section IX also met on Tuesday morning to consider the question of "Fuel, Power and Heat Economies in Individual Countries," the chair being taken by M. Carlos Cecchi. The General Reporter was Professor Dr.-Ing. W. Pauer, who said that, in spite of the rapidly increasing demand for power, there was generally speaking no shortage of supply. The most difficult problem was, in fact, to increase the consumption, so that the plant installed could be employed up to its capacity and be operated economically. Water power was only of supreme importance in countries without other fuel resources, and where it existed side by side with fuel the limits to its utilisation were economic and not technical. The economical transmission of power by coal gas, oil and electricity over long distances had increased the area which could be supplied from a single source, and this area frequently overstepped political boundaries. The progress made within the boundaries of single states might be nullified by the opening up of new sources of power, and it was this circumstance which was compelling international co-operation. At present, hardly a single state was independent in the power sense.

While the supply of solid fuels seemed to be assured for an indeterminate period, the increasing demand for liquid fuel compelled a consideration of the not too distant future when its production would begin to decline. The conversion of solid into liquid fuels was, therefore, a most important problem, especially having regard to the important part played by fuel supplies in the trade balance of many states.

As regards individual countries, the most conspicuous characteristic was the centralisation of supply. This had been stimulated by the development of electrical enginering, which had enabled distant sources of energy, like water power and low-grade fuels, to be converted on the site and transmitted in a form acceptable to the consumer. Heat transmission was also making great progress in districts where the power demand was large, but it must be emphasised that central supplies of every kind were only economically possible when the area supplied had a certain minimum load factor. Measures which would be successful in thickly-populated districts were doomed to failure where the population was sparse. In addition to the solution of technical difficulties, the planning of power systems required the clear delineation of those economic limitations which hampered the execution of technically possible schemes.

A meeting of Section XXXII, also on Tuesday morning, June 17, dealt with "Research Work," Direktor R. J. Jensen being in the chair. The general report was presented by Professor Dr.-Ing. Föttinger, who said that, notwithstanding the wide variety of subjects on which research was being undertaken, a common tendency was recognisable. The fierce competition between nations, the dawning realisation that indigenous resources of raw materials must be economised, and the increase in speed were all heading in an ever-increasing degree to the utilisation of more scientific means of technical research. Both State and industry recognised that expansive and difficult experiments should not be abandoned after the first useful results had been obtained only to be built up again at a considerable expenditure of time and labour to deal with the next problem. Organised research work had, in fact, become the essence and backbone of all human endeavour towards rationalisation and improvement. The chemical, optical and electrical industries owed their present positions to research, and since the war it had been justified in other directions of which the steam investigations of Callendar and the American work on internal-combustion engines were examples. In particular, it might be said that a close contact between the different branches of research would be in the interest of the whole community.

At the conclusion of the sectional meetings on Tuesday morning, the second of the General Addresses was delivered by Professor Dr. D. Serruys, who took "The New Forms of Rationalisation" as his subject. Speaking in French, Dr. Serruys said that the fact that the most efficient utilisation of power resources was the principal object of the Conference was an overwhelming proof of the dawn of a new faith to which all those who thought and worked might adhere. It had taken centuries to make industrialists recognise that discussions on the price of coal were useful and even necessary. It was not less important to avoid waste of that commodity.

Rationalisation might be said to have started with Taylorism, though the latter had been mainly concerned with the scientific side of the workshop and factory problem. It aimed at the avoidance of superfluous movements and at effecting the correct spacing of the necessary pauses in a working process. An analogous development must take place on the economic side. The requirements of a market at any moment must be foreseen, and the purchasing power and requirements of the consumer correctly estimated. A production programme, as simple as possible, must be built up on the foundation thus obtained, and, finally, finance and economics must be welded together to form a harmonious whole.

In Latin countries, the outlook was preponderatingly individualistic, and they had shown themselves more antogonistic to co-operation than the Germans, though recently they had reduced their shortcomings in this respect. France and Italy were fully organised on a syndalistic basis, while in England a tendency in the same direction could be noted, though here again individualism was an obstacle. Primarily this co-operation had taken the form of control followed by the organisation of work. But when the Steel Pact had brought about the regulation of output in different countries, it had not only protected its members from competition, but had enabled a yearly programme of production to be prepared.

It was hoped that the development and interconnection of European water resources would lead to a saving of the very large sums which were now spent in purchasing food from non-European countries. Unity, however, was necessary to make these natural forces fully serviceable for the good of mankind.

On Tuesday afternoon, June 17, there was a meeting of Section XXIII, at which the subject "World Problems of Power Supply Economics" was discussed. The chair was taken by Mr. C. H. Merz, and, in the course of his general report, Dipl.-Ing. F. zur Nedden stated that a careful study of the power obtainable by such methods as utilising the difference between the temperatures of the air and of the water below the ice in the Arctic regions, driving turbines with hydrocarbons of low boiling point, and the exploitation of waste heat from geysers, showed that though technically possible, they were not economically practicable. An exact economical comparison between water and thermal power led to the conclusion that capital cost and load factor were determining considerations. Messrs. Stuevold-Hansen, J. Kinck and A. Norstrand had suggested the erection of an overhead line, approximately 620 miles long and working at 380 kv., to give a supply from South-East Norway to Denmark and Germany. This line would be capable of transmitting 750,000 kw., and it would be possible to supply the town of Lubeck from it at a cost of 4*l.* 15*s.* per kw.-year. The total cost, including the power station, would be 35,000,000*l.* In an alternative scheme, from Sweden, the use of a submarine cable working at 110 kv., was proposed. The capital cost of the station worked out at 22*l.* 10*s.* per kw., and it was estimated that current could be supplied at less than 0·2*d.* per kw.-h. in competition with current produced locally in ordinary steam stations costing 14*l.* to 15*l.* per kw., provided that the capital charges in Norway and Germany did not exceed 5 per cent. and 8 per cent., respectively, and that the base load lasted 6,500 working hours. The overwhelming importance of interest rates and of load factor was, therefore, obvious.

The fundamental requirements of electro-economics were to increase the load factor, thereby decreasing the amount of capital changes borne by each unit generated, and to reduce the capital per kilowatt installed. The increasing range of power transmission was only possible by the use of higher tensions, pressures and velocities, thus increasing the danger to workers. Safety methods organised on systematic lines were therefore necessary.

Section XXXIII met on Tuesday afternoon and dealt with "Standardisation Problems and the Rationalisation of Statistics," Mr. J. H. Damme being in the chair. In the course of his general report, Dr. Leisse stated that two methods of making power statistics of the greatest possible use had been proposed: the purely mathematical method and the graphical method. A more or less fundamental question was whether statistics should be compiled in such a general way that the ordinary person could follow them, or whether strictly scientific methods should be employed. The reliability of statistics concerning power depended on the accuracy with which the collection of the data was carried out. Standardisation of method was desirable if definite and clear comparisons were to be made.

Reporting on "Standardisation," Dr.-Ing. Neuhaus said that all industrialised countries now accepted the fact that standardisation was necesssary, and very nearly all had National Standard Committees which were organised on similar lines. The great question was when to introduce standardisation for a certain product or process.

On the same afternoon, Section XXXIV dealt with the subject of "Education." The chairman was Ing. R. Reich, and the General Report was presented by Professor U. Lohse. The latter pointed out that, in regard to engineering education, two essentially opposite views were held. One postulated that the technical college should provide the student with a general training in technical

principles, that further instructions in special branches should be left to the period during which the engineer was engaged in his profession, and that the necessary knowledge should be gained by self-instruction. The other considered that the student should specialise from the beginning. Great importance was now attached to the study of human economics in view of the increasing mechanisation of industry and the tendency towards rationalisation. It was recognised that successful training was impossible unless the student obtained a knowledge of engineering materials and processes by actually working in the shop, though opinions varied as to the time that should be devoted to practical work and when that work should be carried out.

That sound technical training might be obtained in many ways was admitted, the sole question being which was the quickest and best. The question could only be satisfactorily answered by international collaboration and exchange of experiences. With the increasing ramifications of power economics in different countries, the establishment of fundamental rules for the training of engineers and technicians would appear to be an urgent necessity. It would not only affect the development and improvement of power production, but would benefit the community at large, which was economically interested in such a development either as a producer or a consumer of energy.

On Wednesday morning, June 18, a meeting of Section III was held under the chairmanship of Direktor N. Traaholt, to consider the question of "Three-Dimensional Load Models and Current Tariffs." The General Reporter was Direktor H. Henney, who pointed out that the papers submitted showed the importance that was attached in all countries to the improvement of power factor, and the introduction of such tariffs as would make it possible for the consumer to employ electrical energy for a variety of purposes. The allocation of fixed charges could only be affected by the use of a three-dimensional load diagram (load mountain), which indicated both the costs of generation and the value of the energy to the consumer. It was evident that tariffs must be of many forms and grades. This, however, meant complicated measuring instruments and increased installation costs. It also made it difficult for the consumer to calculate his indebtedness. Generally, opinion was in favour of the use of one meter only, though this was not always possible.

Section IV also held a meeting on Wednesday morning, June 18, under the chairmanship of Sir David Milne Watson. The subject for discussion was "Economic Problems of High-Temperature Distillation," and the General Reporter was Dipl.-Ing. B. Ludwig. The latter pointed out that many problems in high-temperature gasification still remained to be solved, though there existed a feeling that the end of development along this particular line was in sight. A proof of this was that all gas-producing equipment had become very similar, both in principle and operation. At present, therefore, attention was being mainly directed to the refinement of the methods used and the development of the efficiency and reliability of the plant.

Examining the routine of high-temperature gasification, it would be found that the coal was chosen so as to ensure a high gas yield and good coke. In refining and purifying the gas, it had been found most expedient to use the least possible amount of water for cooling and to employ automatic regulation. The removal of tar by electrostatic methods was increasing. This process also facilitated the recovery of the ammonia and benzole. As regards ammonia recovery, purification with ferric hydroxide was still being used in the majority of cases, but wet cleaning was beginning to be successfully adopted, especially in the United States. In Germany, the processes in which ferrocyanide was used in connection with electrolysis were still in the experimental stage. Producer plants were continually being improved. Although there was little difference in their efficiencies, the mechanical producer had marked advantages over the static, as it enabled the grates to be kept clean, manual labour to be eliminated and a gas with a constant calorific value to be used for heating. In addition, coke breeze could be advantageously utilised. The output of the producers per unit of grate area had been considerably increased.

Water-gas plants were being continually improved by the introduction of mechanical stokers and charging equipment, while the output of the individual units had been increased. It appeared that water gas was destined to become the chief source of heat in some countries. Recovery of the waste heat was usual, and was recognised as being necessary. It should be the aim of the gas engineer to increase the flexibility of his plant, to render it adaptable to heavy load fluctuations, and to produce a cheaper gas from a cheaper fuel.

The meeting of Section XXVII, on Wednesday morning, June 18, was presided over by the Hon. Sir Charles A. Parsons, the subject for discussion being "Power Supply on Ships." The General Reporter was Ministerialrat W. Landahn, who pointed out that the limits to the economical use of power on ships were constantly changing, though it might generally be assumed that economy was a maximum when the desired object was attained with a minimum expenditure of labour, money and material. The efforts to reduce this minimum still further were particularly marked in marine engineering. In this connection, the Diesel engine had played an important part, and 55 per cent. of the ships under construction were equipped with that form of prime mover.

As regards operation by steam, though the economy of employing pressures up to 35 atmospheres and temperatures up to 400 deg. C. was recognised, pressures above 60 atmospheres had not yet been practically tried out. If high-pressure steam were to be used successfully on smaller vessels, the most suitable type of prime mover seemed to be a combination of the reciprocating engine and exhaust turbine. The employment of high-pressure steam opened the road to many methods of increasing the overall efficiency of the plant. These included the pre-heating of the feed water and the air, automatic and mechanical furnaces and high-speed turbines. Other equipments could be rendered more economical by the substitution of mechanical stoking for hand firing, and by the conversion of reciprocating engines to the Bauer-Wach system. The rapid advance that had been made in steam technology was amply illustrated by the fact that in modernising such vessels as the Albert Ballin, of the Hamburg-Amerika Line, it had been possible to install machinery of double the capacity, and with only a slightly greater weight, in the same space. It might be expected that, in future, the minimum consumption of fuel oil on multi-propeller vessels equipped with steam plant would be 0·23 kg. per horse-power hour, giving an efficiency of 27·5 per cent.

Outstanding points in the development of the Diesel engine were the solid injection of the fuel, the use of high speeds, the double-acting two-stroke cycle, supercharging, and light construction. The chief requirements were lower fuel consumption, greater reliability and output, and a reduction in weight and space. Though the employment of mechanical gearing permitted a wide choice of propeller and engine speeds and a variety of layouts, it was essential that the compact high-speed units, which had recently been installed in warships, should be capable of developing power on a single shaft. If, in addition, hydraulic couplings were used, great reliability was obtained and torsional vibrations were damped out. In the interests of heat economy, efforts must be made to utilise the waste heat to a greater extent than had been customary, and to discover means of increasing the outlet temperature of the cooling water without decreasing the reliability. In future, there would be no difference between land and marine engines, and the fuel consumption of large units might be of the order of 0·165 kg. per horse-power hour, corresponding to an efficiency of 38·3 per cent. It would be incorrect to assume, however, that only motor ships would be built in future, as in this connection the purpose for which the vessel was intended was a ruling factor.

As regards the electrical drive turbo-electric and Diesel-electric units were in successful operation but prices and weights must be reduced. Electricity was used to a preponderating extent for driving the auxiliaries on motorships, and was being increasingly employed for the same purpose on steam ships, particularly now that motors had been designed which fulfilled the difficult conditions present on the winches and steering gear. The great advantages of the electric drive were centralised generating plant and economic transmission of power. A future problem was the automatic regulation and remote control of the machinery, though, in certain special cases, even that problem might be considered as solved. The auxiliary units had a great effect on the overall efficiency, and their importance would be recognised when it was pointed out that their output was from 15 per cent. to 20 per cent. of that of the main prime movers. These units should therefore be considered as forming a part of the whole, and not as a separate installation. As the work involved on marine installations was particularly strenuous, every new advance in the design of the machinery should be considered from the labour-saving aspect.

A meeting of Section V was held on Wednesday afternoon, June 18, to consider the subject of "Gas Markets." The chair was occupied by Director Dr. Schütte. In the course of his general report, Dr.-Ing. K. Lempelius remarked that the impression conveyed by the papers was that the development of the gas industry was being carried out with the greatest zeal. The markets for all kinds of gas were increasing, the characteristic feature of this expansion being the enormous extension of long-distance transmission. An interconnected network of pipes stretched from the Gulf of Mexico to the Great Lakes and almost to the Atlantic Coast. The protection of this network from corrosion was an important problem, which was being scientifically and practically investigated.

Attempts were being made to increase the economy in consumption by investigations into the best composition of the gas and the most useful pipeline pressure. This pressure was then reduced in accordance with the requirements of the individual consumer, so as to give the best flame.

The subject of "Individual Problems of Power Supply in Different Countries," was considered by Section XXII, on Wednesday afternoon, June 18. The chair was taken by Mr. Terenzio S. Lodispoto, the general reporter being Dr.-Ing. R. Adolph. The papers that had been collected under this heading were largely statistical, and, in commenting on them, the general reporter remarked that, though the demand for electricity had increased in all countries, there was no indication of saturation. Generation was being concentrated in large units, so that the average central station capacity was increasing. Steam was the chief motive power in large generating units, Diesel engines being used to deal with the peak load in sparsely populated districts and near oil fields. All countries which possessed water power were developing it.

The construction of transmission systems in accordance with a uniform national scheme was taking place in most countries, but no definite conclusion could be drawn as to the limit up to which the extension of power stations and the interconnection of transmitting systems offered economic advantages. The large capacity of such interconnected plants necessitated the employment of special measures for maintaining electrical stability This was provided for by the construction of suitable generators and exciters. The rupturing capacity and operating speed of switchgear were increasing.

At a meeting of Section XXXI on Wednesday afternoon, June 18, the subject discussed was "Mechanical Transmission of Power on Vehicles and in Workshops." The chair was occupied by Mr. A. E. L. Chorlton, the general reporter being Professor Dr.-Ing. Kammerer. The latter, in dealing with the transmission of power on vehicles, said that, up to 100 h.p., sliding gears with a friction clutch and a universal joint had proved simplest, and though hydraulic transmission had been employed, it was too heavy for such lower powers. Between 100 h.p. and 200 h.p., change-speed gears in continual engagement with friction clutches for each speed had proved most suitable. On the Hungarian railways, multiple-plate clutches, operated

by compressed air, were used, the weight being 12 kg. per horse-power. Electrical transmission weighed 30 kg. per horse-power. Between 200 h.p and 300 h.p., hydraulic transmission was the most reliable and economical. Its weight was from 10 kg. to 20 kg. per horse-power. On locomotives with outputs up to 1,200 h.p. there were three competitive forms of transmission: the electrical, which weighed 30 kg. per horse-power and had the advantage that shocks and vibration due to the connecting rods were avoided; the supercharged engine with two speed gears, which weighed 20 kg. per horse-power and was cheaper than the electrical equipment, although its operation was difficult, as the tractive effort could only be varied in steps; and a Diesel engine driving an air compressor could also be used. The air was compressed to about 7 atm., after superheating by the exhaust gases to a temperature of from 200 deg. to 300 deg. C., and was used to drive the locomotive. The 2,400-h.p. locomotive for the Canadian National Railways was equipped with two high-speed Diesel engines, which supplied current to eight motors.

As regards the transmission of energy in workshops, the tendency was towards simplification. This was evident from the efforts that were being made to avoid the use of multi-unit drives. For instance, in a radial drilling machine the power was no longer transmitted through the column and arm, but the motor was connected directly to the drill spindle. On spinning frames it was becoming usual to drive each spindle from its own motor. Countershaft-driven gears were being replaced by stepped pinions and adjustable speed motors. In shops, each shaft was driven by its own motor. The simplification of the shafting allowed higher speeds to be used. The ease with which the direct-current motor could be regulated, and with which alternating current could be converted into direct current was responsible for the increasing use of direct current in all workshops.

In the course of the discussion, Mr. J. Geiger called attention to the Diesel compressed-air locomotive which was now being tested on the German State Railways,* and said that it had been found reliable in operation and free from ice troubles, owing to the temperature of the exhaust always being from 100 deg. to 150 deg. C. No dirt or oil collected in the compressor or air pipes, and no trouble had been experienced with the valves. Compared with an electric locomotive it was easier to handle. These views were confirmed by Mr. A. Meyer, who said that this unit weighed only 15 kg. per horse-power, as compared with 60 kg. per horse-power for the steam locomotive. Professor G. Lomonossoff said that some further information regarding the Canadian National Railway locomotive described by Mr. Chorlton was desirable, including the mileage run and on what kind of service it was being used. The rumours that had been spread regarding its failure had created the impression that it was impossible to use Diesel engines for railway work. They were, however, experiencing the usual infantile troubles, the solution of which was a special locomotive type of Diesel engine. This must be light, simple and reliable; especially the latter. So far, the Diesel engines used in Russia had been too heavy and those in Canada too light. The troubles with the latter might also be ascribed to the number of cylinders. This not only meant more parts to go wrong, but was undesirable for mechanical reasons. A Diesel engine for a locomotive should not have more than six cylinders and should run at about 800 r.p.m. Its design might well be a matter for international consideration. The chairman, at the suggestion of the audience, replied to Professor Lomonossoff's question by saying that the trouble on the Canadian locomotive had been due to a faulty casting. It was not necessary to make locomotive engines very heavy. The engines on the airship R 101 weighed 4 kg. per horse-power and ran at 950 r.p.m.; tests showed that they would be quite suitable for railway work.

At the conclusion of the sectional meetings on Wednesday afternoon, the third of the general addresses was delivered in the main Opera House. The proceedings opened with a speech by Mr. A. Sackett, the American Ambassador to Germany, in which he remarked that material development could only be effected by the greater use of electricity. This meant a reduction in the price of the latter. He knew of no other industry in which the selling price of the commodity was 15 times the cost of its production, but in most of the large towns in the United States the price of electricity per kilowatt-hour for domestic purposes was 6 cents, while the cost of its generation, he stated, was from 0·3 cent to 0·4 cent.

A lecture on "The Place of Minerals in a Power Sustained World" was then delivered by Dr. H. Foster Bain, in which he said that in the modern world minerals had replaced the human slavery, on which the civilisation of the ancients had been based. Coal might, in fact, be described as the mainspring of civilisation and electricity as coal at work. If we had cause for gratitude that fuel was available for our use, we should be no less thankful for the many other minerals supplied to us. The quantity consumed of such materials as coal and iron ore was enormous, and the quantity *per capita* of the population had increased rapidly during the last forty years. Warnings had, therefore, not unnaturally been issued that there was danger of exhaustion. But if it were remembered that our geological explorations had heretofore been confined in the main to the surface, or the first thousand feet or so below, it was possible to take a more hopeful view. Granted that metals were present at lower depths in considerable quantity, the problem of future reserves rested on technology and economics.

A short talking film, showing Mr. T. A. Edison seated in his garden and giving a description of the "Birth of the Incandescent Lamp" was also shown. In the evening, the Weltkraftfest was held in the Sportpalast in the Leipzigerstrasse, Berlin. This is a very large hall. Its area must at least equal that of the large hall at the London Olympia, and it possesses the additional advantage that it is entirely surrounded by a stepped terrace and three galleries. The guests numbered nearly 4,000. In accordance with German custom, the speeches were delivered and the entertainments performed between the courses, while the proceedings were directed not by a chairman but by a Master of Ceremonies, who had a squad of trumpeters at his disposal.

The evening began with a speech of welcome delivered by Mr. Arthur Schröder, a leading German actor, after which a dancing display was given by 400 girls from the Berlin schools. Another item was an attempt to link Berlin, London, New York and San Francisco by wireless, and, having done so, to listen to speeches by Mr. T. Sloan, President of National Electric Light Association of America, and Mr. Owen Young in the last-named city, by Dr. von Miller and Dr. C. Koettgen in Berlin, and by Lord Derby and Senatore Marconi in London. This was successfully carried out.

(To be continued.)

NATIONAL FEDERATION OF IRON AND STEEL MANUFACTURERS.—At the annual general meeting of the National Federation of Iron and Steel Manufacturers, held on May 15, the Hon. Roland Kitson was elected President of the Federation for 1931, and Messrs. W. Simons and J. Henderson were elected additional vice-presidents.

INTERNATIONAL CONGRESS FOR CONCRETE, LIÈGE.—The first International Congress for Concrete and Reinforced Concrete is to be held at Liége from September 1 to 6 next. The Chairman of the British Organising Committee, which comprises representatives of various Government Departments and British technical institutions, is Mr. J. Mitchell Moncrieff. The papers submitted by this Committee, and accepted by the Congress, comprise "Stresses in Dams," by Mr. S. D. Carothers; "A Study of Plain and Reinforced Concrete Retaining Walls," by Mr. E. S. Andrews; "Reinforced Concrete in Great Britain," by Mr. A. K. Dodds; "Reinforced Concrete in Engineering: Representative Examples of British Practice," by Mr. M. Gerard; "Work of the Building Research Station on Small Movements in Concrete," by Dr. W. H. Glanville; "The Effect of Temperature on Flat Arches Constructed of Reinforced Concrete," by Mr. C. S. Gray; "Temperature and Cement," by Dr. O. Faber; "The Architecture of Concrete," by Professor B. Pite; "The Composition, Mixing, Methods of Application of Concrete and Reinforced Concrete as used in the Yards and the Control of Same," by Mr. T. R. Grigson; "Some Notes on the Composition, Mixing and Application of Concrete in Engineering Works," by Mr. C. J. Jackaman; and "Pieces in Concrete Piles," by Mr. M. J. C. McCarthy. Further particulars may be obtained from the secretary of the Institution of Structural Engineers, 10, Upper Belgrave-street, London, S.W.1.

* See ENGINEERING, vol. cxxviii, page 748 (1929).

THE WHITE STAR MOTOR LINER "BRITANNIC."

THE motorship Britannic, which leaves Liverpool to-morrow on her maiden voyage to New York, is the third White Star liner to bear that name. The first Britannic, built in 1874 by the builders of the present vessel, Messrs. Harland and Wolff, Limited, of Belfast, had a gross tonnage of 5,004, a length of 455 ft., a breadth of 45 ft., and a depth of 33 ft. 9 in.; and these figures, if compared with those given below for the new vessel, are evidence of the progress in shipbuilding in the period of fifty-six years that have elapsed since the first Britannic was put into service. The second Britannic, built as a hospital ship during the war, was sunk by enemy action in the Ægean Sea in 1916.

The new Britannic, of which a photograph is reproduced in Fig. 1 on page 837, is notable in that she is the first motorship in the White Star fleet and the largest British vessel of that type. As will be seen, she is built with what is now the usual straight stem and cruiser stern, and is equipped with two low, large-sized funnels, one of which is a dummy and contains a smoking room for the engineers. Her principal dimensions are: Length between perpendiculars, 680 ft., moulded breadth, 82 ft., and moulded depth, 43 ft. 9 in., while her gross tonnage is 26,943. The hull is divided into 13 watertight compartments, and the double bottom, which is continuous, is arranged to carry fresh water, water ballast, and fuel oil. Accommodation, of a particularly comfortable character, is provided for a total of 1,550 passengers of the cabin, tourist, and third classes. Notable features of the accommodation are the provision of a swimming pool and tennis courts in the cabin class, and elevators and children's play-rooms in all classes.

The cabin-class dining saloon, which is on C deck, is in the Louis XIV style, and the central portion extends through two decks. The other public rooms in the cabin-class accommodation are on the promenade deck. The forward portion of this is glass-enclosed, and on each side promenades 352 ft. in length are provided. Right forward is a card room, and aft of this is the forward staircase and entrance, which are followed by a spacious lounge decorated in the late Eighteenth-Century English style. In the centre of the lounge is a resilient parquet floor for dancing, and around the walls, chairs and settees are provided in a series of alcoves. On the port side, a long gallery furnished with settees, writing tables, &c., extends to the smoking room. The after staircase leads from this gallery, and opposite it, on the starboard side, is located the children's playroom and the drawing-room, the latter being decorated in the old Colonial style with a colour scheme of white and green. The smoking room is a reconstruction of a Tudor room in an Elizabethan mansion, with oak linen-fold panelling and heavy adzed beams, and aft of this is a verandah café communicating with the smoking room through a revolving door. In a separate structure at the extreme after end of the promenade deck is a well-equipped gymnasium.

A number of suite rooms are arranged on A deck, each suite having a lobby connecting the various rooms, and other cabin-class accommodation is provided on both A and B decks in the form of single or two-berth cabins. In all cases, lavatory basins with hot and cold running water are provided. Considerations of space prevent us from describing the tourist and third-class public rooms and accommodation, but they appear to be more spacious than is usual, and to have been carefully designed to render them comfortable and attractive in all respects.

The Britannic is propelled by two sets of 10-cylinder double-acting, four-cycle Diesel engines of the Harland-B. and W. type, each set being designed to develop 10,000 shaft horse-power at 102 r.p.m., which would give the vessel a speed of about 17½ knots. A view of the starboard engine, taken from the inboard side, is reproduced in Fig. 2 on page 837, the illustration showing the engine undergoing brake trials in the makers' works. The engines, we believe, are the largest marine Diesel units so far constructed, and the fact that men are standing on the various platforms shown in Fig. 2, will enable an idea of their dimensions to be obtained. Actually the cylinders have a bore of 840 mm. (33 in.), and the piston stroke is 1,600 mm. (63 in.). Following the usual Harland-B. and W. practice, the pistons are oil-cooled and the jackets are cooled with fresh water, the latter being circulated through a heat interchanger cooled by sea water. Injection air is supplied by four independent twin-cylinder compressors, each of which is driven by a four-cylinder trunk-type Diesel engine of 850 b.h.p. These compressors, which also supply air to four reservoirs for manœuvring purposes, are located in an auxiliary engine-room forward of the main engine-room, each compressor being placed in line with an electric generating set, as shown in Fig. 3. The compressor cylinders, it will be noted, were not in place

THE WHITE STAR MOTOR LINER "BRITANNIC."

CONSTRUCTED BY MESSRS. HARLAND AND WOLFF, LIMITED, ENGINEERS AND SHIPBUILDERS, BELFAST.

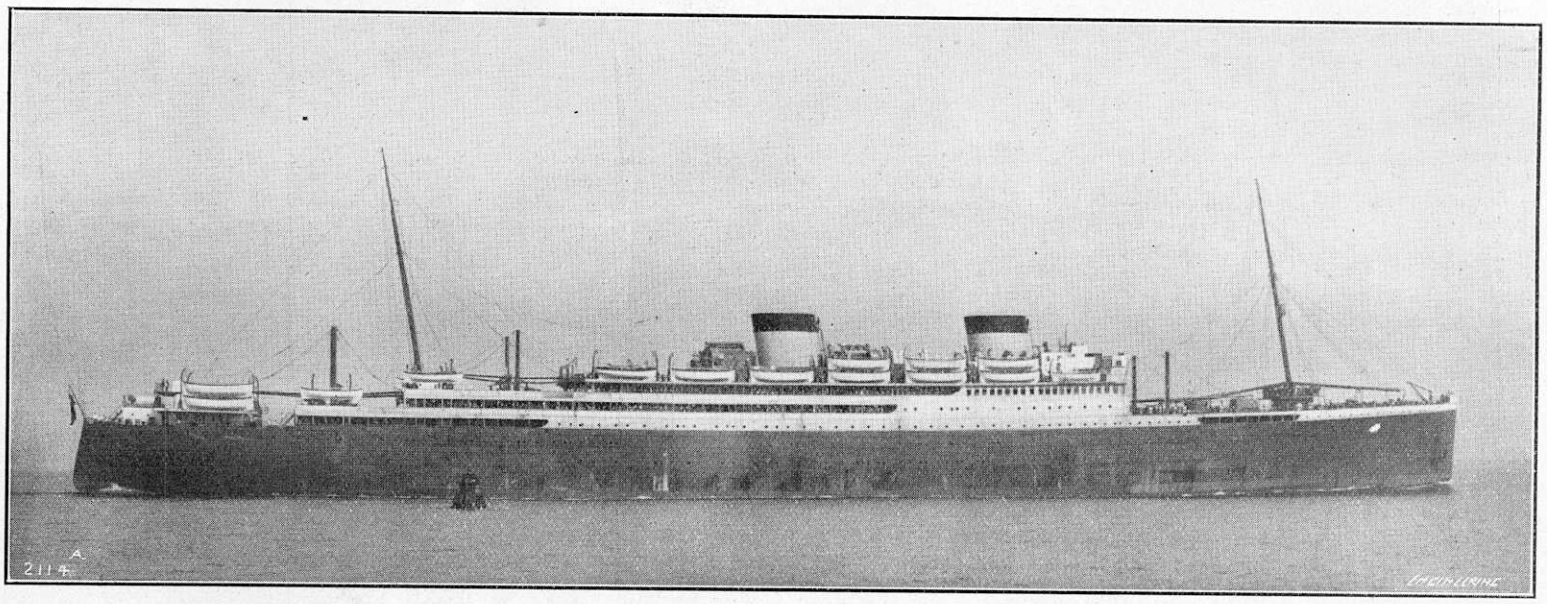


FIG. 1. VESSEL AT SEA.

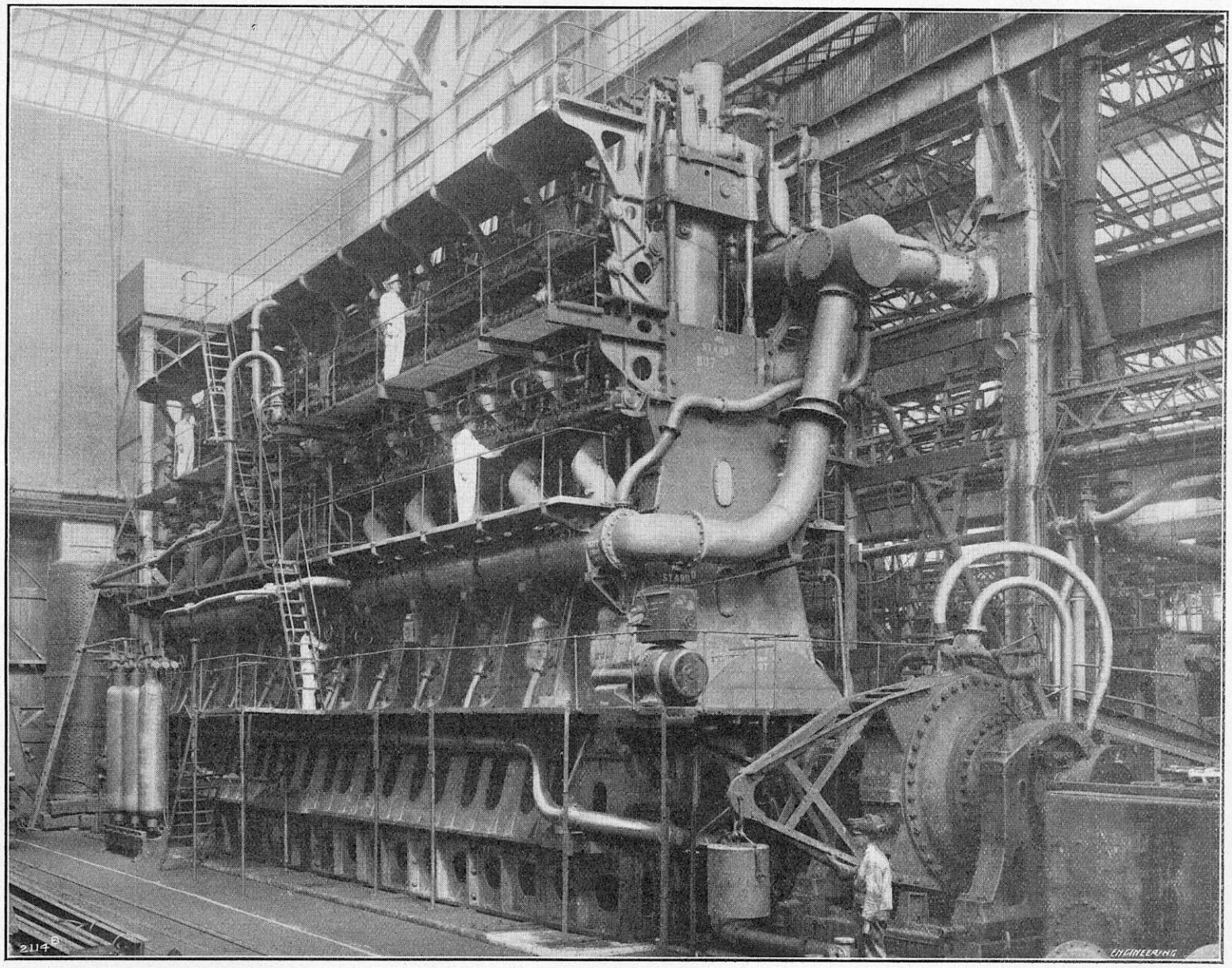


FIG. 2. ONE SET OF MAIN ENGINES.

THE WHITE STAR MOTOR LINER "BRITANNIC."

CONSTRUCTED BY MESSRS. HARLAND AND WOLFF, LIMITED, ENGINEERS AND SHIPBUILDERS, BELFAST.

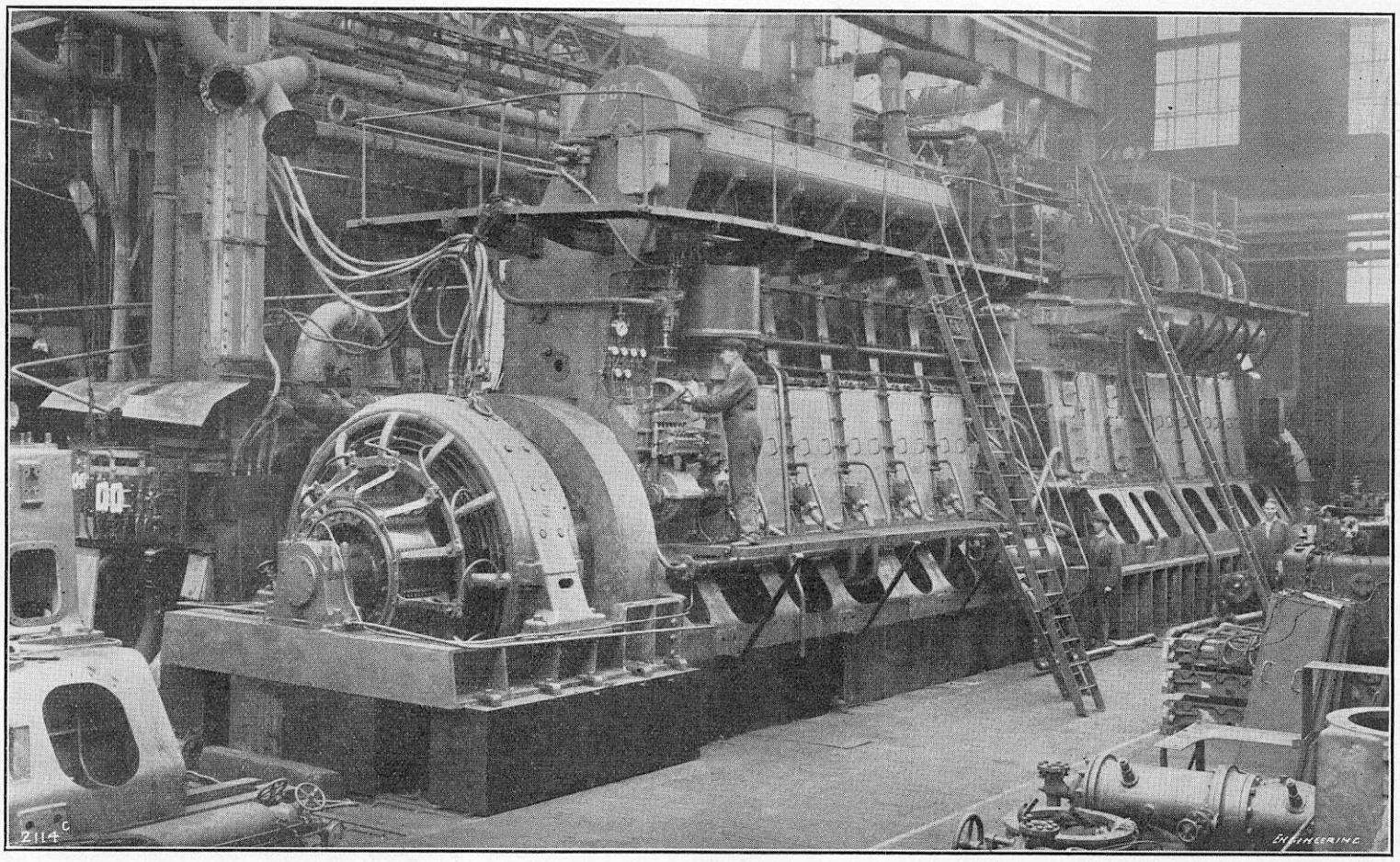


FIG. 3. ELECTRIC-GENERATING AND COMPRESSOR SETS.

when the photograph from which this illustration was prepared was taken. The four electric-generating sets are each of 500-kw. capacity, producing direct current at 220 volts, and are driven by six-cylinder trunk-type Diesel engines, which, like those of the compressors, are of Messrs. Harland and Wolff's construction. A Diesel-engine driven generator of 75-kw. capacity is also provided above the margin line to supply light and power for all essential services in emergency. Four main-engine exhaust-gas fired boilers of the Clarkson type are provided to supply steam for domestic purposes at sea. Another Clarkson boiler, heated by the gases from the generator engines, and two single-ended cylindrical boilers, oil-fired with Todd burners, are available for the same duty either at sea or in port.

The extensive electrical power requirements arise from the fact that the whole of the engine-room auxiliaries and deck machinery are electrically operated, electricity being also used for cooking, heating, and ventilation throughout the ship. Ventilation is provided by 79 electrically driven pressure fans ranging from 10 in. to 55 in. in diameter, about half the number being fitted with steam-heating elements over which the air is passed for warming the vessel. The temperature is automatically controlled by thermostats in the apartments to which the air is supplied. In addition, numerous electrical heaters are distributed throughout the accommodation. The deck machinery includes twelve 3-ton and four 5-ton cargo winches operated by Laurence Scott motors, two warping winches by Messrs. Clarke, Chapman and Company, Limited, and four capstans by Messrs. Napier Brothers, Limited. The steering gear is of the Hastie electro-hydraulic type.

A Hall's CO_2 refrigerating plant is installed for cooling five 'tween-decks spaces. Two horizontal twin compressors direct-coupled to electric motors are provided, together with the usual condensers, evaporators, and brine pumps. The cargo and provision chambers, which are fitted up for the carriage of fruit, fish, meat, &c., are insulated with granulated cork held in position by wood sheathing. An ice-making tank is provided, and there are a number of wine and water coolers operated by independent Frigidaire units to avoid the necessity for running brine pipes through the accommodation. With regard to the navigating appliances, we may mention that the equipment includes a gyro compass, submarine signalling, and wireless direction-finding apparatus. The lifeboats are handled by 20 sets of quadrant-type davits with electric control. In connection with the wireless equipment, it may be of interest to mention that, during the trials, provision was made for constant communication to be maintained between the ship and Messrs. Harland and Wolff's offices in Belfast, by means of wireless telephony, the necessary apparatus having been installed by Messrs. The Marconi International Marine Communication Company, Limited. We understand that the arrangements proved so satisfactory to the builders that they are likely to be employed in future trials.

In conclusion, we may mention that we were present during a trial run of the Britannic in the Irish Sea and North Channel, of about 26 hours' duration, on Sunday and Monday last, during which time the vessel behaved admirably, although the weather conditions did not test her sea-going qualities. There can be no doubt that she will find favour with that large section of the public to whom speed is not a primary consideration. Her owners and builders are to be congratulated on the ship.

LETTERS TO THE EDITOR.

THE DESIGN OF SUBMARINES.

TO THE EDITOR OF ENGINEERING.

SIR,—In reply to Professor O. Flamm's letter, which appeared in your issue of June 13, in connection with an article entitled "Estudio critico del submarino en forma de trebol del Dr. Oswald Flamm," of which I am the author, and which was published in the *Revista General de Marina*, Dr. Flamm appears to have misunderstood the above mentioned "Estudio critico" in view of the fact that I have also extended my calculations to the centre of gravity of the submarine, as may be appreciated on pages 11–18 of the booklet in which this study has been reproduced.

Naturally, the calculations of the centre of gravity which I develop are based upon similar principles as those which are generally followed to demonstrate on a circular shaped submarine that the centre of gravity coincides with the centre of buoyancy. That is to say, none of the strengthening members of the boat nor even the structure of tanks, motors, torpedo tubes, guns, storage batteries, &c., are taken into consideration.

These items can be modified so extensively as to make the centre of gravity move vertically to the desired position in each particular case, but that result does not modify the starting conditions of coincidence of the centre of gravity with the centre of buoyancy on a submerged condition of the submarine.

I very much appreciate Professor O. Flamm's kind offer to give me details should I be interested in his designs, and I would only be too glad to receive any such information which he could send me to my address as below. For his complete information, I am sending him direct a copy of the pamphlet which was published in the *Revista General de Marina*.

Yours faithfully,
CARLOS PREYSLER.

Sociedad Española de Construccion Naval,
Sagasta 25, Madrid, Spain.
June 23, 1930.

THE SUPERCHARGING AND COMPOUNDING OF AERO-ENGINES.

TO THE EDITOR OF ENGINEERING.

SIR,—In the course of an article on "The Super-Charging and Compounding of Aero-Engines," in your issue of the 6th inst., I note the statement that "it is admitted, however, that the application of the sleeve valve to air-cooled engines is likely to be impeded by difficulties in connection with the cooling of the cylinder head."

It may interest your readers to know that there is a 4-cylinder sleeve valve air-cooled engine in existence, in which no difficulty whatever is experienced in keeping the cylinder head, and all other parts of the engine at satisfactory working temperatures.

The system, in which, by the way, I have no financial interest, is known to me as the Morgan-Jones. I mention it only because in your article some doubt is thrown on the possibility of a successful solution.

Yours faithfully,
G. W. WATSON.

50, Pall Mall, London, S.W.1. June 19, 1930.

THE SELECTION AND OPERATION OF PUMPING MACHINERY FOR WATERWORKS.*

By F. E. F. DURHAM, M.I.Mech.E.

(*Concluded from page* 811.)

HAVING from the consideration of factors such as the foregoing decided on the nature of the machinery to be installed, or, should circumstances permit, having allowed manufacturers to tender for the types they can most economically supply, the drafting of the specification will probably be the next consideration. In the closed type of specification, where accompanied by general arrangement drawings, the main features and some details are closely specified, and the minimum dimensions and qualities of the materials of the principal parts stated, as is in general the practice of the Board in the case of reciprocating steam engines, induce close comparative tendering, but makers of steam turbines and oil engines have not been required to depart from their standard productions. Blanks in the specification for tenders to be filled with the dimensions of the principal parts have been provided, and attempts made to bring the various offers on to a comparative basis on receipt of the tenders.

The normal design of the standard triple-expansion pumping engine with the crankshafts strong enough to take for a short period, but in the event of a burst main, the full power capable of being developed by the steam in the cylinders, although normally working at 20 per cent. cut-off, permits high overloads and any normal Triple will, in an emergency, develop up to 50 per cent. overload, made up of 25 per cent. overload per revolution and 25 per cent. increase of speed. With oil engines and steam turbines, however, in view of the use of standard designs and the general practice of manufacturers in competitive tendering to allow 10 per cent. overload capacity, the purchaser should not expect to get more than he has definitely asked for. For waterworks purposes, therefore, it is desirable, having regard to the severe nature of pumping operations compared with electrical working, and the advantage at some future date of being able to pump to a higher head than that originally contemplated, to specify for, and actually to run, machinery of this class for a considerable period at 33 per cent. overload.

In 1922, the pumping machinery at Littleton for supplying the Queen Mary reservoir was under consideration. The estimated usage factor was only 25 per cent., the pumping capacity having to be sufficient to take advantage of periods when the flow of the Thames was both quantitatively and qualitatively suitable, and, delivering to a reservoir of 6,750 million gallons capacity, continuous operation was not absolutely necessary. With the object of securing the lowest overall charges and enabling tenders for Humphrey gas pumps to be made, while securing competition in other directions, an open-type specification was issued with satisfactory results, keen tenders being received from British, Dutch, Swiss and Italian firms.

TABLE I.—*Littleton Pumping Machinery*, 1924.

4 units, 2,330 P.H.P. Total capacity, 300 million gallons per day against 37 ft. head. Estimated average quantity, 75 million gallons per 24 hours. Original estimated total costs from the basic data provided in the specification.

Type.	Lowest Machinery Tender.	Guarantee lb. fuel per p.h.p. per hour.	Total Estimated Costs Capital and Working inclusive of Buildings.	
			Per annum.	Per million gallons 1 foot high.
	£		£	*d.*
Uniflow ..	56,865	1.90	27,200	6.32
Diesel (trunk) ..	79,650	0.53	27,600	6.40
Semi-Diesel ..	75,784	0.55	27,700	6.42
Turbine ..	69,300	1.64	28,200	6.55
Humphrey pump	89,500	1·00	28,500	6·62

With the fall in prices since 1924, the estimated cost would be 6,000*l.* per annum less, and the cost per million gallons 1 foot high, about 1·4*d.* less. Average estimated continuous pump horse-power—590. Estimated usage factor 25 per cent.

TABLE II.—DISTRIBUTION OF 26*s.* 2*d.* RECEIVED FOR PUMPING ONE MILLION GALLONS ONE HUNDRED FEET HIGH. (BASED ON WALTON PUMPING STATION.)

No. 1. Triple-expansion engine and pumps with turbine standby.
No. 2. Two turbines with centrifugal pumps, one as standby.
Designed horsepower—2 of 800. Actual continuous horse-power—700.*
Head—138 ft. Million gallons per 24 hours—24.
Usage factor 44 per cent.

			Item.	No. 1.	No. 2.
				s. *d.*	*s.* *d.*
Capital charges	No. 1—10/8	First unit	1	3 11	1 1
		Turbine standby	2	0 11	1 1
	No. 2—7/2	Boilers	3	1 8	1 10
		Buildings, including roads, &c.	4	4 2	3 2
		Wages	5	7 3	7 3
		Stores	6	0 4	0 4
		Repairs	7	1 8	1 8
Coal No. 1. 6/3	Lost No. 1. 1/6	Lost in: grate, unconsumed coal	8	0 1	0 2
		heating products of combustion	9	0 6	0 9
		heating excess air	10	0 4	0 7
	No. 2. 2/4	burning hydrogen to steam	11	0 3	0 4
		Lost by: Boiler radiation	12	0 4	0 6
No. 2. 9/9	Used. No. 1. 4/9	Usefully employed in heating feed economiser No. 1, 3*d.*, No. 2, 4*d.*	13	—	—
		Usefully employed superheating steam No. 1, 4*d.*, No. 2, 7*d.*	14	—	—
	No. 2. 7/5	Usefully employed generating steam No. 1 4/2, No. 2 6/6	15	—	—
Steam Received from Boilers	No. 1. 4/9	Lost to condenser and by radiation	16	3 6	5 11
	No. 2. 7/5	Lost in mechanical and hydraulic friction	17	0 1	0 4
		Useful expenditure, *i.e.*, energy transferred to water pumped	18	1 2	1 2
				26 2	26 2

Total cost inclusive of capital:—
= 3·14 pence per million gallons 1 foot.
= 0·63 pence per pump horse-power per hour.

* At this pump horse-power the total costs are the same for both units, above this power the reciprocating engine costs would be the lower.

TABLE IV.—*Relative Efficiencies (Hand Firing) Including Economiser.*

	Efficiency.
	Per cent.
14 to 15 per cent. volatile Admiralty Welsh large ..	70
Under 14 and over 15 per cent. volatile Admiralty Welsh large	69
14 to 15 per cent. volatile Admiralty Welsh nuts ..	69
Under 14 and over 15 per cent. volatile Admiralty Welsh nuts	68
Under 16 per cent. volatile large and nuts	68
,, ,, ,, through	64
,, ,, ,, small	61
16 to 29 per cent. volatile large and nuts	68
,, ,, ,, through	67
,, ,, ,, small	64
30 to 35 per cent. ,, large and nuts	67
,, ,, ,, through	65
,, ,, ,, small	62
36 to 40 per cent. ,, large and nuts	64
,, ,, ,, through	62
,, ,, ,, small	60
41 to 45 per cent. ,, large and nuts	62
,, ,, ,, through	60
,, ,, ,, small	58
46 per cent. and over ,, large and nuts	60
,, ,, ,, through	58
,, ,, ,, small	56
Coke large	67
Patent fuel	63

The most advantageous offers of each type received are set out in Table I. The lowest tender, both in actual price, and in estimated yearly cost (calculated according to the data provided in the specification), that of Messrs. Worthington-Simpson, Limited, was accepted. The machinery has not yet been long in continuous full operation, but actual results so far obtained are given in Tables VII and VIII.

In both classes of specification it is necessary to state the amount of liquidated damages to be retained should the guaranteed steam or fuel consumption be exceeded. Better guarantees are obtained when the tenderer is allowed to fix the steam or fuel consumption, and the damage figure stated by the purchaser in his specification is not oppressively high. If tenders are being invited for one unit only, which is to be in continuous operation, the damage figure, if of sufficient amount to yield the income required to pay the whole of the annual loss due to any excess steam or fuel consumption, is likely to be such as to intimidate tenderers and prevent them guaranteeing as good a figure as they would otherwise have done. On the trial they may get the better figure, but the important part played by the consumption guarantees in awarding the contract is likely to be based on very indefinite data, if tenderers are not guaranteeing within several points of what they expect. As an illustration, the "damage" figure on a 1,500-p.h.p. steam turbine and pump to work continuously and costing 15,000*l.*, should be about 1,000*l.* for every tenth of a pound of steam per pump horse-power, and would amount to the whole cost of the contract if the guarantee were exceeded by a pound and a half. If, however, a spare unit is quoted for at the same time, the "damage" figure would properly be reduced by one-half. Should the figure specified be lower than the correct one, it is necessary when considering tenders to consider the guarantees; firstly, as if the accepted tendered should fail to obtain the required figure, in which case the specified "damages" would be deducted from the amount of the contract, and secondly, as if he obtained it, when the capitalised value of his guarantee must be compared with the other tenders.

As considerable sums may be in dispute as a result of a misapprehension of the exact meaning of the clauses in the specification dealing with this matter, it is most desirable to avoid the slightest ambiguity. Up till the present, the Board's practice has been to require the economy of steam turbines and reciprocating engines to be guaranteed in terms of the pounds of steam per pump horse-power per hour, and of boilers when mechanically fired, on the overall efficiency of the boiler, grate, superheater and economiser, &c., when fired with bituminous nuts having a gross calorific value of not less than 12,000 B.Th.U. per lb. For hand-fired Lancashire boilers, as neither the stoker nor the coal is supplied permanently by the contract, and as these provide variables many times greater than can be made by any variation in the design of the boiler, in this instance the dimensions and details would be specified and no guarantee required.

For oil engines, the guarantee asked for is the total gross heat supplied to the engine per pump horse-power per hour, with oil having a gross calorific value of not less than 18,500 B.Th.U. per lb., and in addition a statement of the lubricating oil used per 1,000 hours is required. The preceding guarantees are on the gross calorific value of the fuel, and it is important to make this point clear, as it is not uncommon for tenders to be made on the net calorific value, a difference of some 3 per cent. to 4 per cent., owing to the hydrogen in the fuel, when determining its calorific value in the calorimeter, being reduced to water instead of passing away as steam in either the chimney or engine exhaust gases. In each case the permissible variations on the trial in the quantity, head, steam pressure and superheat, &c., and its duration should be stated. For oil engines, steam engines and turbines with guaranteed oil or steam consumptions, any period over five hours is sufficient, depending on the method of arriving at the quantity pumped. For boiler guarantees, 12 hours should be the minimum for consumptions over 20 lb. of coal per square foot of grate surface per hour, and 24 hours for consumptions much below that rate. The possibilities of error are much lessened if the result of the observations are worked out and tabulated each hour; any discrepancies can then be immediately detected and an estimate formed of the probable percentage accuracy of the results obtained. With a competent team, consistent results can be obtained hour by hour, and the question of whether the guarantee has been obtained or not can be practically settled within half an hour of the end of the trial. It is most inconvenient to have to wade through a sea of figures days after a trial to account for some apparent discrepancy, or more serious still, to have to repeat the whole trial, particularly in cases where coal-consumption guarantees are made, or where the measurement of the water pumped presents difficulties necessitating a prolonged trial to enable the requisite amount of accuracy to be secured. In important and detailed trials the number of individual readings may be very large, and on the 24-hour trials, on each of the four engines and boilers at Littleton, the number exceeded 33,000. Table VII gives the principal results of trials on modern plant carried out by the Board's staff.

* Paper read before the Institution of Water Engineers, on Wednesday, May 28, 1930. Abridged.

PUMPING MACHINERY FOR WATERWORKS.

TABLE VII.—EFFICIENCY TRIALS OF RECENTLY INSTALLED MACHINERY.

Station.	Date of Trial.	Type of Engine and Pump.	Engine Sizes.	Steam Pressure lb. per sq. in. / Superheat deg. F.	Vacuum in. Hg.	Total Head, ft.	Quantity Pumped m.g./per 24 hours.	Slip as Measured by Venturi.	Pump Horse-Power.	Overall Mechanical Efficiency Per cent.	Hydraulic Efficiency Per cent.	Speed R.P.M.	Engine Steam per p.h.p. lb. incl. of Jackets, &c.	Fuel per P.H.P. lb.	Calorific Value of Fuel B.Th.U's. per lb.	Engine Thermal Efficiency p.h.p. Basis, Per cent.	Overall Thermal Efficiency Coal to Water. Per cent.
Hampton	1922	Diesel engines and centrifugal pumps ..	4 cylinders 18 in. × 2½ ft. stroke	—	—	281	4·79	—	284	59·5	—	175·8	—	0·547	19,000	24·5	24·5
Hampton	1926	Trial on same two engines 4 years later ..	—	—	—	271	4·75	—	271	57·5	—	175·5	—	0·558	19,000	24·0	24
Eynsford	1926	Solid injection oil engines, well and surface pumps	4 cylinders 14 in. × 1⅞ ft.	—	—	479·2	0·98	—	99	—	—	201	—	0·537	19,138	24·75	24·75
West Wickham	1923	Vertical triple reciprocating and well pumps	16 in.–28 in.–46 in. × 3½ ft.	165/50	28·5	359	2·37	—	181	90	—	25·3	12·91	1·77	14,400	16·8	10
Lea Bridge	1925	Vertical triple reciprocating pumps ..	24 in.–44 in.–66 in. × 4 ft.	181/124	27·7	190	13·2	—	530	93·6	—	28·8	10·6	1·3	15,006	20·0	13
Walton No. 6	1927	Vertical triple reciprocating pumps ..	25 in.–47 in.–70 in. × 5 ft.	202/100	28·1	237	16·16	2·23	805	94·7	98	28·1	10·38	1·2	13,350	20·5	15·8
Kempton†	1930	Vertical triple reciprocating pumps ..	29 in.–54 in.–86 in. × 5½ ft.	199/91	28·3	220	16·42	2·91	762	97·4	—	21·9	9·89	1·25	12,342	21·6	16·5
Walton No. 5	1927	Steam turbine and centrifugal pumps ..	—	201/133	29·3	243	17·65	—	902	—	—	3432	14·54	2·1	12,152	14·0	10·06
Surbiton	1926	Steam turbine and centrifugal pumps ..	—	190/133	29·4	178	20·04	—	750	—	—	6020	13·24	—	—	15·4	—
Littleton	1926	Horizontal Uniflow engines and centrifugal pumps	28 in. × 3½ ft.	190/160	28·9	38·1	77·68	—	630	73·5	81·6*	127·6	14·21	2·14	10,662	14·4	11·15

* Based on Engine efficiency of 90 per cent. † Preliminary test.

TABLE VIII.—COMPARATIVE COSTS.

Station.	Type.	Period.	Per cent. Factor. Load.	Per cent. Factor. Usage.	P.H.P. Designed.	P.H.P. Continuous.	P.H.P. Per Unit while at Work.	Cost per Ton.	Actual Fuel per P.H.P. Hour.	Overall Thermal Efficiency.	1,000 B.Th.U. per P.H.P. Hour.	Per Million Gallons pumped 1 Foot. Fuel.	Wages.	Stores.	Repairs.	Total.	Capital.	Total incl. Capital.	Total per B.H.P. Hour.
								lb.	Per cent.			*d.*	*d.*	*d.*	*d.*	*d.*	*d.*	*d.*	*d.*
Cricklewood ..	Diesels driving	Month	76	52	3 × 105	164	80	—	0·54	24·8	10·2	1·21	1·06	0·23	0·75	3·25	0·91	4·16	0·83
	Reciprocating pumps ..	Year	77	39	= 315	121	81	82/6	0·56	24·0	10·6	1·23	1·66	0·40	0·90	4·19	1·25	5·44	1·09
Walton (5) ..	Turbine driving centrifugal pumps	Trial	113	113	800	902	902	—	2·08	10·1	25·3	1·10	0·68	0·04	0·16	1·98	0·66	2·64	0·53
		Month	86	86	—	689	689	19/6	2·23	9·1	28·1	1·18	0·89	0·05	0·21	2·34	0·86	3·20	0·64
Walton (6) ..	Triple reciprocating ..	Trial	100	100	800	805	805	—	1·20	15·8	16·1	0·64	0·61	0·04	0·18	1·47	1·06	2·53	0·51
		Month	83	83	—	663	663	20/7	1·45	13·5	18·8	0·81	0·74	0·05	0·22	1·82	1·28	3·10	0·62
Walton (5 and 6 combined)	Triple with turbine as standby	Year	63	32	2 × 800 = 1,600	603	603	19/11	1·77	11·5	22·1	0·95	0·90	0·10	0·25	2·20	1·97	4·17	0·83
Littleton ..	Uniflows driving centrifugal pumps	Trial	108	27	4 × 583	631	631	—	2·14	11·2	22·8	1·26	0·61	0·04	0·13	2·04	1·68	3·72	0·74
		Month	93	14	= 2,332	323	540	22/7	2·38	8·3	30·7	1·40	1·19	0·08	0·26	2·93	3·30	6·23	1·25
Kempton Park ..	Triple reciprocating ..	Preliminary test only	97	97	2 × 1,008 = 2,016	1,950	975	20/4	1·26	16·2	15·7	0·70	0·33	0·05	0·23	1·31	1·16	2·47	0·49
Surbiton ..	Turbine driving centrifugal pumps	Estimated on guarantees received	—	48	4,900	2,333	—	20/–	1·7	11·5	22·1	0·91	0·92	0·14	0·26	2·23	0·88	3·11	0·62

The perfect specification is yet unwritten, but, in addition to the statement of the duties the machinery has to perform, and such details of design and construction as the knowledge of the writer of the specification permits, a very useful purpose is served by describing what may be called the indefinite portion of his requirements. For example, differences of opinion may arise on whether a staircase is to be 18 in. wide and inclined at an angle of 60 deg., or 2 ft. 6 in. wide at 45 deg., or even included at all, while the head-room required, width of passage-ways, points of termination of piping, &c., and such-like items permitting of considerable divergency of opinion, will, if stated at the outset, place contractors on a more equal footing and assist in the contract being amicably carried out. With this in view it has been the Board's practice for some years to supplement their specifications with general arrangement drawings indicating with some precision the layout of the plant and, in the case of reciprocating steam engines, embodying any special details required, reproductions, &c.

Consistent efficiency at largely varying heads is obtained in the case of the steam turbine-driven centrifugal pumps by having these arranged to work either in series or in parallel, while, in common with the Kempton Park engines referred to later, the reciprocating pumps are provided with compound plungers.* This device, peculiar to the Board, maintains the horse-power per revolution at approximately the same figure and gives a very flat steam consumption curve for heads carrying as much as 100 per cent., and should such an arrangement at any time be thought to be of use, there is no reason why it should not be adopted.

Apart from the requirements of smooth and continuous operation, to obtain high efficiency with the reciprocating engine first-class workmanship is a vital factor. Instances of marked differences in the efficiency of two supposedly identical engines have arisen from so simple a cause as steam and exhaust valve leakage, extremely difficult of estimation under the working conditions. The main principles in regard to economic design are fairly simple. They are high steam pressure, a low-pressure cylinder large enough to permit of expansion to a terminal pressure of about 6 lb. absolute, 28 in. vacuum, cylinder clearance volumes not exceeding 2 per cent., pump passages as direct as possible, and a speed through the pump valves approaching 2 ft. per second.

Amongst the relatively serious failures of the Board's units that have occurred during the past ten years, with the exception of a 14-in. diameter crankshaft that had worked continuously for over forty years and whose failure was attributed to an original flaw in the centre of the shaft, most trouble has been caused by the failure of fairly old pump-valve chambers of more or less accepted design, particularly those subject to loads varying from zero to a maximum, such as suction-valve chambers, the fracture extending from the flange of a delivery or manhole branch through the body and flange of the valve chamber; and it has been found desirable in several cases to increase the length of the body where possible and strengthen the flanges and body of the casting between the branch and the flanges of the main casting. A second trouble has been the failure of the ribs supporting the valve plate, and it is now the Board's practice to have separate castings for these, and of cast steel where the pumping head and diameter of the casting make it desirable.

Table II sets out the comparative distribution of expenditure based on Walton Pumping Station of

* See ENGINEERING, vol. cxxii, page 40 (1926).

(1) a reciprocating engine with a steam turbine and centrifugal pump stand-by and (2) a turbine and centrifugal pump with a similar unit in reserve. Under the conditions stated with coal at 19*s.* 6*d.* a ton of 12,700 B.Th.U. per pound, the cost inclusive of capital charges for each combination is the same per million gallons pumped 100 ft. high; an increase in either the cost of coal or the usage factor would be in favour of the reciprocating unit; conversely, a fall would favour the steam turbines. On similar lines, the capital cost of a gravitation supply derived from an upland storage reservoir, excluding distribution mains, filtration and local storage charges in each case, must, to compete financially, not exceed 254,000*l.* for 24,000,000 gallons daily supply delivered at 138 ft. head. Thus :—

	Per million gallons 100 ft. high. s.	d.
Capital charges on 254,000*l.* at 5 per cent. repayment in 100 years...	21	2
Wages, &c.	5	0
	26	2

Similarly, for electrically operated pumps the charge for current should not exceed 3*l.* per kilowatt for a maximum demand of 1,400 kw., plus 0·34*d.* per unit.

	Per million gallons 100 ft. high. s.	d.
Equivalent to 0·51*d.* per unit (750 kw.)	21	3
Capital charges	1	6
Wages, repairs, stores, &c.	3	5
	26	2

On an examination of the Table it will be seen that, by a coincidence, decreasing the capital charges 3*s.* 6*d.* increases the cost of coal a similar amount. Item 5.—The wages are, in fact, the same for the reciprocating and turbine sets, but for turbines alone the staff would be one man per shift less. Item 7.—Repairs costs are at present simply a percentage allocation of the whole of the station repairs and emergency staff, and include ordinary overhauls of boilers, &c. Sufficient actual repairs have not yet been made to arrive at comparative cost figures. Items 9 and 10.—Good stoking, 10·6 CO_2, no CO, only slight improvement possible. Item 11.—Cannot be avoided. Item 12.—Largely an estimate. Item 13.—Not good, but could only be improved by further expenditure. Items 16, 17, 18.—Steam received from boilers. Coal being at the lowest price for some years, the comparison favours the turbine and about balances the somewhat unfair allocation of wages. Item 16.—The principal loss, inherent in all steam units, and could only be slightly improved at probably unremunerative cost by a better vacuum and larger low-pressure cylinders for reciprocating unit and by higher vacuum and further improvements in design with higher pressure and superheat for turbines. Item 17.—Cannot be bettered for reciprocating units, but is being improved for centrifugal pumps. It should be noted that, although the actual heat value of the friction loss is very small—1*d.* and 4*d.* respectively—after allowing for its proportion of capital, wages, and engine and boiler-house losses, it has cost 7*d.* and 2*s.* 6*d.* respectively, in the same way as the 1*s.* 2*d.* value of useful work cost 26*s.* 2*d.* Item 18.—The amount usefully expended, *i.e.*, if we regard the whole expenditure as paid for in heat units contained in coal at 19*s.* 6*d.* per ton of 12,700 B.Th.U. per pound, then the energy equivalent to 1*s.* 2*d.* worth of heat is transferred to the water pumped.

The economical buying of suitable coal is probably the most important single factor affecting the financial economy of a pumping station. Purchasers at liberty to do so may find dealing with selected firms, and consulting them as to the coal most suitable for their requirements, a satisfactory method, the desire on the part of the contractor to retain a remunerative customer being sufficient to place his experience and resources fully at the purchaser's disposal. Such procedure by public authorities is rarely possible, and purchase by public tender is the general rule. Where pumping stations are near to a particular coalfield the varieties of coal economically available would, owing to the cost of carriage from more distant coalfields, be so small in number as to permit of more or less continuous trial being made of all those competing.

The situation of London, however, almost equidistant from coalfields producing coals varying considerably in their characteristics, offers so wide a choice that if purchases were confined to the comparatively few varieties that could within a reasonably limited period be tested in the boilers under actual working conditions, the selection would be unnecessarily restricted. The buying of specific coals on their name value alone is not always satisfactory, the reported evaporative value of the same coal from different stations of the Board at the same time, and from the same station at different times, having varied as much as 20 per cent. To obviate this difficulty, and to ensure that the quality contracted for is maintained, the Board has, since 1911, with the exception of a short interval during the war, bought approximately 180,000 tons per annum on a calorific basis, the price varying with the calorific value of the fuel supplied.

Apart, however, from the above-mentioned reasons, the conditions under which the Board's works are operated are such that in order to make reasonable comparisons of their efficiency it would be necessary to carry out the laboratory work, and determine the calorific value of the coal, even if it were not purchased on such a basis. The difficulty and expense of accurately sampling small consignments of coal would probably render the system unremunerative to the majority of water undertakings, but the author would strongly recommend the calorific determination of at least monthly samples of the coal deliveries, for the purposes of comparison and throwing light on any variations in the efficiency of the plant.

Comparisons of coals of different classes and size, however, cannot properly be made on a calorific basis alone; for example, 1,000 B.Th.U. contained in a Welsh nut coal are of more value than in a Welsh small owing to the greater ease of obtaining more efficient combustion (higher CO_2 and less loss of ash through the grate, &c.). The B.Th.U. guaranteed per pound of coal, therefore, should be corrected by the expected efficiency of the coal, *i.e.*, the percentage of heat expected to be usefully employed. These expected efficiencies vary from 70 per cent. to 56 per cent. for hand firing under the normal conditions of working of the Board's boilers, and have been determined from the results of 300 actual boiler trials on 150 different named coals. They are set out in Table IV.

Generally the coals submitted can be compared on the basis outlined, but occasionally they are either too low in volatile to burn sufficiently freely with the draught available, or are too high in volatile to burn without objectionable smoke under the conditions prevailing at some stations. A few are entirely unsatisfactory by reason of the low fusing temperature of the ash. The basis of comparison, the estimated cost of evaporating 1,000 gallons of water from and at 212 deg. F., is calculated on the laboratory slide rule, 11 ft. long. The name of each coal is written on a celluloid tablet and dropped into a slot in its correct position on the slide rule. It may be of general interest, as illustrating the extraordinary differences in coal values, to note that the following maxima and minima in the calorific value and constituents of coals delivered to the Board have been recorded :—

	Maxima.	Minima.
B.Th.U.'s	15,400	5,050
Ash	49 per cent.	1 per cent.
Moisture	21 ,,	1 ,,
Volatile	56 ,,	3 ,,

While discussing the quality and calorific value of coal supplies, it may be worth noting that, from tests made at one of the Board's pumping stations some years since the depreciation in calorific value of coal in store appeared to be chiefly during the first two or three months, and amounted to from 2 to 3 per cent. In addition, there was a loss in furnace efficiency through increased friability by weathering, but no apparent heating took place in any class of coal in stacks under 7 ft. 6 in. in height. From the economic viewpoint it would appear desirable to defer replacing reserve stock, in the absence of actual heating or serious deterioration in size, for as long a period as reasonably possible, and the majority of coals stored in low piles should be safe to store for two or three years at least.

Stores.—The Board purchase their stores by a stores department, under the control of the chief engineer, strictly competitive prices being obtained, and revision of the lists of contractors, eliminating those who do not quote with keenness. Of the cotton waste, 75 per cent. is reissued after passing through a cleaning plant, and lubricating oil is reclaimed and sold. It is difficult with prices varying as they have done of late to make an estimate, but it would appear that during the past few years the cost of stores has, after correction for the probable variation in price, fallen about 8 per cent. per million gallons pumped 1 ft. high.

As previously stated, the pumping stations inherited by the Board, containing with recent additions nearly 300 engines of an average age of 40 years, totalling 50,000 h.p., with an average continuous output of approximately 15,000 p.h.p., and an average pump horse-power per unit while at work of but 135 and usage factor 31 per cent., resemble in this respect rather a conglomeration of small waterworks than what might be expected in a town of London's magnitude, and the economic results cannot be expected to compare favourably with those obtained where it has been found possible to concentrate the whole of the pumping equipment for a large city in one or two stations. Since the war, however, as a result of the active policy pursued by the Board and its Chief Engineer, new machinery, wherever the condition of the plant demands or is economically possible, is rapidly being installed, and contracts for over 16,000 p.h.p. in units of high efficiency have either been completed or entered into since 1922, particulars of the economic results of some of which are set out in Tables VII and VIII.

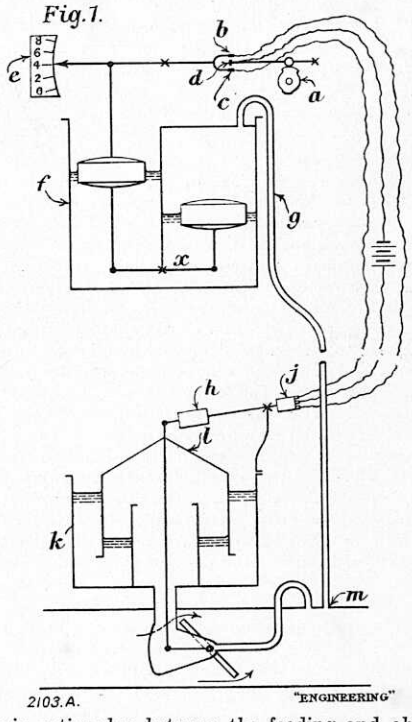
Despite many drawbacks incidental to isolated pumping stations, the author feels that the average coal consumption throughout the Board's works in the last financial year of 3·19 lb. per p.h.p. per hour inclusive of jackets of standing engines, banking boilers and all other losses, compares not unfavourably with the consumption of coal per unit generated in the electricity stations of the United Kingdom, ranging in the year ending March, 1929, from 1·73 lb. for stations of over 30,000 h.p. average continuous output to 11·7 lb. for stations of 30 h.p. average output. The corresponding average figure in the Board's stations for the years 1919–1922 was 3·54, the improvement since then of 10 per cent. being partly due to higher calorific value and partly to the superior economy of three new engines. Continuous records are kept of the operation of the machinery.

In conclusion, the author would like to place on record his thanks to Mr. H. E. Stilgoe, Chief Engineer, for permission to include the tables and figures given, and also to the staff of his section for assistance in their preparation. These may be found useful on occasion, but their accuracy could be improved so as to render them extremely valuable if other members would supply any available similar information.

AUTOMATIC GAS-PRESSURE CONTROLLER.

In many towns the mains used for gas distribution are so small as to render the maintenance of a uniform pressure at the more remote parts of the network difficult. This disadvantage can, of course, be overcome by laying new and larger mains or, more economically, by supplying gas at high pressure to strategic points. When the latter course is adopted, it is obvious that the maintenance of the correct feeding pressure is important, and this can be effected by selecting places on the outer edge of the network and controlling the pressure at the feeding points, so that the pressure at those places remains constant. This procedure, however, has the disadvantages that

Fig. 1.



there is a time-lag between the feeding and observation positions, and that some electrical connection between the two is necessary. Moreover, it has been found that the correct value of the pressure in the network is ensured if a given known value is maintained at the feeding point. This latter pressure is determined by experience and, we understand, is the same for the same hour of the same day each year, while it does not vary for several weeks at a time, even during the summer and winter solstices, or when sudden changes, such as storms or fog, occur in the meteorological conditions. The only exception to this rule is that the pressure variations on Sundays are not the same as those on week days.

Working on these lines, Mr. J. L. Hodgson has designed a governor, which has been introduced

AUTOMATIC GAS PRESSURE CONTROLLER.

CONSTRUCTED BY MESSRS. GEORGE KENT AND COMPANY, LIMITED, ENGINEERS, LUTON.

Fig. 2.

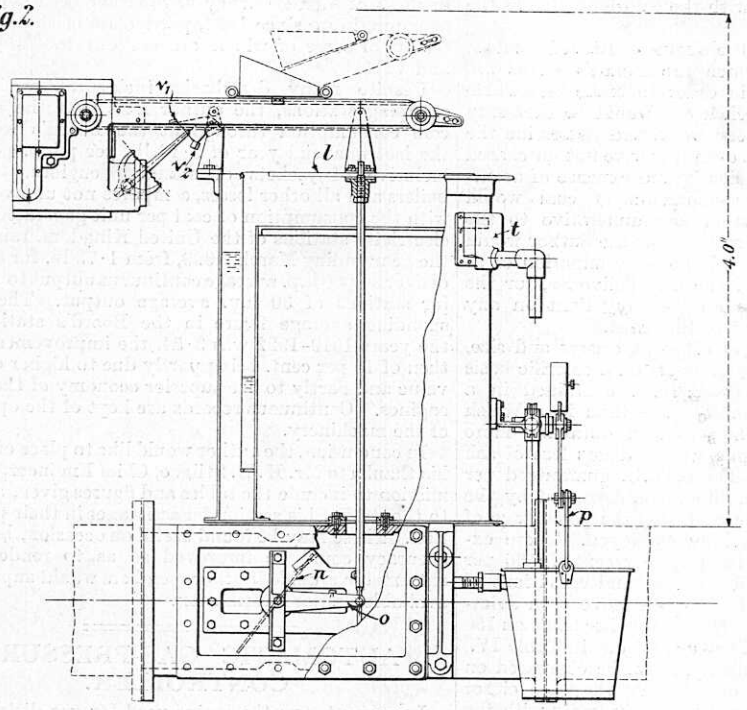


Fig. 3.

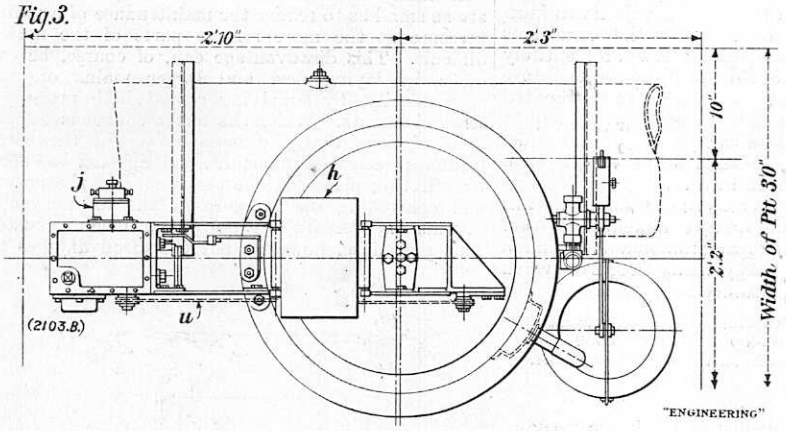
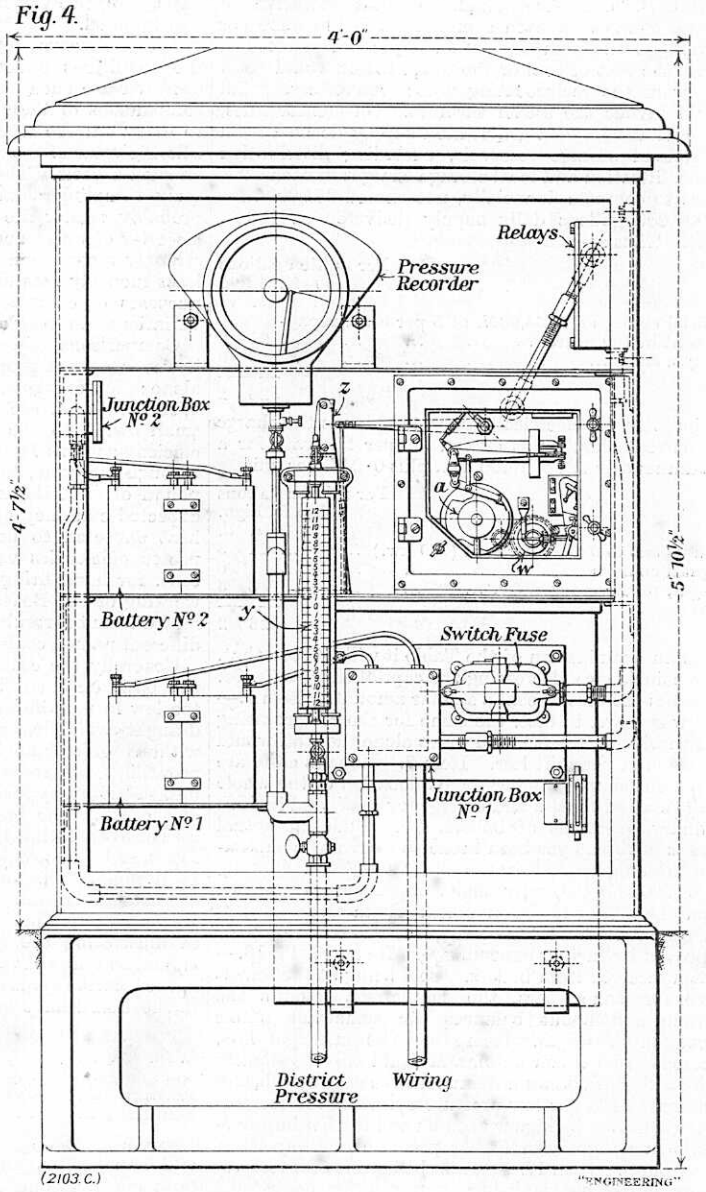


Fig. 4.



by Messrs. George Kent, Limited, of Luton, the object of which is to vary the feeding pressure in accordance with a pre-determined time schedule. The governor is shown diagrammatically in Fig. 1. It consists of a pressure regulator and control pillar. In the latter is a cam *a*, shaped according to the pressure required, and rotated by clockwork once every twenty-four hours. The cam operates a contact arm, the outer end *d* of which floats between two contacts *b* and *c*, making contact with one or other of them if the pressure indicated by the cam is not the same as that which actually exists at the bottom outlet of the pressure regulator *k*. When such a difference in pressure occurs, the motor *j* is started and the weight *h* is moved either to the right or to the left along the beam by which it is carried, thus loading the regulator bell *l* to the pressure indicated by the cam. The governor also comprises a water U-tube *f* containing two floats, which are arranged so that they compensate for any change in water level over a range of about 2 in. This is effected by connecting one of the floats to the rod carrying the contacts *b* and *c*, thus altering the position of the latter relative to the contacts. The tube *f* is also connected by a pipe *g* to the feeding point *m*, so that the supply pressure is indicated on the scale *e* by a pointer on the other end of the contact rod.

The pressure regulator, which is arranged for mounting in a pit in the roadway, is shown in detail in Figs. 2 and 3, and a photograph of it is reproduced in Fig. 5, on the opposite page. Referring to Fig. 2, it will be seen that it consists of a butterfly valve *n*, the spindle of which carries the crank arm *o*. This arm is connected to a vertical rod, which, in turn, is screwed into the cover of the water-sealed bell *l*. The underside of this bell is connected to the supply main, so that it is exposed to the outlet pressure. When the upward thrust on the bell due to this pressure exceeds the loading as determined by the weight *h* in Fig. 3, the former rises and closes the admission valve, so that the pressure is maintained at the required value. The controller is provided with a safety device. This consists of a weighted arm *p*, which carries a bucket and is attached to the admission valve. When the back pressure rises beyond the safe limit, this bucket is rapidly filled with water through a horizontal slot and the weir box *t*, so that the gas is cut-off.

As will also be seen from Fig. 3, the motor *j* is connected to the weight *h* through a gear box, sprocket and chain *u*. The gears are totally enclosed and run in oil, so that they are unaffected by the damp atmosphere in the pit, while the gear box itself forms a balance weight at the end of the arm. As the motor has only to move the loading weight *h*, the input required is as low as 13 watts, and it is supplied by nickel-iron accumulators, which do not require changing more than once a fortnight. The stops v_1, and v_2 in Fig. 2 are provided to operate a switch, which opens the motor circuit if the bell passes beyond its limit positions in either direction. Similar switches are provided to cut out the motor if the weight moves too far to either to the right or left. As shown in Fig. 1, the motor is provided with two supply leads and a common return. Only one side of the circuit is therefore broken when these switches operate, the result being that, after the conditions which have caused the disturbance have been removed, the motor is ready to be started up again.

Details of the cam and contact arms are given in Fig. 4, and these parts can also be seen in Fig. 6, on the opposite page. As already explained, the shape of the cam *a* is determined by the pressures which it is required to maintain at different times of the day, as indicated on the dial. Actually there are two cams on the same axis, one for week days and one for Sundays, and two pairs of contacts which are operated by one or other of the two cams. The change-over from one cam to the other is made automatically by a switch, the timing of which can be adjusted by the dial *w*. A pressure recorder is also fitted. The outlet pressure is introduced to the upper side of the right-hand float in Fig. 1, the movement of the float being transmitted through the beam *x*, to the contact arm. These floats are so arranged that the lowering of the water level by 1½ in. due to evaporation, will not affect the accuracy of the scale indication. A guage *y*, Fig. 4, and an adjustable link are provided to enable the reading of the pointer *z* to be correctly set.

THE AIRPORT AT ST. HUBERT, MONTREAL, QUEBEC.

THE Department of Public Works of Canada is now engaged on the completion of what is expected to be when finished, one of the best equipped airports on the North American Continent. The site chosen is at St. Hubert, Que., about 10 miles from Montreal, the aerodrome being approached by road through Longueuil, on the Chambly Road, or by the Canadian National Railway line to St. Hubert station, which adjoins the airport. The aerodrome is being laid out on a site of 975 acres, and additional land is available for further expansion. The original site is very level, and sufficiently removed from adjacent hills to provide manœuvring space for large dirigibles using the mooring mast, now approaching completion, in anticipation of the arrival of the British airship R 100. The illustration which we give on page 844 shows part of the site and the mooring mast.

The layout, as planned, consists of three runways radiating from the central point at angles of 120 degrees, to suit all directions of wind. These runways are 150 ft. in width, and from 1,800 ft. to 2,000 ft. in length. A taxiway 100 ft. wide connects the outer ends of runways Nos. 2 and 3, and will eventually encircle the whole field to connect with the terminus of runway No. 1. The angle between Nos. 1 and 2 runways forms a space for the dirigible mooring mast and its surrounding anchors. The hangars, garages, shops and demonstration buildings are distributed along the taxiway. In the construction of these runways and taxiways the asphalt emulsion known as Colas has been used; this is now manufactured in Canada by Messrs. Flinkote Roads, Limited.

AUTOMATIC GAS-PRESSURE CONTROLLER.

CONSTRUCTED BY MESSRS. GEORGE KENT AND COMPANY, LIMITED, ENGINEERS, LUTON.

(*For Description, see Page* 841.)

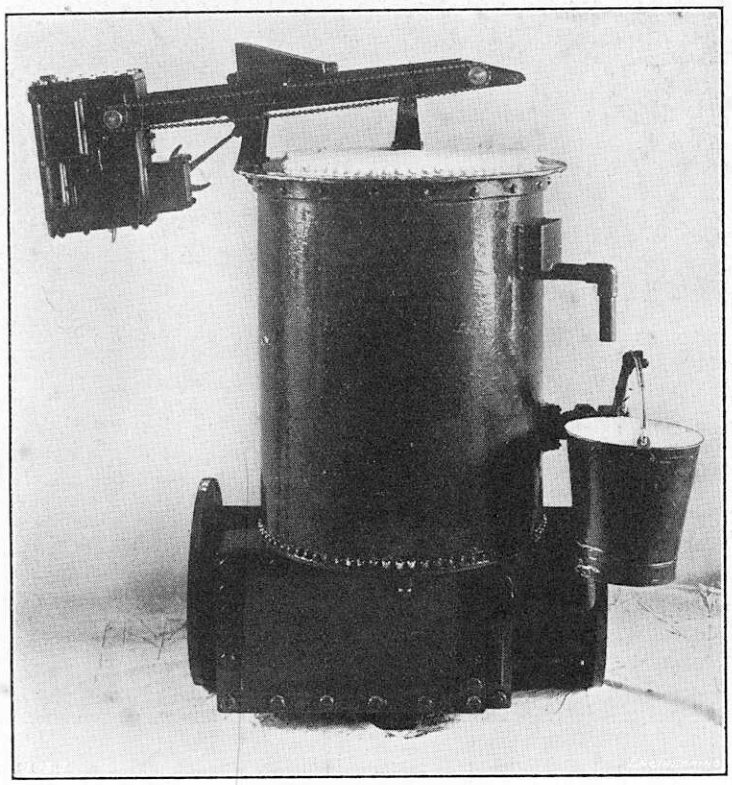


FIG. 5. PRESSURE REGULATOR.

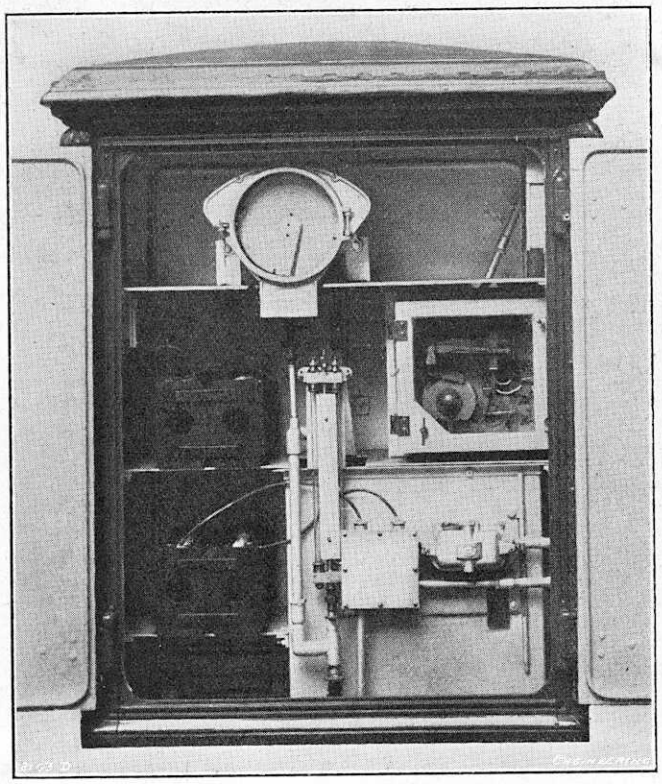


FIG. 6. CONTROL PILLAR.

The site of the air base was selected in 1927 by representatives of the Air Ministry in London and the Dominion Department of National Defence, and is situated on the south shore of the St. Lawrence River, in open country free from smoke and other flying hazards. Routes lead into Montreal over both the Victoria Bridge and the new Montreal Harbour (South Shore) Bridge. The Department of National Defence has established radio and meteorological services.

A paper read by Mr. R. de B. Corriveau, of the Department of Public Works, Ottawa, before the Engineering Institute of Canada, in February last, gave particulars of the mooring mast, etc. We reproduce from this the following: The mooring tower itself is a self-contained steel structure anchored to concrete footings. At the base of the tower is a two-storey building, cruciform in shape, to house the mooring winches, heating plant, &c., and to provide lobby entrance, retiring rooms and offices. Fairleads for side cables to yaw winches are located 250 ft. from the centre of the tower. There are 24 concrete blocks, spaced at 15-deg. intervals, on the circumference of a circle of 750-ft. radius. These are for anchoring the 25-ton snatch blocks through which the yaw cables pass from nose of ship to fairleads. The tower is an octagonal structure, 171 ft. high, surmounted by a steel plate turret 25 ft. in diameter, from the top of which projects a telescopic mooring arm to which the nose of the airship is to be attached. The total height of the tower to the top of the mooring arm is 205 ft., and the arm can be extended 7½ ft. This telescopic arm, weighing 15 tons, is mounted on gimbal bearings and counterweighted, through a system of cables and pulleys, to swing 30 deg. from the vertical and in any position of the compass. It is operated by compressed air. When the ship's nose is cupped, the arm is contracted, brought back to its vertical position and locked so as to permit the ship to swing with the wind. The tower itself consists of eight posts on a base 69 ft. 2 in. in diameter, tapering to a diameter of 25 ft. 8 $\frac{1}{16}$ in. at the passenger platform level, 171 ft. The posts are braced diagonally between levels of horizontal bracing, which occur at intervals of 28 ft. 4 in. In addition to this regular system of horizontal bracing, there is a heavy network of joists 19 ft. above ground, to support the reinforced concrete floor, and another 29 ft. above ground for the reinforced concrete roof of the building at the base of the tower. There are horizontal struts supporting the searchlight platform, and heavy girders covered with checkered plate floors at the elevator landing and passenger platform. In the centre of the tower, there is an elevator and stair shaft 16 ft. square. Four columns are placed at the corners of the elevator and stair shaft, from ground to roof of base building, to support the floor and roof loads. The searchlight platform, 142 ft. 6 in. above ground level, is equipped with searchlights which are used to spot the anchorages on the ground, and generally to facilitate airship moorings at night.

A movable platform landing stage is provided on the passenger platform, connecting over the guard rail with the airship's gangway. Passengers descend a stairway inside the turret to the elevator landing, 14 ft. 2 in. below, and then proceed by elevator to the lobby on the ground floor, 156 ft. 10 in. below.

The low-pressure steam-heating plant installed on the ground floor was designed to heat the two-storey building to a temperature of 70 deg., and the enclosed and insulated elevator-stair shaft to a temperature of 50 deg. F. in severe weather. Cast-iron radiators are installed in the lobby, machinery house and rest rooms, as well as in the mooring head. In the elevator shaft, special fin-type radiators had to be used to fit the confined space. The heating plant is fired with oil.

The contract for the manufacture and erection of the steel tower was awarded to Messrs. Canadian Vickers, Limited, of Montreal, the tower containing nearly 290 tons of steel, and the mooring head 87 tons of steel and equipment. The mooring arm, 26 ft. long with gimbal bearing, the whole weighing about 17 tons, was hoisted up the elevator well before the erection of the stairway.

In the design of the airship mooring tower the contractors provided for a pull at the tower head of 90,000 lb. with a factor of safety against uplift of 1·325. The Canadian Engineering Standards Association Standard Specification for Steel Structures for Buildings No. A16, 1924, was used. The calculated deflection at top of tower, due to 30 lb. per square foot wind pressure and pull of airship, is 0·995 in.

In this connection, it may be recalled that the Cardington mast when tested by applying a pull of 67,200 lb. at the top, deflected 1¾ in. and went back to the vertical. The R 101 exerted a maximum pull of 33,600 lb. when riding a gale at the top of the Cardington mast. This dirigible has been reported to have veered over 90 deg. in less than one minute, without any serious strain to ship or mast at Cardington.

In connection with the swinging arm, there is a vertical two-stage air compressor direct coupled to a motor at ground level. The compressor charges the air receiver at base of tower to a pressure of 400 lb. per square inch. The air from this receiver is reduced down to 150 lb. per square inch and is supplied at that pressure to the receiver on the passenger platform by a 2-in. diameter flanged pipe line. Air at 150 lb. per square inch is used for the locking cylinder, top and bottom, and for bringing in the ram against the resistance of the ship and the centreing gear. The air is further reduced to 25 lb. per square inch pressure for the recoil receiver, which is slung underneath the passenger platform. This air is used for pushing out the ram and holding it out until the bucket or cone on the nose of the ship enters the cup on the swinging arm. A recoil gauge graduated in tons is fitted in the control cabinet to show the pressure under the piston in the cylinder of the swinging arm when the ram is hauled down by the main haul winch against the pressure of 25 lb. to the square inch. The 400 lb. per square inch and 150 lb. per square inch air receivers are fitted with lock-up safety valves. The 25-lb. per square inch recoil receiver and the reducing valves are fitted with adjustable relief valves.

Each of the eight tower posts rests upon a concrete base 11 ft. by 13 ft. 6 in. by 9 ft. 6 in. deep. The base building consists of 12-in. tile walls, with stucco exterior, tile partitions and plaster finish inside, reinforced concrete floor and roof finished with copper flashings, metal doors and window sash, chimney, with all necessary plumbing and lavatory fixtures.

All machinery in the tower is electrically operated. The power cable is carried underground a distance of 2,100 ft. Two transformers step down the supply from 2,200 volts to 550 for machinery, and another transformer to 110 volts for lighting. There is a motor generator set for charging the airship batteries,. The tower is flood lighted below the passenger platform. The electrical installation was carried out under the regulations of the Quebec Inspection Bureau.

To develop an adequate water supply for the airport, an arrangement was made with the Canadian National Railway to use St. Lawrence river water from the twin railway tank at Southwark, 2½ miles from St. Lambert, where there is a hydrant pressure of 25 lb. An 8-in. main was laid along the C.N.R. right of way, a distance of two miles to the pump house on the airport property. The distribution pipes are 8 in. in diameter for high-pressure raw water to the mooring tower, one mile distant, and 6 in. for high-pressure raw water to serve hydrants, hangars, &c., located in another direction. To distribute domestic water, 4-in. pipe was laid in the same trenches as the high-pressure pipes.

To deliver petrol or Diesel oil to the fuel tanks of the

THE AIR PORT OF ST. HUBERT, MONTREAL.



airship, the Aqua flotation system has been adopted. The installation includes a 10,000 gallons pressure storage tank placed underground and connected to the domestic water service. Water enters the tank under pressure and displaces the petrol, which is forced up the tower through a 2-in. pipe. There are automatic valves with an auxiliary tank installed at the base of the tower to prevent the water rising above the ground level and to control the petrol supply. A sump pit and electric pump are provided to drain the water from the storage tank to field under-drains when the petrol is being stored into the tank. The storage tank is equipped with a spray blending header, so that water under pressure can be used for blending fuel oil to any desired degree.

The Airship R 100 requires 5,000,000 cub. ft. of hydrogen for her gas-bags. It is estimated that one-tenth of this supply will have to be replenished after a transatlantic trip. To meet this demand, a Silicol hydrogen plant of 40,000 cubic ft. per hour capacity and a gas holder of 50,000 cubic ft. have been provided at St. Hubert. There are two generating units, each of 20,000 cub. ft. capacity, installed in a special building alongside the gas holder, 2,500 ft. away from the mooring tower, both being connected to a 12-inch low-pressure hydrogen main. Ferro-silicon and caustic soda are used to generate the hydrogen. The gas holder works under a pressure of 5 in. water-gauge. At the top of the tower, pressure is reduced through a regulator valve to 30-mm. water gauge, and the gas is metered before it reaches the airship's supply pipes in the mooring head. As the plants can operate above their rated capacity, provision has been made to meter up to 60,000 cub. ft. of hydrogen per hour. All connections are electrically welded.

At the base of the tower, on the ground floor of the machinery house, there are three variable-speed electro-hydraulic winches. Two of these are for the yaw cables and one for the main haul cable. These winches are of the spur-gear type, driven by electric motor through Waterbury hydraulic transmission gear, and are capable of handling a load of 33,600 lb. at 50 ft. per minute and a light line at 150 ft. per minute. When the airship's cone is being drawn into the cup of the mooring arm the speed of the winches will be reduced to a minimum, as for inching heavy loads. The motors are alternating-current, 85-h.p., constant-speed machines, on 550-volt, three-phase, 60-cycles supply, running at 430 r.p.m.

The drums are designed to hold 5,000 ft. of ¾-in. diameter special mooring cable coiled in five layers. This is to provide for the larger airships of the future. For mooring the 5,000,000-cub. ft. airships 2,000 ft. of cable have been provided for the main haul winch, and 3,000 ft. each for the yaw winches. There is an automatic spooling device on each drum, and the main haul cable is guided by a fleeting sheave, 40 in. in diameter and set 25 ft. away from the main winch.

The base plates of the winches provide for future installation of petrol engine auxiliary power. The drums are arranged to be disconnected from the transmission and act as free drums controlled by an operator at the mooring platform.

A Klaxon annunciator system is provided for the drum release at the main haul cable winch and yaw cable winches. The winches are further controlled from the operating platform by Selsyn servo-motor remote-control apparatus, consisting of transmitter servo-motors at remote-control stands, electrically connected to receiver servo-motors mounted above the hydraulic transmission of each winch. There is also a cable-tension meter for indicating the pull of the main cable.

To prepare for mooring, the main haul cable is let down to the ground through the mooring arm and hauled to leeward 800 ft. The yaw cables are led through the fair leads and snatch blocks on either side, some of which can be seen in the view reproduced. The airship approaches slowly up wind and is brought down gradually to 900 ft., paying out its main cable through the mooring cone from a winch in the bow. The speed of the ship is eased off a little more, and the two cables are connected by snatch-coupling, the ground crew signalling to the ship and tower head. Ballast is dropped from the bow and the main cable is then tautened. The ship is next adjusted for trim and equilibrium, and signals to the tower that she is ready to be hauled down. The yaw guys are paid out from the ship's bow winches and connected up by snatch couplings to the yaw-winch cables from the tower. The guys are hauled taut, and the main winch then continues to haul until the ship's cone engages in the mooring arm cup. The telescopic arm is next contracted, centralised, and locked. The ship cables are then run off the tower winches and reeled up on the bow winches. When ready to cast off, the ship slips a pendant through the mooring arm.

In carrying out the construction of the mooring tower and providing the services connected therewith, the Department of Public Works of Canada has received the active co-operation of the Department of National Defence, which is the Governmental body entrusted by the Dominion Government with the development not only of military, but also of civil aviation. Active help and advice was received also from the officials of the Air Ministry in London.

THE END OF THE ONE HUNDRED AND TWENTY-NINTH VOLUME.