

THE LOWER BHAVANI DAM, MADRAS.

By R. DORAI RAJAN.

WHAT is claimed to be the world's longest dam is nearing completion across the Bhavani River in the State of Madras, India. The dam forms the basis of an extensive irrigation scheme in Southern India, put in hand in 1947 as part of the five-year development plan for irrigation and farming.

Fig. 1, herewith, shows the site of the dam, and the extent of the area covered by the five-year plan can be seen from Fig. 2. The Bhavani project will bring an added advantage of security to the area by giving control of the river, which, twice within the past ten years, has caused disastrous flooding and great damage in its lower reaches. The proposal to store the water of the Bhavani is not new, having been suggested more than 100 years ago by Sir Arthur Cotton, who was the first to propose the storage of the flood waters of the rivers of

Southern India for the purposes of irrigation. Disagreement as to where the dam should be built, on the Bhavani or across the River Cauvery at Mettur, caused the project to be held in abeyance. In 1914, however, on the advice of Colonel W. M. Ellis, R.E., then Chief Engineer for Irrigation, the Government of Madras proceeded to construct the dam across the Cauvery, which was described and illustrated in vol. 133 of *ENGINEERING* (1932). The Bhavani project was indefinitely postponed, but was resuscitated in 1947, when Congress sanc-

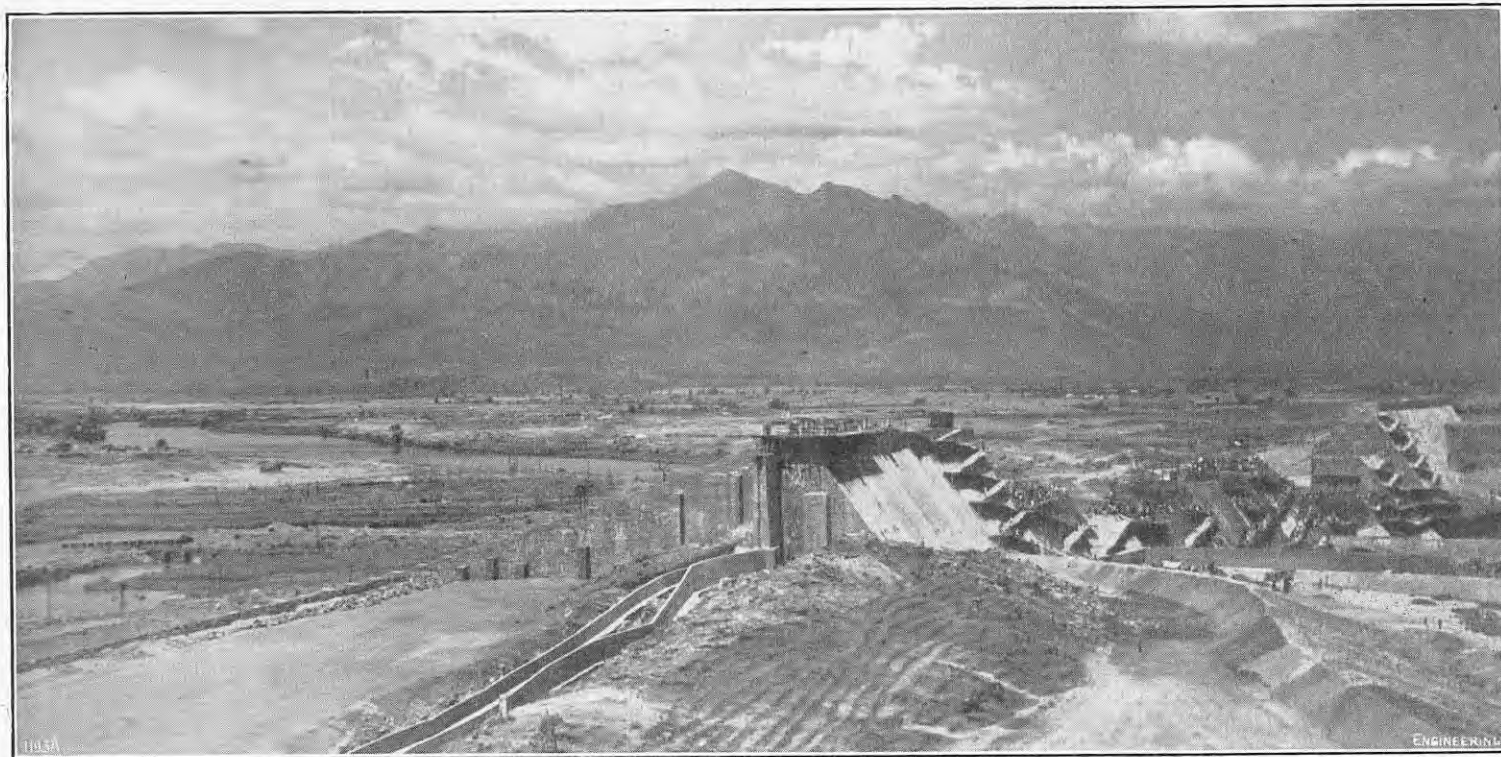


FIG. 1. SITE OF THE DAM.

Fig. 2. IRRIGATION PROJECT, SOUTHERN INDIA.



tioned it as one of the first post-war development schemes in the five-year plan for irrigation.

The site of the new dam is 79 miles from the source of the Bhavani, just below its confluence with the River Moyar. It will impound an effective storage capacity of 30,000 million cub. ft. of water in a reservoir having an area of about 30 sq. miles, roughly triangular in shape, and with a shoreline of nearly 78 miles; the maximum length of the Bhavanisager (as the reservoir is to be called) will be 13.8 miles, and its width 8.4 miles. Compensation water for established riparian farmers will be allowed to flow down the existing river bed, but water for the new irrigation scheme will be taken through a main canal 125 miles long and distributed through supplementary canals, with a total length of nearly 500 miles, to give water to 207,000 acres in the eastern part of the Coimbatore district. Alternate crops of cotton and millet will be raised, with, it is hoped, an annual value of more than 25 million rupees.

The overall length of the dam is to be 29,400 ft., of which the central portion, in the river bed, will be a masonry structure, 1,523 ft. long. Figs. 1 and 3 show the earthen bund on each flank. The bund on the left flank will be 16,040 ft. long, and that on the right 11,840 ft. A typical cross-section of the earth dam is shown in Fig. 9, on page 779. The initial design required the central length of masonry dam to be 8,400 ft. long, but close study of recent work undertaken in the United States enabled earth-fill to be substituted for a large part of the masonry, with a consequent saving of several hundred thousand rupees. A somewhat unusual feature of the dam is its great length for the relatively small storage capacity; but this disadvantage is largely offset by the fact that the area to be submerged is mostly reserved forest,

LOWER BHAVANI DAM, MADRAS.

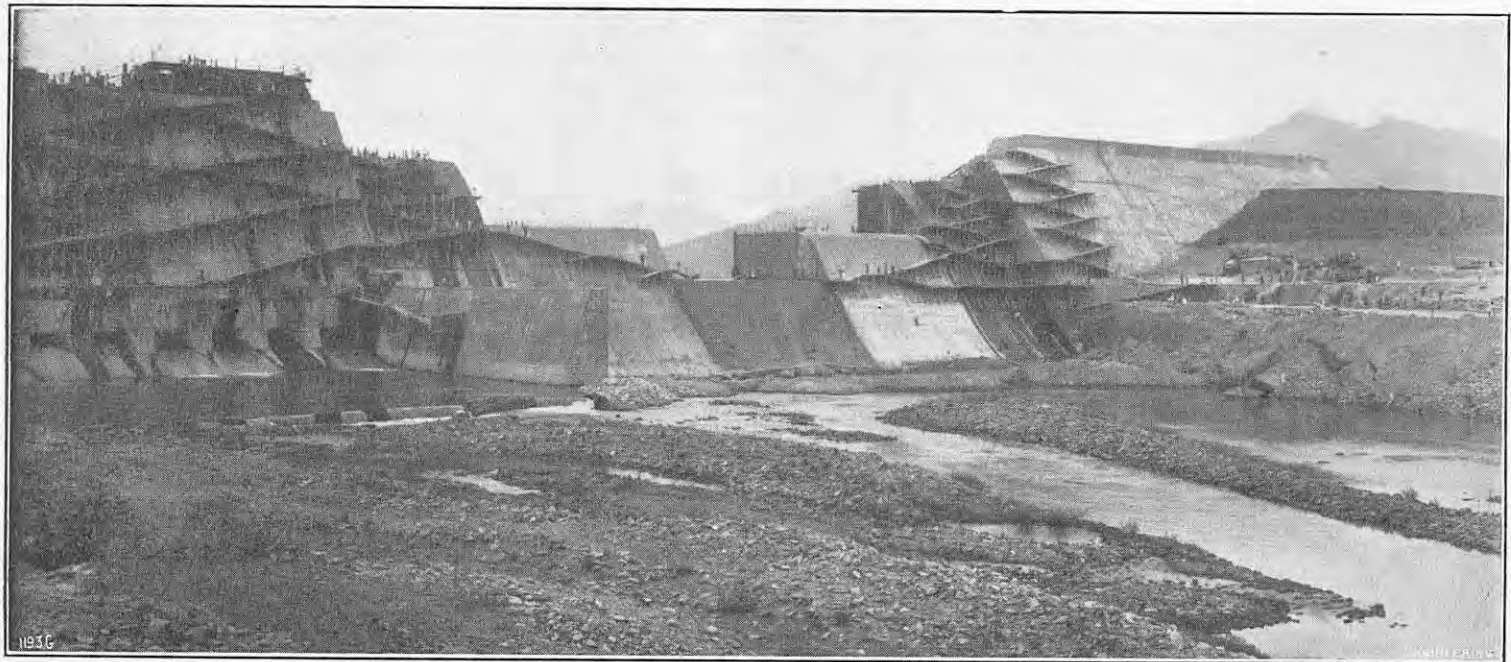


FIG. 3. CONSTRUCTION OF THE MASONRY DAM.

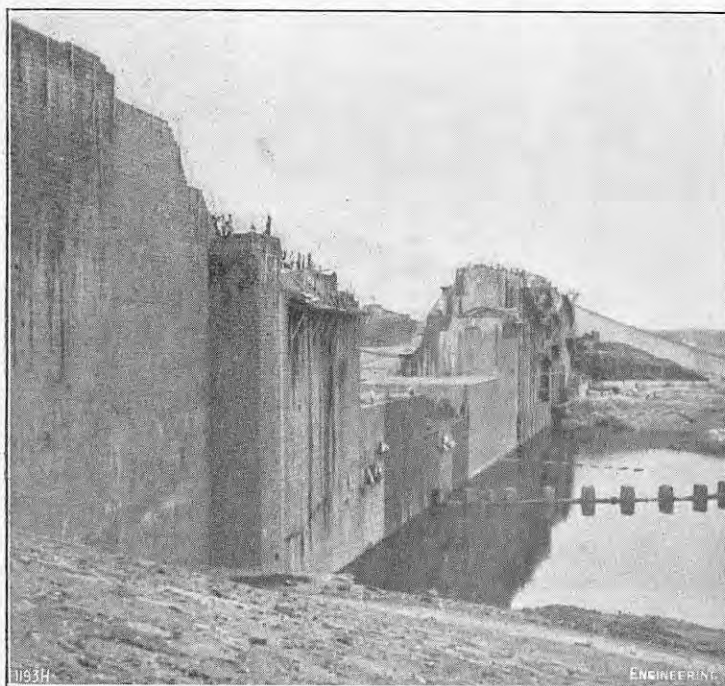


FIG. 4. WATER FACE OF DAM ADJACENT TO SPILLWAY.

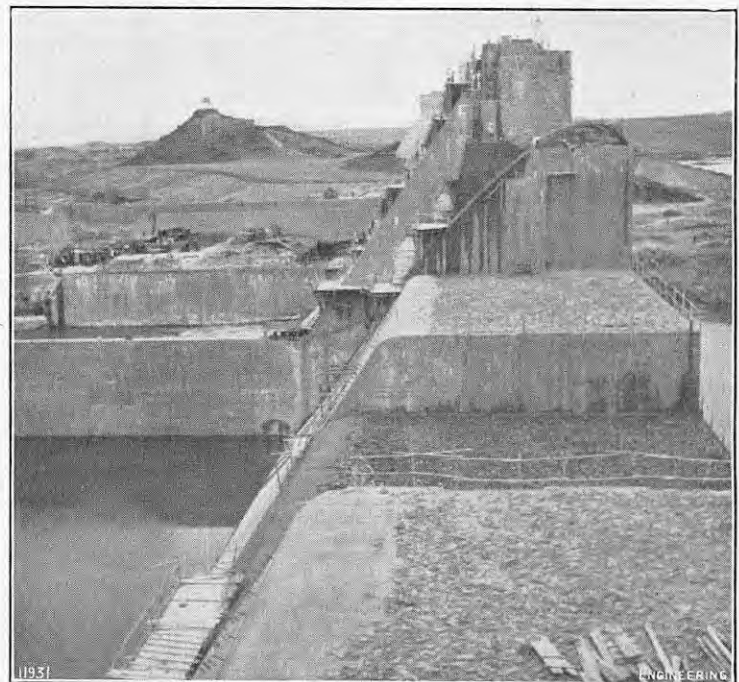


FIG. 5. CONSTRUCTION OF SPILLWAY.

which is thinly populated, so that a much smaller number of people will be displaced than would have been the case had more valuable lands been affected.

The foundations in the river bed were constructed within a cofferdam built round three sides of a rectangle, about 500 ft. long by 300 ft. wide; the fourth, or open side, was located on the left bank of the river. Sixteen vents with needle shutters were provided in both the upstream and downstream sides of the cofferdam, sufficient to pass and control the normal discharge of the river. During the first stage of construction the river was diverted round the right side of the cofferdam; in the second stage, the diversion was sealed off and the river returned to its normal route, passing through the vents in the cofferdam and over the masonry already placed during the first stage of construction. During the third and fourth stages of construction, the flow was re-diverted through river sluices provided in the right flank of the dam while construction of the central portions was

completed. In times of flood the river was allowed to flush over sections of the masonry dam that were kept low in the line of the river bed for that purpose, as shown in Figs. 3, 4 and 5, above.

A shift of between 43 ft. to 70 ft. downstream from the original alignment of the masonry dam was made because of the poor quality of the rock under the foundations. Even on the amended alignment, however, satisfactory foundations could not be made at the expected depths, but had to be taken down to between 60 ft. and 70 ft. below the river bed. Seepage through the laminated strata of the bed-rock has been reduced by drilling 820 grout holes, averaging 80 ft. in length. To reduce the upthrust, vertical drainage pipes have been built into the dam from the foundation to a drainage gallery, 7 ft. 6 in. high by 5 ft. wide, that runs the full length of the masonry portion; this gallery, shown on the cross-section of the dam in Fig. 7, on page 779, is situated 15 ft. behind the water face except in the locality of a sluice gate, where it is stepped back to 21 ft. behind the face.

The central masonry dam consists of two bulkhead sections, 357 ft. long on the left and 770 ft. long on the right, located on either side of the spillway section, which is 396 ft. long. The crest of the spillway is 103 ft. above the river bed, but nine radial gates, each 36 ft. long by 20 ft. deep and carried from eight piers and the bulkheads, have been provided so that the top water level can be raised to 118 ft. above the river bed immediately and 123 ft. at a future date. A freeboard of 10 ft. has been provided at most sections, and the roadway is carried over the masonry dam at 140.5 ft. above the river bed.

The shaped spillway has been designed to give a maximum discharge of 122,000 cusecs at a head of 20 ft., and model experiments have shown the proposed form to have a discharge coefficient varying between 3.09 and 4.0. The top of the spillway has been built in Portland cement concrete and the toe has been moulded to an arc of a circle. It ends in reinforced-concrete baffle blocks, backed by a continuous wall, 4 ft. higher than the blocks, to

LOWER BHAVANI DAM, MADRAS.

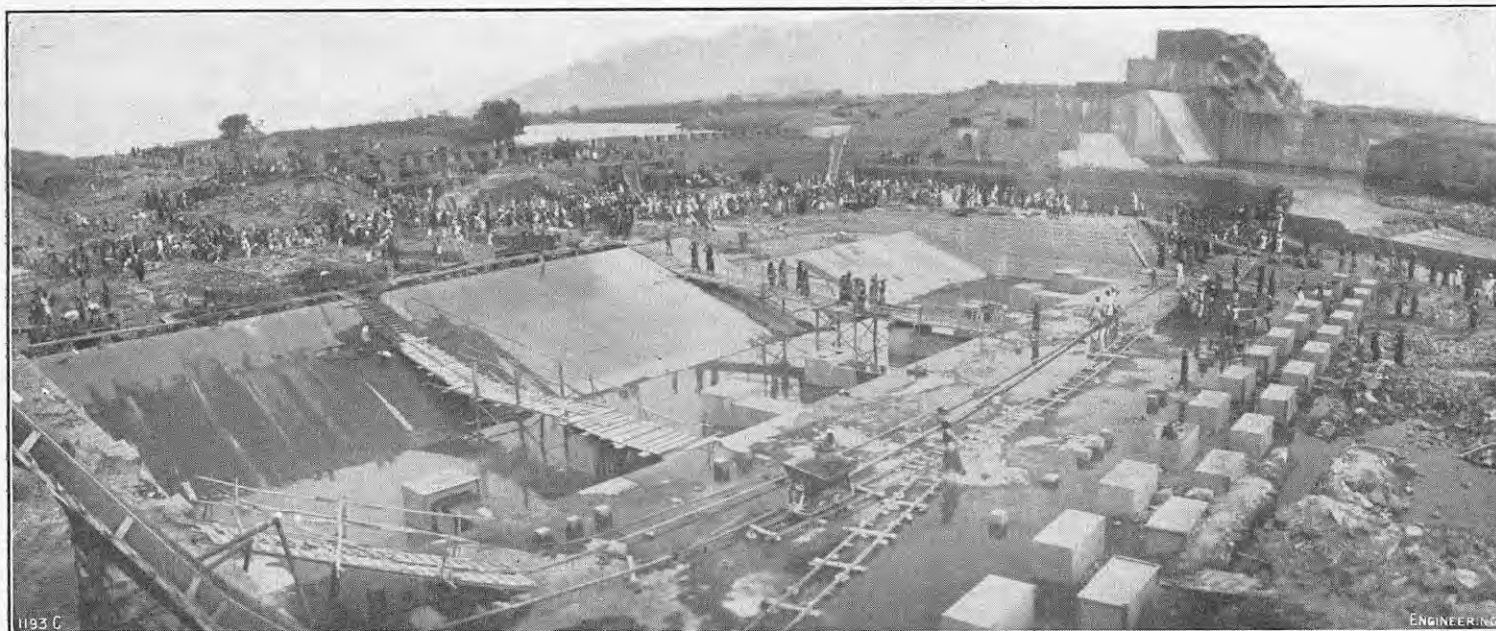


FIG. 6. CONSTRUCTION OF SPILLWAY AND STILLING BASIN.

Fig. 7. SECTION THROUGH SPILLWAY.

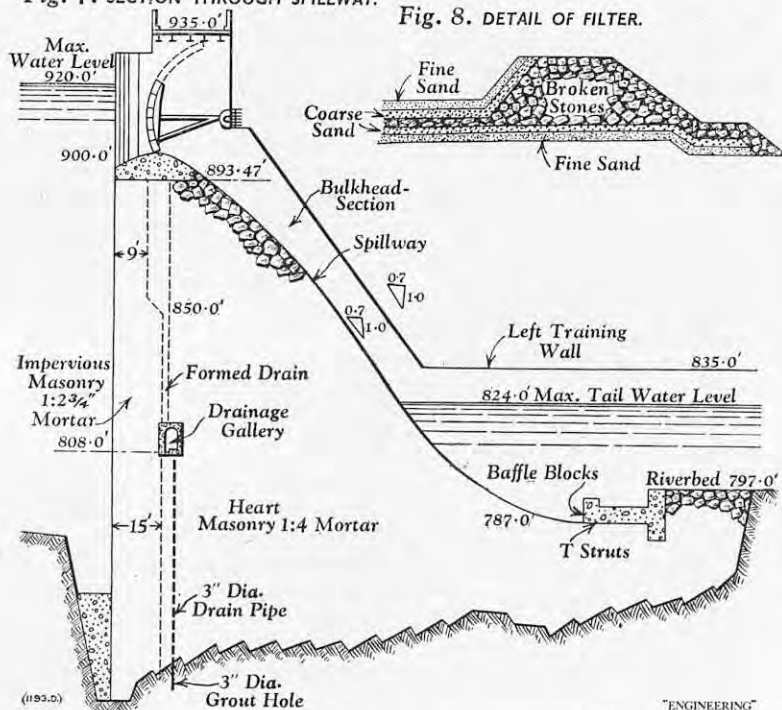
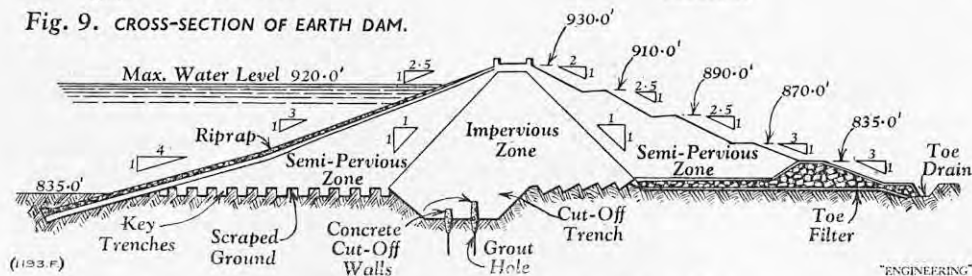


Fig. 8. DETAIL OF FILTER.



FIG. 10. ERECTION OF SLUICE GATES.

Fig. 9. CROSS-SECTION OF EARTH DAM.



form a stilling basin at the foot of the spillway; it is shown during construction in Fig. 6, herewith. This arrangement is designed to dissipate the energy of the falling sheet of water, which will reach the bottom of the spillway with a velocity approaching 80 ft. per second when the radial gates are fully raised.

Within the length of the right bulkhead, adjacent to the spillway, are nine river sluices with openings 6 ft. by 10 ft., and having their sills 18 ft. above the river bed. These sluices have been provided to ensure the minimum discharge of 1,000 cusecs of compensation water. Beyond these river sluices are four penstocks, 8 ft. in diameter, which will

ultimately feed turbo-generator sets, designed to develop 2,500 kW each when working under a head of 76 ft. Beyond the penstocks are five canal sluices, with the same dimensions as the river sluices and with the sill level 43 ft. above the river bed, which are designed to deliver the full supply of 2,300 cusecs that is required from September to March for the irrigation of the development area of 207,000 acres. They are shown in course of erection in Fig. 10, on this page. All the sluice gates in the dam have been made in Germany by the Maschinenfabrik Augsburg-Nürnberg A.G. Each sluice has a dry well for the inspection of gates, gears and chambers. Particular attention has

been given to the shaping of the inlets and outlets to reduce the risk of cavitation. Trash racks are provided over each inlet. The flow through the sluices is expected to be sufficient to remove any silt that may be deposited at the foot of the dam.

The masonry in the bulkhead sections of the dam has been built of blocks 60 ft. long. In the spillway, the blocks are either 63 ft. or 90 ft. long. The complex staging that was constructed so that the masonry and mortar could be carried on to the dam is shown in Fig. 3. The contraction joints between the blocks are constructed in the following manner. The adjacent vertical faces of two blocks are finished with a double line of chisel-dressed stones, set at a distance apart of $\frac{3}{8}$ in., the gap between the faces being filled with mortar. Across the joint, 18 in. behind the water face of the dam, a seal has been made by incorporating a copper stop, 19 in. wide by $\frac{1}{8}$ in. thick, crimped at the joint to permit movement, and held in place by $\frac{1}{2}$ -in. diameter bolts, grouted into the adjacent stones. At the front and back of the copper strip, rebates have been left in the stones and these are packed with a

high-grade asphalt, great care being taken to ensure the continuity of this asphalt bar. The total volume of masonry in the dam amounts to 14 million cubic feet.

The earthen bunds on each side of the masonry dam are constructed as shown in the typical cross-section in Fig. 9, on page 779, and are, in effect, artificial hills with a greatest height of 110 ft. and a base width of 990 ft. The roadway along the top of the earth dam is level at 123 ft. above the river bed. Trapezoidal cut-off trenches, varying in bottom width from 20 ft. to 65 ft., and with side slopes of 45 deg., have been taken down to the rock, which has been drilled and grouted. Where the height of the bund is less than 40 ft., no cut-off wall has been provided, but either one or two cut-off walls have been constructed where the height of the bund is between 40 ft. or 50 ft., or is greater than 50 ft. The cut-off walls are 20 ft. high and are taken down 10 ft. below the bottom of the trench. The inside ends of the bunds are protected from the action of the water by retaining walls, built integrally with the bulkhead sections of the masonry dam.

The core of the dam, of compacted impervious earth, has a trapezoidal shape with a top width of 20 ft. at a depth of 5 ft. below the top of the bund and side slopes of 45 deg. down to ground level. The upstream toe of the core coincides with the top edge of the cut-off trench. The casings overlying the core are of semi-impervious soil, the front and rear slopes being determined from stability calculations based on the slip-circle method of analysis. After clearing and removing the top soil, the foundation for the earthen bunds was scarfed to provide a key for the casings.

From the heel of the core, the rear half of the base of the earthen dam is covered by a horizontal filter, 5 ft. 6 in. thick, which is shown in detail in Fig. 8, herewith. It consists of a layer of crushed rock, 18 in. thick, sandwiched between two 12-in. layers of coarse sand, with additional layers of fine sand above and below it. At the heel of the dam, the horizontal filter expands into a filter and drainage trench, of trapezoidal section. The purpose of the filter is to protect the fine-grained core soil of the dam, which otherwise might be carried away by seepage. The rear slopes of the bund have been turfed, and drainage channels cut at regular intervals. A blanket of quarry rubbish against the water face of the dam is protected by a 3-ft. thickness of carefully hand-packed rubble and will act as an inverted filter should there be a sudden draw-down of the water in the reservoir.

The selection of the materials for the bunds, and the spreading, watering and compacting of them, are under the control of a field laboratory at the site, where regular day-to-day tests are made of all the materials used. A variety of earth-shifting equipment, including scrapers, dumpers, lorries and tippers, has been employed to transport the earth to the bund, where it has been spread in 8-in. layers by bulldozers and graders, watered as required, and finally rolled and compacted (to a density of 140 lb. per cubic foot) by sheep's-foot rollers and road rollers. To achieve a good bond between successive layers, disc harrows were used to scarify the placed material before spreading the next layer of earth. The total volume of the two bunds, including the cut-off trenches, is 161 million cubic feet.

At times, the total labour force employed on the dam and the associated works has reached the considerable total of 30,000, of whom 10,000 were actually working on the site of the dam itself. In addition, a further 30,000 labourers were working on the excavations for the irrigation canals. The cost of the dam and the ancillary works has been put at Rs.58.7 million and that of the canals at Rs.40 million. The dam has been built in little

more than four years, though its construction had been expected to take six years.

Taken in conjunction with the Krishnarajasagar and the Mettur reservoirs, the Bhavanisagar will effect complete control over the flood waters of the Cauvery valley. The electricity generated at the new power station will be fed into the 110-kV high-tension line from the Moyar station, which runs close to the left bank of the River Bhavani. It is hoped that the new facilities will encourage the development of industry within the area. The situation is particularly suitable for a textile industry, as cheap power will be available and cotton can be grown on about half of the area that is to be irrigated. It is also possible that a tourist industry will develop, for the area now offers attractive opportunities for hunting, fishing and boating.

The dam and other works have been undertaken for the Madras Government, in collaboration with the Central Water-Power, Irrigation and Navigation Commission, by the Madras Public Works Department. The dam was designed by Mr. A. R. Venkatachari, chief engineer for irrigation, and the engineer in charge of its construction was Mr. A. Srinivasan. Mr. K. Hariharan was responsible for the construction of the canals.

LITERATURE.

X-Ray Crystallographic Technology.

By DR. ANDRÉ GUINIER. English translation by T. L. TIPPELL. Edited by PROFESSOR KATHLEEN LONSDALE, F.R.S. Hilger and Watts, Limited, (Hilger Division), 98, St. Pancras-way, Camden-road, London, N.W.1. [Price 56s. net.]

SHORTLY after Dr. Guinier's *Radiocristallographie* was published in 1945, Professor Lonsdale, in the course of a review, commended it "as a really excellent work" and expressed the hope that it would be possible to bring out an English translation and to produce it in a more durable and attractive form than was feasible during the occupation of France. In response to this appeal, Messrs. Hilger and Watts arranged for the present translation to be made by Mr. Tippell, and persuaded Professor Lonsdale to edit what, in view of the changes introduced by herself and by the author, is virtually a new edition of the original work. Though it is "addressed specially to technicians who want to use the methods of X-ray crystallography and not to crystallographers," Dr. Guinier adds that his aim has been "to make the treatment sufficiently complete for the reader to be able to interpret even special diagrams or complicated cases that he may meet."

The text is divided into five parts, the first of which contains a general account of the properties of X-rays and of apparatus for generating X-radiation. Useful hints are given on methods of detecting a beam of X-rays and for measuring its intensity, together with many practical details concerning the construction and operation of X-ray tubes and associated equipment. It may be noted here that the term R_i , which occurs in three places on page 24, should read R_λ . Part II covers the elements of crystallography and the theory of X-ray diffraction by crystals which form the indispensable foundation for the interpretation of X-ray patterns and in which proper prominence is given to the reciprocal lattice. The 85 pages of Part III comprise three chapters devoted to the experimental methods for obtaining diffraction diagrams when the specimen consists of a crystalline powder or a microcrystalline solid, a single crystal, and when the incident radiation is strictly monochromatic. The measurement and interpretation of the resulting Debye-Scherrer lines and of the spots on rotating crystal and Laue diagrams are carefully explained

and a full account of the curved crystal monochromator is included.

In Part IV consideration is given to the principal problems to which X-ray diffraction methods can be applied. These involve the study of crystal texture, including the investigation of the size and orientation of the elementary crystals in the specimen, the determination of the crystalline lattice and the exact measurement of its parameters, and the determination of the structure of the crystal so that arrangement of the atoms within the unit cell of the lattice can be ascertained. Thus far, the crystals have been assumed to be ideal, with the atoms located exactly at the lattice points of geometrically perfect periodic lattices. This restriction is removed in Part V, where the effects of crystalline imperfections, mechanical deformations and the influence of thermal agitation are studied. The remaining chapters deal with the diffraction of X-rays by amorphous substances and the determination of the size of submicroscopic particles by low angle scattering.

Theoretical derivations of formulae quoted in the text are collected together in the first appendix, which includes a section on stereographic projection. Other appendices contain a comprehensive selection of tables of physical data and structure types of the elements, atomic scattering factors, K and L emission lines and absorption edges, mass absorption coefficients, lattice planes arranged in order of diminishing spacing for four types of lattice, correspondence between the Bragg angle and lattice spacing for five X-ray wavelengths, and crystallographic data for certain common substances. Footnotes are avoided by making the name index serve as a bibliography—a commendable innovation. Notable features of this admirable working manual are the care taken to provide directly usable information about the various experimental techniques, and the careful choice of representative examples based on the author's own experience, illustrated by a series of reproductions of actual photographs and worked out in detail.

Waves and Tides.

By R. C. H. RUSSELL, M.A., and COMMANDER D. H. MACMILLAN, R.N.R. (Ret.), F.R.I.C.S. Hutchinson's Scientific and Technical Publications, Stratford-place, London, W.1. [Price 25s. net.]

THIS composite study of related subjects, which contains 350 pages and is illustrated by 100 diagrams and 16 plates, is divided into two sections, "Waves" being dealt with by Mr. Russell, and "Tides" by Commander Macmillan. The former author's preface to "Waves" claims modestly that his motive was merely to give "... a description of how waves behave in the writer's opinion and according to those from whom he derives his opinions"; and he submits that, "In the study of waves there is plenty of scope for speculation and for personal opinions." The first four chapters, "Characteristics of Ocean Waves"; "Ideal Waves"; "The Generation of Waves by Wind"; and "Waves Near the Shore," while touching upon matters of fundamental importance, hardly amplify them sufficiently to give the promised understandability, nor yet the reasons for their validity. Certainly, the subject gives the author a wide scope for his speculative opinions, based apparently upon a somewhat narrow selection of data. For example, he concludes that "The shattering of rigid structures is caused by temporary forces, determined more by the shape of the waves than by their energy, and the erosion of beaches is similarly dependent principally on the shape of the waves." If such a statement were true, it would also shatter the world of maritime engineering. He does not develop the point further.

The chapter on "The Generation of Waves by Wind" explains satisfactorily the difficulties of the

subject, though, from the abundance of observed data obtainable from world-wide sources, it might have been extended with advantage. The author's note on the soaring tactics of gulls on a change of wind speed has an instructive practical appeal; it shows that no opportunity should be neglected to provide evidence on natural phenomena. On the important subject of "Waves Near the Shore," he develops his argument with acumen until, on page 81, he flatly contradicts what he terms a "widely held conception" that the friction drag on the water particles at the seabed causes the waves to steepen and topple over. He gives the model experiments of Suquet as the authority for his statement, but Suquet did not say, or imply, that this was the case. What he did say was that while, on a flat slope (1 in 25) a rough bed throws the break towards the shore, relative to the point of break of a smooth bed, for a steeper slope the effect would be reversed. The rest of this section deals with "Reflection, Diffraction, Refraction and Wave-Induced currents"; "Movement of Material by the Sea"; "The Effect of Wave Action on Structures"; and "Wave Measuring." This may be called the practical or applied section, where opinions are subject to the severe test of demonstration. Plate II, relating to it, bears the caption, "Characteristic shape of waves driven by the wind. The wind is blowing and the wave moves from left to right." The illustration is a magnificent photograph of a wave, but it is not characteristic of a wind-driven wave; it has all the appearance of one which is partly reflected either from a rounded breakwater head or from the hull of a vessel.

In the chapter on refraction, etc., no mention is made of the pioneer work done by the Spanish engineer, Professor Iribaren. The modern approach to the subject is actually an extension of his keen observations and his careful analysis of full-scale phenomena in the Bay of Hendaye, from which the Californian Oceanographical Research Organisations have formulated notable refinements, although these are not always applicable to the shores of Western Europe. It was Iribaren, too, who gave the lead to the fruitful study of wave-induced currents. In the caption to Fig. V.5, Refraction Diagram, the letters "C and E" should read "B and D." In dealing with "Movement of Material by the Sea," the author says, with particular reference to Selsey, that wave action at 12 ft. below low water is negligible and yet, at the very spot referred to, the seabed has been lowered over 10 ft. by erosion since 1920. Mr. Jack Duvivier has recorded, in the *Proceedings of the Institution of Civil Engineers*, that the tidal current at that point is so strong that divers could only work one hour before and after slack water.

Chapter VII, "The Effect of Wave Action on Structures" opens with the sentence "The failure of marine structures is most commonly brought about by the action of waves in undermining their foundations," but here again the premise is not developed, though the author does give examples of the power of the seas in shifting breakwaters and hurling huge blocks about. The more recent failures of the breakwaters at Algiers, Catania and Antofagasta, which experts of renown declared to have failed by shear, under enormous shock pressures, seem to have escaped his attention.

While the part of the book which deals with waves is open to some criticism, and for that reason has been discussed at some length, Commander Macmillan's study of "Tides" conveys an immediate sense of the care and assurance of the practical and patient observer. The twelve chapters are so skilfully marshalled that to read them is as pleasant as it is instructive, while his explanations of the variations of tidal phenomena are clear, concise, and convincing.

It would have been of advantage to have included,

in the chapter "Tidal Theory To-day," the more recent researches on coastal embayments which give rise to co-oscillating systems deriving energy from the ocean tides rather than from the direct action of lunar and solar gravitational forces. Another point that should be noted is that the simple geometrical patterns which the author uses to describe the occurrence of standing waves, though admirable as illustrations, are actually over-simplifications. In Nature there is considerable damping of the primary and reflected waves and distortion of the geographical distribution of phase differences. It could be further emphasised that exceptionally high tidal ranges appear to be due to two or more stages of amplification, resulting from the combined effects of reflected and resonant systems.

Nomographic Charts.

By C. ALBERT KULMANN. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 36, U.S.A. [Price 6.50 dols.]; and McGraw-Hill Publishing Company, Limited, 95, Farringdon-street, London, E.C.4. [Price 55s. 6d.]

NOMOGRAPHIC charts have long been employed in commerce and industry for the purpose of solving an equation of given form. Those which solve the complete cubic equation, for instance, can be utilised in a wide variety of problems in structural engineering, hydraulics, and other branches of technology. Further, more elaborate charts, with movable transparent sheets, have been constructed for applications in hydromechanics and aerodynamics in which as many as 12 variables are involved. In his book, Mr. Kulmann takes full advantage of these facts by presenting 92 charts which have proved to be of great value in his own engineering practice.

The charts are arranged in six main groups, of which the first may be used in place of tables for finding the powers and roots of numbers of likely occurrence in engineering calculations, reciprocals, and the circumference and area of circles. In addition to charts showing the reciprocals of reciprocal sums, the present value of an annuity, and similar data, the second group includes nomograms of the properties of rectangles, isosceles trapezoids, and right triangles, by means of which it is possible to write down the area, sectional modulus, or moment of inertia of a section of given dimensions. The next group, of 37 charts, for use in hydraulics, is more comprehensive in scope, ranging from the discharge over weirs and through orifices of different types, and the flow in both open channels and pipes, to the specific speed and other details of hydraulic turbines, and the rainfall run-off as given by the Burkli-Ziegeler formula. The fourth group provides graphical solutions of Rankine's formula for stanchions, of the usual equations for the stress in beams and shafts, together with information of potential value to the structural engineer. In the next group, on calculations in thermodynamics, there are graphical solutions to problems which are associated with the operation of boiler installations, as, for example, the flow of steam through orifices and pipes, the throttling calorimeter, the loss of heat through various causes, the factor of evaporation, and boiler efficiency. In the final group, the author gives, in graphical form, the solution of 17 equations which enter into the consideration of electrical plant when the aim is to estimate the power factor in terms of different variables, surge impedance, surge admittance, voltage characteristics, current-characteristic factors, and vector equivalents. Throughout the book the reader will appreciate the care with which the author has constructed these charts and prepared the explanatory notes on the use of them. Although the work contains no new information for the professional engineer, he may consult it with advantage in circumstances where a slide-rule might have been employed for the same purpose, so far as accuracy is concerned.

380-KV POWER-TRANSMISSION SYSTEM IN SWEDEN.

(Concluded from page 750.)

380-KV SWITCHING STATION.

The 380-kV switching station at Harsprånget, illustrated in Fig. 8, on page 782, is equipped with six single-pole circuit-breakers, but the three at present in service can be operated as a triple-pole circuit-breaker. They can, however, also be operated individually when it is necessary to bring the standby transformer into circuit. The same arrangement applies to the isolating switches, which are illustrated in Fig. 11, Plate LIX.

The high operating voltage, and still more the magnitude of the voltage rises that may be experienced under certain conditions, obviously made it necessary that the rupturing capacity of these circuit-breakers should be made as great as possible. Calculations showed that a rupturing value of 8,000 MVA would be necessary and the design has, therefore, been carried out on this basis. During the first years of operation, however, the figure is not likely to exceed 2,300 MVA.

The design of circuit-breaker actually adopted has been based to a considerable extent on that of the air-blast units used on the existing 220-kV lines in Sweden.* A fundamental principle of this design is that the supporting insulation is separated from the insulation to earth which is incorporated in the pneumatic and mechanical operating gear, so that the failure of parts occasionally subjected to severe mechanical stresses will not jeopardise the rest of the apparatus. The contact system consists of several breaks in series, the number chosen being such that the recovery voltage per break is between 30 kV and 50 kV at the rated rupturing capacity, while the stroke of the main break has been selected so that the rupturing capacity is a maximum.

The construction of the breaking contacts used is shown in Fig. 15, on page 783. They are electrically connected in series and are simultaneously operated pneumatically. The number of elements is small enough to enable them to be arranged in a single stack as shown at *a* in Fig. 16. The leakage current required to secure an even voltage distribution across the eight breaks is very low and can easily be broken by the isolating switches *b* and *c*. The flash-over voltage has been increased by using a number of horizontal pointed ribs which protrude radially from the top of the supporting insulator, as also shown in Figs. 9 and 10, which is an outline drawing of one pole of a 380-kV air-blast circuit-breaker. The employment of further breaks would only have increased the flash-over voltage very slightly.

The insulation resistance between the terminals of each pole is provided by the air in the gap between the contacts of the open isolating switch. It has been possible to bridge this gap by a single blade which is made of Duralumin with a conical section, as shown in Fig. 11, Plate LIX, the wall thickness tapering towards the free end.

The contacts are controlled on a "combined" system whereby the blast air and the control air are supplied to the opposite sides of a piston. When the moving contacts open, both air ducts are filled simultaneously and the control air is then rapidly released. Although with this arrangement the opening time is slightly longer than with certain other methods, it has the advantage that the contacts part at the moment when the pressure curve is at its optimum value. The air system has also been designed so that, in spite of the ducts being rather long, all the breaks occur simultaneously. Care has

* See K. I. Lindstrom, "Air-Blast Circuit-Breakers for 220-kV and Higher Voltages for Swedish Networks," Conference Internationale des Grands Reseaux Electriques à Haute Tension. Paper No. 105 (1948).

380-KV SWEDISH TRANSMISSION SYSTEM.

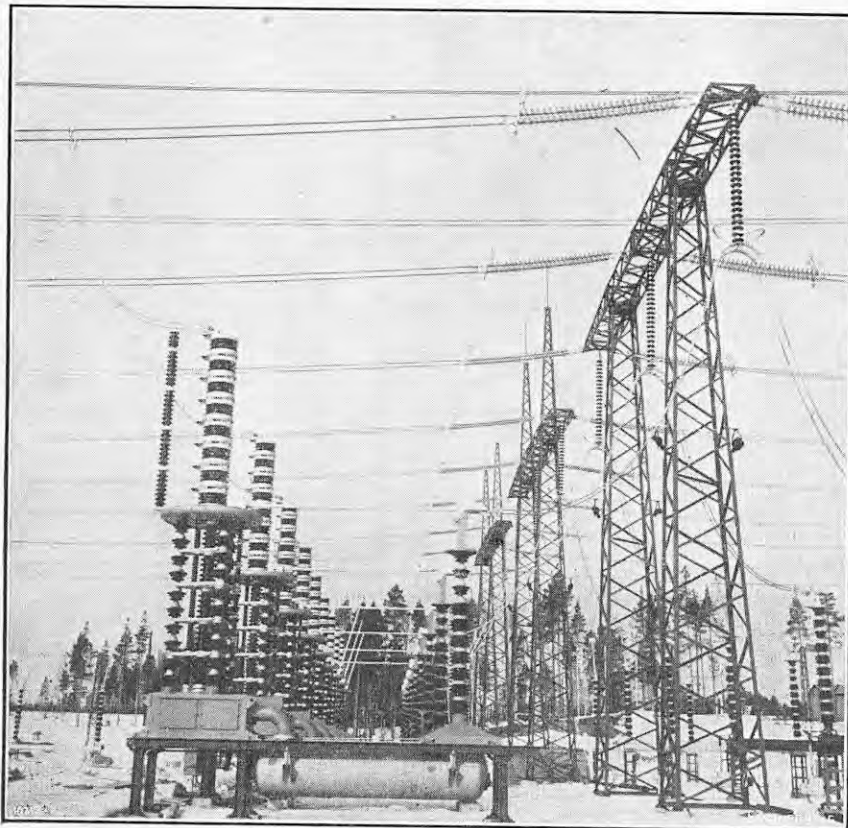


FIG. 8. SWITCHGEAR AT HARSPRÄNGET.

been taken to ensure that there is no leakage between the ducts carrying the blast and control air, so that the pressure in the latter falls rapidly when the valves are opened. Rapid re-closing is ensured by maintaining the isolating switch closed and the power breaks open during the dead interval, and thus providing sufficient insulation strength across the latter. To prevent the waste of blast air, an automatic reduction valve is fitted below the lowest breaking contacts, thus decreasing the pressure at this point to a value just sufficient to keep the contacts open and to maintain the necessary insulation strength. Towards the end of the dead interval, when the breaks are about to re-close, the pressure is restored to its full value, so that the full breaking capacity is again available. The circuit-breakers are equipped with voltage-limiting resistors, to reduce the switching surges, and are designed so that rupture occurs in about 0.1 second with an air pressure of 15 atmospheres. The associated current transformers are illustrated in Fig. 14, Plate LIX.

TRANSMISSION TOWERS.

The general appearance of the towers carrying the Harspränget-Hallsberg 380-kV transmission line is shown in Figs. 12 and 13, Plate LIX, and Fig. 17 gives the principal dimensions. The material used in their construction is high-grade steel with a minimum tensile strength of 33 tons per square inch, thus effecting a considerable reduction in weight. The uprights consist of angle irons, which are welded to bracing pieces, the latter being corrugated to provide extra stiffness. Each upright includes a base piece which rests on a foundation of steel beams, which, in turn, rest on 8 to 12 sleepers. These bases project a short distance above the ground and support the central and upper sections of the upright, each of which is about half the remaining height of the tower. These two upper sections are bolted together, an arrangement which had to be adopted for reasons of transport. The other connections are welded, a specially-designed flash-welding machine having been used for this purpose. Where the towers had to be erected

in rocky ground the foundations were levelled off with concrete, while in marshy ground 30 ft. poles were used instead of sleepers and the towers were stayed in a direction at right angles to the line. The cross-arms, which are normally about 80 ft. long, consist of channels, which are strengthened by diagonal bracing and are made up of a number of welded units bolted together on site. All the steelwork was hot galvanised and, where the bases are buried in ground likely to cause corrosion, zinc protection sheets were also provided.

The normal weight of a tower is 7.2 tons, which is equivalent to 37 tons of steel per mile, with the usual span of 1,080 ft. The height of the cross-arm from the ground is usually about 75 ft., and the conductor spacing is 39 ft. Where the line is likely to be exposed to exceptionally heavy icing, however, this span has been reduced, so as to enable the conductors to carry a superimposed load of 2½ lb. per foot instead of the 2 lb. per foot allowed on normal stretches.

As may be seen in Figs. 12 and 13, Plate LIX, each phase conductor consists of two 0.92 sq. in. steel-aluminium cables of the Feral type, with a diameter of 1.25 in., the aggregate equivalent copper section being 1.024 sq. in. This material, which was manufactured by Svenska Metallwerken, is 30 per cent. stronger than copper and weighs 30 per cent. less. It is also estimated that a saving of about 40 per cent. in cost was effected by its use. The cables were drawn up so that they are subjected to a tension of 3.8 tons per square inch at 32 deg. F. and the sag of a normal span of 1,080 ft. at 122 deg. F. is 33.5 ft. As can also be seen in Fig. 12, the two conductors of each phase are suspended in the same horizontal plane, the distance between them being 17½ in. This spacing is maintained by distance pieces, which are inserted so that the free length of conductor does not exceed 430 ft. The distance between the two is therefore never less than 8 in., except occasionally in high winds, thus fulfilling the conditions necessary to prevent trouble from corona. The electromagnetic forces acting on the conductors tend to draw them together, and the

Fig. 9. ONE POLE OF 380-KV CIRCUIT-BREAKER.

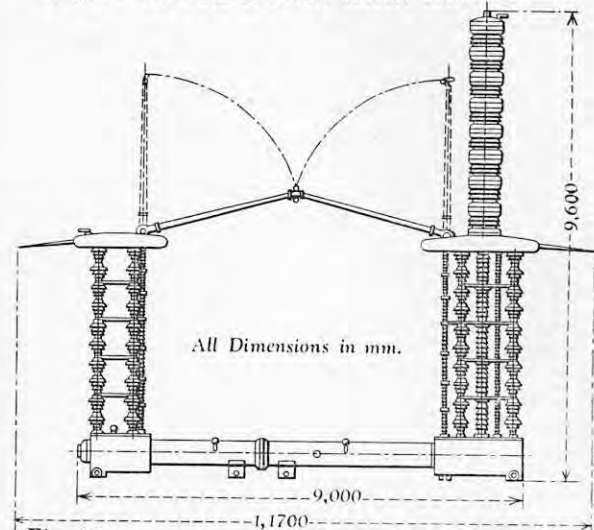
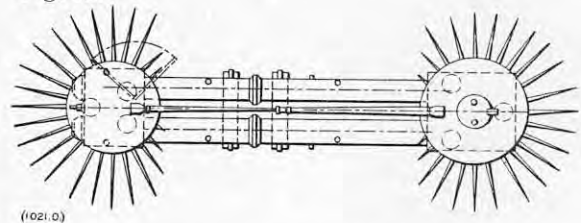


Fig. 10.



electrostatic forces tend to separate them when the current is large. Calculation and experiment have shown that the former predominates, so that after a certain critical value has been exceeded the conductors touch and remain in contact until the current falls to a second lower critical value. To prevent this happening, the conductors have been anchored at intervals of not more than 1,150 ft.

CONDUCTOR DESIGN.

The type of conductor used on the 380-kV line was selected after comparisons had been made with single and multiple types, containing three and four cables per phase. It was found to have the advantage over a single conductor of larger diameter, the line reactance being reduced by as much as 26 per cent. with a spacing of 17½ in., and consequently the stability was appreciably increased. The critical corona voltage is also high, so that solid steel-aluminium cables of moderate diameter can be used without giving rise to excessive loss from this cause or to undue radio interference. The use of double conductors also obviates the employment of single conductors of the tubular or expanded type which, besides being costly, have larger diameters owing to the inclusion of non-conducting material. The reactance, corona loss and radio interference could, of course, have been further reduced by using three or four conductors per phase, but the gain, it is considered, would have failed to compensate for the additional cost and complications. With the conductor arrangement chosen, the ohmic resistance of the line is 0.0442 ohm and the reactance 0.53 ohm per phase per mile, while the line capacitance is 0.177 microfarad per mile, corresponding to a reactive power of 800 kVA per mile at 380 kV.

The double conductor is usually connected to a single string of insulators, as shown in Figs. 12 and 13, Plate LIX, and in Figs. 18 and 19, opposite. Where the vertical load on the cable is high and the line is on a wide angle, double strings are employed. Three types of insulator have been adopted. The first of these is a porcelain insulator of Swedish manufacture, which is employed when the working load does not exceed 4 tons. Twenty discs spaced at 6.7 in. are used for a single string, giving a

380-KV SWEDISH TRANSMISSION SYSTEM.

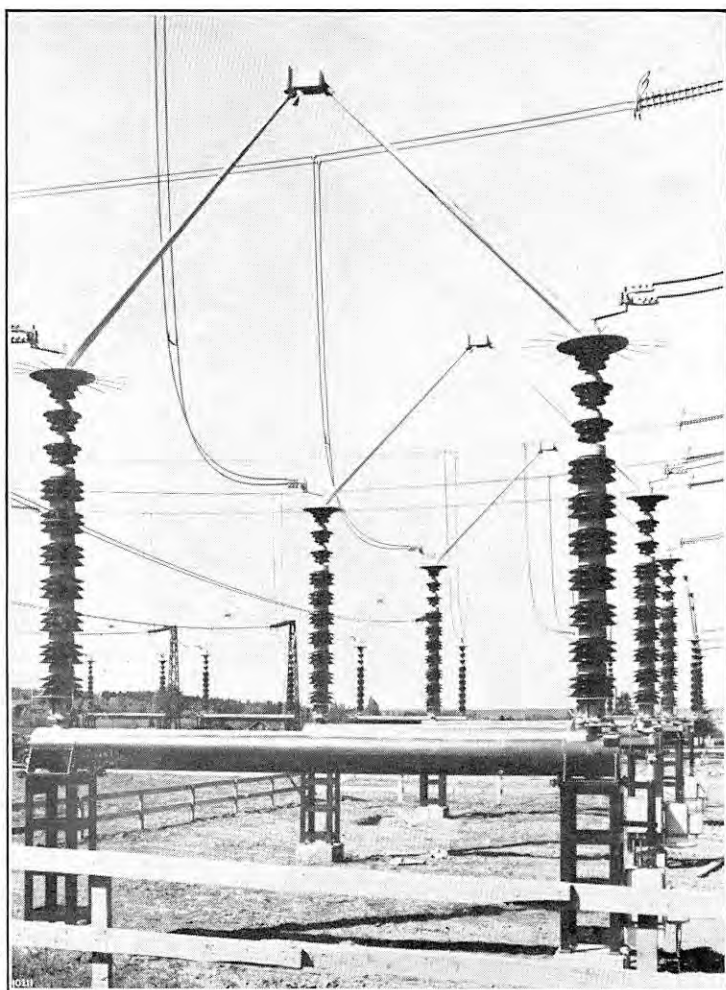
(For Description, see Page 781.)

FIG. 11. ISOLATING SWITCHES.

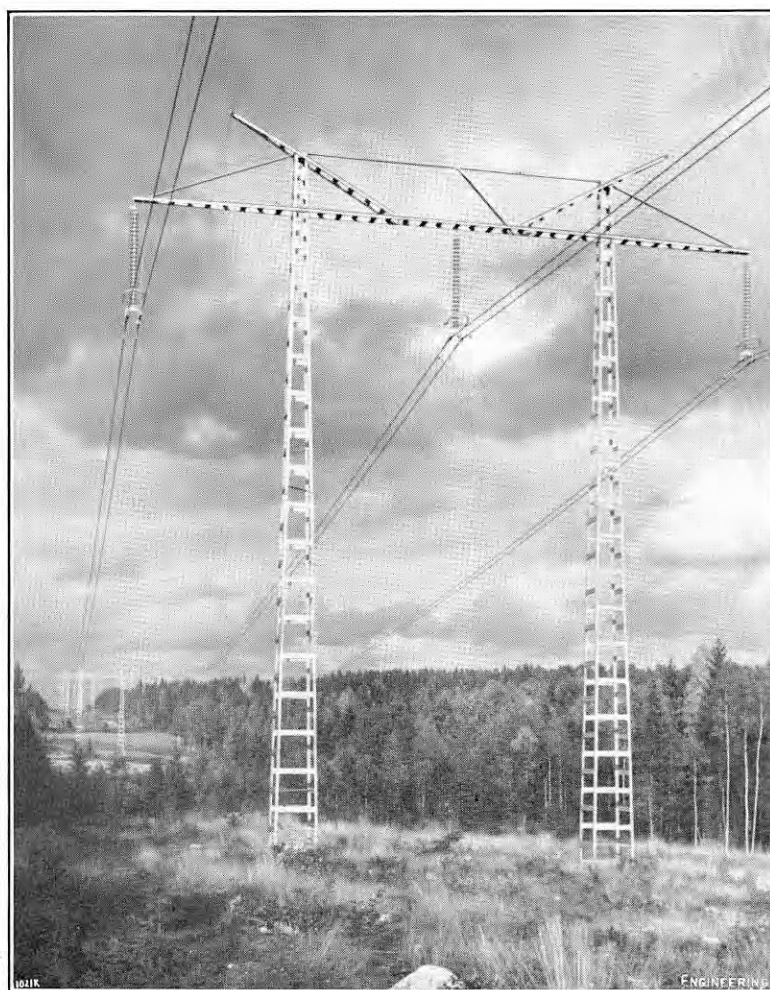


FIG. 12. TYPICAL TRANSMISSION TOWER.



FIG. 13. DOUBLE CONDUCTOR SUPPORTED BY SINGLE INSULATOR STRING.

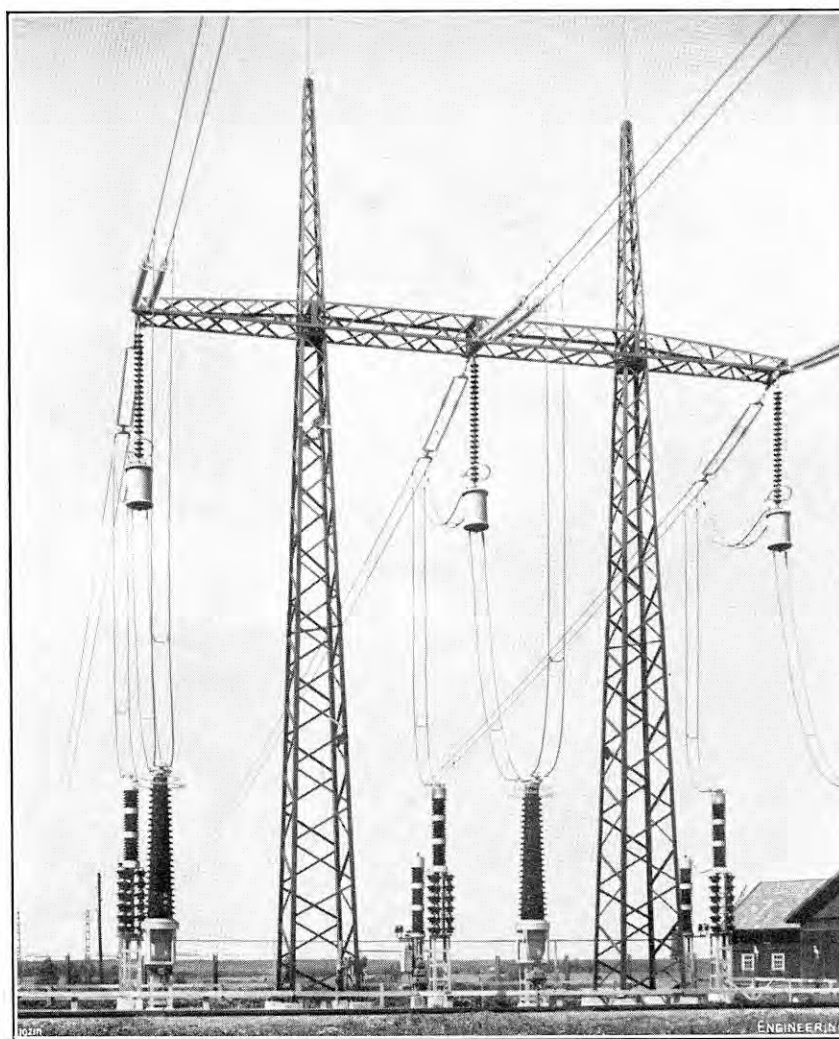


FIG. 14. ARRANGEMENT OF CURRENT TRANSFORMERS.

380-KV SWEDISH TRANSMISSION SYSTEM.

380-KV AIR-BLAST CIRCUIT-BREAKER.

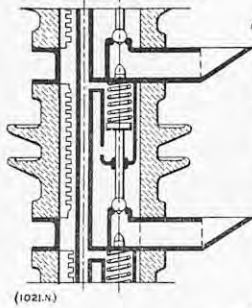
Fig. 15.
BREAKING ELEMENT.

Fig. 16.

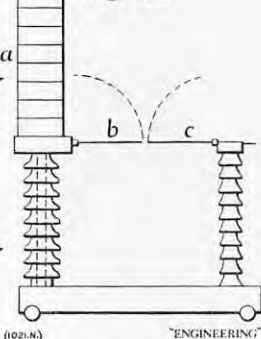
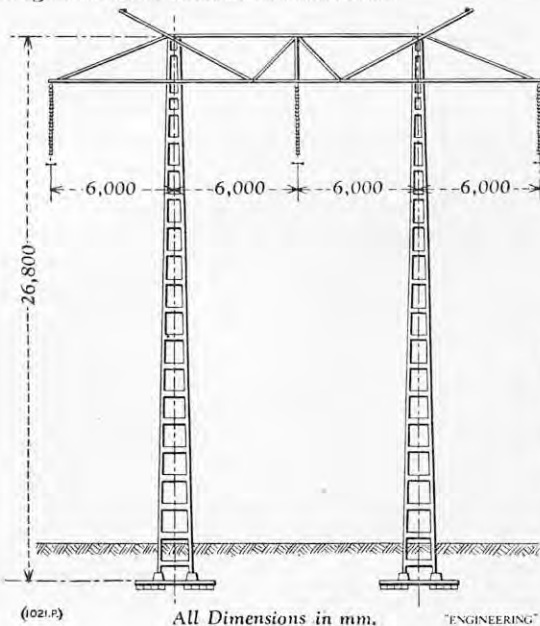


Fig. 17. 380-KV SYSTEM AT HALLSBERG.



flash-over clearance across the string of 115 in. and a total length from the cross-arm to the centre of the conductor of 13.8 ft. The total length of the double string is 15.3 ft. The impulse strength of the single string is 1,580 kV, when exposed to a 1/50 positive impulse wet test. The second insulator is of British make and is of glass. It is employed when the loading exceeds 4 tons but is not greater than 5.5 tons. The single string consists of 22 discs spaced at 6.23 in. In this case, the flash-over clearance is 119 in., and the impulse strength 1,620 kV. Triple strings of these insulators are used at the anchor towers. The third insulator, which is also of porcelain for a 4-ton maximum load, is of American manufacture. The single string consists of 23 discs with a spacing of 5.75 in., a flash-over clearance of 113 in., and an impulse strength of 1,560 kV. In all cases the voltage stress across the lower elements is reduced to a safe value by the use of grading rings, as shown in Fig. 18. The same illustration shows the arcing horns which are fitted at the upper end of the string. Each string carries a yoke to which standard cable clamps are secured and these clamps, in turn, carry the double conductor. As can be seen in Fig. 13, Plate LIX, the cables are provided with protective wrapping to prevent damage from vibration. Dampers are also fitted for the same reason on each side of the clamps. The lines which run through trackless forest took four years to complete, the work being carried out entirely by the State Power Board. The greater part of the electrical equipment for the substations was manufactured by Allmänna Svenska Elektriska A.B., who also gave valuable assistance in the design of the transmission system.

As will be seen from Fig. 2, on page 748, *ante*, the 380-kV Harsprånget-Hallsberg line is connected to

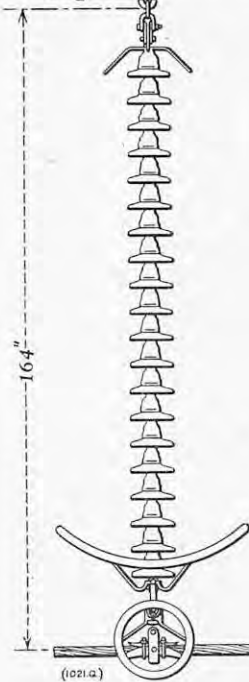
SUSPENSION INSULATOR STRING, 300-KV LINE.
Fig. 18.

Fig. 19.



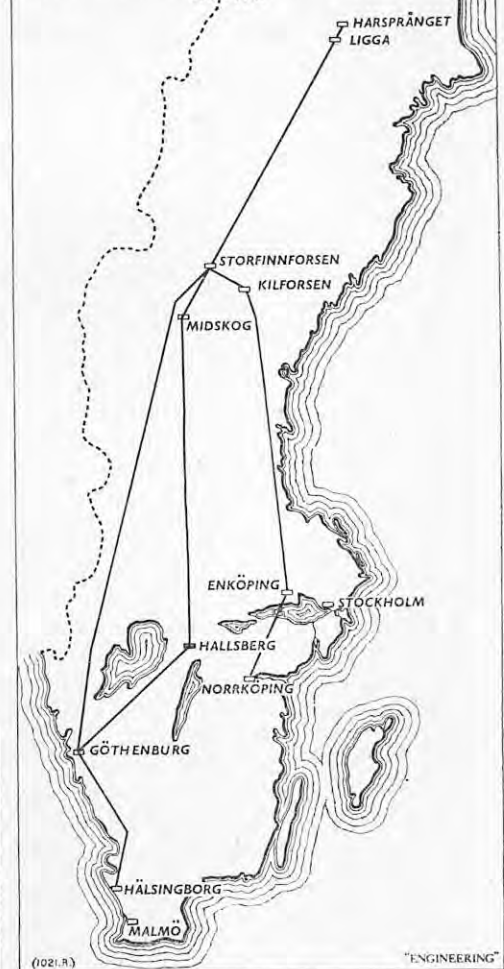
the 220-kV system at Midskog through four single-phase transformers, the rating of which is 110/110/75 MVA/408 $\sqrt{3}$ /258 $\sqrt{3}$ /36.5 kV. These transformers are of four-core design with windings on the two central limbs only. The fourth unit acts as a reserve and is equipped with switching arrangements similar to those at Harsprånget, so that it can take the place of one of the others without interrupting the supply. The tertiary winding is used to supply four single-phase regulating transformers, which are rated at 15 MVA/32 $\pm$ 55 $\sqrt{3}$ kV and are connected to the neutral point on the 380-kV winding. The relatively high voltage of this tertiary winding was chosen so that the phase and short-circuit currents should not be so large as to necessitate the use of a split-phase winding. Nevertheless, the equivalent two-winding rating of the transformer amounts to 750 MVA per phase.

The tertiary winding also supplies a phase-shifting transformer, which consists of three 16.7-MVA single phase units with a voltage ratio of 32 $\sqrt{3}$ /58 $\sqrt{3}$ to 29 $\sqrt{3}$ kV. A winding of this transformer is connected in series with the 220-kV winding on the main transformer and with an excitation winding, which is supplied from the tertiary winding of that group. These tertiary windings are also connected to three 60-MVA reactors. The object of the phase-shifting transformers is to equalise the loads on the 380-kV and 220-kV lines when the two are connected in parallel. Otherwise, there would be a risk that the lower voltage lines would carry more than their share of the load, since this is distributed in inverse proportion to the impedances and not to the resistances of the two systems.

The dimensions of the main transformers were limited by transport difficulties, since they had to be taken to the site from the nearest railway station, a distance of about 40 miles. A special trailer was built for this purpose and strengthening of the bridges and roads was also necessary. The switchgear at Midskog includes nine single-pole circuit-breakers for controlling both the north and south bound lines and the connections to the main transformers.

At Hallsberg, which forms the present termination of the 380-kV line, the voltage of the power transmitted from Harsprånget is stepped down and fed

Fig. 20. 380-KV TRANSMISSION SYSTEM IN 1956.



into the existing 220-kV network, as shown in Fig. 3, on page 748. Two transformer groups are installed for this purpose, one of which consists of three 100/100/50-MVA single-phase auto-transformers with voltage ratios of 400 $\sqrt{3}$ /225 $\sqrt{3}$ /21.5 kV, and three single-phase regulating transformers with voltage ratios of 21.5 $\pm$ 20 $\sqrt{3}$ kV. Each regulating transformer carries a winding which is connected in series with the 220-kV winding of the main transformer and an excitation winding which is supplied from the tertiary winding of the main transformer, to which it is solidly connected.

The main transformers have three leg cores, of which only the centre one is wound. Auto-connection of the 380-kV and 220-kV windings has been employed with a view to reducing both the cost and reactance and cutting down the losses. In addition to exciting the regulating transformers the tertiary windings on the main transformers also supply a 20-kV 'bus-bar' whence power is transmitted to two 60-MVA reactors, a synchronous condenser with a rating of 75 MVA when over-excited, and two 1.5-MVA transformers for local supplies. A second synchronous condenser is being installed and, when this is in use, the 'bus-bar' will be sectionalised and one synchronous condenser, one reactor and one local transformer will be connected to each transformer group.

The 380-kV switchgear includes six single-pole circuit-breakers and enables each transformer group to be connected to the line through its own circuit-breaker or the two to be joined together and connected through one of the circuit-breakers. At both Midskog and Hallsberg the switchgear is protected by overhead earth wires and care has been taken to make the "earths" up to a distance of three miles from the station of exceptionally low resistance. At each of the three stations, two diverters are installed near the transformers.

FUTURE DEVELOPMENTS.

The Harsprånget-Midskog section of the 380-kV line, which has just been described, was put into regular service on March 30, 1952, and the southern section followed a week later. Thereafter, extensive tests were carried out in order to study the switching conditions which might occur in operation. Measurements were also made of the disturbances caused to radio reception, the radio transmission over the line and the employment of the line for carrier-wave transmission. During these tests, 150 MW was transmitted over the whole length of the line, while the simulation of switching conditions which might be met with during both normal and abnormal operation showed the correctness of the calculations made with regard to stability, voltage rise and reactive power. More recently, measurements have been made both of parasitic disturbances and corona loss, while the value of the over-voltages which occur when the load on a long line is cut out are being verified experimentally; at the same time the switching equipment is being tested.

As regards the future, further 380-kV lines will be required for transmitting power from new stations immediately to the north of Midskog. These stations include one at Storfinnforsen (100 MW), which will be connected to the existing line about 35 miles north of Midskog, and at Kilforsen (240 MW) from which power will be transmitted over a 380-kV line 21 miles long to Storfinnforsen. This line will subsequently serve as a 'bus-bar' for all the large power stations in the district. Later, a further line will be constructed from Kilforsen to Enköping, as shown in Fig. 20, page 783, where the voltage will be stepped down to 220 kV.

As mentioned on page 585, *ante*, a 140-MW power station is being constructed at Ligga on the Stora Lule Alv immediately to the south of Harsprånget and will be connected to the existing 380-kV line, the carrying capacity of which between Midskog and Hallsberg will be increased from 450 to 700 MW by the installation of series capacitors. It is also proposed to extend the 380-kV line from Hallsberg to Gothenburg and thence to Malmö, as well as to build a new line from Storfinnforsen to Gothenburg, a distance of about 430 miles, and a further new line from Enköping to Norrköping. Later still, extensions of the system are envisaged up to the time when all the water power economically available has been developed.

These new 380-kV lines will exhibit some novel features.* As a result of experience, it has been decided to lower the insulation level from 1,775 to 1,500 kV, thus reducing the cost of a substation with two transformer sets and three 380-kV lines by about 8 per cent. While the present arrangement of conductors seems to be the most economically favourable and will be retained, the transmission capacity of the lines will be increased by the installation of series capacitors on an extensive scale. It is anticipated that in this way it will be possible to increase the stability to 800 MW per line. The cross-section of the conductor will then probably have to be increased by adding a third cable. Auto-connected transformers will probably be employed to convert the voltage from 380 to 130 kV. This will mean the direct earthing of the neutrals of the 130-kV networks, as opposed to present Swedish practice, and the adoption of extensive protective measures for the telephone and low-voltage installations. As regards the new generating stations, that at Ligga will be equipped with 380-kV three-phase transformers as well as low oil-content circuit-breakers. New types of air-blast circuit-breakers will be installed on the 380-kV network.

* See A. Rusck, B. G. Rathman and G. Jancke, "The Swedish 380-kV System," Conference Internationale des Grands Réseaux Electriques à Haute Tension. Paper No. 404 (1952).

SCIENTIFIC RESEARCH IN AUSTRALIA.

Continued from page 765.)

An increasing research effort is now being directed towards the utilisation of Australia's low-rank coals. The year under review has seen the completion of a new laboratory for this work, where methods are being developed for the complete gasification of Victorian brown coal, whereby it is intended to produce gas suitable for the synthesis of liquid fuels and chemicals, as well as town's gas of high calorific value for urban distribution. A new fluid-bed gasification unit, incorporating numerous improvements, has been constructed to provide quantitative data on the influence of operating variables on the performance of fluid-bed systems. A pilot plant has also been designed for research into the effects of operating pressures up to 20 atmospheres.

The scope of industrial chemistry is further exemplified by investigations of foundry sands, which include surveys of Australian sand deposits, study of sand cores to develop improved organic core binders, and experiments with Australian bentonite clays to determine in what applications they can supersede imported bentonites for the production of synthetic moulding sands. Many of these and other similar researches present problems associated with the peculiar properties and behaviour of fine particles. One such problem to which attention has been given is the separation of finely divided solids from either gas or liquid suspensions. Some results obtained from tests with dilute suspensions have been applied to the design and construction of a centrifugal dust and mist separator, by which, it is expected, small particles will be segregated with relatively little consumption of power. In the case of particle examination by air-borne elutriation, a tendency for the finer fractions to adhere to the glass walls of the elutriator has been troublesome during the examination of gypsum for use as a constituent of plaster. Irradiation of the gas elutriator, with the idea of destroying electrostatic charge, has not proved entirely successful, and it has been necessary to remove the finest particles by a special preliminary treatment before submitting the remainder of the experimental samples to orthodox fractionation.

The metallurgical research of the organisation is mainly of a physical character, and has been specially concerned of late with the metallography of the alloys of titanium. An investigation, by the hydrogen-pressure method, of the allotropic transformation in alloys of pure titanium with vanadium, chromium, manganese, iron, cobalt and nickel, respectively, has shown that the temperature is depressed by all these elements. Other work, on the effects of age-hardening on the mechanical properties of titanium when alloyed with 6 to 10 per cent. of iron, has revealed that, though these alloys are not hardened by quenching, they respond to subsequent heat treatment at temperatures between 350 deg. and 400 deg. C. The addition of oxygen to titanium has been found to raise the allotropic transformation temperature and to increase tensile strength, with some reduction of ductility. The absorption of oxygen and other gases by titanium has led to a research, now in hand, on the kinetics of gas reactions with this metal at various temperatures. In view of the great reactivity exhibited at temperatures above 500 deg. C., it is important to ascertain how titanium and its alloys will react at the high temperatures to which they may be exposed in engineering service. A new method has been developed for producing metallic titanium by the electrolysis of titanium trichloride, dissolved in a molten halide mixture. The only other metals to be specially studied during the year are lead alloys, for which the complex relationship between thallium content and creep rate, and the mechanism by which slow deformation occurs under prolonged stress, are the subjects of long-term research.

Those properties of metals which affect frictional and surface phenomena are the special study of the Tribophysics Division, which has recently acquired an electron-diffraction camera to assist its researches. These have included various practical aspects of

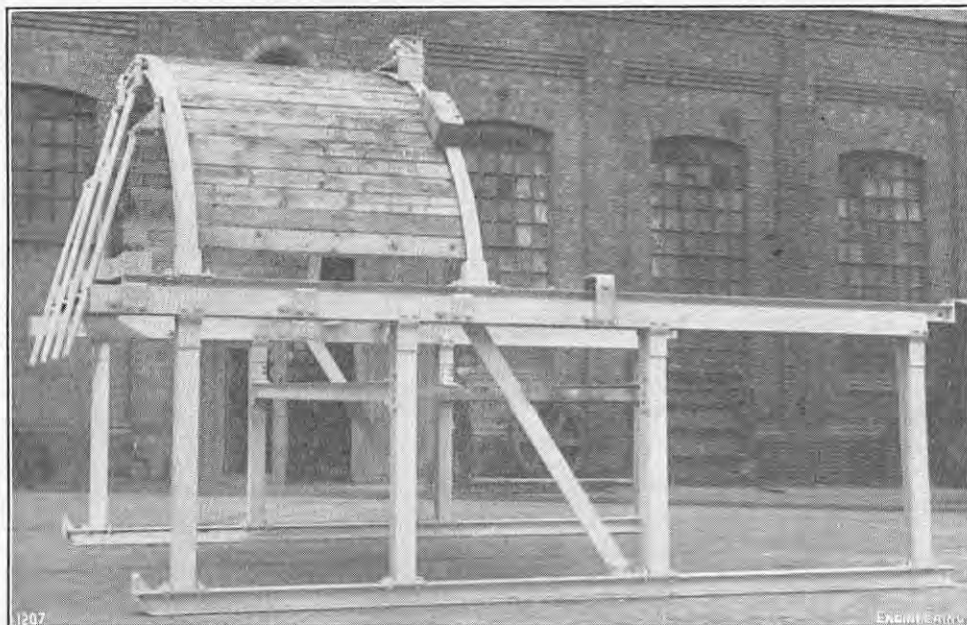
mechanical friction and lubrication, but the more fundamental work has been directed to the properties of surface films comprised of long-chain compounds, and the surface tension of solids. As exemplifying work of the more practical sort having immediate engineering applications, a precise evaluation of bearing performance has been completed over a wide range of operating conditions, showing that the maximum load-carrying capacity and the minimum friction of white-metal bearings can be achieved only with the highest geometrical accuracy of manufacture, associated with extremely careful alignment. From other lubrication experiments, in which the stability of the oil film between a piston ring and its cylinder wall is being appraised by continuous measurement of the electrical resistance of the film, it appears that, under normal warm-engine operating conditions, the oil film is maintained even though no more than a minute quantity of oil is present. The film, however, always breaks down with the change in direction of piston movement at top and bottom dead centres. The most adverse condition in a petrol engine is that of being started cold, when condensation of petrol on the cylinder walls may completely rupture the oil film and, for as long as several minutes, prevent its reformation. Similarly, it has been shown in the laboratory that an adsorbed water film on a polished metal surface has a considerable influence on the rate of spreading of oil.

The formation of surface films of polar long-chain substances on solid surfaces by adsorption from solution is being investigated by direct measurements on metal oxides, for which contamination difficulties are less troublesome than in the case of metals. The industrial technologies of powder metallurgy and sintering processes demand the fullest possible understanding of the surface energy of solids. This subject is being experimentally investigated, therefore, by measuring the length changes in fine wires under prolonged tension at high temperatures. Wires a few thousandths of an inch thick, extruded *in vacuo*, are maintained at a temperature slightly below the melting point, and the tensile force is measured which just balances the contraction due to surface tension. Electrolytic polishing is another industrially important technology, the basic mechanism of which had been under investigation for some years, and is still being studied. It appears from recent experiments that the polishing is due to the formation over the metal surface of an oxide film which becomes covered by a viscous liquid layer of the products of electrolysis. It follows, therefore, that the surface of an electrolytically polished metal surface is always, and inevitably, contaminated with oxide.

Also subject to long-term research are various aspects of metal physics associated with crystalline structure and plastic deformation, the special objectives here being to learn more than is known at present about the defects of crystalline lattices which give rise to dislocations, and about the crystal re-arrangements after plastic deformation. The lattice distortions due to deformation manifest themselves by a broadening of the lines in X-ray diagrams. To obtain more precise information about the exact shapes of such lines, a technique employing strictly monochromatic radiation is now being successfully employed, the resulting low-intensity X-ray lines being detected by Geiger counter spectrometers. From the line shape, the energy associated with lattice distortions can be calculated and is correlated with values obtained by direct measurements. The energy stored in the deformation of a metal is liberated by annealing and can be measured as the difference between the specific heats of a specimen in the deformed and fully-annealed conditions. To determine this very small difference, a highly sensitive method, involving a differential milliwattmeter and automatic temperature control within 0.1 deg. C., is giving results accurate to about 5 per cent., such that effects of the grain size of the metal, the characteristics of the deformation and the previous history of the specimen can be observed.

In another related research, the effects of cold work on electrical resistivity have been measured for wires of several metals and alloys, drawn at temperatures ranging from -183 deg. C. to +100

GATEHEAD PROTECTIVE CANOPY FOR MINES.



deg. C. and tested at the same temperatures. The general outcome has been to show that, the higher the temperature at which deformation (in these experiments due to drawing the wires) takes place, the smaller is the consequent increase of electrical resistivity. The reasonable explanation advanced is that, at high temperatures, the dislocations in the metal lattices are more mobile and can diffuse more readily out of the crystals. When resistivity is plotted against temperature, the curves for annealed and deformed wires are nearly parallel.

An associated, but more specific, investigation of the relative deformation of the phases in duplex brass has also been performed by drawing wires of widely varying composition, the temperature at which re-crystallisation begins being used as an index of the degree of deformation. The growth of new crystals during re-crystallisation of deformed metals has been examined by the use of polarised light, but was found too erratic, for reasons which are not clear and are being sought by an experimental attempt to correlate the inhomogeneity of deformation with the mode of re-crystallisation. The extremely rapid mode of phase change in metals which can occur, as in the hardening of steel by the formation of martensite, in such a way that no interchange takes place in the position of neighbouring atoms, has been studied by a new technique in which movement of the atoms during phase transformation is deduced from various observable features, notably change in external shape. The same technique is now being used to examine the effects on external shape of phase changes due to thermally activated diffusion. From such investigations of the order-disorder transformation in a copper-gold alloy, and of the precipitation in supersaturated copper-beryllium alloys, it appears that the mechanisms by which nucleation-growth, on the one hand, and transformations of the martensite type, on the other, may not differ very fundamentally.

Many researches of interest to engineers and physicists are associated with the Australian National Standards Laboratory, established in 1938 in the grounds of the University of Sydney, primarily to enable the Weights and Measures Administration of the Australian States to be based on unique Commonwealth standards. The statutory functions of the Laboratory, in maintaining, testing, and calibrating primary and sub-standard equipment, are carried out by the Divisions of Metrology, Physics and Electrotechnology, upon which devolve a good deal of experimental work as well as the duties of assisting industry and promoting the extended use of standard measures and practices throughout the Commonwealth. The Metrology Division, for instance, is expected to assist industrial education in such matters as the application of fine measurements to production engineering, or the

criticism of engineering designs. Examples of more specific assistance to industry include the examination of gear-hobbing machines, and the measurements of a gear, 12-ft. in diameter, and its mating pinion. A recent acquisition is a linear dividing engine, of 40 in. capacity, which has been used for ruling scales, gratitudes and surface-texture standards. Service to professional surveyors, some of whom are in State Departments, will shortly be increased by the completion, now in progress, of a geodetic base with which it will be possible to calibrate surveying tapes to the accuracy (of the order of one part in a million) requisite for triangulation base lines.

A paper due for publication in the near future describes the theory, experimental production and application of multiple-beam reflection interference fringes with transmission-like characteristics. This interferometric technique offers several important advantages over ordinary methods involving reflection fringes, and it has been studied in detail by the metrology staff, who have employed it with conspicuous success for vibration measurements and for problems in the structure of metal surfaces. Some of this admirable and valuable work doubtless owes its origin to the fact that practical experiments in Australia on wavelength standards of length are still delayed by the difficulty of obtaining, from overseas, materials for the construction of the essential apparatus. It is hoped that, very shortly, it may be possible to acquire some radiant sources of the artificially-produced isotope mercury 198, which will be used for the realisation of a length standard in terms of the wavelength of light.

An interesting metrological technique follows an investigation of the factors conducive to the buckling of thin specimens subjected to lapping operations. As the outcome, some slip gauges of nominal thicknesses 0.01 in. and 0.02 in. have been entirely machine-made, and are of the highest quality as regards flatness and parallelism of the measuring faces.

(To be continued).

ALMANACS AND CALENDARS.—Wall calendars with tear-off sheets showing on each the current month in heavy type, and the preceding and following months in smaller type, have reached us from the Allis-Chalmers Manufacturing Co., 728, Salisbury House, London Wall, London, E.C.2; Aveling-Barford Ltd., Invicta Works, Grantham, Lincolnshire; Brook Motors Ltd., Empress Works, Huddersfield; Davidson & Co., Ltd., Sirocco Engineering Works, Belfast; C. A. Parsons & Co., Ltd., Heaton Works, Newcastle-upon-Tyne, 6; A. V. Roe & Co., Ltd., Greengate, Middleton, Manchester; and G. Savitt & Sons, Ltd., 20, Brewer-street, London, W.1. A desk diary, having one week to each page, has been received from the British Oxygen Co., Ltd., Bridgewater House, Cleveland-row, St. James's, London, S.W.1.

GATEHEAD PROTECTIVE CANOPY FOR COAL MINES.

We illustrate on this page a gatehead safety canopy that has been developed at Gedling Colliery to give protection to men engaged on the work of taking down the rock ledge left behind by the advance of the coal face. When a new shallow seam is being worked, a rock ledge is left that has to be cut away so that a full-height roadway can be extended up to the working face. This locality, at the end of the gate road, is known as the gatehead, and there is always a danger of an accident at this point due to falling debris; temporary protection is therefore required until the permanent support can be erected. Prior to the introduction of the canopy, protection was obtained by lashing up a shield from materials to hand. It is claimed for the gatehead canopy that it provides the necessary temporary support and protection more quickly and easily than other possible methods.

The canopy comprises an undercarriage, fabricated from steel joists, supporting a sliding shield made from heavy timber slats spanning between two steel arches. A steel rack, hinged to the leading arch, gives support to the ripping face. The bottom members of the undercarriage are formed as skids to reduce the difficulty of pushing the whole frame forward to the rock ledge; where the floor of the road is clear and level this can be done by levering the frame but, where rougher conditions obtain, jacks are used, working off convenient skew-backs. After shot firing, the canopy is pushed into the unsupported area to give protection while the debris is cleared away to allow the framework to be moved forward and made ready for the next ripping shift. The permanent supports for the roof of the road are erected immediately behind the shield.

So far, four gatehead canopies have been built and are in use at Gelding Colliery, and as more become available their use will be extended throughout the East Midlands division of the National Coal Board. The canopy was developed by Mr. C. Round, until recently manager of the Gelding Colliery and now sub-area manager of No. 6 (Bestwood) Area, and Mr. C. K. Woodhead, a fitter at the colliery. The work of Mr. Round and Mr. Woodhead has been recognised by the Board's Awards Tribunal, who are empowered to make payments for inventions by members of the Board's staff.

EFFLUENT CHANNEL FORMED BY EXPLOSIVES.—By the use of explosives, Imperial Chemical Industries Ltd. have made a channel 8 ft. wide and 1,200 yards long near the mouth of the River Tees to carry away the effluent from their Wilton Works. Owing to the nature of the ground, it was not possible to construct the channel by conventional methods, and it was therefore decided to place explosives, about 2 ft. below the surface, along the whole length of the proposed route. The charges were fired simultaneously.

MARKING OF IMPORTED GOODS.—With the return to normal commercial competition, the law relating to the marking of imported goods, which lost much of its relevance in the abnormal conditions of the war-time and immediately post-war period, has regained its pre-war importance. Hence, the Board of Trade have issued regulations concerning the marking of imported goods, which regulations have recently come into full force again. A list of the goods which are the subject of Orders in Council can be obtained from the Board of Trade, Industrial and Manufacturing Department, Horse Guards-avenue, Whitehall, London, S.W.1.

COMBINED NESTING AND STACKING TRAYS.—We have received from Messrs. James Hustler and Son, Ltd., White Lund, Morecambe, Lancashire, particulars of their "Nestak Tote Box," for the holding and conveyance of stores, small components, etc. The boxes are rectangular in plan, with sloping sides and ends so that they can be nested when empty, and are fitted with carrying handles which can be turned inwards, in which position the handles serve as brackets to support another similar box, so enabling them to be stacked. The boxes are available in four sizes, and can be supplied in mild steel, light-alloy sheet, or perforated metal, suitable for use in degreasing or plating operations, etc.

THE IRON AND STEEL INSTITUTE.

(Continued from page 766.)

CONTINUING our report of the autumn general meeting of the Iron and Steel Institute, we deal with the afternoon session of Wednesday, November 26, which was devoted to the discussion of ten papers concerned with "The Thermodynamics of Steelmaking." The papers were presented during the morning session and were given in abstract form on page 765, *ante*.

THE THERMODYNAMICS OF STEELMAKING.

Mr. W. A. Cameron, who opened the discussion, stated that Mr. A. Jackson's paper, from the details given of modern mixer practice and the record of experimental work on the treatment of molten metal between the blast furnace and the mixer, was of immediate value to the industry. It was interesting to note that recent results given indicated that the work done in the mixer was equivalent to a reduction in the metallurgical load in the open-hearth furnace of about 40 per cent. This was based on potential slag volume when using mixer metal as compared with direct blast-furnace iron, assuming that no primary slag was removed. A reduction of this order should mean increased output from steel-making furnaces, which would vary with the iron burden used, being probably negligible at 30 per cent., or under, but reaching the value of 25 per cent. given by Mr. Jackson on a 75-per cent. hot-metal burden.

Mr. R. W. Evans stated that in spite of the progress made in elucidating the physics and chemistry of processes at high temperature, steel-making was still largely an art and not a science. The perfection of flow and temperature measuring techniques had enabled operators to exercise more control, but even now, some 80 years after the first heats had been made in Bessemer converters and in open-hearth furnaces, steel metallurgists were still far from being able to make their results scientifically reproducible. Surely, therefore, the steelmaker, above all other manufacturers, had a need of exact qualitative and quantitative knowledge of the high-temperature reactions which governed the efficiency and economy of his processes. One of the difficulties, however, was to transfer fundamental conceptions and results to practical applications in the steelmaking processes. It must be borne in mind that a great deal of work was now being done all over the steelmaking world on these problems. Thus it was necessary that steel men should have means of making quick and accurate measurements and analyses if they were to avoid a situation developing in which a large amount of useful knowledge was available but they were unable to put it to practical use.

The average open-hearth operator had not the time, nor in many cases was he equipped technically, to deal with conceptions such as were embodied in the papers on thermodynamics. Consequently, another step must be taken, also at a fairly high theoretical level, by which these conceptions could be translated into ideas which would definitely help the open-hearth operator. Referring first to the paper by Dr. N. C. Tombs and Dr. A. J. E. Welch, it seemed possible, in an open-hearth furnace, for the silica roof material to be dissipated as gaseous silicon monoxide. There was some evidence in practice that this did take place. For instance, a silica roof wore rapidly in a reducing atmosphere, and in the early stages of working on a 150-ton furnace, fired with 100 per cent. cold coke-oven gas, the interior surface of the roof rapidly disappeared. It was puzzling to know where it had gone, as the slag composition did not confirm that it had all dropped into the bath. It might have been evolved as SiO which was later re-oxidised to silica. If this were possible, it would add greatly to knowledge of this very worrying feature of silica roof wear. The free energy of formation of tetracalcium phosphate was the subject of a research described in a paper by Dr. J. B. Bookey. This by itself was of no more use to the open-hearth manager than the nitrogen in his combustion air; it would be the further steps, making

use of these important constants, which would shed light on practical applications, so that he looked forward to developments in this work. Turning to the paper on "The Free Energy of Formation of Magnesium Phosphate," also by Dr. Bookey, the practical problem was here stated with greater clarity. Despite numerous investigations of the equilibria between liquid iron, containing phosphorus, and slag of various complex constitutions, the relative roles of lime and magnesia in effecting dephosphorisation were still not clear. It would be an advantage to elucidate this question.

As a practical man, he viewed the two papers on soda slags with certain misgivings, bearing in mind the bad effect of soda on almost all steelworks refractories. The paper on the thermodynamics of sulphides, by Dr. F. D. Richardson and Mr. J. H. E. Jeffes, again provided knowledge which would be useful if further steps could be taken to elucidate the mechanism of desulphurisation in the steel-making processes.

Mr. D. A. Oliver stated that, sooner or later, the practical steelmaker would have to become accustomed to thermodynamic notation. It was, however, a tragedy that thermodynamics had managed, somehow or other, to "give birth to about three kinds of algebra," and various authors used different symbols. These problems were holding up advance in application.

In their general conclusions, Dr. Tombs and Dr. Welch stated that the results now reported established that silicon monoxide might be expected as a normal product of reduction of silica (or silicates) at temperatures in and above the steelmaking range, and the thermodynamic data given were sufficient to predict the behaviour of silicon monoxide in at least the simpler reactions. Unfortunately, commented Mr. Oliver, the steelmaker did not have simple reactions, and, in view of the increased use of the oxygen lance, he might expect to get far more of this silicon monoxide in the future than he had ever had in the past.

Mr. P. Walker asked Mr. Jackson two questions, namely, what was the minimum amount of manganese which he would consider as suitable for his process, and what modifications, if any, did he make in his practice, either at the blast furnaces or in the melting shop, when his active mixer was off for repairs. The next speaker, Mr. V. Giedroye, said it was clear that it could not be expected that an active mixer could play two roles, to remove silicon and to desulphurise the iron. It was true that flotation of manganese sulphide could lower sulphur in the metal, but this method was expensive and wasteful. It became increasingly important, therefore, to remove sulphur before the metal was transferred to the mixer. Many steel plants were already doing this by using the soda-ash process with varying degrees of success. An alternative method of desulphurisation using solid lime would seem to be more satisfactory, but had not yet been sufficiently tried on a works scale. Not only could the problem of sulphur removal be solved by the use of solid lime but also the other problem, that of blast-furnace slag finding its way into the mixer. Mr. Jackson had emphasised the deleterious effect of this slag. If a teapot ladle, filled with lime coated coke or some similar material, were placed between the transfer ladle and the blast-furnace runner, not only was a considerable degree of desulphurisation achieved, but also all traces of blast-furnace slag were removed. Desulphurisation by soda ash was widely used, but its application was not really standardised, so that it was often the source of trouble. Some firms used soda-ash mixed with lime as a desulphurising agent. In the light of the work of Dr. W. R. Maddocks and Dr. E. T. Turkdogan, this practice seemed to be correct, since, when a limey slag was formed, the unreacted sodium oxide could not be retained and was at least partially volatilised. In this way the destruction of the open-hearth roof could be diminished. It would certainly be useful to investigate what were the optimum conditions for the soda-ash process.

Dr. A. H. Leckie stated that the connection between Mr. Jackson's paper and the others was really very much closer than most persons would gather from the discussion. Magnesium would desulphurise iron very effectively, but apparently

it was too costly, even when the reaction was calmed down a little by adding lime. That was also, probably, the main objection to calcium. Both calcium and magnesium had boiling points rather close to the temperature of the pig iron, so that they vaporised readily. Cerium had a higher boiling point, and that was why it was possible to get it into the iron rather more readily, as Mr. H. Morrogh had done in his nodular-iron experiments. If steel men wanted to use cerium, supplies might be easier to obtain than in the past.

Dr. T. P. Colclough said that the day constituted a milestone for a great deal of work which B.I.S.R.A. investigators had been doing over the last five years, and it was satisfactory that the work had reached a stage at which the data collected were precise enough for some practical lessons to be learned from them. By reading Mr. Jackson's paper, steelmen had a very much better picture of what was happening in mixers than was the case two or three years ago. It was of particular importance to note the emphasis which had been put on the fact that it was apparently impossible, in a mixer to desiliconise and desulphurise at the same time. In view of the growing amount of pig iron which must be used per ton of steel made, it became of increasing importance to focus attention on methods of encompassing, probably separately, a reduction of silicon and a reduction of sulphur.

Mr. D. J. O. Brandt stated that Mr. Jackson had shown that it was not easy to desiliconise with oxygen or iron-oxide scale in the ladle or in the mixer owing to mechanical difficulties, and he had said that if he tried lancing oxygen into the ladle there was considerable difficulty with fumes. Up to a point, these difficulties had been overcome on a small scale, and it had been done very successfully by Mr. Emrys Davies, at the works of the Brymbo Steel Company, where the shop had to be operated on direct metal because there was no mixer. Brymbo had a small blast furnace which yielded only 18 to 20 tons at each tap and made about 100 tons a day. The open-hearth furnaces were of between 40 and 80 tons capacity. Each furnace took about 20 tons of hot metal, and the rest of the pig charge was added cold, the remainder, about 50 per cent., being scrap. Over the past year there had been successfully developed a system of desiliconisation in a special transfer ladle, using an oxygen lance, before the metal went into the open-hearth furnace. By means of the oxygen lance, the silicon, which, to begin with, was between 1.2 and 1.3 per cent., was brought down to about 0.5 per cent. About one-quarter to one-third of the manganese, which was usually from 1.2 to 1.3 per cent. to start with, was lost, but quite considerable and very useful sulphur elimination was obtained at the same time. This was chiefly due to the fact that, before the metal was charged to the transfer ladle, some limestone was put in the bottom, with a little fluorspar.

Dr. F. D. Richardson, in a brief reply to the discussion, said that there was no other way of representing all the data than by heats, entropies and free energies, and the industry would reap the benefit of all this work when the new, young metallurgists who were learning their subject in this way went into the works, where they could use, in solving their problems, the information which was being built up. It would not solve a problem immediately, but it would indicate the lines along which to find a solution. Mr. Evans had referred to the roof wearing away owing to SiO formation. If there were unburned CO in contact with the roof, as for instance if the ratio CO : CO₂ was 100 : 1, and with large volumes of gas passing, quite large proportions could obviously be carried away. Mr. A. Jackson also briefly replied and the meeting was adjourned until the following morning.

(To be continued.)

BANKSIDE POWER STATION.—The British Electricity Authority announce that the first two oil-fired boilers and the initial 60-MW generating set in the new Bankside power station in London will begin commercial operation within the next few weeks and will provide a limited amount of electricity at periods of heavy demand during the winter. Owing to difficulties in obtaining cast-iron casings, the flue-gas washing plant will not be ready for three or four months.

THE SMITHFIELD SHOW.



FIG. 11. "MAJOR" COMMERCIAL TRACTOR; FORD MOTOR CO., LTD.

THE SMITHFIELD SHOW
AND AGRICULTURAL
MACHINERY EXHIBITION.

(Concluded from page 757.)

THE Smithfield Show and Agricultural Machinery Exhibition, which closed on the evening of Friday last, December 12, was made the occasion by several manufacturers for the introduction of new machinery. The Ford Motor Company, Limited, Dagenham, Essex, were showing for the first time a new version of their Fordson Major tractor. Known as the Fordson Major commercial tractor, the new machine, as its name suggests, has been developed to meet the requirements of commercial users and is suitable for haulage duties in factories, docks, jetties, etc., and for shunting operations on railway sidings. The commercial tractor is illustrated in Fig. 11, above, from which it will be seen that it bears a close resemblance to its agricultural predecessor. It can be fitted with either a Diesel or petrol engine, the former developing 40.5 h.p. and the latter 39.5 h.p. at 1,600 r.p.m. There are six forward gears, the ratios of which are designed to give speeds of from less than 1 mile an hour to more than 14 miles an hour. There are high and low reverse ratios, the latter being particularly suitable for manoeuvring in confined spaces. The tractor is fitted with foot and hand brakes, the former acting on the rear wheels and the latter on the transmission. The footbrake is specially powerful, the brake drums having a diameter of 14 in. and a width of 2½ in. Particular attention has been paid to the design of the drawbar attachment, which combines a simple automatic hitch with a spring to obviate snatch when taking up the load and is arranged so that there is no need for the driver to leave his seat when coupling or uncoupling.

TRACTOR-HAULED COMBINE HARVESTER.

Marshall, Sons and Company, Limited, Gainsborough, were showing their new combine harvester. This machine, which is known as the model 626, is illustrated in Fig. 12, on page 792. It is a tractor-hauled engine-driven unit having a 6-ft. cut and a 3-ft. wide threshing drum. The four-bladed reel is engine-driven and its position is adjustable both horizontally and vertically. The cutting range is from 2 in. to 20 in. and the header is spring-balanced so that it rides uneven ground and returns automatically to the preset cutting height. The crop is fed by an auger on to a short central canvas

3 ft. wide, from which it is taken by a chain-and-rake elevator to a beater which, in turn, feeds the drum. This has a diameter of 18 in. and incorporates eight ribbed-type beater bars, the normal drum speed being 1,320 r.p.m. An alternative sprocket is available, which, when installed, gives a drum speed of 730 r.p.m. A wired-type concave is used; this has 10 bars and blanking plates are supplied for small seeds. The riddles, casings and trays are longitudinally divided to give even dressing by air blast, particularly on hillsides or sloping ground. There are three bagging spouts, two for best-quality grain and one for small seeds and dust. The machine is driven by a Ford petrol engine developing 20 brake horse-power at 2,250 r.p.m., the governed speed.

SELF-PROPELLED COMBINE HARVESTER.

Massey-Harris, Limited, Barton Dock-road, Stretford, Manchester, were also showing a new combine harvester, but in this case a self-propelled unit. Known as the No. 780, the new unit, which is illustrated in Fig. 13, on page 792, has a width of cut of 12 ft. It is driven by an Austin six-cylinder or Morris four-cylinder petrol engine, both of which develop 56 brake horse-power at the governed speed. The drum, which is of the rasp-bar type, has a width of 32 in. and a diameter of 22 in. and the standard sprockets give speeds of 790 r.p.m., 900 r.p.m., and 1,040 r.p.m. Other sprockets are available, however, to give speeds of from 380 r.p.m. to 1,160 r.p.m. There are four straw washers 37-in. wide and an escape grid is fitted between the concave and straw washers to allow grain to fall through to the grain pan instead of on to the straw walker. The table is fitted with a feathering auger which directs the cut crop into a three-chain vertical elevator, and can be adjusted in height electrically from 2 in. to 28 in. There are 24 speeds which give a speed variation of from 1 to 7 miles an hour. Extra equipment available with the machine includes a pick-up reel, pick-up attachment, straw spreader and a Raussen-dorf press.

FIGHTER AIRCRAFT WITH "SAPPHIRE" ENGINE.—The first Hunter fighter aircraft, designed and constructed by the Hawker Aircraft Co. Ltd., Canbury Park-road, Kingston-on-Thames, to be fitted with a Sapphire jet engine, has recently made its maiden flight. The Sapphire axial-flow jet engine is designed and constructed by Armstrong Siddeley Motors Ltd., Coventry, and an earlier mark of this engine has been type-tested at a static thrust of 8,300 lb. The Hunter F2, it is stated by the Hawker company, is faster than the Mark 1 Hunter.

HIGH-SPEED TESTING OF
AIRCRAFT TYRES.

For many years, the Dunlop Rubber Company have used, at their works at Fort Dunlop, Birmingham, a special type of machine for testing, at speeds up to 420 miles an hour, racing tyres for motor cars. Tyres designed for this purpose have a low "drag" or rolling resistance, and are comparatively lightly loaded, so that adequate power for testing can be provided by a 150-h.p. electric motor. Aeroplane tyres, however, are subjected to different working conditions, involving a combination of loading and speed which made it impracticable to use the existing machine for testing them, or to redesign it for that purpose. This is particularly the case with tyres intended for use on modern jet aircraft, with high landing speeds, which impose on the tyres a very rapid acceleration of rotation together with heavy loading. The firm have therefore designed and constructed an entirely new testing machine, stated to be the fastest of its kind in the world, which can test tyres at speeds up to 300 miles an hour, under loads up to 8 tons. It is capable of dealing with tyres ranging in size from 17 in. to 37 in. tread diameter, at revolutions up to 3,000 a minute, and can reproduce all the landing, taxi-ing and take-off conditions likely to be encountered by the tyres of present and prototype jet aircraft.

As can be seen from Figs. 1 to 4, on pages 788 and 789, the machine has two parallel axles on which are mounted the wheels carrying the tyres under test, and which can be pressed together while being driven through gearing by a Rolls-Royce Merlin 724.S aero-engine, having a maximum output of 1,725 brake horse-power at 3,000 revolutions per minute and a boost pressure of 20 lb. per square inch. With 14 lb. boost, the engine has a continuous output of 1,300 brake horse-power at 2,850 r.p.m. It is provided with oil and coolant heat-exchangers and a water-cooled exhaust system. As the airscrew shaft of the engine runs at 0.42 of the crankshaft speed, it is connected by a torque tube to a speed-increasing gear, with a ratio of 0.42 to 1, so that the testing machine is driven at the crankshaft speed.

The engine is started by means of a portable rectifier equipment. The controls are arranged to produce a direct movement of the boost-control lever at speeds from zero to 1,000 r.p.m. for various test conditions, and for starting and warming-up the engine. Between 1,000 and 3,000 r.p.m., the throttle is controlled through the medium of a de Havilland airscrew constant-speed unit, which delivers oil to a servo-cylinder forming part of the throttle link. Any change of load between 1,000 and 3,000 r.p.m. therefore results in an automatic opening or closing of the throttle, so as to maintain a constant crankshaft speed. To deal with accidental over-speeding, there is an electronic cut-off in the magneto circuits which earths both magnetos when a crankshaft speed of 3,080 r.p.m. is attained.

In contrast to racing-car tyres, aircraft tyres, as a result of their light construction and their high deflection when running, have high rolling-resistance or "drag" characteristics. This is the reason for the use of an engine of such high power; at a steady speed of 240 m.p.h., for example, the largest tyre that can be tested on the machine would require more than 500 h.p. to drive it. The sudden application of a drag load of this magnitude—such as might occur during a landing test—requires a large reserve of power to ensure a reasonably constant speed; and a considerable excess of power is needed, also, to produce the desired acceleration when running loaded. The use of an engine such as the Rolls-Royce Merlin under such conditions offers substantial advantages; it is small in size, gives the required speeds with a minimum of gearing, provides an extremely flexible drive, and is a self-contained unit; whereas an electric-motor drive would have been more expensive and would have increased the peak load on the factory system by some 10 per cent. and without giving the speed variations needed in testing aircraft tyres.

Hitherto, the only available method of securing actual performance data from tyres under the

TESTING MACHINE FOR AIRCRAFT TYRES.

THE DUNLOP RUBBER COMPANY, LIMITED, BIRMINGHAM.

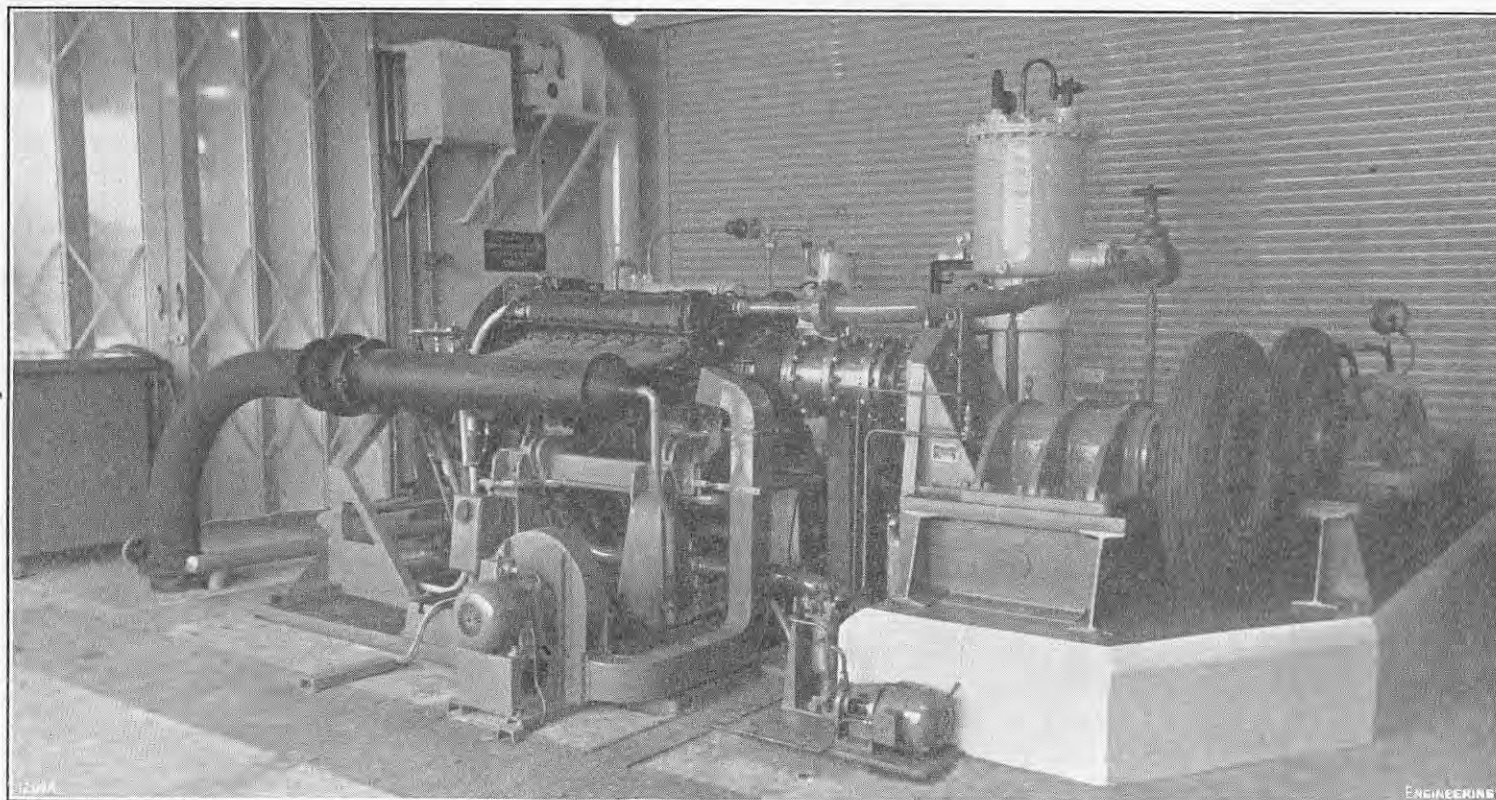


FIG. 1. VIEW OF MACHINE FROM DRIVING SIDE.

extreme conditions imposed by high-speed aircraft has been to test them in actual service, the results of which are far from precise. With the new machine, tests can be undertaken quickly, under reproducible conditions, and in complete safety. With the controls provided—which are grouped on a main panel in the control room, as shown in Fig. 4—it is possible to simulate automatically all stages of a landing-test sequence, namely, impact loading, load relief or “float” of the aircraft, and the resumption of the load, equivalent to the static weight of the aircraft as it rolls to a standstill, over periods corresponding to those actually experienced on a landing strip. In addition, many aspects of tyre behaviour can be studied, under running conditions, which it would be difficult to observe in actual service, such as centrifugal growth, tyre distortion during impact, wave phenomena, and tyre deflection as a result of centrifugal stresses. The tyres are loaded by a pneumatic cylinder, operating at 300 lb. per square inch. Two tyres are tested in contact, one wheel and tyre being mounted on an overhung power-driven spindle (a nickel-steel forging) and the other on a “dead” spindle, mounted on the saddle of the machine. Both wheels run on S.K.F. self-aligning roller bearings.

The tests which will be undertaken on the new machine fall into three categories, namely, take-off cycles, landing tests, and taxiing tests. In the first-mentioned series, the tyres will be fully loaded against each other and will be accelerated to the take-off speed, the load being decreased meanwhile to zero; but there will be one departure from a strict simulation of actual practice in that the tests of the larger types will start from a slow running speed and not from rest. This is necessary to avoid the risk of indenting the bearing races of the driving spindle by applying a heavy static load.

In the landing tests, the driving tyre, representing the ground, is set spinning at landing speed; the idler tyre, at rest, is then rammed against the driven tyre for a short period, retracted for a further short period to simulate “float,” and then reloaded during the run-down period. Automatic timers can be pre-set to govern the three stages of this test cycle. With pneumatic loading, it is not possible to reproduce the landing cycle exactly, as the initial bounce of the cycle takes between two and three seconds on the machine, but rather less than that in

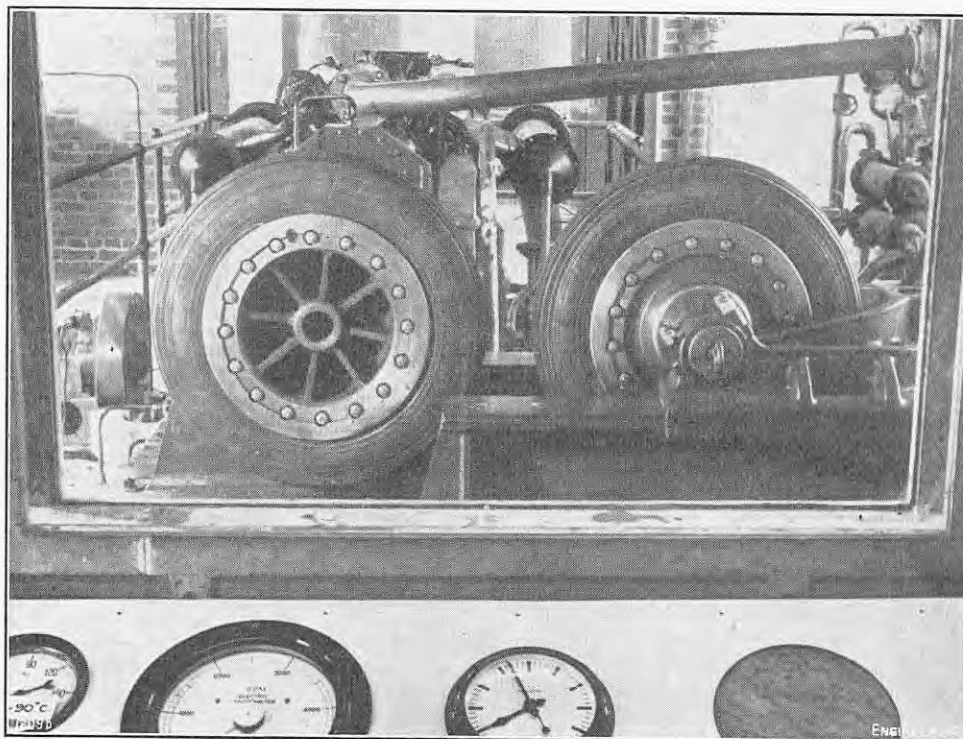


FIG. 2. TYRES MOUNTED ON MACHINE.

service. This difference is not important, as what is wanted is to produce the high shear stresses in the tyre when it is instantaneously jerked from rest to landing speed, together with the ensuing high impulsive load. Considering this part of the cycle only, the machine test is probably more severe than the tyre would encounter in practice, because of the longer period at maximum landing speed. During the running-down part of the landing cycle, the test departs from reality in that the engine is used to bring the tyres to rest; this is unavoidable, as it would be impracticable to brake the idler wheel against the driving wheel, i.e., against the engine. The machine was not designed to carry out any form of braking or energy absorption tests.

Taxiing tests are carried out at relatively slow

speeds under full load, with brief acceleration bursts. These tests are generally of longer duration than the take-off or landing cycles, as they represent a major part of the time, during the life of a tyre, when it is undergoing heavy flexing stresses. The tests proposed at present have been designed on the basis of speeds and tyre loadings as specified for the appropriate aircraft. Some of these aircraft being in the early prototype stage, it is likely that the testing speeds may be rather higher than will be regularly attained in service. The tests will enable a rapid assessment to be made of casing structural performance, tread-to-casing bond strength, bead movement, tyre growth, and temperature generation, in addition to the features of performance already mentioned.

TESTING MACHINE FOR AIRCRAFT TYRES.

THE DUNLOP RUBBER COMPANY, LIMITED, BIRMINGHAM.

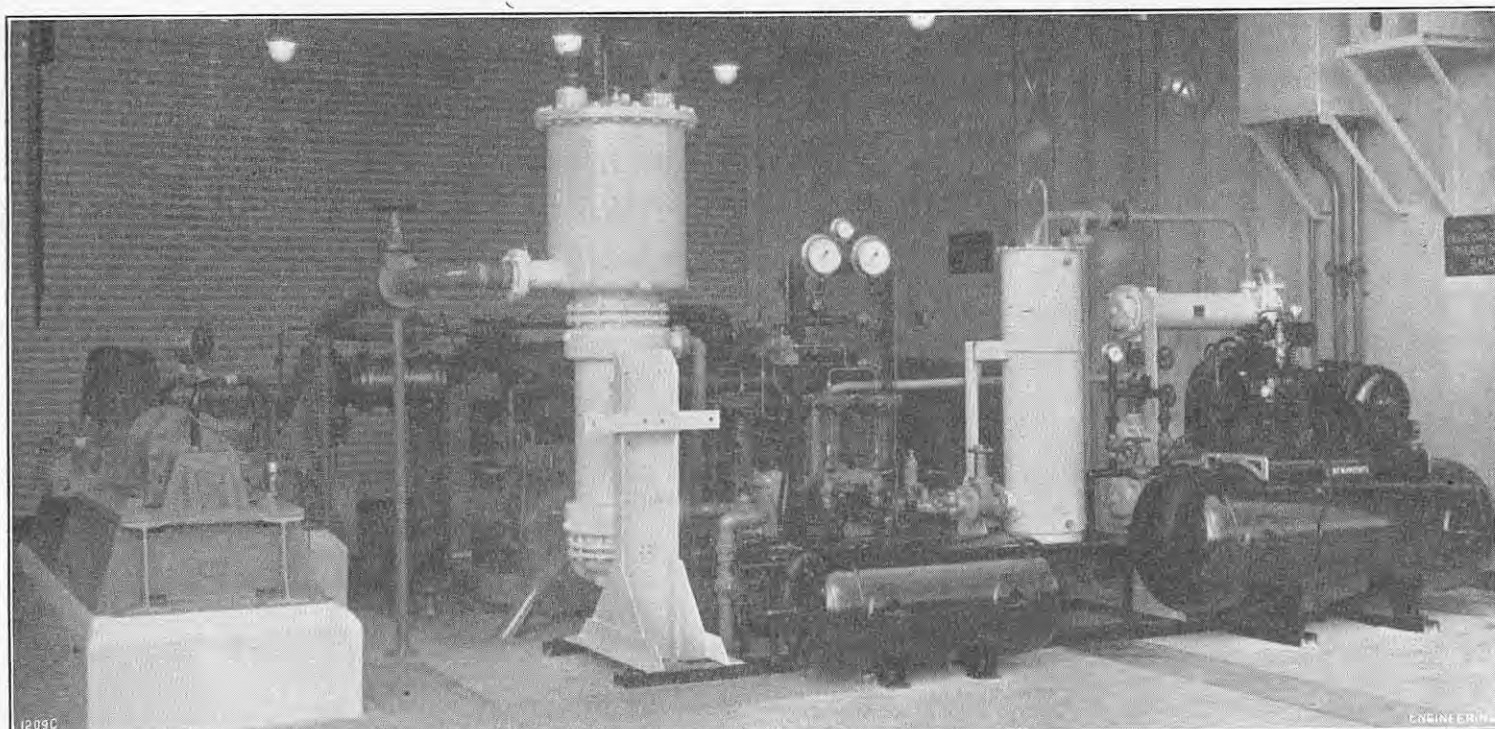


FIG. 3. COMPRESSORS AND HEAT EXCHANGERS.

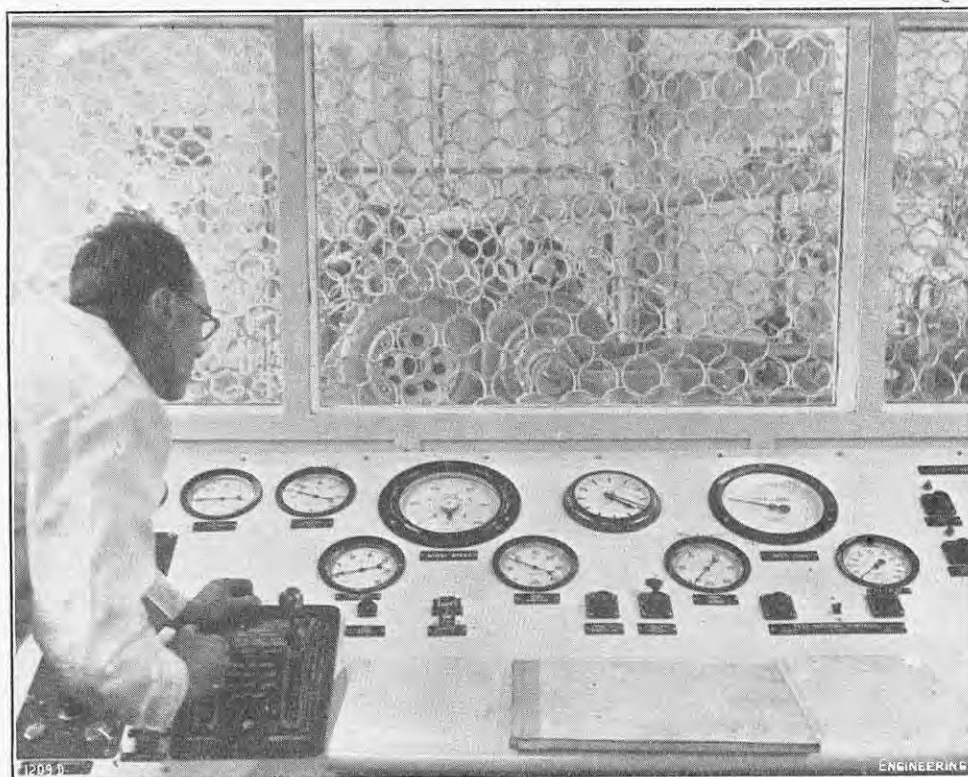


FIG. 4. VIEW THROUGH OBSERVATION WINDOW, SHOWING PROTECTIVE NETTING.

The results of the tests will indicate, of course, how the tyres may be developed, but the immediate consideration is to perfect the machine itself. Developments are pending in three directions. Electronic equipment has been installed to enable approach velocities of the idler tyre to be measured. It will also enable some measurements to be made of tyre deflection and centrifugal growth, pending the installation of optical equipment early in the New Year. Secondly, alterations are to be made to the compressed-air circuit. At present, the idling tyre is loaded on to the driven tyre by supplying compressed air to the loading cylinder from two inter-connected air receivers, charged by a continuously-running air compressor. It is proposed to modify the compressed-air circuit to give two leading pressures; by this means, a

heavier "bump" load will be possible for the first part of the landing, to be followed by the remainder of the cycle as previously outlined. This is an essential step, as the idler tyre assembly has much less inertia than a landing aircraft.

The rate of loading or retraction of the tyres is governed by adjustment of the control valves on the air supply. These valves are situated at present in the engine room and a modification is in hand to allow valve adjustments to be made from the control room. Adjustments during test-cycles will ultimately be made in unison with the automatic cycle-timing apparatus. Special steel wheels were designed to avoid wheel failures during the tyre tests. As a precaution, the wheels were tested up to 4,200 r.p.m. to ensure safety from centrifugal stresses developed during high-speed

running. The equipment includes a range of idler spindles to accommodate actual aircraft wheels for all the tyre sizes to be tested. It is not intended to mount aircraft wheels on the driving member.

The use of solid steel wheels imposes enormous shear stresses on the tyre during the initial impact of the landing test, due to the very high inertia of the wheels. Precise calculations of the instantaneous torque necessary to jerk the idler tyre into motion are not possible at this stage, but the magnitude is such that the engine speed, without the constant speed unit, is brought down from near its maximum speed almost to stalling speed. Using a standard aircraft wheel for the idler type under the same conditions, the effect on engine speed is very small. Tread wear has already been shown to be rapid under landing test conditions when using the steel wheels.

The test house is comparatively small, having a floor area of only 950 sq. ft. Its main part, that containing the Rolls-Royce engine and the test machine, has walls of reinforced brickwork, 13½ in. thick, and a reinforced-concrete roof slab 6 in. thick, to withstand the vibration from the engine and machine, and as a safety measure in case the test wheel and tyre should fly into pieces from centrifugal force or excessive pressure.

The observation window consists of two sheets of armoured plate-glass, 1 in. and ¾ in. thick, respectively, set in a steel frame. In addition, to minimise the danger of damage from bursting tyres or wheels, a heavy curtain of 4-in. grommet torpedo netting, extending from floor to ceiling, surrounds the tyre mountings on the machine to protect the engine and equipment, and those working on it. This can be seen in Fig. 4. The engine bed was made 9 ft. 6 in. deep, in concrete. The foundation was designed on generous lines because of the large amount of vibration and over-turning effect, due to the spinning and pressure of the test tyre. When a test is in progress, the two large roller shutters, 11 ft. 6 in. high by 22 ft. long, forming almost the entire length of the two side walls, are opened in order to dissipate the effects of blast. In view of the possibility of the tyres catching fire and of the dangers arising from the use of high-octane fuel, an elaborate CO₂ fire-prevention system has been installed. It is operated from the control room and can envelop the engine and tyres, and fill the service trenches, with CO₂ vapour. The CO₂ is supplied from bottles in the engine room.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

NEED FOR HIGHLY-SKILLED CRAFTSMEN.—The engineering industry in Britain was not being supplied with a sufficient number of highly-skilled craftsmen, in spite of the vast sums now spent on education, said Dr. D. Rebbeck, a director of Harland and Wolff, Ltd., at the annual presentation, in Glasgow, on December 6, of awards to apprentices attached to the firm's Diesel-engine works. That fact was affecting high-management policy as well as the design of machines, and the main aim in many organisations was to plan production programmes so that the work could be done by unskilled or semi-skilled persons. If such a policy were pursued in Britain for a sufficiently long time, he added, the skill of the people would deteriorate and a manufacturing system would be created which could be copied by nations having a low standard of living, to this country's grievous harm.

EDINBURGH'S WATER SUPPLY.—The potential supply of Edinburgh's water undertaking was increased by 6,000,000 gallons a day on December 5, when the chairman of the water committee, Councillor Walter Gerrard, performed the opening ceremony of the first phase of the 365,000l. Fruid-Menzion scheme in the Peeblesshire hills. The daily output for the city now reaches a figure of 39,500,000 gallons. The scheme has taken three years to reach its present stage.

VEHICLE MANUFACTURE AT NEWHOUSE.—The factory at Newhouse Industrial Estate owned by Euclid (Great Britain), Ltd., is to be extended to about one and a half times its present size. Work will begin in the spring and production should start in September, 1954. The company manufacture heavy vehicles designed by the American parent firm, and used mainly by public works contractors. Their extension policy, which they hope to complete by 1956, will give them an annual output of 600 vehicles.

FORTH ROAD BRIDGE.—The Forth Road Bridge Joint Board have estimated a capital expenditure of 118,000l. for the year to May 28, 1953, it was reported on December 10, at a meeting of Midlothian County Council. It was also stated that considerable progress had been made during the year with the preparation of plans for the roads and roundabouts on the north side of the River Forth. Drawings for the foundation works were also well advanced and could be made ready within three months for the letting of contracts.

EXTENSIONS AT ROTHESAY HARBOUR.—On December 8, Rothesay Harbour Trust deferred to a special meeting, to be held within a fortnight, proposals put forward by the harbour committee for the erection of new pier buildings at an estimated cost of 50,000l., and for extension of the West Pier at an estimated cost of 35,000l.

INVERNESS-BLACK ISLE FERRY.—A recommendation that a relief vessel should be acquired, to be built at Fraserburgh at a cost of 7,985l., and having sheltered accommodation for 75 passengers and a turntable capable of handling four medium-sized cars or one lorry of a maximum weight of 8 tons, has been made by the Kessock Ferry Joint Committee to Inverness Town Council and Ross County Council, joint owners of the ferry linking Inverness with the Black Isle in Ross-shire. The service is maintained at present by the Eilean Dubh, built two years ago, and a small vessel for foot and cycle passengers only.

CLEVELAND AND THE NORTHERN COUNTIES.

BY-PRODUCT STEAM AT TYNE WORKS.—Owing to delay in obtaining delivery of the necessary materials, a scheme proposed by Imperial Chemical Industries Ltd., to reduce the electricity consumption of the firm's Prudhoe-on-Tyne works from the national grid is not likely to be completed until the end of next year. The company propose to use steam from a sulphate of ammonia drying plant to operate a turbo-generator. At present the works take about 15,000 units hourly from the grid, which, in future, will be supplied from the plant. The consequent saving in production costs, it is estimated, should repay the outlay within two years.

SHIPBUILDING ECONOMICS.—In his speech when presenting prizes to the firm's apprentices, Lieut.-Colonel T. E. Smith, managing director of Smith's Dock Co. Ltd., South Bank-on-Tees, urged a reduction in the number of man-hours needed to build a ship. After referring to the firm's full order book, he gave a

warning that if, at the end of the boom, they were not producing the most economically-built ships, they had no hopes of getting orders in a slack time. Lieut.-Colonel Smith added that Smith's Docks would begin work shortly on a tanker of 18,000 tons, the biggest ship yet built at the yard.

COLLIERY DEVELOPMENTS AT TYNEMOUTH.—Coal drawing is expected to commence soon at the new Rake Lane drift of the National Coal Board at Tyne-mouth. About 130 miners will be employed and the output will be 200 tons a day. The Coal Board have been granted permission by Tynemouth Corporation to sink boreholes south of Shiremoor to determine the characteristics of the underlying seams. The Board state that the boreholes are not connected with any plans for further coal workings in the Tynemouth area.

HOLIDAYS IN SHIP REPAIRING YARDS.—Tyne ship-repairing employers have discussed with local officials of the Confederation of Shipbuilding and Engineering Unions, the employers' proposals for an alteration in the annual-holiday arrangements in repair yards. Instead of the yards being closed down completely for the two weeks' annual holiday, the employers suggest that the holiday should be staggered among groups of employees. This would allow repair work to be maintained without interruption. The employees are expected to agree to the proposal.

RYHOPE COLLIERY REORGANISATION.—The Durham Divisional Coal Board have modified a reorganisation plan at Ryhope Colliery near Sunderland, following opposition to the original proposals from the men. Under the first proposals, about 156 miners would have become redundant and another 94 would have been transferred to other collieries. The revised plans provide for the transfer of 59 miners to neighbouring pits and the paying-off of 18 miners over the age of 65. After the reorganisation, Ryhope Colliery will work two shifts a day instead of three.

LABOUR TROUBLE AT GATESHEAD WORKS.—After a one-day stoppage, employees in the pneumatic-tool section of the Close Works of Sir W. G. Armstrong, Whitworth and Co. Ltd., Gateshead, have returned to work. The men, it is understood, objected to a chargehand being employed to demonstrate a particular machine, and also to the piece rates proposed by the firm for a certain job. The strikers went back to work to allow the matter to be investigated by the Amalgamated Engineering Union.

LANCASHIRE AND SOUTH YORKSHIRE.

SHORT-TIME WORKING.—As a result of a contraction in trade, a number of employees, including melters, forgers, rollers and helpers, are on short time in the special-steel trades of Sheffield. Steelmakers believe that the number will be extended unless trade is freed from the controls and restrictions which, it is urged, hinder the expansion of home and foreign business.

STEEL PRODUCTION.—At the works of the Steel, Peech and Tozer branch of the United Steel Companies, Ltd., the weekly production from the steel furnaces in November, at 15,635 tons, was 55 tons a week less than the 1950 average. At the Ickles wheel mill, however, where modernised plant has been installed, production has risen from 655 tons a week in 1950 to 1,003 tons a week this year. At the Templeborough bar mill the output has gone up by another 100 tons a week.

HIGH STEEL SALES.—Mr. Frank A. Hurst, chairman and managing director of Samuel Osborn & Co. Ltd., Sheffield, has stated that the highest sales total in the history of the company has been achieved in the present financial year; but, he added, already there is evidence of a recession in trade. Mr. Hurst, who has been with the firm for 55 years, recently presided at a ceremony at which Lady Osborn made presentations to 33 employees of 50 years' service or more.

THE MIDLANDS.

RURAL WATER SUPPLIES IN WORCESTERSHIRE.—A test borehole is being sunk at Astley, Worcestershire, for Martley Rural District Council, to prove water supplies at an estimated depth of 450 ft. Only 5 per cent. of the houses in the district have a piped water supply at present, and the wells from which the remainder of the area's supplies is drawn produce water of doubtful quality. When the water is reached by the new borehole, a pumping test of 14 days' duration will be carried out, and if the quantity available is satisfactory, approval will be sought for the completion of the scheme. This will involve the sinking of a second borehole, the construction of three small reservoirs,

and the laying of the necessary mains, at an estimated total cost of about 340,000l.

A TELFORD TOLL-HOUSE.—An appeal to its members has been launched by the Bewdley (Worcestershire) Civic Society for 1,500l. to repair the Eighteenth-Century octagonal toll-house on Bewdley Bridge. The toll-house, like the adjacent bridge over the River Severn, was the work of Thomas Telford (1757-1834), the famous civil engineer and first President of the Institution of Civil Engineers. Repeated flooding of the river has undermined the foundations of the toll-house, and it has been condemned as dangerous in its present condition.

TOWN HALL ACOUSTICS.—To improve the acoustics of Walsall town hall, the Council have decided to install diffusion-type loudspeakers, similar to those used in the House of Commons. An order has been placed for nine loudspeakers with Troughton and Young (Manufacturers), Ltd., London. The town hall was built in 1905, and its acoustic properties have been a source of frequent complaint.

MINE LAND FOR HOUSING.—The Town Council of Tipton, Staffordshire, are negotiating for the purchase of some of the land owned by J. and S. Baggot, Castle Farm Colliery, Castle-road, Tipton. Castle Farm Colliery, which is operated under licence from the National Coal Board, is a small drift mine employing about 11 men underground, and producing mainly fireclay, though some coal is also mined. It is the sole remaining colliery at work in Tipton, an area formerly noted for its production of Staffordshire "Ten Yard" coal. There will be no interference with the work of the mine.

FACTORY CIVIL DEFENCE.—Lieut.-Col. P. A. Chubb, civil defence officer for the Black Country works of Stewarts and Lloyds, Ltd., has made an appeal for greater interest to be taken in factory civil defence work. Colonel Chubb said that, except in the case of a few large firms, he was not aware what arrangements had been made in the West Midlands. He asks that anyone who is responsible for factory civil defence should get in touch with him at Stewarts and Lloyds, Ltd., Bilston Steelworks, Bilston.

MR. E. MATTHEW HARVEY.—The death has been announced of Mr. E. Matthew Harvey, managing director of Matthew Harvey & Co. Ltd., hardware manufacturers and ironfounders, of Walsall.

SOUTH-WEST ENGLAND AND SOUTH WALES.

EXTENSIONS TO WELSH GAS GRID.—Probable extensions to gas grids in Wales were outlined by Mr. E. M. Edwards, a member of the Wales Gas Board, at Swansea on December 9. They would provide for a system to supply 41 gas undertakings between Monmouthshire and Carmarthenshire in the south, and, in the north, a system to supply initially eight undertakings in the Wrexham-Deeside area with possible extensions to 24 undertakings along the North Wales coast, and a third system, based upon Pembroke Dock in the west, to serve initially four undertakings with possible extensions to a further two. Mr. Edwards, who was addressing the South-Wales branch of the Institution of Mechanical Engineers, said that additional gasmaking plant having a capacity of 6,000,000 cub. ft. a day was under construction at Port Talbot. The Board had preliminary plans for new plant at Swansea and extensions at Llanelly. The final decisions on the Swansea and Llanelly projects would be affected by the results of current negotiations for the purchase of additional quantities of coke-oven gas from the Steel Company of Wales.

SUGGESTED SEVERN BARRAGE FOR ALUMINIUM PRODUCTION.—A suggestion made at a meeting of the Cardiff City Council that the Government's scheme to erect a 144,000,000l. aluminium plant on the Volta River, on the Gold Coast, could be advantageously replaced by a barrage scheme and works on the Severn, is to be considered at the next meeting of the City development committee. Mr. Llewellyn Jenkins asked the committee to make representations that bauxite from West Africa could be shipped for smelting in South Wales, thereby creating a new aluminium industry.

WELSH COAL TRADE.—Following the decision of miners in the Rhondda Valley to resume normal working, coal production in the coalfield has risen. Last week, the output rose by more than 40,000 tons to 486,660 tons, but it still remained about 30,000 tons below the level reached in the corresponding period of last year. The total traffic passing through the seven principal South-Wales ports, during the first eleven months of 1952, rose from 18,835,177 tons last year to 20,836,848 tons.

NOTICES OF MEETINGS.

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

INSTITUTION OF CIVIL ENGINEERS.—Airport Division: Tuesday, December 30, 5.30 p.m., Great George-street, Westminster, S.W.1. "The Reconciliation of Civil Engineering Problems with International Standards in the Siting and Planning of Airports," by Mr. A. S. MacLaren. **Maritime Division:** Tuesday, January 6, 5.30 p.m., Great George-street, Westminster, S.W.1. "The Reconstruction of Greenwell's No. 1 Dry Dock and Ancillary Works at Sunderland," by Mr. Harry Ridehalgh. **Midlands Association:** Thursday, January 8, 6 p.m., James Watt Memorial Institute, Birmingham. "Prestressed Concrete in Civil Engineering Works," by Mr. A. J. Harris.

INSTITUTION OF ENGINEERING INSPECTION.—London Branch: Thursday, January 1, 6 p.m., Royal Society of Arts, John Adam-street, W.C.2. "Standardisation and Inspection," Dip.-Ing. E. G. Brisch. **Coventry Branch:** Tuesday, January 6, 7.30 p.m., Technical College, Coventry. "Developments in the Manufacture and Use of Glass," by Dr. R. E. Bastick. **South-Western Branch:** Tuesday, January 6, 7.30 p.m., Grand Hotel, Broad-street, Bristol. Film Display. **Birmingham Branch:** Wednesday, January 7, 7.30 p.m., 95, New-street, Birmingham. Film Display.

INCORPORATED PLANT ENGINEERS.—Peterborough Branch: Thursday, January 1, 7.30 p.m., Offices of the Eastern Gas Board, Church-street, Peterborough. Open Discussion on "Automobiles." **Birmingham Branch:** Friday, January 2, 7.30 p.m., Imperial Hotel, Birmingham. (i) "Metal Spraying for Protection," by Mr. W. E. Ballard; and (ii) "Reclamation of Worn Parts by Metal Spraying," by Mr. R. Wallwork. **London Branch:** Tuesday, January 6, 7 p.m., Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Discussion on "The National Fuel Policy." **Edinburgh Branch:** Tuesday, January 6, 7 p.m., 25, Charlotte-square, Edinburgh. Open Meeting. **South Wales Branch:** Tuesday, January 6, 7.15 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "A Plant Engineer Tours America," by Mr. G. E. Halter. **Southampton Branch:** Wednesday, January 7, 7.30 p.m., Polygon Hotel, Southampton. "Metallising in Relation to Plant Maintenance," by Mr. J. Porter.

INSTITUTION OF MECHANICAL ENGINEERS.—Friday, January 2, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. Meeting in conjunction with the *Industrial Administration and Engineering Production Group*. "Principles and Practice Governing Interchangeability and the Specification of Manufacturing Limits of Size as Influenced by Statistical Considerations," by Captain G. C. Adams. **South Wales Branch:** Tuesday, January 6, 6 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Contemporary Methods of Watch Production," by Mr. R. A. Fell and Mr. P. Indermuhle. **London Graduates' Section:** Tuesday, January 6, 6.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Industrial Power Transmission Clutches and Couplings," by Mr. K. J. Freeman. **Institution:** Friday, January 9, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. Thomas Lowe Gray Lecture on "Welding in Marine Engineering," by Mr. H. N. Pemberton. **Automobile Division:** Tuesday, January 13, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Life Assessment Tests for Commercial Vehicles," by Mr. J. H. Alden. **East Midlands Branch:** Wednesday, January 14, 7.30 p.m., County Technical College, Newark-on-Trent. Repetition of the Thomas Hawksley Lecture on "The Mechanism of Work-Hardening in Metals," by Professor N. F. Mott.

INSTITUTION OF STRUCTURAL ENGINEERS.—Western Counties Branch: Friday, January 2, 6 p.m., The University, Bristol. "Unusual Design for a Large Constructional Shop," by Mr. F. R. Bullen. **Northern Counties Branch:** Tuesday, January 6, 6.30 p.m., Cleveland Scientific and Technical Institution, Middlesbrough. Open Meeting. **Institution:** Thursday, January 8, 6 p.m., 11, Upper Belgrave-street, S.W.1. "Construction of Eight Prestressed-Concrete Tanks," by Colonel A. R. Mais and Mr. A. C. Little.

JUNIOR INSTITUTION OF ENGINEERS.—Friday, January 2, 7 p.m., Townsend House, Greycoat-place, S.W.1. Film on "Packaged Power," introduced by Mr. H. M. Louch. **Midland Section:** Wednesday, January 7, 7 p.m., James Watt Memorial Institute, Birmingham. Chairman's Address on "Some Aspects of Modern Materials Handling," by Mr. O. J. B. Orwin. **Institution:** Friday, January 9, 7 p.m., Townsend House, Greycoat-place, S.W.1. "Automatic Feed Pressworking," by Mr. C. H. Crawford. **Sheffield Section:** Monday, January 12, 7.30 p.m., Livesey Clegg House, Union-street, Sheffield. "Science Looks at Works Corrosion," by Mr. H. G. Gow.

INSTITUTION OF PRODUCTION ENGINEERS.—Liverpool Graduate Section: Friday, January 2, 7.30 p.m., Exchange Hotel, Tithebarn-street, Liverpool. Discussion

on "Industrial Administration." **Nottingham Section:** Tuesday, January 6, 7 p.m., Victoria Station Hotel, Milton-street, Nottingham. "Economics in Production Engineering," by Dr. F. A. Wells. **South Wales Section:** Thursday, January 8, 6.45 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Precision with Production," by Mr. G. H. Clements. **Leicester Section:** Thursday, January 8, 7 p.m., Bell Hotel, Leicester. "Placing Machines and Practice," by Mr. G. Butler. **London Section:** Thursday, January 8, 7 p.m., Old Ship Hotel, Brighton. Film Display. **Reading Section:** Thursday, January 8, 7.15 p.m., Great Western Hotel, Reading. "The Use of Rubber as an Engineering Material," by Mr. G. W. Trobridge. **West Wales Section:** Friday, January 9, 7.30 p.m., Central Library, Alexandra-road, Swansea. "Electronics in Industry," by Mr. A. G. Hickman. **Eastern Counties Section:** Friday, January 9, 7.30 p.m., Public Library Ipswich. "Motion Study: Some Practical Applications," by Mr. R. Craven.

INSTITUTION OF ELECTRICAL ENGINEERS.—South Midland Centre: Monday, January 5, 6 p.m., James Watt Memorial Institute, Birmingham. "Post-Graduate Activities in Electrical Engineering," by Mr. W. J. Gibbs and others. **Merseyside and North Wales Centre:** Monday, January 5, 6.30 p.m., Royal Institution, Colquitt-street, Liverpool. "Uses of Earthed Signal Conductors on Transmission Circuits," by Mr. W. Casson. **District Meeting:** Monday, January 5, 6.30 p.m., Crown and Anchor Hotel, Ipswich. "275-kV Developments on the British Grid," by Mr. D. P. Sayers, Dr. J. S. Forrest and Mr. F. J. Lane. **Measurements and Radio Sections:** Tuesday, January 6, 5.30 p.m., Victoria-embankment, W.C.2. "An Improved Scanning Electron Microscope for Opaque Specimens," by Mr. D. McMullan. **North-Western Centre:** Tuesday, January 6, 6.15 p.m., Engineers' Club, Manchester. "The Characteristics and Control of Rectifier-Motor Variable-Speed Drives," by Mr. P. Bingley. **North Midlands Centre:** Tuesday, January 6, 6.30 p.m., 1, Whitehall-road, Leeds. "Electronic Telephone Exchanges," by Mr. T. H. Flowers. **Southern Centre:** Wednesday, January 7, 6.30 p.m., Technical College, Brighton. "275-kV Developments on the British Grid System," by Mr. D. P. Sayers, Dr. J. S. Forrest and Mr. F. J. Lane. **Institution:** Thursday, January 8, Victoria-embankment, W.C.2., 4.30 p.m. "Nuclear Reactors and Applications," by Sir John Cockcroft, F.R.S. 6 p.m., Symposium on "Nuclear Reactor Instrumentation."

BRITISH INSTITUTION OF RADIO ENGINEERS.—London Section: Monday, January 5, 6.30 p.m., London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. "The Modern Single-Layer Selenium Photo-cell," by Dr. G. A. Veszi. **Scottish Section:** Thursday, January 8, 7 p.m., 39, Elmbank-crescent, Glasgow, C.2. Film Display.

INSTITUTE OF BRITISH FOUNDRYMEN.—Sheffield Branch: Monday, January 5, 7.30 p.m., College of Commerce and Technology, Pond-street, Sheffield, 1. Discussion on "Methods of Making a Typical Casting in Iron, Steel and Non-Ferrous Metal." **West Riding of Yorkshire Branch:** Wednesday, January 7, 6.30 p.m., Technical College, Bradford. "Economic Use of Metal in Foundry Practice," by Mr. D. W. Hammond. **Burnley Section:** Wednesday, January 7, 7.30 p.m., Municipal College, Ormerod-road, Burnley. "Production of Heavy Castings," by Mr. C. F. Lawson. **Lincolnshire Branch:** Thursday, January 8, 7.15 p.m., Technical College, Lincoln. Report on "Flow of Metal," presented by Mr. E. M. Currie. Also at the **Scottish Branch:** Saturday, January 10, 3 p.m., Royal Technical College, Glasgow. **Newcastle Branch:** Saturday, January 10, 6 p.m., Neville Hall, Westgate-road, Newcastle-upon-Tyne. "Ultrasonic Methods of Inspection," by Mr. N. H. Baddeley.

ENGINEERS' GUILD.—West Midlands Branch: Tuesday, January 6, 6.30 p.m., Imperial Hotel, Birmingham. "Presentation of Technical Information," by Professor R. O. Kapp.

INSTITUTE OF FUEL.—Scottish Section: Tuesday, January 6, 7 p.m., Royal Technical College, Glasgow. "The Ridley Report and After," by Mr. Gerald Nabarro. **North-Western Section:** Thursday, January 8, 6.30 p.m., Engineers' Club, Manchester. Various papers on "Fuel and Fuel Efficiency." **East Midland Section:** Wednesday, January 14, 7 p.m., Welbeck Hotel, Nottingham. "Peak Steam Demands and Thermal Storage," by Dr. E. G. Ritchie.

INSTITUTE OF METALS.—Oxford Section: Tuesday, January 6, 7 p.m., Black Hall, St. Giles, Oxford. "Recent Advances in Alloy Chemistry," by Dr. J. W. Christian. **Birmingham Meeting:** Thursday, January 8, 2.30 p.m., The University, Edgbaston, Birmingham. Informal Discussion on "Rolls and Their Maintenance in the Non-Ferrous Metals Industry."

NEWCOMEN SOCIETY.—Wednesday, January 7, 5.30 p.m., Institution of Civil Engineers, Great George Street, Westminster, S.W.1. Ordinary General Meeting. "Some Factors in the Early Development of the Centrifugal Pump, between 1689 and 1851," by Mr. L. E. Harris.

PERSONAL.

H.M. THE QUEEN has been graciously pleased to become Patron of the North-East Coast Institution of Engineers and Shipbuilders.

The Council of the Institute of Fuel, 18, Devonshire-street, Portland Place, London, W.1, have unanimously agreed to award the Melchett Medal for 1953 to DR. HAROLD HARTLEY, C.B.E.

The Fellowship of the Illuminating Engineering Society, 32, Victoria-street, London, S.W.1, has been awarded to MR. W. E. RAWSON-BOTTOM and DR. L. KNOPP.

MR. P. ARTHUR WELLS, M.A., M.Sc., F.Inst.P., deputy secretary and secretary designate, since April 1, 1951, of the Royal Sanitary Institute, 90, Buckingham Palace-road, London, S.W.1, assumes the secretaryship of the Institute on January 1, 1953. He also takes office as secretary of the Royal Sanitary Institute and Sanitary Inspectors Examination Joint Board on the same date.

MR. ARTHUR DAVENPORT, F.R.Ae.S., has relinquished his seat on the board of Westland Aircraft Ltd., but his services are retained as a consultant.

MR. F. C. GALE, chief superintendent engineer to the Tyne-Tees Shipping Co. Ltd., Newcastle-upon-Tyne, has retired after 35 years of service.

MR. RAYMOND BIRKETT, D.F.C., has been appointed Civil Air Attaché to the British Embassy, Paris. He succeeds AIR MARSHAL DOUGLAS COLYER, C.B., D.F.C., who has accepted a part-time appointment to deal with civil-aviation matters in certain other countries of Western Europe.

MR. M. I. PRICHARD, MR. F. E. BLACKSTONE and MR. C. D. MACQUAIDE have been invited to become assistant directors of R. A. Lister & Co. Ltd. They have been selected from the executive staff of the R. A. Lister groups of companies.

The Brush ABOE group of companies announce that MR. D. G. HAWKINS has been appointed general manager of the National Gas and Oil Engine Co. Ltd., Ashton-under-Lyne. He is already a member of that company's board.

MR. B. G. HOUSEMAN, managing director of Houseman and Thompson Ltd., Newcastle-upon-Tyne, has been elected chairman of the Northern branch of the National Union of Manufacturers.

A new board of directors has been appointed for R. H. Windsor Ltd., Chessington, Surrey; MR. R. E. G. WINDSOR, however, remains managing director. MR. A. G. DENNIS, LL.M., is chairman, and the two other new members of the board are MR. H. V. YORKE and MR. C. NORMAN BAKER, F.C.A.

MR. B. R. FRASER, B.Sc., has been appointed assistant refinery manager of the refinery now nearing completion at Coryton, Essex, of the Vacuum Oil Co. Ltd.

Awards of Mond Nickel Fellowships, for 1952, have been made to MR. A. G. DUCE, MR. F. G. HORTON, MR. H. A. LONGDEN, and MR. G. P. KEMPSON.

MR. S. J. HARLEY, B.Sc., M.I.Mech.E., M.I.P.E., chairman, and MAJOR G. W. MOORE, LL.B., deputy-chairman, Coventry Gauge and Tool Co. Ltd., have been elected to the board of the Pitter Gauge and Precision Tool Co. Ltd. Mr. Harley has been elected chairman of the board, in succession to BRIGADIER-GENERAL R. F. LEGGE, C.B.E., D.S.O. Comp.I.E.E., who has retired from the chairmanship but remains a director.

MR. J. V. ROBERTS, A.R.Ae.S., a specialist in helicopters, has joined Short Bros. and Harland Ltd., Belfast, as assistant designer in charge of the design and technical aspects of rotary-wing aircraft.

MR. J. BIRKBECK, A.I.R.I., has taken up the appointment of production manager to Brynmawr Rubber Ltd.

MR. D. C. THOMSON, M.A. (Edin.), B.A. (Oxon.), has been appointed director of welfare of the British Electricity Authority. He succeeds MR. J. W. THOMAS, who retired last September.

MR. F. A. S. GILMORE has been appointed sales engineer, in the Birmingham and Coventry area, to Murad Developments Ltd., Stocklake, Aylesbury, Buckinghamshire.

MR. H. N. NORBURY has joined Henry Meadows Ltd., Wolverhampton, as sales manager.

As from January 1, 1953, MR. G. H. BRECHLEY, branch manager, Kerry's (Great Britain) Ltd., Warton-road, Stratford, London, E.15, is appointed sales manager, cycle division, and MR. E. E. KERRY, northern area manager, is appointed branch manager, Stratford.

A. C. MORRISON (ENGINEERS), LTD., Loughborough, have appointed MR. S. A. BUCHAN, 88, Pittodrie-place, Aberdeen, to be their representative in Scotland.

FOUNDRY SERVICES LTD., Long Acre, Nechells, Birmingham, 7, announce that their telephone number has been changed to East 1911 (10 lines).

EXHIBITS AT THE SMITHFIELD SHOW.

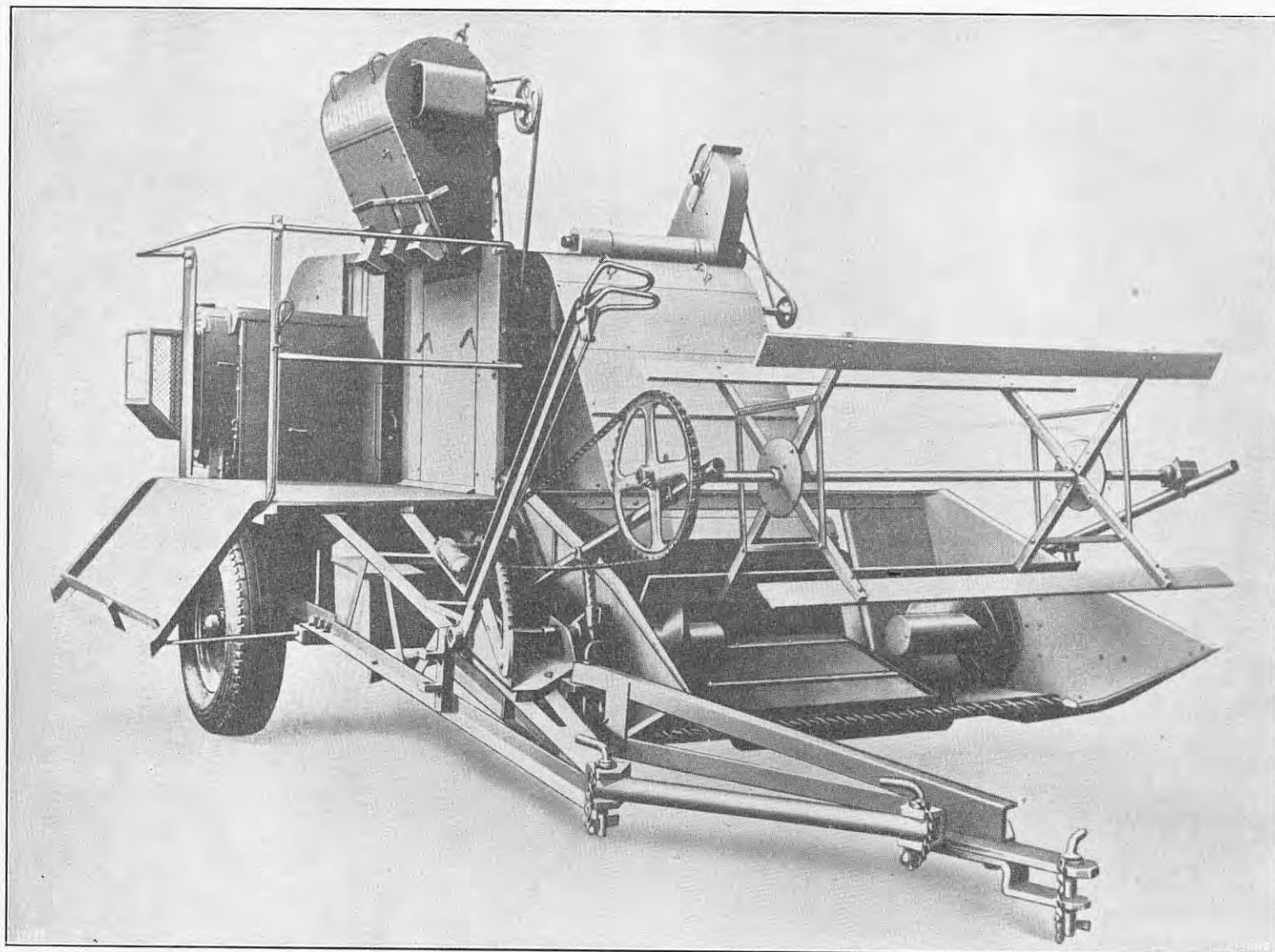
(For Description, see Page 787.)

FIG. 12. TRACTOR-HAULED COMBINE HARVESTER; MARSHALL, SONS & CO., LTD.



FIG. 13. SELF-PROPELLED COMBINE HARVESTER; MASSEY-HARRIS, LTD.

ENGINEERING

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

Registered at the General Post Office as a Newspaper.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

Telegraphic Address:

ENGINEERING, LESQUARE, LONDON.

Telephone Numbers:

TEMPLE BAR 3663 and 3664.

All editorial correspondence should be addressed to the Editor and all other correspondence to the Manager.

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.

SUBSCRIPTIONS.

ENGINEERING may be ordered from any newsagent in town or country and from railway book-stalls, or it can be supplied by the Publisher, post free, at the following rates, or twelve months, payable in advance:—

For the United Kingdom and all places abroad, with the exception of Canada	£5 10 0
For Canada	£5 5 0

Subscriptions for periods less than twelve months are based on the price of a single copy, namely, 2s. 3d. post free.

ADVERTISEMENT RATES.

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

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

TIME FOR RECEIPT OF ADVERTISEMENTS.

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

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

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

INDEX TO VOL. 173.

The Index to Vol. 173 of ENGINEERING (January-June, 1952) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher. In order to reduce the consumption of paper, copies of the Index are being distributed only in response to such applications.

CONTENTS.

	PAGE
The Lower Bhavani Dam, Madras (Illus.)	777
Literature.—X-Ray Crystallographic Technology. Waves and Tides. Nomographic Charts	780
380-kV Power-Transmission System in Sweden (Illus.)	781
Scientific Research in Australia	784
Gatehead Protective Canopy for Coal Mines (Illus.)	785
The Iron and Steel Institute	786
The Smithfield Show and Agricultural Machinery Exhibition (Illus.)	787
High-Speed Testing of Aircraft Tyres (Illus.)	787
Notes from the Industrial Centres	790
Notices of Meetings	791
Personal	791
Productivity in Practice	793
"Jane"	794
Notes	795
Letters to the Editor.—Vector Method of Solving Vibration Problems. Illuminated Lifting Barriers for Railway Level Crossing	795
The Problem of the Dynamic Vibration Absorber (Illus.)	796
Hatfield Technical College	796
Symposium on the Properties of Metallic Surfaces The Institution of Naval Architects' Autumn Meeting	797
The Air and the Future	798
Labour Notes	799
Optical Dynamic Weighbar for a Fatigue-Testing Machine (Illus.)	800
Oil-Storage Tanks at Canvey Island	801
Design and Operation of Dunston "B" Generating Station (Illus.)	802
Launches and Trial Trips	804
Cargo-Loading System for Aircraft (Illus.)	804
Steam and Power in the Gas Industry	804
Soil-Boring Machine (Illus.)	805
Size Distribution as a Quality Factor of Blast-Furnace Coke (Illus.)	805
Argon-Arc Spot-Welder (Illus.)	807
Notes on New Books	807
Trade Publications	808
Books Received	808
Contracts	808

- PLATES.

Plate LIX.—380-kV SWEDISH TRANSMISSION SYSTEM.

Plate LX.—THE DUNSTON "B" GENERATING STATION OF THE BRITISH ELECTRICITY AUTHORITY.

ENGINEERING

FRIDAY, DECEMBER 19, 1952.

VOL. 174.

No. 4534.

PRODUCTIVITY IN PRACTICE.

RATHER more than three months ago the Anglo-American Council on Productivity published their final report; not as the final one of the series, for a considerable number of the reports of the 47 industrial teams who visited the United States have still to see their conclusions in print, but as an indication that the functions of the Council were officially terminated and that no more teams would be sent out. The cessation of their activities was not the result of any impression that the organisation had outgrown its usefulness, but of the termination, on June 30, 1952, of Marshall Aid, this being the date initially fixed for the winding-up of the investigations which were the Council's *raison d'être*. Commenting on the final report in our issue of September 12, on page 341, *ante*, we recalled that the object of the Council was "to promote economic well-being by a free exchange of knowledge in the realm of industrial organisation, method and technique, and thereby to assist British industry to raise the level of its productivity"; and we repeated the question that has been asked so often as the successive reports appeared—What practical benefit has resulted in any of the industries concerned, that can be traced directly to the experience gained by the teams in their visits to the United States?

The final report itself answered that question in part by stating that "it has been found impossible to discriminate clearly between action taken as a result of a productivity team's visit, and what has happened as a part of normal development in the post-war period"; but there had been positive development in seven industries, five of them concerned with engineering, which had sent teams to America. One of the five was the steel founding industry—the first of them all to send out a team; a fact which imparts additional interest to the inquiries that have been proceeding since then in that industry, under the auspices of the British Steel Founders' Association.

The first report of the steel founders' team was issued in September, 1949, and a subsequent report, entitled *Progress in Productivity*, was published in October, 1951. It was shown that, since 1949, several foundries had increased their output per man-hour by 10 to 15 per cent., and in some the increase had been as much as 30 per cent. It was felt by the Association, however, that much more might have been done, and that (in the words of a statement officially issued during the present week) "the efforts to gain the fullest measure of benefit from the team's recommendations to some appreciable extent have been and still are frustrated by the partial failure of those who work in the industry to grasp what now ought to be apparent, namely, that the consequences of failure to increase productivity are so grave as to demand the immediate abandonment of any attitude which constitutes an obstacle to doing so."

The realisation of the dangers of the situation led the British Steel Founders' Association to hold a conference in November to investigate the position. At the conference, which was representative of all grades of management from managing directors to chargehands, the points under discussion were grouped into three main divisions, namely, the problem of management, with particular reference to leadership and personal relations; the human attitude to productivity, as applied to the industry as a whole; and mechanical devices and workshop methods. The discussions are stated to have been "exceedingly frank," and if, in some respects, the conclusions reached appeared to verge upon the obvious, it is certain that nothing but good could result from a candid recognition of their nature and importance. The representation was wide, there being 126 delegates from 41 member firms in the Association, collectively representing, on a production basis, 88 per cent. of the tonnage of steel castings produced by members of the Association and 70 per cent. of the whole output of the industry in the United Kingdom. It may be remarked that the steel founding industry is not part of the iron and steel industry as at present constituted, in that the member firms are not basic steel producers.

With regard to the questions of management and leadership, the delegates were unanimous that there was no substitute for good leadership. It is not easy to see how they could have maintained any other point of view. Some delegates, however, are stated to have been "highly critical of British management for failing to select and train a new class of industrial leaders, capable of dealing with modern problems, including that of personal relations." They expressed the opinion that there was "room for a great advance in the selection and training of personnel" to the end (accepted as "essential") that "every employee should be carefully trained for, and employed in, the job for which he is best suited," and that this training should apply especially to those selected for supervisory posts.

In the discussion on the human attitude towards productivity, which was presided over by Professor P. Sargant Florence, of the Department of Commerce in the University of Birmingham, it was agreed that the British working man reacted only

to a limited extent to purely monetary incentives; he had his own very moderate target figure and, having attained it, was disinclined to strive for anything higher. It may be supposed that the combined effects of high taxation and restricted freedom to purchase what he will, extending over many years, have had considerable influence in inducing that frame of mind; only the middle-aged and elderly can remember what it was like to buy freely in an open market. The conference agreed, however, that something should be done "to educate the British worker to an appreciation of the greater degree of comfort and enjoyment that increased productivity will bring within his reach," and emphasised the "fact that the skilled worker is in a position to better his standard of living by extra effort to a far greater extent than any other member of the community." Means of doing so were exemplified by showing films and lantern slides illustrating some of the improved equipment and methods which have been introduced into the industry from the United States and which, it was urged, "every British steel foundry could and should adopt immediately."

The conclusions of the Conference on the trade unions' relation to productivity are a little reminiscent of Mark Twain on the subject of the weather—"everyone talks about it, but nobody does anything." The first comment, that "the problem of productivity is one for industrial management and is not a trade-union responsibility," seems to crystallise in a sentence the essential difference between the American shop-floor attitude towards the subject and the prevalent view of British labour; and it is open to question whether the next conclusion is altogether justified, namely, that "trade unions have so far failed to realise that restrictive practices, based upon out-of-date fears and prejudices, are seriously retarding productivity." If they have not learned that by now, supported as it has been by so many of their own members who have been to America with the productivity teams, they are incapable of learning anything; which we simply do not believe. If British working men, more especially the relatively small proportion who sway the voting in trade-union lodges, can be made somehow to see that their appointed leaders are not there solely to fight employers, but may serve the interests of the rank and file equally well and sometimes better by a little frank collaboration with managements, a long step forward will have been taken.

The Conference, it is stated, "condemned all restrictive practices, whether on the part of management or operatives." The delegates "strongly criticised the frustrating practice of rate-cutting by management and the arbitrary restrictions on the up-grading of semi-skilled labour and on schemes for adult apprenticeship imposed by the unions." This is an obviously sensible attitude, on all counts, and not less so because, in fact, it postulates nothing new. It requires some qualification, however, and that is provided elsewhere in the summary, where, after urging that "all injustices existing in present incentive schemes must be removed immediately," the note is added that, in particular, established piece-work rates "must be regarded as sacrosanct while production processes remain unchanged." There may still be managements who are apt to cut piece-rates without having introduced any improved process, but by now they must be relatively few, and the example of their more enlightened fellows should make them progressively fewer. If a single trade-union would have the courage to come out boldly in favour of the utmost use of improved methods without seeking to impose hampering and wasteful restrictions, it is more than probable that others would speedily follow; for the benefits would be so great that they could not be disguised, nor could any management afford to be niggardly in sharing them.

"JANE."

KIPLING once wrote a story in which he introduced the notion that "Janeites" were a sect of persons devoted to the works of Miss Austen. This, of course, was false; Janeites are, in fact, the legion of addicts to *Jane's Fighting Ships*,* and very many of them have no other maritime connection. In a lifetime of more than 50 years, the *Jane* whom they revere has acquired a strong corporate personality, hardly, perhaps, as feminine as the ships surveyed, and expressed in a literary style—terse, nervous, scrupulous to the point of fussiness, and sometimes pungent—in marked contrast to the polished urbanity of the publishers' foreword.

That introduction records that, to avoid an increase in price, it has been necessary to reduce the number of pages. It must be said at once that this compression, from 546 to 454 pages, has been done with remarkable skill, and that Janeites will have no cause for complaint. The tables of gun performance, which were always about 15 years out of date, have been suppressed; and this might also be taken as an indication that the *élan vital* of sea warfare has passed from the gun to the submarine torpedo and the strike aircraft. Further compression might usefully be achieved by omitting the so-called silhouettes. For the rest, the foreword notes the current tendency to restore naval strength by recalling ships from the disposal lists, and the increased emphasis on anti-submarine frigates, escorts, and minesweepers.

Aircraft carriers have taken precedence over battleships since the edition of 1950-51. The new photographs of H.M.S. Eagle confirm that she is bigger as well as uglier than the war-time Implacable class, having a flight deck over 800 ft. long; this compares with 1,040 ft. for the U.S.S. Forrestal, laid down in July last. The great difference is that the Eagle, apart from exhibiting a sawn-off stern which is an offence to the eye, retains the island form of superstructure, whereas the Forrestal promises to be a flush-decked ship with a retractable bridge. Pictures of the reconstructed cruisers Birmingham and Newcastle show that British naval architects have now abandoned the tripod in favour of the American lattice mast. The statement that some of the 24 British frigates included in the programme of new construction are to be Diesel-driven is of interest, as this factor may be of immense importance if a really large fleet of them has to be built. The "full conversion" of destroyers into anti-submarine frigates, as exemplified in the Rocket and Relentless, seems to involve an enormous amount of work for a result which, it may be hoped, is better than it looks; but the "limited conversion" now illustrated by the Tenacious appears to involve little beyond the substitution of "squid" anti-submarine mortars for the after 4.7-in. twin guns and the removal of the foremost torpedo-tube mounting. The pages covering the ships of the Royal Australian, Canadian, and New Zealand Navies still do not suggest that these fleets are in any way commensurate with the population, wealth, and seaboard of their respective countries; but the warships of India and Pakistan are a likelier-looking assembly than were those of the Royal Indian Marine.

The foreword does well to offer a reminder that the United States Navy now has "the largest peace-time fleet ever maintained by any country... as large as all the other navies of the world put together." Among the few innovations demanding notice is the conversion of two cruisers into "Tactical Command Ships" or professional flagships, equipped with extensive radio and accommodation, but lightly gunned. There are now photographs of the

SSK type of submarine, designed to hunt and kill its own kind and exhibiting a huge bulbous bow full of asdic gear; and also of the fast attack submarines of the SS 563 class, capable of exceeding 17 knots submerged and engined with two-cycle Diesels with 16 cylinders, disposed radially in four banks.

The strength and composition of the Russian fleets remain obscure. There has been no substantial change in the section relating to submarines, which continues to report about 120 of these vessels building and 370 in service or reserve. Of the latter, a large number are of pre-war vintage and some 130 are small coastal boats with a limited radius of action. It is hard to see why *Jane* thinks that the 72 pre-war submarines of the Shtcha class are "a particularly effective and dangerous type," since their performances in World War II did nothing to suggest this. Such phrases, however apocryphal they may be, are nevertheless treasured by Janeites, who (it may be said) like to declaim these classic utterances to solemn chants. Indeed, the chant currently used by them as a rallying cry is the deathless one "said to be most unhealthy, insanitary and badly ventilated," composed for the Russian battleships of the Gangut class over 30 years ago, and used uninterruptedly ever since. It may be true enough, but there is such a thing as relativity.

A survey of the present edition reveals the undecided trend of design in relation to light cruisers, destroyers, frigates, and escorts, all of which types tend to shade off into one another in a confused and unsatisfactory way, as if to suggest that the naval staffs do not know what they really want. As an example may be cited the warships of the T 47 class, building in France, which could arguably be ranked in any of the four categories and may well be an attempt to combine the qualities of all of them. Among the smaller navies, it may be observed that the two 10,000-ton cruisers laid down by Holland in 1939 are not yet completed, and that all major war vessels in the Norwegian fleet have been acquired from Britain, the United States, or Germany. The only second-class navy to command respect is that of Spain, whose warships form a balanced fleet of homogeneous classes, reasonably modern and nearly all built in Spanish yards.

Turning to the "museum pieces," it may be noted that the last of the hideous saurian monsters with the authentic "ironclad" appearance is the Argentine Pueyrredon, launched by Ansaldo in 1897, and that the cruiser *Avrora*, a veteran of Tsushima, is still a unit of the Russian navy; but Janeites will mourn with real regret the disappearance of the Chilean Huascar, a veteran of the 'seventies which was hotly embroiled in many a South American fracas, and, while engaged in piracy on the high seas, was the target for the first automobile torpedo fired in anger. We have, however, the authority of His Excellency the Chilean Ambassador, speaking at the annual banquet of the Worshipful Company of Shipwrights on October 22, for her continued existence afloat. The prize for the warship with the most changes of name is won by the *Esmeraldas*, of Ecuador, with eight—one being *Entropy*, which, as Pepys would observe, "is very strange." It has to be regretted that the ugliness prize must be awarded, for the second year running to the British destroyers of the *Daring* class.

No Janeite will allow that *Jane* can err, as this would be heretical. It is, however, permissible for the faithful to believe that alternative spellings exist for "John I. Thornycroft" of "Wolston" and for "Cammel Laird," for the cancelled Weapon-class destroyer "Cutless," and for German midget submarines of the "Seehond" type; and that Flushing and Vlissingen may possibly be one and the same place.

* *Jane's Fighting Ships* 1952-53. Edited by RAYMOND V. B. BLACKMAN. Sampson Low, Marston and Company, Limited, 25, Gilbert-street, London, W.1. [Price 84s.]

NOTES.

THE INSTITUTION OF MECHANICAL ENGINEERS.

THOUGH there is a considerable body of literature on the strength and flexibility of curved pipes, the case of pipe-bends in which the radius of curvature is small in relation to the radius of the pipe cross-section has not been adequately treated. In recent years, however, for many applications in gas turbines, and in the oil and chemical industries, pipe-bends have been used in which the radius of curvature is only three times the pipe radius, and it is this circumstance which rendered significant the two papers presented to the Institution of Mechanical Engineers on Friday, December 12. Dr. Nicol Gross, M.I.Mech.E., was author of a paper on "Experiments on Short-Radius Pipe-Bends," and also joint author, with Professor Hugh Ford, D.Sc. (Eng.), Ph.D., Wh.Sc., M.I.Mech.E., of a paper on "The Flexibility of Short-Radius Pipe Bends." In the former paper, Dr. Gross said that C. E. Stromeyer was the first to draw attention to the fact that failures in pipe-lines took place in the curved portions at points of the cross-section of the pipe-bend which in the past were thought to be located on its neutral axis [ENGINEERING, vol. 84, page 316 (1907)]. The direction of cracks which occurred in service showed that stresses causing failure were circumferential stresses, even in pressureless pipes. These failures could be explained by existing theory if Kármán's analysis, which dealt with displacements only, was extended to the investigation of the stresses occurring in the cross-section of pipe-bends. The experiments which Dr. Gross described were carried out, under the auspices of the British Welding Research Association, on short-radius pipe-bends of seamless and welded types. The results showed that, for such pipes subjected to bending without internal pressure, no element of a welded bend was more highly stressed than the corresponding element of the seamless bend; that the two longitudinal welds connecting the two half tori of a welded bend did not affect the flexibility of the portion of pipe-line composed of the pipe-bend and straight pieces of pipe; and that there was no evidence to show that, under otherwise identical conditions, the seamless type of bend would sustain greater ultimate loads than would the welded bend. The tests on short-radius pipe-bends subjected to internal pressure showed that, if the cross-section deviated appreciably from circularity, considerable bending stresses were superimposed, and also that, after yielding had occurred, pipe-bends were capable of sustaining considerable increases in pressure before they burst. With welded bends, if a complete-penetration weld, free of imperfections, were deposited, the static bursting pressure should be the same as that expected in a seamless tube. The effect of small imperfections in the weld were similar to that of small surface imperfections such as centre-punch marks, etc. Dr. Gross and Professor Ford, in their joint paper, derived a simple and reliable method of calculating safe working conditions in the design of pipe-bends. They showed that the modification to Kármán's analysis described in the other paper was satisfactory for values of the pipe factor down to $\frac{2hR}{r^2} = 0.09$ (where $2h$ was the thickness of the pipe, r the mean radius and R the radius of curvature), and to values of $\frac{R}{r} = 2.2$. A surprising finding was that the peak stresses due to an externally-applied moment were reduced by a superimposed internal pressure, and even when the pressure was raised to $2\frac{1}{2}$ times the maximum working pressure the bend was subjected to no more severe stress combination than in the pressureless state.

THE METROPOLITAN WATER BOARD.

The hearers, and subsequent readers, of Mr. H. F. Cronin's presidential address to the Institution of Civil Engineers on the development of London's water supply into the present organisation of the Metropolitan Water Board will find an interesting appendix to it in the 49th annual report of the Board, for the year ended March 31, 1952; not the least

interesting item, perhaps, being a note that, during the year, Mr. M. W. Piggott and Mr. G. W. Messingham retired from the service of the Board. They were the last of the 556 officers and 2,907 employees of the constituent water companies whose properties and functions were transferred to the Board under the provisions of the Metropolis Water Act of 1902. Mr. Messingham retired on May 19 and Mr. Piggott on June 27, 1951. The total supply of water from all sources (the principal source being, as always, the Thames) was 117,836.4 million gallons, representing a daily average of slightly less than 322 million gallons, of which 98.24 per cent. went directly to the Board's area and the rest to adjacent undertakings which take a bulk supply. The daily average abstraction from the Thames by the Board and two of the suburban companies was 228.6 million gallons out of an average natural flow at Teddington of 2,034 million gallons, in round figures. This abstraction, 11.24 per cent., was less than in the previous year, when the proportion was 12.14 per cent. It is an indication of the fluctuations with which the Board have to contend, and the need for ample reservoir capacity, that the actual daily flow of the river fell below 500 million gallons on 54 days in the twelve months, and exceeded 5,000 million gallons on 13 days. The flow in the river Lee ranged between still wider limits, being below 40 million gallons a day on 12 days and over 500 million gallons on four days. The grand total of water supplied during the year represented 526.1 million tons and the distribution per head, to an estimated population of 6,426,500, was 49.22 gallons; 32.81 per cent. was supplied through revenue meters. A substantial addition to the Board's reservoir capacity was made by the inauguration, on September 4, 1951, of the William Girling reservoir at Chingford, so named after Mr. W. H. Girling, O.B.E., the chairman. Authority was received in February, 1952, to fill it to the top water level of 71 ft. above Ordnance Datum. During the year covered by the report, 26.48 miles of new mains were laid, bringing the total length of mains to 8,513.12 miles. The number of pumping engines in use was 295, of 66,460 collective horsepower, including 12 portable pumps. The fuel consumed in pumping was 116,308 tons of coal, 119 tons of coke, 1,150,577 gallons of oil and 49,742,000 units of electricity, representing a standard coal equivalent of 150,062 tons. The report may be obtained from the Staples Press, Limited, 14, Great Smith-street, London, S.W.1, at the price of 5s.

PRODUCTION OF WOODWORKING MACHINERY IN THE UNITED STATES.

Among the teams of observers who visited the United States last year to study American workshop methods under the auspices of the Anglo-American Productivity Council was one representing that section of the British machine-tool industry which is concerned with the manufacture of woodworking machinery. Their report has now been published and may be obtained from the office of the United Kingdom section of the Council, at 21, Tothill-street, London, S.W.1, at the price of 3s. 6d. The team, consisting of ten members, visited nine English firms before leaving for America and paid official visits to 17 American works during their tour. In addition, various members called unofficially on eight further works and also visited the Forest Products Research Laboratory at Madison, Wisconsin. They came to the conclusion that the British industry compared "very favourably" with the American industry in productivity, quality and design, though, as in the case of other industries, they realised that each had much to learn from the best practice of the other. They found that, on the whole, the British industry was the better housed and equipped, and, in the case of machines which were "custom-built" in small batches—which applies to a large proportion of woodworking machines—they saw little evidence that the overall productivity per man-hour was greater in the United States than in Britain. In some instances, however, where factories were concentrating on the production of a limited range of the lighter types of machines, for which there was a steady demand from both countries, the makers were able to adopt methods approaching those of

mass-production and, in general, those methods were "far ahead" of corresponding practice in Britain on comparable products. By comparison with American firms, the team considered, too many British firms were making too many models, with the result that there was an undesirable amount of overlapping within the industry. Labour-saving received more attention from the American than from the British maker, with a view to reducing not only his own labour costs, but also those of his customer; and, in the works, much more use was made of mechanical handling appliances. The American machines examined were no better than the British types, in the team's opinion, and some were definitely inferior; in general, too, the American machines were much more expensive. American managements are described as being "enterprising and receptive of ideas, competition being upheld as the essential spur to progress." Of the labour employed, fewer than 20 per cent. had served an apprenticeship.

LETTERS TO THE EDITOR.

VECTOR METHOD OF SOLVING VIBRATION PROBLEMS.

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with interest the article by Mr. C. H. Helmer on vector methods in vibration which appeared on pages 620 and 685, *ante*. These techniques are obviously of great value. If any of your readers are anxious to pursue this subject, they will find it dealt with in the books by W. T. Thomson (*Mechanical Vibrations*, Prentice-Hall, 1947) and C. E. Inglis (*Applied Mechanics for Engineers*, Cambridge University Press, 1951).

As Mr. Helmer points out, the vector method may be applied to many problems. My colleague, Mr. D. B. Welbourn, and I have devised an extension which, we think, may be of interest. It deals with the dynamic vibration absorber and a description is submitted for your consideration.* We have also developed a method to deal with crankshaft vibration, including the effects of damping, and hope to be able to submit a further article before long.

Yours faithfully,

R. E. D. BISHOP.

Engineering Laboratory,
Trumpington Street,
Cambridge.

December 5, 1952.

[* This article appears on page 796.—Ed., E.]

ILLUMINATED LIFTING BARRIERS FOR RAILWAY LEVEL CROSSING.

TO THE EDITOR OF ENGINEERING.

SIR,—In reference to the illustration and article in your issue of November 28, on page 703, *ante*, on lifting barriers for a level crossing, we note that you describe the poles in such a way that the impression conveyed is of a one-piece tubular tapered pole. The poles are of the "Adastra" galvanised sectional-steel type, designed by us, and are made from short tapered tubular sections, welded together. The poles, curtains and pedestals were fabricated in our works.

Yours faithfully,

for POLES, LIMITED,
F. SOUTHALE.

Nickel Works,
Tyburn-road, Erdington,
Birmingham.

December 12, 1952.

THE LATE MR. A. CALDWELL, O.B.E.—Mr. Allan Caldwell, O.B.E., naval architect, died on December 9 at Paisley, at the age of 62. A native of Ayrshire, Mr. Caldwell joined Constants, Ltd., London, 42 years ago, ultimately becoming a director. He specialised in the design and construction of small craft and wrote a book on *Screw-Tug Design*. Mr. Caldwell was a Liveryman of the Worshipful Company of Shipwrights, a member of the Institution of Naval Architects and a member of the Institute of Marine Engineers.

THE PROBLEM OF THE DYNAMIC VIBRATION ABSORBER.

By R. E. D. BISHOP and D. B. WELBOURN.

THE steady forcing of the simple system of Fig. 1 is governed by the well-known equation

$$m\ddot{x} + c\dot{x} + kx = F_0 \sin \omega t. \quad (1)$$

The particular integral of the form

$$x = X_0 \sin(\omega t - \xi), \quad (2)$$

gives the steady solution and the vector method of evaluating X_0 and ξ is, perhaps, the best.* To do this, we contemplate the vertical projections of rotating vectors representing each term of equation (1) (see Fig. 2).

The advantages of this method are the following: (i) The geometry of Fig. 2 enables us to write down the solution (2) in terms of F_0 , ω , and the parameters of the vibrating system.

(ii) By simple graphical means, we can proceed from an assumed value of X_0 to find the position and magnitude of the relevant F_0 vector whence, by proportion, the actual value of X_0 is easily found.

(iii) The nature of the motion of the system of Fig. 1, as different values are taken for ω , can be visualised from Fig. 2. Equally, the effects of varying the parameters m , c and k can be studied.

There is a considerable literature on the dynamic vibration absorber† but this problem appears always to be treated analytically. The purpose of this article is to discuss this problem from the rotating-vector point of view.

System of Two Degrees of Freedom.—The system to be discussed is that of Fig. 3; there are other ways of arranging the damping, but they can be handled by the method to be described.

The equations of motion of the two masses are

$$\left. \begin{aligned} m_1 \ddot{x}_1 + (c_1 + c_2) \dot{x}_1 + (k_1 + k_2) x_1 \\ = c_2 \dot{x}_2 + k_2 x_2 + F_0 \sin \omega t, \\ m_2 \ddot{x}_2 + c_2 \dot{x}_2 + k_2 x_2 = c_2 \dot{x}_1 + k_2 x_1, \end{aligned} \right\} \quad (3)$$

and, by means of vectors, we seek solutions of the form

$$\left. \begin{aligned} x_1 &= X_1 \sin(\omega t - \eta), \\ x_2 &= X_2 \sin(\omega t - \xi). \end{aligned} \right\} \quad (4)$$

Starting with an assumed value and orientation of X_2 , the vector diagram of Fig. 4 can be constructed. This gives, first, the magnitude and direction of X_1 and then the F_0 vector. Thus, by proportion, we can find the true values of X_1 and X_2 from a known value of F_0 .

The "picture" of Fig. 4 can now be used to examine how the absorber reacts to different working conditions.

Special Cases.—Two cases concerning the undamped absorber are of particular interest. They relate to the tuned absorber and to the condition of resonance. In the tuned absorber, with setting $c_1 = c_2 = 0$, we consider the state of affairs when

$\omega^2 = \frac{k_2}{m_2}$. In Fig. 4, it is clear that the X_1 vectors are all zero, giving the configuration of Fig. 5, from

which we see that $X_2 = -\frac{F_0}{k_2}$, which is, of course, confirmed analytically.

At resonance, if $c_1 = c_2 = 0$, the condition that F_0 should vanish is shown in Fig. 6. This can be stated in two ways:

$$\left. \begin{aligned} k_2 X_2 &= (k_1 + k_2) X_1 - m_1 \omega^2 X_1, \\ k_1 X_1 &= m_1 \omega^2 X_1 + m_2 \omega^2 X_2. \end{aligned} \right\}$$

Eliminating X_1 and X_2 ,

$$[(k_1 + k_2) - m_1 \omega^2] (k_2 - m_2 \omega^2) = k_2^2 \quad (5)$$

* See Inglis, *Applied Mechanics for Engineers*, Cambridge University Press, 1951, page 311.

† See Den Hartog, *Mechanical Vibrations*, third edition, McGraw-Hill, 1947, page 119; also Inglis, *loc. cit.*, page 343.

THE DYNAMIC VIBRATION ABSORBER.

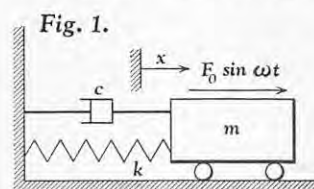


Fig. 1.

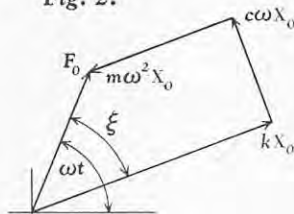


Fig. 2.

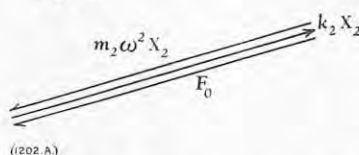


Fig. 3.

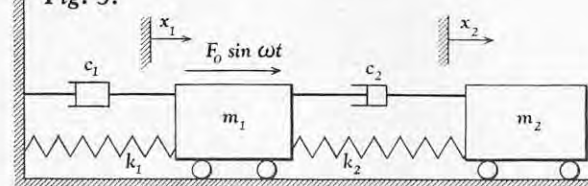
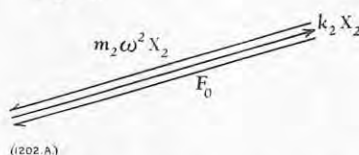


Fig. 4.

Fig. 5.



(202 A)

Thus, if equation (5) prevails, finite amplitudes correspond to zero applied force or infinite amplitudes result from a finite applied force.

Conclusion.—The vector method described is simple and is far less cumbersome than analysis. This is particularly desirable in teaching. It is possible to add more degrees of freedom to the system of Fig. 3, still using the vector method of finding the steady state of vibration. Extensions of this sort are being examined.

HATFIELD TECHNICAL COLLEGE.

THE new technical college at Hatfield, which was formally opened by H.R.H. the Duke of Edinburgh on Tuesday, December 16, will provide increased educational facilities in a part of Hertfordshire which has recently become a centre of engineering activities. In particular, it will obviate students having to travel to London for that purpose and will enable advanced instruction to be given locally in aeronautical work and, later, in other engineering subjects.

The college buildings are erected on a 90-acre site, which was the gift of Mr. A. S. Butler, chairman of the de Havilland Aircraft Company, Limited, Hatfield. When erection was begun shortly after the war, bricks, steel and labour were all scarce. The architect, Mr. Howard Robertson, in collaboration with the consulting engineer, Mr. F. J. Samuely, therefore devised a system of reinforced-concrete construction, consisting of uprights and roof trusses, which were prefabricated on site and lifted into position. The resulting frame is in some cases filled in with brick, but the surfaces between the windows are faced with shingles of cedar. Shingles are also used for roofing the assembly hall and gymnasium. The area of glass is very large, the result being a lightness of external appearance and excellent internal illumination. Care has been taken to guard against settlement or any movement due to temperature change by the free use of rubber expansion joints. Steam and other services are obtained from plant on the sites and electricity from the mains of the Eastern Electricity Board. The main contractors for the buildings were Messrs. Gilbert Ash, Limited.

The college, of which Dr. W. A. J. Chapman is principal, provides day and evening courses in technical and design engineering, works and production engineering, and building, as well as in commerce and the retail trades. Facilities are also available for the advanced study of physics and

chemistry, and there is a Department of Social and Professional Studies. The Technical and Design Engineering Department, of which Mr. A. N. Barber is the head, is situated in a building separate from the main block, and at present provides instruction in mechanical, aeronautical and electrical engineering to a level which should enable successful students to join one of the professional institutions. It is hoped to establish full-time courses leading to the award of external university degrees in engineering, as well as "sandwich" courses. Progress in both these directions will, however, depend on the co-operation of the managements of local industries.

The existing facilities in this Department include an aerodynamics laboratory containing return-flow, closed-jet and smoke tunnels; an aircraft structures and materials laboratory, which has been equipped to demonstrate and investigate the principles of the theory of structures and to test actual aircraft components; and an aircraft ground engineering laboratory, which is provided with apparatus for illustrating the design and construction of typical airframes, as well as of aircraft engines and gas turbines and their associated electrical and control equipment. A temporary laboratory for the study of heat engines and hydraulics contains equipment for testing an experimental steam boiler, a reciprocating engine and a turbine. There are also low-speed and high-speed internal-combustion engines and apparatus for ascertaining the calorific value of fuel and the viscosity of liquids, and for studying the laws governing the flow of water over weirs and notches and through pipes, channels and orifices. The electrical-engineering laboratories are equipped with a good selection of modern machines, including a mercury-arc rectifier and a single-phase alternator. There are also a materials and metallurgical laboratory and a general-science laboratory for teaching elementary applied mechanisms.

The Works and Production Engineering Department, under Mr. J. D. Smith, provides courses not only in production and machine shop engineering but in welding, electrical installation, heating and ventilating, and agricultural engineering. A special feature of both this and the Technical and Design Engineering Department will be the facilities for training in foremanship. The Building Department provides courses in carpentry and joinery, brickwork, plumbing, painting and decorating, as well as in welding and lead burning.

SYMPOSIUM ON THE PROPERTIES OF METALLIC SURFACES.

(Continued from page 751.)

At the afternoon session of the general meeting of the Institute of Metals, held at the Royal Institution, London, on November 19, the remaining six papers in the symposium on the "Properties of Metal Surfaces" were discussed. They were "The Influence of Machining and Grinding Methods on the Mechanical and Physical Condition of Metal Surfaces," by Mr. P. Spear, Mr. I. R. Robinson and Mr. K. J. B. Wolfe; "The Effect of Lubrication and Nature of Superficial Layer after Prolonged Periods of Running," by Dr. F. T. Barwell; "The Effect of Surface Conditions on the Mechanical Properties of Metals, Mainly Single Crystals," by Professor E. N. da C. Andrade, F.R.S.; "The Effect of Surface Conditions on the Strength of Brittle Materials," by Professor C. Gurney; "The Influence of Surface Condition on the Fatigue Strength of Steel," by Mr. R. L. Love; and "The Influence of Surface Films on the Friction and Deformation of Surfaces," by Dr. F. P. Bowden, F.R.S. and Dr. D. Tabor. The chairman was Dr. D. G. Sopwith.

Mr. D. A. Oliver, who presented the six papers as *rapporteur* said that they dealt particularly with the production and characteristics of surface obtained by known means, which ranged from widely-used engineering methods to electrolytically-polished, stress-free surfaces cleaned by high-vacuum techniques. The effects of surface films on the mechanical properties were considered, and what happened when they were brought into rubbing contact with one another was carefully reviewed.

The first paper, by Mr. Spear, Mr. Robinson and Mr. Wolfe, attempted to give comprehensive correlated information on the nature of a machined surface following drilling, turning, grinding, honing and super-finishing for a variety of materials, including mild steel, Duralumin and a leaded 60:40 brass. The resulting surface smoothness or roughness had been recorded, some idea of the state of residual surface stress had been obtained by back-reflection X-rays, and the general degree of work-hardening produced on the work-piece had been explored by direct hardness measurements. In the turning experiments, high-speed steel, carbide, and a new alumina-ceramic tipped tool had been included. The conclusions of this largely original research conveyed the broad conception that a machined surface could be expected to have a certain surface smoothness or texture and be work-hardened to a certain depth and that this layer was in a highly stressed condition, the surface layer stresses probably being tessellated.

The next paper, by Dr. Barwell, entitled "The Effect of Lubrication and Nature of Superficial Layer after Prolonged Periods of Running," was a critical survey of what was known of the conditions existing in bearings when both liquid and solid lubricants were present and under conditions of speed and loading leading to failure by surface breakdown. Continuous wear, scuffing, pitting, abrasion, and fretting corrosion were all dealt with, and to some extent this paper supplemented the last of the series, by Dr. Bowden and Dr. Tabor. Dr. Barwell gave a detailed discussion of actual failures occurring in bearings, and thus this critical survey was a happy bridge between the purely engineering and the more physical-chemical points of view. The effects of phosphating on steel and of anodising on aluminium were also mentioned, and finally the important part played by metal soaps was considered, when the bearing metal could react chemically with the lubricant.

The next paper, by Professor Andrade, entitled "The Effect of Surface Conditions on the Mechanical Properties of Metals, Mainly Single Crystals," constituted a discussion of the mechanical and other effects of oxide coatings on single crystals, with due emphasis on fundamental phenomena. This contribution was a blend of original experimental research and a critical review of contemporary work. Much light was thrown on the so-called Reh binder effect, and a satisfactory alternative explanation was given.

It should perhaps be stated by way of clarification that P. A. Reh binder and his collaborators found that the contact of a surface-active liquid in a non-polar hydrocarbon—in particular 0.2 per cent. oleic acid in a non-polar hydrocarbon oil—had a striking effect on the mechanical and electrical properties of metals and other substances. These investigations recorded that, with single crystals of tin and zinc, the wetting produced a marked decrease in the yield stress and an increase in electrical resistance. Work by Dr. Andrade and Dr. R. F. Y. Randall, however, has shown that the mechanical Reh binder effect was due to the disruption by the liquid of a hardening oxide film. It appeared that such effect as occurred was not due to penetration of the active liquid into surface cracks, as claimed by Reh binder, and did not take place when the metal surface was really clean. Moreover, no one, so far, has been able to confirm the electrical effects reported by Reh binder.

Continuing, the *rapporteur* stated that after considering the production of controlled oxide films by direct oxidation and by electrolytic means, this work having been mainly carried out on cadmium, zinc, tin and silver, Professor Andrade described the strengthening or weakening effects of different procedures. Finally, the interesting suggestion was made that the running of dislocations might actually carry atoms of the surface contaminant into the metal, and, though this was not quite certain, it would appear to be a useful point for discussion.

Professor Gurney's paper on "The Effect of Surface Condition on the Strength of Brittle Materials" gave an account of how a really brittle but only partly crystalline non-metallic material such as glass behaved mechanically. The mechanical characteristics changed when the surface of glass was attacked by water and carbon dioxide, and this resulted in delayed fracture. The paper clearly restated the classical contributions of A. A. Griffith with regard to inherent surface cracks or imperfections and extended the argument by a record of the author's own experiments in this field. The concept of a finite time to fracture depending on the applied stress had been worked out. The fatigue experiments on glass specimens, of great interest in themselves, had been harmonised with static-fatigue tests and tests at variable frequency. This had been done by taking time as the variable. An interesting discussion of the strength of glass having an undamaged surface was contained in this paper, and an explanation of the data was given by regarding glass as a very viscous liquid containing holes in the lattice, which, in any case, was probably not arranged like that of a perfect crystal. Furthermore, the high strength of fine fibres was traced to the healing of the larger weak patches during drawing, and the freezing-in of the drawn configuration during rapid cooling, although other factors were not excluded. The discussion on glass was supplemented by a final section on other brittle materials, including plastics and ceramics. A parallel was drawn between the attack of organic liquids on the surface of plastics and the action of water and carbon dioxide on glass. In this conference, devoted primarily to metals, this illuminating paper was accorded a special welcome.

The paper by Mr. Love, entitled "The Influence of Surface Condition on the Fatigue Strength of Steel," was a comprehensive survey of the whole field. The first part of the paper comprised a critical review of the subject itself, while the remainder developed the subject factually and systematically and contained ten tables of summarised data. After a discussion of the effect of machining and polishing, other surface treatments were considered, such as flame- and induction-hardening. Other sections then followed on the influence of carburising, decarburisation, nitriding and cyaniding, and the data under each head were clearly presented. Some of the data appeared contradictory, but, generally speaking, the conclusions which could be drawn were clear. The influence of surface rolling and pressing were next reviewed, followed by the effects of cold-working produced by straightening or overstraining a component or by deliberately shot-peening it to work-harden the surface. In the

discussion it was hoped that some attention would be given to experience with shot-peened components, because the data presented in the paper suggested that this method of increasing fatigue resistance required great care in application or it might not be successful.

Still further sections were presented on the effect of non-ferrous metallic coatings, and the deleterious effects of electroplated finishes were clearly brought out. In most cases there was a serious loss in fatigue strength due to plating. If a soft metal such as lead or zinc were deposited first, followed by a harder metal such as nickel or copper, it seemed possible to avoid a serious drop in fatigue strength in the component in question. The loss in strength was attributed to weakness in the plating itself, which failed under comparatively low fatigue loads; then, because of the good adherence of the plated coating, the underlying material was weakened by the notch formed by a crack in the plating. Presumably, in the cases of lead and zinc, a plastic flow occurred in preference to early work-hardening followed by cracking, but the clarification of this issue would appear to be very important. The paper concluded with a discussion of the effects of metal-sprayed coatings, phosphate coatings, and of the acid-pickling process. The improvements ascribed to carburising were most impressive, and it would be helpful to learn whether, in engineering practice, carburising was specified merely to enhance the fatigue resistance of parts which otherwise could be left in the normalised or heat-treated condition.

The last paper of the series, by Dr. Bowden and Dr. Tabor, entitled "The Influence of Surface Films on the Friction and Deformation of Surfaces," dealt comprehensively with the phenomena of friction between rubbing surfaces and how this was profoundly modified by air or oxygen as compared with a technically-clean surface *in vacuo*. It was shown that the plastic, polytetrafluoroethylene, was the only material which was not greatly affected by the presence of an oxidising atmosphere. The paper also discussed very thoroughly the effect of adsorbed water films and oxidised films produced electrolytically, and attention was drawn to the profound changes in friction between clean and oxide-coated metals. An excellent discussion on the Beilby layer followed and recent views on its structure were carefully and fully stated. Friction between polished surfaces was then considered in detail, and interesting deductions were drawn from micro-hardness tests. Following that morning's discussion, a little more time might usefully be given to discussing what was meant by the statement that the Beilby layer was amorphous, unless it had recrystallised systematically. The paper concluded with a discussion of lubricant films and the question of metallic transfer in relation to the observed values of friction. Finally, mention was made of other types of protective film and the very low frictional characteristics of polytetrafluoroethylene-impregnated porous metal. This remarkable combination maintained a very low coefficient of friction up to 300 deg. C.

(To be continued.)

WASTAGE OF COAL.—Mr. A. L. Ford, in his presidential address to the North of England Institute of Mining and Mechanical Engineers at Newcastle-on-Tyne on December 6, referred to the present waste in the use of coal and asserted that the average efficiency in the use of 200 million tons consumed in Great Britain was only 15 per cent. In some cases, such as in coal-fired locomotives and in domestic fires, the efficiency of utilisation was as low as from 6 to 10 per cent. Mr. Ford emphasised how imperative it was that the most diligent research work should be continued, and on a national basis.

SPACE HEATING DIRECTLY BY GAS: ERRATA.—We have been asked by the Chandos Engineering Co. Ltd., 17, High-street, Egham, Surrey, to amend two statements in the article on their Gasanair heater, which appeared on page 767 of our December 12 issue, and which do not apply to the latest types of heater now supplied by them. The Carbocell chamber is constructed in cast iron, and not in welded mild steel; and it is provided with a bolted cover with a gastight gasket, which serves both for charging and discharging, instead of with separate doors for the two operations.

THE INSTITUTION OF NAVAL ARCHITECTS' AUTUMN MEETING.

(Continued from page 755.)

THE eighth and last paper in the programme of the autumn meeting in Italy of the Institution of Naval Architects, held jointly with the Associazione Italiana di Tecnica Navale was presented in Rome on September 29. The author was Mr. A. J. Williams, R.C.N.C., who described "An Investigation into the Motions of Ships at Sea."

THE MOTION OF SHIPS AT SEA.

The material presented in the paper, the author stated, was obtained in the course of various sea trials carried out by the Admiralty for the purpose of obtaining data for use in the design of stabiliser systems, the vessels concerned being the aircraft-carrier Vengeance and the destroyer St. Kitts in 1949, the frigate Cygnet in 1950 and 1951, and the cruiser Cumberland in 1951. To analyse the motions of a ship, with its six degrees of freedom and no fixed datum, apparatus was used which consisted of a free and a constrained gyroscope, the free gyro remaining steady in space, while the other was constrained to precess about the axis of the motion to be recorded. Instruments were developed which would record simultaneously the displacement, velocity and acceleration of roll, pitch and yawing motion, these motions being indicated by quadrant plates and converted into electrical signals which could be amplified and recorded. Three sets were required for the complete description of a ship's motion. In general, it was found that the rolling period of a ship in heavy weather tended towards a unique value for large amplitudes, and there was reason to believe that it was the still-water rolling period of the vessel. In the absence of data from sea trials of conventional warship designs, it was submitted that a useful approximation to the mean value of the still-water rolling period T_R in a deep or half-loaded condition, was given by the equation T_R (in seconds) = $2.55 \Delta^{1/2}$, Δ being the deep displacement in tons. Heavy rolling approximated closely to simple harmonic motion, and no appreciable error was involved in calculating angular velocities and accelerations on that assumption. Under confused sea conditions, the predominant rolling period was the appropriate still-water period, and the author suggested a statistical law governing the frequency of occurrence of roll amplitudes of various magnitudes. The overall probability of "really heavy motions" during a ship's time at sea was found to be "very small indeed."

DISCUSSION.

Professor G. Rabbeno, opening the discussion, said that, in 1935, he had presented to the Association Technique Maritime et Aeronautique a memorandum on "The Stabilisation of Ships in a Wavy Sea," which was published in vol. 39 of the Association's *Bulletin*. In it, he drew attention to the fact that the greatest discomfort caused to passengers by extensive rolling was due to tangential acceleration. Following that statement, Professor A. Servello had suggested in his work on the stability of ships (*Tecnica Italiana*, No. 3, 1951) that the value of the maximum transverse tangential acceleration at the level of the highest part of the superstructure should be taken as a measure of the rolling in waves. Numerical values of that acceleration could be fixed for the various types of merchant ships, from which values the determination of the most suitable GM for each case could be deduced. The modern tendency in American naval construction, for security reasons, seemed to increase towards limits never assumed before, the initial metacentric height of passenger ships at the beginning of a voyage being about 1/20 of the ship's breadth. To reduce the effects of high values of the tangential acceleration on fast passenger ships it might then be necessary to close successively the uppermost decks of the superstructure to passengers as the sea conditions worsened. Alternatively, perhaps water ballast tanks at a high level might be provided.

Professor A. M. Robb said that he welcomed

Mr. Williams's cautious attitude towards his problem, because, comparatively recently, a very elaborate paper on rolling had been presented to another institution, in which the authors, on the basis of their mathematics, were quite satisfied that they could tell whether a ship was safe from capsizing. Unfortunately, just after that paper was read, the Flying Enterprise circumstance arose, to knock the bottom out of all their mathematics. He doubted whether, at present, it was necessary to go farther with the mathematics than Mr. Williams's very simple addition to the classic Froude theory, the addition of a term with the resistance varying as the velocity only. He would join issue with Mr. Williams, however, on his statement that, unfortunately, the damping was not proportional to the angular velocity Θ alone, but also included the square of the angular velocity, which brought the term $b\Theta^2$ into the extinction. He thought that old expression had been fairly well killed by Mr. M. P. Payne in 1924 and Mr. Gawn in 1940. It was necessary, as a practical measure, to accept and adopt the assumption that the resistance varied as the angular velocity alone. It was not correct, but it was near enough to the truth. The important thing was that the ship would roll heavily only when she met waves of about her own natural period. The other thing that mattered was the position of the ship at the maximum angle on the wave. Those were the two important elements, from the theory, and he regretted that, in Mr. Williams's experimental investigation, there were no data on the wave slope. It was of no use to check the mathematical expression unless the wave slope could be related to the maximum angle. It appeared from photographs of ships rolling that, in every case, they seemed to roll towards the crest of the wave, which was another piece of evidence that completely justified the simple mathematical consideration.

Professor Sir Thomas H. Havelock, F.R.S., found the paper of much interest, not only for its main purpose and the main results, but because there were so many interesting side tracks to explore. For instance, in the paper there was an attempt to apply a statistical formula to the probable amplitude of rolling in a random sea. What was the definition of a completely random sea? He presumed that the answer would be some kind of mathematical specification such as was given in the appendix. However, it appeared that Mr. Williams was not able to find completely random conditions at sea; perhaps the completely random sea was also a convenient mathematical fiction, like the completely regular sea. The work showed that, in general, the motion of the sea had underlying regularities with random perturbations superposed; and there was a corresponding response in the motions of the ship, depending upon the characteristics of its natural oscillations. Turning to the general conclusions, it would appear at first sight as if forced rolling did not occur; but presumably that conclusion must be taken as subject to the conditions under which the observations were made. If there were regular waves which would have produced forced rolling, the ship's course was such—or was altered to be such—that it was not allowed to develop. The amplitude of the forced pitching varied in a cyclical manner, suggesting interference by a second period; that was supposed to be due to superposed free pitching, constantly regenerated by the irregularity of the sea. That was probably true; in fact, if the problem were approached only in terms of the simple linear theory of pitching, that was the only other period that could be considered. In view of the heavy damping of free pitching, however, it was difficult to see how it could be maintained with sufficient regularity to give the observed effect. The same phenomenon occurred with models in a tank, where, presumably, the waves were smooth and regular. No doubt, the cyclical variation of amplitude was more regular in a tank than in the open sea, but it seemed to be the same effect, and, naturally, that suggested a common cause. The fact was that the present simple theory of pitching was inadequate for motions of large amplitude, even in regular waves. Another point, not referred to in the paper, was the possible coupling of the natural oscillations. The author's analogy,

that a ship was a filter tuned to a certain selective frequency, was attractive, but, unfortunately, it must be complicated by more detail. There were three selective frequencies; and, further, heaving, pitching and rolling were not generally independent, but were coupled. Coupling was usually assumed to be small and had been neglected, but he was sure it must be taken into account for motions of large amplitude; the effects might be quite important for motion in a rough sea, especially perhaps for heaving and pitching. In that connection, he asked whether records were taken of heaving; or could that motion be deduced from records taken during pitching?

Mr. V. G. Shephard (Director of Naval Construction, British Admiralty), in a written communication which was read by Mr. R. W. L. Gawn, said that ship designers had always regarded information on the motion of ships in seaways as fundamental to their art and had regretted that their thirst for knowledge on the subject was limited by the measurements they could make and the accuracy with which they could be taken. The last decade or so had seen great strides in instrumentation techniques, rendering available means of recording the motions of a ship more completely and accurately than ever before. There were still, however, some components of the motion which were not so fully or so accurately covered as could be wished, and, unfortunately, it had not been found possible to record in so much detail and with such a high degree of accuracy the characteristics of the sea which were the cause of the ship's motion. The advance in the ability to record and study the fundamentals of ship motions came at a most opportune time, because, with present-day stabilising equipment, the knowledge could be turned to practical account, both by the designer of a liner, to increase the comfort of the passengers, and by the designer of a warship, to make her a better platform for offensive and defensive weapons.

They had only begun to touch the fringe of a most involved and complex subject, and it was imperative to continue the studies. Theory seemed to have gone about as far as it could until more experimental evidence became available, but obtaining it was costly and took a great deal of time. However, it was not unreasonable to expect that soon there would be available a number of statistical instruments which would supply useful information without the necessity for the continuous presence of specialist scientific teams. Advances in knowledge could be much expedited, and the need for costly trials with ships at sea much reduced, if more facilities were available for model experiments, but such facilities were complex in character and their first cost was high. There was no doubt, however, that they were a good investment for any organisation vitally interested either in reducing ship motion or in a more complete knowledge of its characteristics. The author had limited his investigation to a precise objective and had wisely confined his measurements to what was happening to the ship, paying no more than passing attention to the state of the sea which was causing the motion. His conclusions, that when the ship was rolling heavily the motion was very nearly simple harmonic, and that, as the amplitude of roll increased, its period tended to a unique value approximating to the still-water rolling period, were of great significance, and would be searchingly studied by those concerned with stabilisation problems.

(To be continued.)

ELECTRICITY SUPPLY TARIFFS AND SHORT-TIME WORKING.—The standard industrial tariffs for electricity recently adopted by the North Western Electricity Board consist of a kilowatt demand charge and a charge per kilowatt-hour, thus providing an incentive to long hour usage. Owing to short-time working, particularly in textile mills, however, it has been found that the reduced consumption has led to an increase in the average price. The Board have therefore decided to introduce ceiling prices of 2d. or 2½d. per kilowatt-hour (depending on the tariff in force), except in certain special cases; and to make this charge retrospective from the date on which the consumer became liable under the new tariff. This policy will continue until March 31, 1953.

THE AIR AND THE FUTURE.*

By AIR COMMODORE F. R. BANKS, C.B.,
O.B.E., M.I.Mech.E.

IN my first address† and in a subsequent lecture I attempted to give some idea of the historical development of the aviation engine; and I indicated the principal technical advances, such as supercharging, together with the use of improved fuel, which determined further progress and success in building engines and aircraft of outstanding performance in the last war—to the Whittle jet-propulsion gas turbine. It is my purpose to-night to show how the future may be affected by the progress in engine and aircraft development, and also by the rapid advances made in other complementary fields of endeavour.

Prior to the advent of the aviation gas turbine, the aircraft designer was never long satisfied with the power available for his needs; but when the turbo-jet arrived and so quickly established itself he was, temporarily, faced with more power than he could effectively use. In the first place, the high power available from the gas turbine could not be used effectively with the conventional airframe because of the rise in "drag" or resistance of the aircraft to the air. This prevented the machine from going faster, regardless of the power used, due to a "shock wave" forming on the aircraft surfaces in regions of high induced velocity. These Mach number‡ limitations were already present in piston-engined aircraft such as the Spitfire and the Typhoon, before the advent of the gas turbine.

Naturally, the performance of the supersonic aircraft is also affected by this compressibility feature of the air; and the pressure wave, which normally travels at sonic speed and is, therefore, able to keep ahead of the sub-sonic aircraft, is overtaken by the supersonic machine and "attaches" itself, in the form of a shock wave, to the frontal parts of the latter—thereby increasing the "drag" up to the limiting Mach number of the aircraft.

German research into high-speed flight in the last war produced a practical method of delaying the onset of the shock-wave effect by giving some degree of sweep-back to the wing, and the tail. From this research also came the Delta wing. A very thin wing would probably give equally good and, perhaps, better results, certainly for supersonic flight, if it could be made sufficiently strong and torsionally stiff. Its thickness would, however, have to be in the order of from 5 to 7 per cent. of the wing chord or width. This presents quite a design and structural problem, but one capable of eventual solution by the use of special materials and radical design. The principal disadvantage of the thin wing is that little or nothing can be put inside it, such as fuel and, in the case of the military aircraft, armament. The Delta wing is ideal for this purpose, since it is relatively thick and can contain a large proportion of the fuel and equipment.

These aerodynamic improvements have now taken us up to the so-called sound barrier (Mach No. 1); and some experimental and research machines, notably the Douglas Skyrocket, have exceeded the speed of sound by a good margin, i.e., they have flown at over 1,200 m.p.h. at an altitude of 79,500 ft. The Skyrocket is an interesting research aircraft. It has a wing span of 25 ft. with a sweep-back of 35 deg. The all-up weight is 15,000 lb., which includes about three tons of fuel for its four rocket tubes. This fuel is used up in, approximately, four minutes. Originally, it was fitted with a conventional turbo-jet engine for take-off, but this was removed to make room for more rocket fuel, and the machine itself was then carried to altitude, slung in the bomb bay of a B.29 and launched at about 30,000 ft. The Skyrocket flies faster than the Earth's rotation, which is about 1,000 m.p.h. at the Equator.

One of the difficulties attending high-speed flight of the future will be that of insulating the pilot, his crew and the passengers from the heat generated by the high-velocity passage of the aircraft through the air, the friction of which considerably raises the temperature of the outer skin of the aircraft. In the case of the Skystreak, a machine built before the Skyrocket, a failure of the cockpit refrigeration occurred causing the temperature to rise to 165 deg. F. Apart from personnel comfort and safety, the modern light alloys used in aircraft construction show a reduction in strength of about 10 per cent. at 200 deg. F. (93 deg. C.) and 50 per cent. at 400 deg. F. (205 deg. C.). Therefore, I cannot envisage rapid development of supersonic aircraft except for special and urgent military requirements. Flight at supersonic speeds demands a very large increase in the thrust of the engine to enable the machine to pass from the sub-sonic, through the sonic (trans-sonic), to the supersonic; and then the aircraft man will again be short of power, as he was in the piston-engine era.

It is an interesting speculation that a fuselage of, say, the size of the Bristol Britannia could sustain itself in level flight at about 1,000 m.p.h., without wings, by its own aerodynamic "lift" and that of its tail surfaces—provided, of course, it was of the right shape for supersonic speed. This may sound attractive for the future, but, apart from the enormous power required, it is probably impracticable of attainment, since wings would be needed for take-off and landing and at all flight speeds below the maximum; and the technical (mechanical) problems of designing a folding wing, to stow it and still carry an economic payload, are practically insurmountable.

DEVELOPMENT OF GUIDED WEAPONS.

In the case of military aviation, another more recent development has further complicated the final issue. This is the advent of the guided weapon or missile, which had its start during the war when the Germans produced the pilotless V-1 and V-2 weapons—and also a bomb which, when released, could be guided to its target from the aircraft. The latter was used against shipping with some effect. To-day, the guided weapon is being intensively developed for defensive and offensive purposes, thanks to the advances made in electronics and radar, etc. This weapon, which comprises a warhead propelled by a rocket or by a combination of a rocket and a ram-jet, can either be guided from the ground by radar and electronic devices, or launched and "homed" on its target, an enemy bomber, without ground aid. It is the latter method, of automatic guidance, which is now receiving great attention.

While the guided weapon is presently of relatively short range, though having much higher rate of climb, velocity and altitude than the piloted fighter, its main use is for defensive purposes, to combat the enemy bomber; but it is only another step to apply the guiding and homing principles to a long-range vehicle, such as a crewless bomber, a long-range rocket or a ram-jet. A bomber without crew, which would be a one-way machine and self-destroyed at the target, could be built for about one third of the all-up weight and cost of a normal bomber of the same bomb capacity. These developments may eventually eliminate the piloted

fighter and, over a somewhat longer period, render the conventional bomber obsolete.

There are, already, aircraft built which have rocket armament in place of guns, and the next step could be a "carrier" aircraft for guided weapons. Such a machine would be designed to cruise far from its base, to locate and home by radar on the enemy bomber while the latter is some distance from its target, releasing the missiles when within range. The obvious intermediate defensive-attack machine for day operation, between the present jet fighter and the guided weapon to come, is the piloted rocket fighter, similar to the German ME.163 of the last war.

All these new developments of the last decade have made it very difficult for the air staffs of the world to formulate any definite forward plans. If they commit themselves to a massively expensive Air Arm of conventional pattern (with the gas turbine in place of the piston engine) they may find, too late, that the potential enemy has an effective guided weapon, rendering their bomber force obsolete almost overnight. But since a specification cannot yet be written for an "all-can-do" guided weapon, a nice balance has to be struck in ordering sufficient numbers of present-day fighters and bombers to cover the unknown period which must elapse before "push-button" weapons are finally proved.

Whatever happens, the effect of these developments upon military aviation in the next ten and 20 years will be profound, and may, for instance, alter the whole concept and set-up of the Royal Air Force. The piloted fighter will probably disappear within ten years (in favour of the guided weapon), and the orthodox bomber in 15 or 20 years. Assuming that all the principal countries eventually achieve the same success in the guided-weapon field, it is conceivable to envisage a stalemate in the air—with "ground-to-air" and "air-to-air" missiles so accurate in their ability to hit each other that air warfare as such passes out of the picture, leaving "ground-to-ground" missiles of short and long range to take their place, in lieu of artillery. But such technical perfection rarely happens; and there must always remain some insurance in the form of, say, large quantities of well-proved "ground-to-air" guided weapons immediately available, to ensure the maximum protection against the delivery of the most lethal weapon of destruction which has yet been devised by man—the atomic bomb.

There is some apprehension of the present high production cost of the guided weapon, on the assumption that many thousands would have to be supplied. But its cost is very small indeed when compared with that of a modern air force equipped with the latest fighters and bombers; particularly when taking into consideration the enormous complementary cost of airfields with 10,000-ft. runways, and the ground crews and other personnel which are necessary to maintain and sustain a large air force.

I believe it has been estimated that the cost of shooting down one German bomber in the last war was 500,000£, based on the original value of all the guns, the predictor equipment employed and the ammunition expended during a particular engagement. Therefore, even if each guided weapon cost, say, 20,000£ and registered one hit for every six or even 12 missiles launched, the effort involved would be well worth while—always remembering that the target to be hit may be one carrying the atomic bomb. If all these things come to pass, the role of an air force in about 20 years' time will be that of a highly-developed transport organisation to carry men and equipment to the operational areas and theatres of war.

The present-day jet fighter and jet bomber cost between five and ten times more than the equivalent aircraft used in the last war. Then, fighters such as the Hurricane and Spitfire could be built and equipped for about 5,000£ apiece and bombers like the Lancaster for 60,000£ to 70,000£ each. But a modern jet-propelled day fighter will cost anything from 25,000£ to 50,000£, an all-weather or night fighter 150,000£, and a large bomber 700,000£ to 1,000,000£. Some of the largest bombers now being built in the United States cost more than

* Presidential address to the Junior Institution of Engineers, delivered in London on Friday, December 12, 1952. Abridged.

† See ENGINEERING, vol. 173, page 54 (1952).

‡ Mach number is the ratio of the speed flow of a gas to the speed of sound at the same conditions. Put differently: the Mach number of an aircraft is the ratio of its speed to that of sound, which latter is proportional to the square root of the absolute temperature of the air. For instance, the speed of sound (Mach No. 1) at normal temperature (60 deg. F.) is about 760 m.p.h., and at the low temperature at the tropopause (35,000-36,000 ft.) is approximately 660 m.p.h. Ernst Mach, from whose name and work is derived the term "Mach number," was born on February 18, 1838, at Turas in Moravia. He studied at the University of Vienna, and in 1864 became professor of Mathematics at Graz. He returned to Vienna as Professor of Physics. Subsequently, he changed his chair to that of the "Theory of Inductive Sciences." He retired from active life in 1901 and left Vienna shortly before the first World War, to live in obscurity in Munich, where he died on February 19, 1916. Professor Mach's researches in the supersonic field on the flight of projectiles and shock waves are original and classic; but it is only in recent years that his name has become generally known, due to this work and its present great importance in relation to modern aerodynamics progress.

1,000,000l. each; and the electronic fighting, navigating and bombing aids with which they are equipped represent a large proportion of the total cost of the air-frame and its engines. In fact, the cost of this equipment alone is in many cases several times that of a complete bomber of the last war.

Since these costs mainly represent man-hours of effort, it is difficult to see how any country to-day, with the possible exceptions of the United States and Russia, can embark upon a production programme involving more than a few hundred aircraft per month, of all types—including military transports, small communications aircraft, helicopters, etc. In the case of axial-type turbo-jet engines such as the Avon and Sapphire, only about one-third or less of these units could be built to-day, as compared with the number of piston engines which were produced in the last war, assuming that the same effort and equivalent facilities were available.

THE FUTURE OF CIVIL AVIATION.

Civil aviation has now been with us for some 25 or 30 years, but its expansion since the last war has been such as to leave no doubt whatsoever of its future. While it can only compete in a fractional way with railways and shipping as a cargo carrier, civil aviation is certainly complementary to these two methods of transport in carrying passengers and has, in fact, made serious inroads into their passenger business. Even as a cargo carrier it can, in many cases, deliver its relatively small unit loads to many remote and inaccessible places far more economically and quickly than the combined efforts of the railway, shipping and road and animal transport.

The Atlantic crossing, which is so important to the Old and New Worlds, became the goal of the aviation pioneer immediately after the first World War; and the feasibility of regular Atlantic crossings was finally proved in the last war, when many hundreds and even thousands of persons were flown both ways in flying boats and in improvised bombers. Bombers themselves, and even fighters, such as the Canadian-built Mosquito aircraft, were delivered to this country "under their own steam," sometimes non-stop, from the North American continent.

The first non-stop crossing of the Atlantic was made by John Alcock and Whitten Brown in 1919, in a Vickers Vimy biplane fitted with Rolls-Royce Eagle engines. They started from Newfoundland and landed in Ireland. Practically the whole flight, of 16 hours and 12 minutes, was in terrible weather, with the machine only a few feet from the surface of the sea. There was little opportunity for Brown to take astral sights and there were no instruments which permitted blind flying. It was a great feat by two very brave men.

Eight years later, Charles Lindbergh crossed non-stop from New York to Paris in 33½ hours. In 1951, the Canberra crossed from Northern Ireland to Newfoundland, against the prevailing headwinds, in 4 hours and 18 minutes. Thirty-three years after the Alcock and Brown crossing, and on the 25th anniversary of Lindbergh's flight, the first scheduled airline flight by a jet transport machine was made from London to Johannesburg by the Comet, in an elapsed time of 23 hours and 34 minutes. Still more recently, a Canberra completed the round trip from Ireland to Newfoundland and back in about half the time taken by Alcock and Brown for the single journey.

Since the historic flights of Alcock and Brown and Lindbergh, the North Atlantic has been flown well over 100,000 times; and the records for 1951 show that some 340,000 persons were ferried by the scheduled airlines alone, or nearly one-third of the total of those who crossed the Atlantic that year. There are, to-day, more than 200 scheduled airlines operating over Continental and world routes, totalling about three-quarters of a million miles, with something in excess of 4,000 aircraft. Allowing for those out of service for maintenance, and assuming a round figure of 4,000 machines in operation, a daily rate of 500 miles per aircraft produces the impressive total of 2,000,000 miles flown each 24 hours.

(To be continued)

LABOUR NOTES.

HEAVY engineering is reported to be one of the basic industries which are to be examined by members of the policy sub-committee of the Labour Party, with a view to determining whether they will be suitable for nationalisation in the near future. The other industries to be investigated are shipbuilding, textile machinery, and aircraft construction. Approval of this course of action was given at a meeting of the policy sub-committee in London on Monday last. It was decided that the guiding principles to be applied should be whether and, if so, to what extent, the public ownership of these industries would be likely to increase production and improve the balance of payments position in the sterling area.

The meeting of the policy sub-committee followed a meeting of the national executive committee of the Labour Party on Saturday and Sunday last. In a statement issued subsequently by Mr. Morgan Phillips, the Party's secretary, it was announced that the committee had given considerable and detailed consideration to the major economic problems confronting the nation and the world at the present time. Special attention had been given to what the committee regarded as being the world's key problem, namely the dollar gap. The problem had a two-fold character. There was the difficulty of meeting the United Kingdom's lack of dollars, and that of making good the dollar shortage of the rest of the sterling area.

The committee unanimously recognised, the statement continued, that there was an urgent need for a plan which would help the United Kingdom to achieve greater viability and enable it to make a larger contribution towards the coherence of the sterling area. A rapid expansion of production, especially in the basic industries, was essential. Some proposals with that aim in view had been remitted to special sub-committees for expert guidance. The broad framework of the agreement which had been reached during the week-end regarding the Party's future policy would be reported to a conference with the General Council of the Trades Union Congress, which it was intended to hold in the near future. The General Council would be invited to take part in the work of the sub-committees. It was hoped that the Party's statement of policy would be ready for publication in the spring of next year.

An interesting reference to the progress of the patternmaking industry in Scotland is contained in the *Monthly Report* of the United Patternmakers' Association for December. Mr. W. B. Beard, O.B.E., the Association's general secretary, writes that trouble which had arisen in Scotland on the question of metal patternmaking appeared to have been settled amicably. Three men were concerned in the dispute, namely, a non-unionist and two who belonged to other unions than the U.P.A. They had been engaged for some years on work in connection with metal patterns, and had acquired a fair degree of skill, having, presumably, commenced their careers as pattern finishers, but their employers regarded them as fitters and declined to up-grade them or to pay them the wage rates applicable to patternmakers. Members of the Association accordingly placed an embargo on master patterns belonging to the firm, as a result of the failure to secure an agreement, and this position continued for some weeks.

Attempts were then made by the Engineering and Allied Employers' National Federation, Mr. Beard states, to discuss the dispute with the U.P.A. at headquarters level. The Association's executive committee, however, refused to instruct its members to make use of local negotiating machinery to determine whether metal work on patterns constituted patternmaking, unless such discussions were allowed to take place free from any limitations, as the committee decided that, on no account, would it be involved in a reference to the engineering-industry's central conference on an issue of that

kind. The committee stated that it was prepared to enter into a national discussion on the difficulty, but that the embargo on the firm's master patterns would have to remain, because the payment of patternmakers' wages to employees working on metal patterns was a matter which the committee regarded as settled.

Later, further discussions took place between the firm and its employees belonging to the Association, and a settlement agreeable to all parties was reached. This provided that the firm should dismiss the three men as fitters, re-engage them as patternmakers, and pay them at the rate due to their improved status. To enable this course to be taken, the three men were admitted members of the Association's ancillary section. Mr. Beard concludes by expressing the hope that apprentices will have an opportunity to perform this work in the near future.

Leaders representing both sides of industry met Mr. R. A. Butler, the Chancellor of the Exchequer, in London on Wednesday last, to discuss the Government's plans for the re-organisation of the nation's industrial resources, designed to meet the development needs of the various Commonwealth countries. The main problem requiring solution appears to be how to supply these countries with capital goods at a rate of from 250 to 300 million pounds per annum, while, at the same time, increasing Britain's exports to non-sterling countries by about 10 per cent. This requires that more attention shall be given to the production of capital goods for export, at the expense of consumer goods.

The Chancellor, who was accompanied by Mr. Duncan Sandys, the Minister of Supply, and Sir Walter Monckton, the Minister of Labour, referred to a number of hopeful trends in Britain's trading achievements during recent months. Although the country's total exports declined during 1952, there were useful increases in particular industries. For example, production in the engineering, electrical and shipbuilding industries improved by 5 per cent. in the first seven months of the current year, compared with the corresponding period in 1951. The inability of manufacturers to guarantee the early delivery of their goods has been a severe obstacle in the expansion of trade in capital goods. No doubt this was one of the problems discussed on Wednesday. Other meetings of a similar character will take place at intervals.

Winding enginemen employed at collieries in the Yorkshire coalfield ceased work on December 13, in support of their demands for an increase of 3s. a shift in their wage rates. The men concerned, who are members of the Yorkshire Winding Enginemen's Association, an organisation included in the National Union of Mineworkers, claim that increases of up to 3s. a shift have been granted recently by the East Midlands Divisional Coal Board to enginemen employed in its area, in spite of similar concessions having been refused by the North Eastern Divisional Coal Board, which controls collieries in Yorkshire. Under the terms of a national agreement concluded on December 31, 1951, shift rates for enginemen were increased by 1s. 11d., on condition that the maximum rate was in no case to exceed 29s. 11d. After these adjustments had been made, where necessary, the pay of enginemen throughout the country varied from 26s. 11d. to 29s. 11d. a shift.

It appears that, at a later date, the East Midlands Board granted further increases in certain instances, thereby raising the rates of some of its enginemen to the ceiling level of 29s. 11d. a shift. These increases are claimed to have amounted to 3s. a shift in some cases. On Monday last, Sir William Lawther, President of the National Union of Mineworkers, stated that union officials had asked the Yorkshire enginemen to make their application for an increase through the industry's proper negotiating machinery, as requested by the Divisional and National Coal Boards. Their strike action was contrary both to the terms of the conciliation machinery and the national rules.

OPTICAL DYNAMIC WEIGHBAR.

Fig. 1. SECTION B-B.

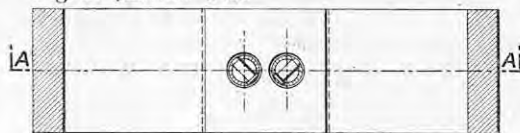


Fig. 2. SECTION A-A.

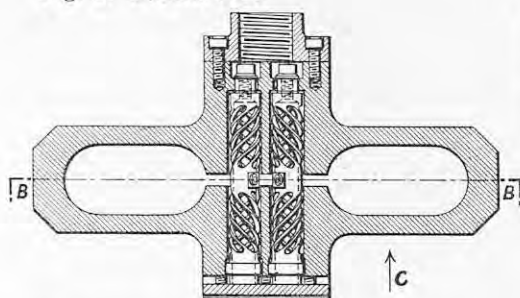
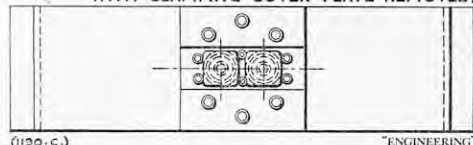


Fig. 3. VIEW IN DIRECTION OF ARROW 'C' WITH CLAMPING COVER PLATE REMOVED.



OPTICAL DYNAMIC WEIGHBAR FOR A FATIGUE-TESTING MACHINE.*

By P. G. FORREST, B.Sc. (Eng.).

THE normal method of measuring alternating loads in a Haigh fatigue machine is by a stress meter mounted on the machine panel. This meter measures the voltage induced in search coils wound on the armature of the machine. For calibration a strain-gauge bar is used; this is a 0.3-in. square-section test-piece having a 2,500-ohm wire resistance strain gauge stuck on each face. It is calibrated in a static tensile machine, and then used dynamically to provide calibrations of the stress meter in terms of load. The latter calibrations have shown that variations of up to 5 per cent. may occur. It was therefore decided to design and make a weighbar which could be fitted permanently in a Haigh machine in series with the test piece, to give a direct measure of the load range during tests. The problem may be considered in two parts: the design of a weighbar to give a deflection not exceeding 0.01 in. under the full load range of 1.5 tons, and the design of an extensometer to give a measurement of this deflection with an accuracy of 1 per cent.

As may be seen from Figs. 1, 2 and 3, the weighbar consists of a loop, a deflection of the centre occurring due to the flexibility of the sides and ends. An overall length of 9½ in. is used in order to keep the stresses well below the elastic limit of the material. Experience has shown that most of the variation in weighbar calibrations can be traced to the end fixings. In order to minimise this effect, the centre of the weighbar is integral with the loop and has been made as stiff as possible. An adaptor is shown fixed to the top of the weighbar. This permits the use of two different types of test-piece holders, one for threaded and one for button-ended test-pieces. No attempt was made to calculate accurately the dimensions of the weighbar to give the stiffness required. Instead, a measurement of the stiffness was made before final machining, and the final dimensions were estimated from this. The weighbar is illustrated in Fig. 4; and in Fig. 5 part of a Haigh machine is shown with the weighbar in position; the furnace used for high-temperature tests has been removed in order to show the test-piece.

From previous experience it is known that with a simple rhomb and mirror system, the static and

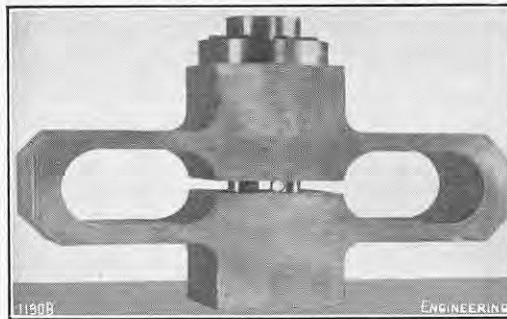


FIG. 4. WEIGHBAR.

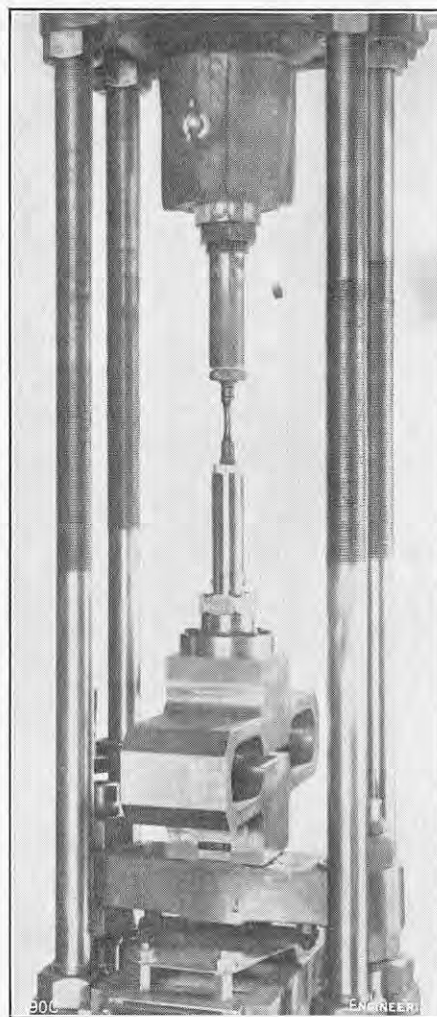


FIG. 5. WEIGHBAR IN HAIGH MACHINE.

dynamic calibrations could differ by up to 4 per cent. It was therefore necessary to use a method which avoided the relative motion involved between a rhomb and its seating. The method chosen makes use of the rotation of a spiral spring due to an axial deflection. Two such springs are used, the two halves of each spring having six-start 45-deg. helices cut in opposite directions. This was made by mounting the tubes from which the springs were made in a milling machine with one end in a dividing head geared to the machine to give the required helix angle. The mirrors were made by polishing optically-flat surfaces on the ends of stainless-steel rods. They are fitted at the centre of the springs approximately at right-angles to one another. The springs are fixed in the weighbar with an initial extension of 0.015 in. The maximum deflection applied to them, when in operation, is 0.010 in., so that the shear stresses are always in the same direction.

The rotation of the mirrors is magnified optically to give a measure of the spring deflections. A lens of focal length 2 m. is fixed close to the weighbar. An illuminated slit is placed at the focus of this lens, so that a parallel beam of light emerges from the

lens on to the mirrors. After reflection, the beam of light returns through the lens and is brought to a focus on a celluloid scale. The mirrors are set at an angle slightly less than a right-angle, so that two images of the slit appear on the scale, one after reflection from the left-hand mirror on to the right-hand mirror, and vice versa. If a static tensile load is applied to the weighbar the two images move apart a distance proportional to the static load. If a dynamic load is applied each image spreads into a band of light, the increase in band width being proportional to the dynamic load.

The weighbar was calibrated in a Haigh machine with the strain-gauge bar used for calibrating the stress meter. Static and dynamic calibrations were made, and in each the scale readings were proportional to the load. For the static calibration the scale deflection was 10.75 cm. per ton (at a scale distance of 2 m.), and for the dynamic calibration 10.7 cm. per ton for each band. The scale can be read to half a millimeter, i.e., to better than ½ per cent. of the full-load scale deflection. The natural frequencies of torsional and transverse vibration of the springs are each about 100,000 cycles per minute, so that the weighbar is expected to operate satisfactorily at speeds considerably higher than 2,000 cycles per minute, and, in particular, at 6,000 cycles per minute on the new type of Haigh machine. In order to measure the stresses set up in the weighbar, wire resistance strain gauges were stuck on it at positions where the stress was expected to be high. Under a static load of 1.5 tons, the maximum stress measured was 9 tons per square inch.

OIL-STORAGE TANKS AT CANVEY ISLAND.

A NEW oil installation is being built at Holehaven, Canvey Island, for the Regent Oil Company, Limited, 117, Park-street, London, W.1, to provide additional storage capacity and distributing facilities for petroleum products in the Thames area. About 30 acres of land have been acquired and 25 storage tanks are being erected by the Oxley Engineering Company, Limited, Clarence-road, Hunslet, Leeds, 10; the sub-contractors for the pipework are William Press and Son, Limited, 22, Queen-Anne's Gate, London, S.W.1, and electrical work is being undertaken by Thorpe and Thorpe, Limited, New Broad-street, London, E.C.2. The capacity of the tanks varies from 500 to 4,000 tons each and they are being built within two main reinforced-concrete bunds which are sub-divided to limit the capacity of any division to a figure not exceeding 10,000 tons of petroleum. The new installation will have a total capacity of 60,000 tons and it will be worked in conjunction with the neighbouring plant of London and Coastal Oil Wharves, Limited, with whom the Regent Oil Company have a storage agreement.

A jetty, with a deep-water berthage of about 40 ft. of water at low tide, is being constructed to receive ocean-going tankers with a cargo capacity of up to 30,000 tons. A second jetty is also being built to handle coastal tankers and barges. Steel box-piles supporting deck beams of reinforced concrete and a prestressed-concrete deck are being used for the construction of both jetties, which are being built by J. L. Keir and Company, Limited, 7, Lygon-place, London, S.W.1.

The site is being surrounded by a ring fire main that will be fed by four pumps with a combined capacity of 2,000 gallons per minute. The pumps will draw water from a reservoir of 1 million gallons capacity which will be maintained by drainage from the site discharging into it through interceptors. Any excess drainage will be passed to the river through sluices. In the event of fire the reservoir will be re-charged at high tide by opening the river sluices. The principal civil engineering contractors, responsible for the buildings, fire walls, tank foundations, roads and drainage are John Howard and Company, Limited, 13, Buckingham Gate, London, S.W.1. Mr. B. J. Ellis, O.B.E., F.Inst.Pet., 49, Hallam-street, W.1, and Mr. J. H. R. Haswell, M.I.C.E., 9, Sussex Mansions, Old Brompton-road, London, S.W.7, are the consulting engineers for the work.

* Communication from the National Physical Laboratory.

DESIGN AND OPERATION OF DUNSTON "B" GENERATING STATION.*

By A. HOWELL and J. B. JACKSON.

THE Dunston "B" power station of the British Electricity Authority on the River Tyne was designed for a capacity of 300 MW in six 50-MW units. Three of these units were installed initially in 1933, and a fourth was added in 1939. Each turbine was supplied from four boilers, two of which had a continuous output of 156,000 lb. of steam per hour, and two, in which reheaters were incorporated, an output of 125,000 lb., the pressure being 625 lb. per square inch and the temperature 825 deg. F. in all cases. The reheat pressure was 151 lb. per square inch at the continuous maximum rating and the reheat temperature 800 deg. F. The lower output of the reheater units was chosen so as to give the same maximum fuel consumption in all four boilers, thus permitting the use of the same fuel-burning equipment. Eight of the boilers were stoker-fired, while in the others pulverised fuel, obtained from the dust from an adjacent coal-cleaning plant, was employed. The alternators had a continuous maximum rating of 50 MW, the generating voltage being 13.5 kV and the speed 1,500 r.p.m.

When the installation of the fifth and sixth sets was begun in 1945, it was decided to adopt unitised operation in order to save both capital and operating charges. A combination of circumstances made it advisable to adhere to the existing steam pressure, in order to provide partial inter-connection between the sets. The temperature of both the main steam and reheat steam was, however, raised to 850 deg. at the turbine valves. The new turbines are designed for a speed of 3,000 r.p.m., a change which has produced a less bulky set and has resulted in the use of three cylinders instead of two and of two exhausts instead of one. The high-pressure cylinders have no overload by-pass, so that the most economical and maximum continuous ratings are both 50 MW. The main oil pumps are driven by separate alternating-current motors instead of from the high-pressure shafts, as the advantages of this arrangement, such as reduction of fire risk, seemed to outweigh the drawbacks. A steam-driven pump is also provided and is brought into service automatically if the electricity supply fails or the oil pressure is lost.

GOVERNING ARRANGEMENTS.

There is only one high-pressure governor valve, in addition to the combined emergency and stop valve. The high-pressure and intermediate-pressure governors are mounted on a cross-shaft, which is driven from the high-pressure shaft. The intermediate-pressure governor normally keeps the two governor valves in the steam chests on either side of the intermediate-pressure inlet fully open, but begins to close them when a rise above normal speed occurs; a margin being allowed to prevent the intermediate pressure valves from interfering with the normal governing and, on loss of load, to allow the high-pressure governor to close first. Any rise of pressure in the pipe to the reheater inlet, owing to mal-functioning of the governors, is prevented by a relief valve; or, if this should fail, by a pressure trip on the exhaust pipe. A vacuum-operated device reduces the load if the vacuum falls below 22 in. and trips the machine at the steam and electrical ends on a further fall to 15 in. Should this fail, a second device, set at 2 lb. per square inch, trips the machine. These devices ensure that the only likely cause of excessive condenser pressure is leakage past the high-pressure emergency valve and this can be dealt with by a 12-in. atmospheric valve, instead of by the larger valves required on machines not otherwise protected.

In an attempt to reduce aeration by an alternative method to the overflowing system, the elevated hot wells are maintained at 195 deg. F. by steam

heating coils. Electrical "topping" heat is provided for light load use. Two motor-driven feed pumps are provided for each boiler, each of which has sufficient capacity for full load. To facilitate the quick-starting of a standing feed pump, a warming connection has been provided. This consists of a small by-pass across the discharge non-return valve of each pump through which, by opening the suction valve and the by-pass across the delivery valve, hot water may flow back through the standing pump from the discharge header.

The change of generating voltage from 13.5 kV to 11 kV has enabled machines and transformers of more standard design to be used. Special care has been taken to minimise rotor-coil distortion, and, in particular, thicker copper than usual has been employed for the windings. The excitation current is accordingly higher (about 630 amperes at normal load) and, in view of the difficulties experienced with direct-coupled high-speed exciters handling even lower currents, a motor-driven exciter running at 1,000 r.p.m. has been used. The same motor also drives the single alternator ventilating fan, an arrangement which helps to maintain the exciter speed when the voltage is reduced owing to system faults, because the fan contributes more flywheel effect in proportion to its load.

BOILERS.

The maximum output of each of the new boilers is 410,000 lb. of steam per hour at 625 lb. per square inch and 865 deg. F., reheating 365,000 lb. of steam at 147 lb. per square inch from about 563 deg. to 865 deg. F. The equivalent evaporation rate on a heat unit basis is 460,000 lb. of steam per hour. This represents a margin for adverse running conditions, equivalent to 8 per cent. of the main steam quantity. The new boilers are of the high-head type and are supported independently of the steelwork of the building. The arrangement of the furnace is shown in Fig. 1, on Plate LX. The front and rear walls are of the standard Bailey type, while the side walls are formed of bare tangent tubes. This is one of the first applications of this design in Britain. The height of the drum centre-line above the basement is 95 ft. The combustion chamber volume (including the furnace hopper) is 30,000 cub. ft., the boiler surface 5,250 sq. ft., the superheater surface 10,700 sq. ft., and the reheater surface 45,000 sq. ft. The surfaces of the high and low temperature economisers are 5,850 sq. ft. and 20,600 sq. ft., respectively, and of the air heater 93,400 sq. ft.

The 16 double-ported Calumet burners fire horizontally through the front furnace walls in two rows. The average height of the furnace is 30 ft. to the screen tubes at the furnace outlet. Secondary air is admitted round the burners and through two rows of ports in the rear of the furnace, thus creating additional turbulence and giving some measure of control over the length of the flame. Eight retractable burners in the front furnace wall are provided for lighting up and are automatically spark-ignited when they reach their working position. The single steam-and-water drum is solid-forged and has an internal diameter of 4 ft. 11 in. and a parallel length of 41 ft. 3 in. It is 3½ in. thick and weighs 53 tons. Steam scrubbers and cyclones are installed in the drums to ensure the high degree of purity specified for saturated steam, namely, a maximum of 1 part per million of solids with a boiler water concentration not exceeding 1,000 parts per million. This corresponds to a maximum wetness of 0.1 per cent. Blind nipples have been provided in the appropriate headers for the addition of more convection evaporating surface, if this should be found desirable for the better adjustment of the superheat temperature.

REHEATER EQUIPMENT.

The superheater is of the self-draining multi-loop type, the primary section being of mild steel and the secondary section of ½ per cent. molybdenum steel. The steam temperature is controlled between 80 and 100 per cent. output by hydraulically-actuated gas by-pass dampers, which are operated manually from the boiler control panel. This system was adopted as being sufficiently rapid in response at this temperature and as being simple and relatively immune from mechanical failures.

Surface control, although more sensitive, was considered less reliable. The convection reheater is in two consecutive gas passes with a diversion wall of refractory material 34 ft. high and 34 ft. wide between them. To allow for the temperature and pressure differences between one side and the other, steam cooling with elements shunted across the reheater was considered. In view, however, of the difficulty of providing sufficiently rigid elements and of the possible attenuating effect of short-circuiting relatively cooled steam to the reheater outlet header (since little heat absorption would take place) it was decided to retain natural air ventilation by means of a hollow construction, the cooling air entering at the bottom of the wall and emerging under two canopies at the top of the reheater portion of the unit. In view of the method used for supporting the walls, special bricks of light-weight refractory material were used. The total weight of the wall is about 24 tons. The temperature at the reheater outlet is controlled between 80 and 100 per cent. of the continuous maximum output by gas by-pass dampers, which are operated in the same way as the superheater by-pass dampers.

The economiser consists of three sections in series on the water side—an upper and lower bank and a "topping" section. On the gas side the gas passing through the reheater flows through the two main banks and then to the air heater, while that by-passing the reheater flows through the topping section and lower bank only. This arrangement minimises the gas-leaving loss when the reheater is being by-passed on the gas side. The two vertical shaft regenerative air preheaters have small internal air by-passes; and under banked conditions dampers and cross-connecting ducts between the main gas and air ducts ensure a cooling circulation of air through both the gas and air side elements to avoid distortion due to unequal expansion and jamming when starting. The two forced-draught and two induced-draught fans have inlet vane control, which in the former case is regulated manually and in the latter automatically by the furnace pressure. The forced-draught fans are situated on the annexe roof, but draw air from above the reheater portion of the boiler, to ensure maximum recovery of heat from the boiler house generally, and from the cooling air, which issues from the reheater division wall. The induced-draught fans are at ground level outside the annexe.

PULVERISERS.

Each boiler has four constant-speed ball-and-ring pulverisers with associated primary-air fan, coal feeder, classifier and seal-air fan. The coal feeder motor is automatically controlled by the quantity of primary air and the amount of coal in the mill. Each mill is under pressure from a constant-speed primary-air fan, the output of which, and hence the output of the mill, is damper-controlled. The classifier motor has eight speeds to facilitate control of the fineness of the mill product. The specified hourly capacity of each mill group is 9 tons of coal with a moisture content of 8 per cent. and a Hardgrove grindability index of 50 per cent. The required fineness of the product through a 200 B.S. mesh sieve is 70 per cent. Each boiler has two electrostatic precipitators between the air heater outlets and the induced draught fans, the gas flowing horizontally through two successive banks of electrodes.

OPERATION AND MAINTENANCE.

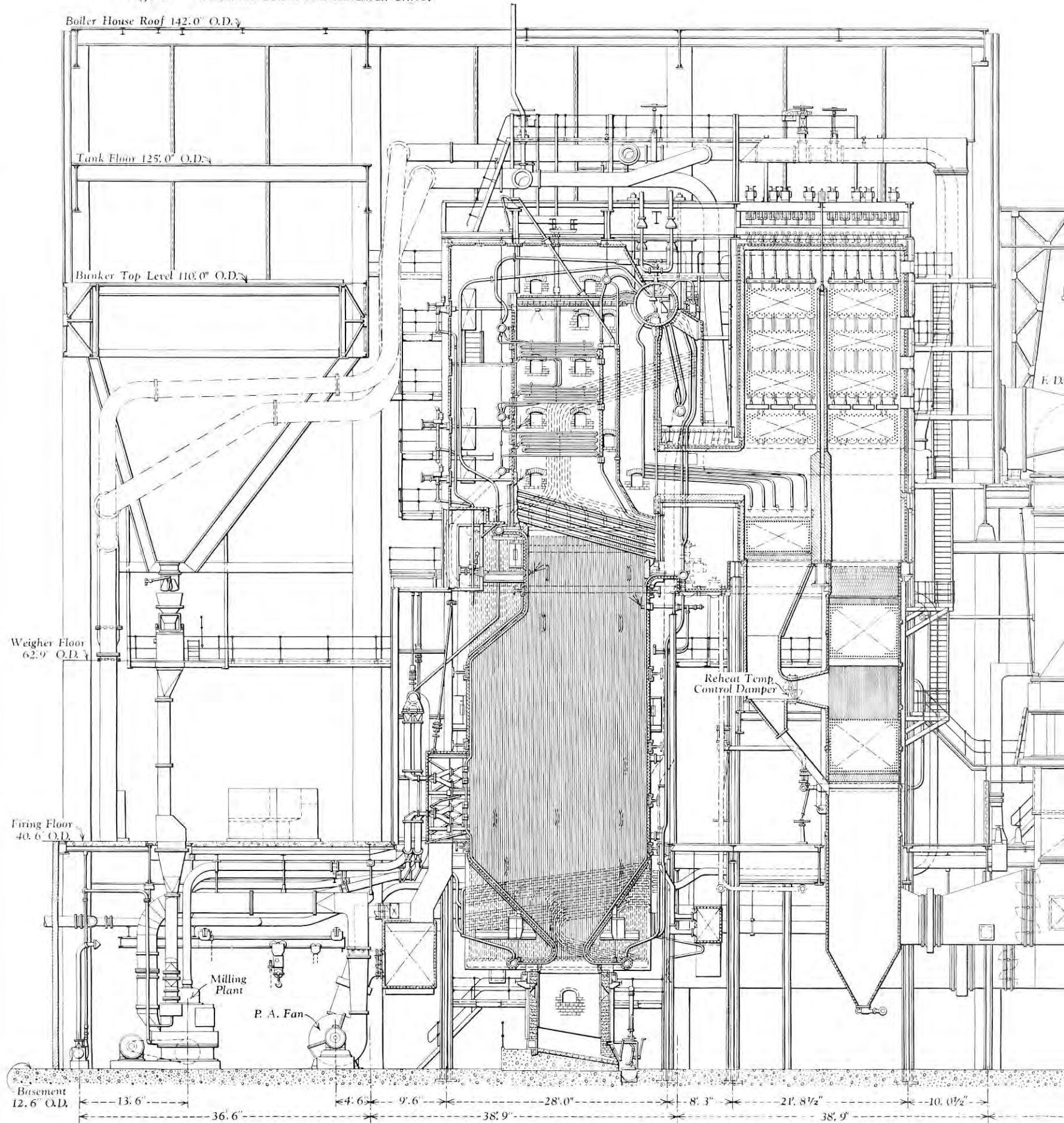
The two generating units, known as Unit 5 and Unit 6, respectively, consist of one boiler and one turbine with pipe work and auxiliaries and have a total installed capacity of 100 MW. They are operated as a separate plant by a shift consisting of ten men. The controls for the two boilers are hydraulically actuated from a desk-type board under the charge of a leading stoker, while the steam controls and gauge boards of the two turbines are in the care of a fitter-driver. These two men are directly under an assistant charge engineer, who is responsible for the operation of the two units. This method of grouping the units into pairs permits a notable economy in manpower and makes possible the employment of better men in senior positions. The shift charge engineer and his elec-

* Paper entitled "The Design and Operation of Dunston 'B' Generating Station, with Particular Reference to 50-MW Turbo-Alternators Unitised with Reheater Boilers," read before a Joint Meeting of the Institutions of Mechanical and Electrical Engineers on Friday, October 24, 1952. Abridged.

THE DUNSTON "B" GENERATING STATION

(For Description)

Fig. 1. COMBINED BOILER AND REHEATER UNITS.

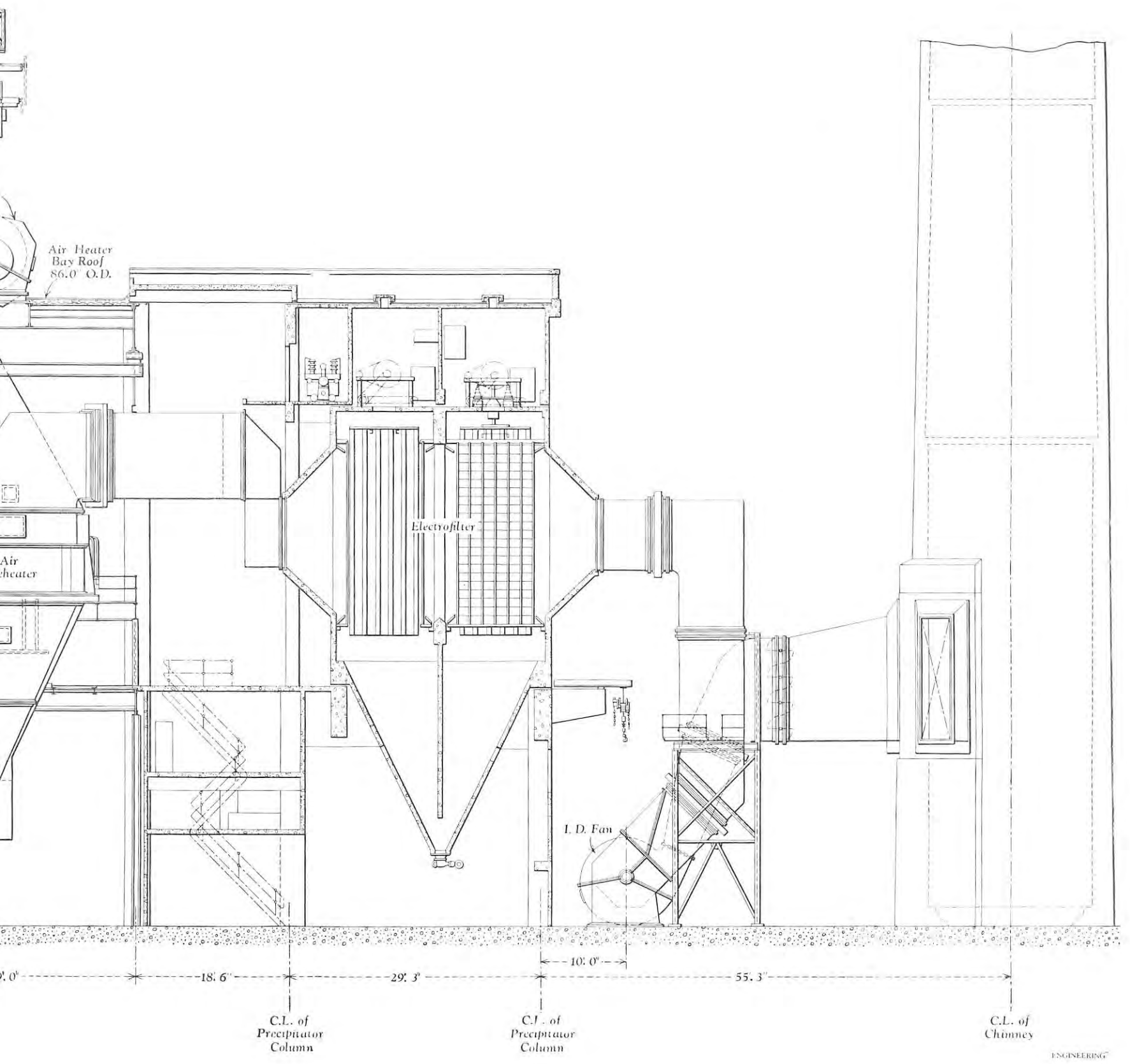


(1140 A)

(To go between

OF THE BRITISH ELECTRICITY AUTHORITY.

(see Page 802.)



DUNSTON "B" GENERATING STATION.

Fig. 2. STARTING UP FROM COLD.

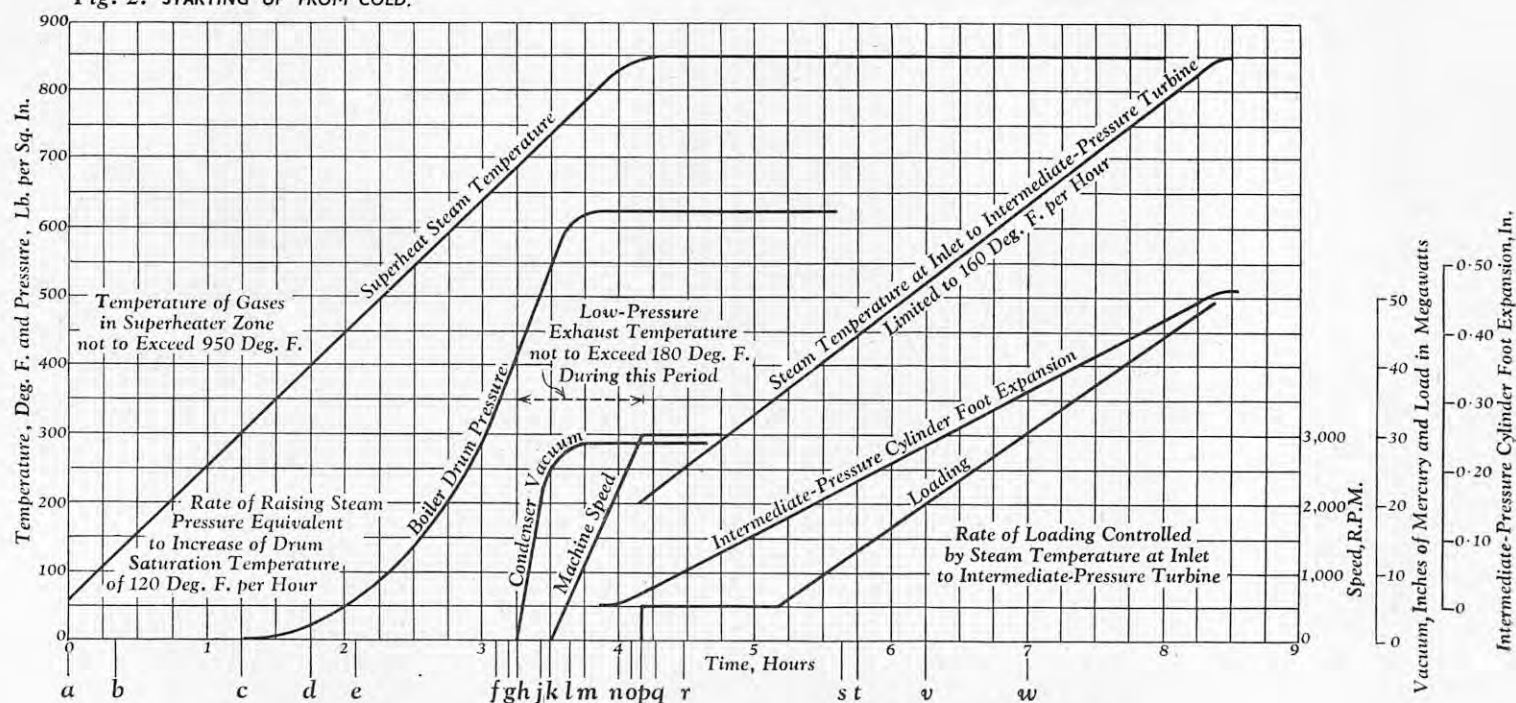
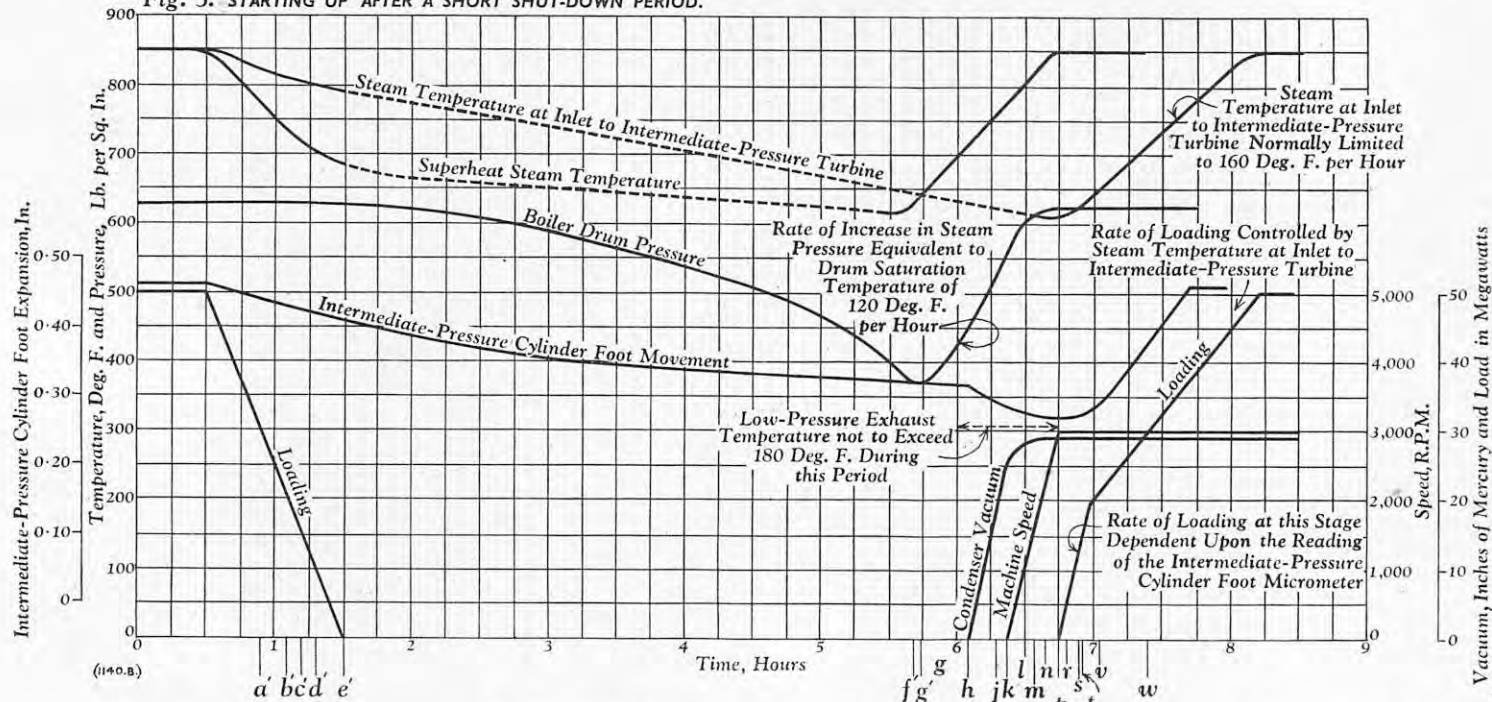


Fig. 3. STARTING UP AFTER A SHORT SHUT-DOWN PERIOD.



a One forced-draught and one induced-draught fan running; air heaters running; four oil burners lighted.
 a' Mill shut down.
 b One mill started.
 b' One oil burner lighted.
 c Steam at air cocks.
 c' Second oil burner lighted.

d Air cocks closed.
 d' Second mill shut down.
 e Superheater drains closed.
 e' Third mill shut down.
 f Extraction pump started.
 f' Four oil burners lighted.
 g Gland steam on.
 g' One mill started.
 h Quick-start ejector started.

j Main air ejectors started; quick-start ejectors shut down.
 k Begin running-up on turbine stop-valve by-pass.
 l Barring motor shut down.
 m Start feed-pump.
 n Exciter/ventilating - fan motor started.
 o Alternator air cooler in circuit.

p Machine synchronised.
 q One main air ejector shut down.
 r Superheater and reheater gas by-pass dampers shut to normal.
 s Second mill started.
 t Two oil burners shut down.
 v Remaining oil burners shut down.
 w Third mill started.

trical staff are common to the whole station and the day staff allocated to the new plant, excluding those engaged in maintenance, numbers nine.

The procedure which was eventually evolved for starting from a cold condition is indicated in Fig. 2. This shows that the full load on the unit is reached eight hours after the first burner has been lighted. The rate of loading is governed by the rise in temperature of the steam at the inlet to the intermediate-pressure turbine. This is normally limited to 160 deg. F. per hour, but on several occasions a rise of 250 deg. F. has been permitted and no harmful effects have been observed. The reheat temperature tends to rise steeply after synchronising; and it is necessary to restrict the load to 5 MW for at least an hour. In the initial stages of operation, particular attention was paid to the tempera-

tures of the metal of the superheater and reheater tubes during the period of raising pressure. It was anticipated that overheating of the reheater tubes might occur owing to the lack of steam flow; and to limit this effect as far as possible the superheater gas by-pass dampers were closed. Thermocouples were peened into both the superheater and reheater tubes, and the highest temperatures recorded, while pressure was being raised, were 1,050 deg. and 900 deg. F., respectively. Since then, both superheater and reheater gas by-pass dampers have been kept fully open during the period of raising pressure and no trouble has been encountered. Both these dampers are closed to their normal running positions as soon as possible after synchronising and their operation at loads above 5 MW is not permitted, except for the purpose

of preventing the superheated and reheated steam temperatures from rising above their designed values. During the first three hours the machine is on barring gear with the main oil pump running and the auxiliary steam pump on regulator by-pass. The reheater inlet and outlet steam valves are open and the reheater by-pass valve shut. The boiler stop valves and superheater and reheater gas by-pass dampers are opened, while the economiser recirculating connection is open until the boiler is fed with water. All the feed heaters are in commission.

When running the machine up to speed no undue difficulty has been experienced in keeping the low-pressure exhaust-steam temperature below a maximum of 180 deg. F., but after a short shut-down it has been found necessary to apply load quickly to prevent undue cooling of the intermediate-

pressure cylinder. After a shut down of 5 hours the temperature of the intermediate-pressure cylinder is about 650 deg. F. and it is necessary for a load of 20 MW to be applied in 15 minutes to prevent contraction. The low-pressure exhaust branch temperature in these circumstances is 130 deg. F. at the commencement of running-up. This falls to 78 deg. F. at 2,000 r.p.m. and rises to 155 deg. F. immediately before synchronising with an absolute pressure of 0.7 in. of mercury in the condenser. No difficulties have been experienced while shutting down. The load is reduced to 30 MW when one mill is taken off. One oil burner is lighted at 20 MW and the second at 15 MW. At 10 MW the second mill is shut down. Below 10 MW the recirculating valve on the condensate line is opened to maintain maximum cooling-water supply through the ejector. When the machine is off-load the third mill is shut down and any further control is carried out by the two oil burners. The machine is allowed to run down to a speed of 1,000 r.p.m. at full vacuum and when stationary is put on the barring gear for at least 12 hours.

Fig. 3 shows the shutting-down and starting procedure for normal operational service when the boiler and turbine are hot. The plant is used for base-load purposes only and no attempt has been made to develop a quick-starting technique. The times shown refer to an overnight shut-down of 5 hours.

SUPERHEATER TEMPERATURE CONTROL.

Soon after the unit boilers were commissioned it became apparent that the gas by-pass controlling the superheater outlet temperature was insufficient to bring the steam temperature down to the designed figure at full load. This also affected the reheated steam temperature, which became too high when the superheater gas by-pass dampers were open. As a temporary expedient, slots were cut near the bottom of the vertical baffles to permit a greater quantity of gas to be by-passed. At the first annual overhaul of each unit an additional row of generating tubes was fitted, the slots in the bottom of the baffle were filled in, and a plastic baffle was fitted between the superheater outlet and the by-pass outlet to increase the draught pull across the by-pass damper. The designed steam temperature is now obtained at full load with the superheater by-pass damper one-half to five-eighths open, and this is regarded as satisfactory.

(To be continued.)

LAUNCHES AND TRIAL TRIPS.

S.S. "WORLD ENTERPRISE."—Single-screw oil tanker, constructed by Vickers-Armstrongs Ltd., Walker, Newcastle-upon-Tyne, for World Tankers Corporation, Panama. First vessel of two. Main dimensions: 663 ft. overall by 86 ft. by 45 ft. 9 in.; deadweight capacity, about 32,500 tons on a draught of 34 ft. 5 in. Double-reduction geared steam turbines, developing 12,500 s.h.p. in service, constructed by Parsons Marine Steam Turbine Co., Ltd., Wallsend-on-Tyne. Steam provided by two Foster Wheeler oil-burning boilers. Speed, 16 knots. Launch, September 16.

M.S. "MIDDLESEX."—Single-screw cargo vessel, built and engined by Alexander Stephen & Sons, Ltd., Glasgow, for the New Zealand Shipping Co., Ltd., and the Federal Steam Navigation Co., Ltd., London, E.C.3. Main dimensions: 469 ft. 6 in. by 64 ft. 6 in. by 42 ft.; deadweight capacity, 10,300 tons on a draught of 27 ft. 4 in.; gross tonnage, 8,230. Two Stephen-Sulzer Diesel engines geared to one shaft through electromagnetic couplings. Launch, September 23.

M.S. "HAROLD SLEIGHT."—Single-screw oil tanker, built by the Blythwood Shipbuilding Co., Ltd., Scotstoun, Glasgow, for the Singapore Navigation Co., Ltd., Singapore. Main dimensions: 460 ft. between perpendiculars by 61 ft. by 34 ft. 1 in.; deadweight capacity, about 12,600 tons. Burmeister and Wain six-cylinder single-acting four-stroke Diesel engine, developing 3,600 b.h.p., constructed by John G. Kincaid & Co., Ltd., Greenock. Launch, September 24.

M.S. "CHINKOA."—Single-screw cargo liner, with accommodation for twelve passengers, built and engined by Barclay, Curle & Co., Ltd., Whiteinch, Glasgow, for the British India Steam Navigation Co., Ltd., London, E.C.3. Eighth vessel of a series for these owners. Main dimensions: 485 ft. by 62 ft. 6 in. by 40 ft. 9 in. to shelter deck; gross tonnage, about 9,000. Barclay Curle-Doxford six-cylinder opposed-piston oil engine, developing 6,800 b.h.p. at 116 r.p.m. Launch, October 2.

CARGO-LOADING SYSTEM FOR AIRCRAFT.



CARGO-LOADING SYSTEM FOR AIRCRAFT.

IN New Zealand, a new system has been developed by engineers of the Government Railways for loading and unloading cargo from two Bristol Freighter aircraft. These aircraft are operated by Straits Air Freight Express, Limited, Wellington, New Zealand, for the Government Railways, on a ferry service carrying some 500 tons of freight a week across the Cook Strait between the North and South Islands. The system consists of two parallel sets of railway tracks set flush with the ground about 30 ft. apart. Two low conveyor gantries, one for loading and one for off-loading, span between the tracks and are mounted at each end on a four-wheel bogie. Each gantry, which is known as a traverser, is driven electrically, and either end can be raised or lowered to register with a lorry or the sill of an aircraft. Each traverser carries two flat trays known as "cargons," with wheels set into their undersides. The cargo is about 16 ft. long and can hold about three tons of miscellaneous freight. Two cargons together fill the hold of a Bristol Freighter, resting at each side on specially designed lips, and retained at each end by buffers. The normal cargo floor of the aircraft has been removed to accommodate the cargons.

The loading and unloading operations are carried out as follows: goods delivered at the railway terminus are packed on to lorry-mounted cargons. (The wheeled cargon can easily be pushed on to a lorry by three or four men.) The cargons are then transported to the airfield and are loaded on to the traverser by means of an endless chain conveyor running beneath the traverser. The Freighter aircraft taxis up to the rails and aligns itself, against chocks, at right-angles to the track. The nose doors of the Freighter are opened, and the two traversers approach the aircraft from either side, the empty one being lined up with the sill of the hold. The endless chain is hooked to the loaded cargons in the aircraft and the cargons are conveyed from the hold on to the traverser, which moves away. The loaded traverser moves into its place, and its cargons are transferred to the hold. This traverser then withdraws, and the aircraft taxis forward across the tracks into the take-off position. The cargo unloaded from the Freighter is meanwhile transferred from the traverser on to lorries which convey it to the railway yards.

Before the introduction of the cargon and traverser system, loading and unloading were carried out by fork-lift trucks and manual labour. The new method, it is stated, has reduced the time between the aircraft touching down, unloading and taking off again fully laden, from one hour to just over 20 minutes.

"AERODYNAMIC DRAG": ERRATUM.—In the heading to the review of *Aerodynamic Drag*, which appeared on page 716 of our issue of December 5, the price in this country was incorrectly given; it should have been 42s. 6d.

STEAM AND POWER IN THE GAS INDUSTRY.

THE application of mechanical aids to the processes of gas manufacture has made a substantial contribution to the general progress of the gas industry. Mechanisation is being introduced wherever possible to improve efficiency as well as to reduce the cost of production and this is increasing the demand for steam and electricity, together with other sources of power. The whole subject, covering the economics of waste-heat recovery and of the relative merits of direct-fired boiler plant, electrical generators and gas turbines as auxiliary prime-movers has been discussed in a paper entitled "Steam and Power in the Gas Industry,"* by Mr. L. J. Clark, B.E.M., M.Sc., M.I.Mech.E., joint deputy station engineer, Beckton Gas Works, North Thames Gas Board.

An analysis of the costs of operation at a number of gas works in the North Thames Gas Board's area, said Mr. Clark, showed that the direct cost of steam and power varied between 2½ per cent. and 10 per cent. of the total direct costs of the works. The wide variation found depended upon local conditions and upon such factors as the size and geographical location of the works; the type of carbonising plant and the extent to which waste-heat recovery was practised; the relation of the base load to the seasonal load and the type of plant; the suitability of the steam-raising plant for burning coke breeze and the extent to which it was used; the distribution pressure of the gas; the extent to which the processes of benzole recovery, gas drying, liquor concentration or sulphate production were practised; and, finally, the effectiveness with which the power services had been modernised. The losses associated with extensive steam distribution and with direct supplies to small prime-movers might be high. The general aims of any scheme for modernisation included the substitution of electrical motors for all small and scattered prime-movers, the grouping of steam-raising and consuming plants within the smallest possible area, and the maximum use of high-pressure steam in large back-pressure or pass-out turbines for driving centralised pumping units or electrical generators.

Only where the plants are isolated, or run intermittently, Mr. Clark considered, was the installation of oil engines economical. It was possible for gas works to be entirely self-supporting in steam and in electricity, generated entirely from waste heat. Modern carburetted water-gas plants, could be made to provide more steam than for their own requirements and so become exporters of power to the general works system.

In Lancashire boilers, attempts to use coke breeze by mixing it with larger coke proved unsatisfactory with hand-firing, because combustion efficiency was low and the carry-over of dust into the flues necessitated frequent cleaning. Between

* Paper presented to the 8th International Gas Conference in Brussels, June 18, 1952, and to the London Section of the Institution of Gas Engineers on Tuesday, November 18, 1952.

the wars, boiler economy was improved considerably by installing Lancashire boilers operating at pressures up to 160 lb. per square inch and equipped with superheaters. The use of coke breeze alone as a boiler fuel became possible with the introduction of the mechanical chain-grate stoker. The initial difficulty with the stokers—that of maintaining a sufficiently high rate of ignition of the breeze to prevent the fire from running back with the travel of the stoker—was largely overcome by fitting pre-ignition arches to maintain a layer of hot gases over the fuel intake, and by the more recent adoption of a forced recirculation system, hot furnace gases being drawn through the fuel bed to raise its temperature. Water-tube boilers with mechanical stokers were most satisfactory for units with a capacity in excess of 15,000 lb. of steam per hour, but only in gasworks with an output of more than 15 million cub. ft. a day. The possibility of using oil-fired boilers was also considered, but in small works two types of fuel-fired boiler might not be justified. In such a case, with a battery of three or more Lancashire boilers, some should be fitted with chain-grate stokers for burning breeze and the rest should burn liquid fuel.

For many purposes, electrical installations had much in their favour. Recent practice had been to adopt alternating-current equipment, to take advantage of high-tension distribution, the simplicity of constant-speed motors, and interchange of power with the public supply system. The generating efficiency of the public supply was higher than that of the average private installation, though the internal generation of power might become economic where use could be made of surplus waste-heat steam or where appreciable quantities of coke breeze were available. Summarising, Mr. Clark found that, whereas works with a maximum demand of less than 100 kW were most economically fed from the public supply, internal generation was economical for works with a demand above 250 kW, provided that the steam was raised from otherwise waste products.

Other topics discussed included the effect and advantages of incorporating a carburetted water-gas plant in a gasworks, and the general modernisation of existing plants, bearing in mind the need to maintain output during the turn-over period. The choice of prime-mover, in particular for gas-pumping plant, was treated fully and the paper concluded with a brief reference to the future of the gas turbine in the gas industry. The temperature of waste gases from continuous vertical retort installations, Mr. Clark pointed out, was well suited to the gas turbine. Furthermore, the low-pressure process steam required for supplying the retorts, and for gas-making processes generally, could be raised conveniently from the low-grade heat rejected by the gas turbine. The large oil-fired gas turbine also had great possibilities; for example, as a stand-by unit for operating under conditions of a low load factor.

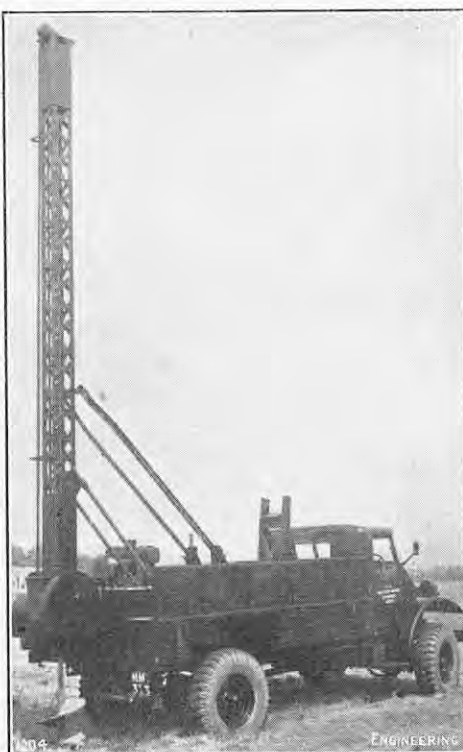
LOW-POWER RADIO TRANSMITTING STATION AT TOWYN.—A low-power radio transmitting station is to be built by the British Broadcasting Corporation at Towyn to serve the Aberystwyth, Towyn and Aberdovey areas as well as that between Cardigan and Pwllheli in Wales. While the station is under construction a caravan transmitter, which will be brought into use on Sunday, December 14, is temporarily to radiate the Welsh Home Service on 341 metres.

LECTURES ON METAL WORKING.—A course of six illustrated lectures on "The Plastic Working of Metals" will be delivered at fortnightly intervals, commencing on Thursday, January 8, 1953, from 7 to 9 p.m., at the Sheffield College of Technology, Department of Engineering, Pond-street, Sheffield, 1. The course is intended for those who hold Higher National Certificates or have reached an equivalent standard and who desire to refresh or extend their knowledge of the working of steels in rolling, forging and other processes from the engineering and metallurgical points of view. The lecturers are all members of the staff of the metal-working laboratories of the British Iron and Steel Research Association. There will be a period for discussion after each lecture and advance notice, in writing, of any problem which it is desired to bring forward will be welcomed.

SOIL-BORING MACHINE.

A NEW soil-boring machine which can be mounted on a lorry or trailer has been developed at the Road Research Laboratory, Harmondsworth, Middlesex, of the Department of Scientific and Industrial Research, and is shown in the accompanying illustration. The machine is capable of drilling clean boreholes up to 20 in. in diameter and 16 ft. deep in most soils. The boring bar can be brought from the travelling to the working position in one minute and it will bore vertical or inclined holes in a wide range of soils at a rate of about 1 ft. a minute. The machine can be used for making test bores when investigating sites for roads or buildings, and also, when short piling is required, for boring holes that are then filled with concrete.

The machine is a self-contained unit driven by an air-cooled twin-cylinder Diesel engine developing 7 brake horse-power at 1,200 r.p.m. An important feature is a lattice mast, 9 in. square in cross section, which can be raised from its sloping



travelling position into the vertical by a pair of feed screws driven from the engine through a friction clutch. The main pivot of the mast is carried in trunnions mounted on the outside of the gearbox located at the lower end. The boring bar is of square section and is driven by a gear wheel having a square hole in the boss through which the bar passes as the boring tool descends. The bar is steadied at its upper end by a bearing mounted in a housing which can slide inside the mast.

The boring bar is attached to an endless chain which passes over a free sprocket at the top of the mast and a driving sprocket at the bottom. It can be raised by power but may be lowered either by power or under its own weight, a hand-brake being provided to control the rate of feed. The shafts, for driving and lifting the bar have been arranged co-axially with the main pivots of the mast to permit boring with the mast inclined. A reversing gear enables a change of direction to be made in the case of all the controlled motions. The normal speed of rotation of the boring tool is between 50 and 100 r.p.m. and the average rate of withdrawal is approximately 3 ft. per second.

Three types of boring tool have been developed. The first consists of a circular plate welded to a vertical stem, the plate having two sectors removed and the resultant leading edges being bent down to give a slight lead. Separate cutting edges, tipped with a hard material, are provided that can be bolted to these leading edges. The sector openings are covered with non-return flaps which permit the spoil to pass upwards through the tool.

This tool has been found to be satisfactory in most soils but the cut-away portions will allow only small stones to pass through. A second tool, with a two-start helical form, has therefore been made. This is suitable for coarse loosely compacted gravels but tends to ride over large stones if they are tightly embedded. A third tool has therefore been designed for boring through such materials. It is fitted with two spikes, about 4 in. long, located about two-thirds of the radius of the plate from the centre, and these spikes loosen any large stones which would not otherwise be disturbed.

SIZE DISTRIBUTION AS A QUALITY FACTOR OF BLAST-FURNACE COKE.*

By J. TAYLOR and J. D. GILCHRIST.

THE belief is widely held that the physical properties of blast-furnace coke are at least as important as the chemical, but really satisfactory evidence of the role played by the physical properties is very meagre. Despite the great interest in the subject over many years there is still no general agreement as to which are the important properties or how they should be measured. The importance of coke size in the combustion zone becomes evident when the two extreme cases, i.e., very large and very small, are considered; the problem is to determine the significance of this factor over the normal range. Because of its probable importance, more attention has been devoted to this aspect of the problem than to pore structure, density, etc., although they also have been the subjects of much research. The size of coke in the tuyere zone is a function not only of the size distribution, as manufactured, but also of the degradation both outside and inside the furnace. The great height and weight of the stock column in a modern furnace predisposed the belief that breakdown in the furnace must be considerable and therefore the strength of coke, i.e., the ability to withstand such breakdown, ought to be of first importance. In consequence, the strength of coke has been studied more than any other property. Correlation between strength and blast-furnace performance, however, is disappointingly inconclusive. This is in part due to the limitations of the methods used in measuring strength. The various shatter, drum and stability indices do not place cokes in the same order and no conclusive proof has yet been offered to show that any particular index is more reliable than another. A further difficulty is that of assessing blast-furnace performance and particularly the allowances to be made for the very large number of variables other than coke quality. It is probably fair to say that when dealing with coke from one source, the shatter test or one of the drum tests can show a correlation with furnace performance but that the correlation tends to break down when cokes of different origins are considered.

The success of certain furnaces working with cokes of inferior strength, as normally measured, together with numerous observations that the size of coke in the tuyere zone did not differ markedly from that of the coke as charged, have suggested that greater attention ought to be devoted to the size and size distribution before charging. Admittedly, the evidence that coke suffers little breakdown in passing down the furnace rests largely on visual examination. L. M. Sapozhnikov† has reported taking samples at various levels from the stock line to the tuyeres down a furnace. These show a progressive breakdown in size, particularly in the lower high-temperature region, but this breakdown is such that the size distribution of the coke, as charged, is still the dominant factor in controlling the distribution at the tuyeres. Moreover, the degradation of cokes of widely differing drum strengths was remarkably similar, which again suggests that the size distribution at the stock line is more important than the strength measured at

* Read before the West of Scotland Iron and Steel Institute on Friday, October 24, 1952. Abridged.

† Iron and Steel Institute Translation No. 218 (1945)

ordinary temperatures. It may be that cold strength is not necessarily a reliable guide to strength at the temperatures prevailing in the furnace. Little has been published on this aspect of the subject, the experimental difficulties are obviously formidable, but such as has appeared* suggests that much of the difference between strong and weak cokes in the cold is eliminated at higher temperatures. There is, therefore, reason to suppose that the effect of breakdown within the furnace has been exaggerated and that the size distribution of the coke at the furnace stock line may be the more important factor.

The early work on this problem had the unusual merit of giving a positive and definite result. E. C. Evans† showed that if fines were screened out of blast-furnace coke just prior to charging into the furnace there was an overall saving of coke, i.e., not only were some 2 per cent. of fines recovered but there was also a decrease in the consumption of large coke. However definite this finding, it only touched the fringe of the problem. Accepting as a fact that the size range of the coke as charged is important, there remained the problems of the best method of characterising the size range, and relating these characteristics to furnace performance. These are essential in order to put the pre-treatment of coke, i.e., screening, crushing and storage, on a sound technical footing. There is also the vital question of the relative importance of the size grading as charged and the strength of the coke. The problem has been investigated under the aegis of Panel No. 9 of the British Coke Research Association with the co-operation of a number of member firms over the past few years. As in so many investigations of this type, no really definite conclusions could be drawn from the results, the major difficulty being the fact that the blast-furnace process is exceedingly complex with a large number of variables which are not capable of exact control. Nevertheless, the data are of considerable interest and at least serve to dispel certain misconceptions.

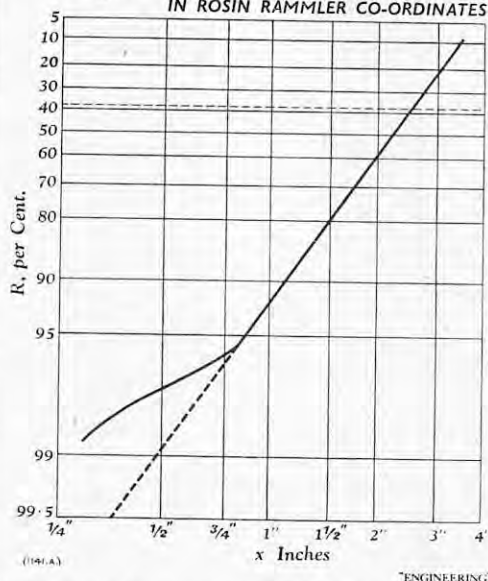
MEASUREMENT OF SIZE GRADING.

A minimum of two parameters, one a measure of the average size and the other of the size range, is required to characterise the distribution of broken solids. For this, however, the material should conform to one of the mathematical distribution laws. In the first place, therefore, a large number of screen analyses were examined to see whether they could be expressed by a single mathematical equation. It appeared that, except at the finer sizes, there was quite a good agreement with arithmetic probability, logarithmic probability or Rosin-Rammler distributions, but in each case there was an excess of "fines" (approximately $\frac{3}{4}$ in. screen size). While this excess was usually not more than 5 per cent. of the total, it constituted the major portion of the fine fraction. This represents a great drawback to the use of any of these expressions.

Experiments carried out at a later stage and described elsewhere‡ on the breakdown pattern of broken solids have shown that no single mathematical expression can be expected to fit a complete screening analysis, because two products result from the breakdown of a large-sized solid. The one, following a nomenclature introduced by J. G. Bennett, R. L. Brown and H. G. Crone in a contribution to the Institute of Fuel in 1941, is called "Residue" and contains all the coarse particles; the other is the "Complement" and contains all the fines. The size distribution of the residue is Gaussian, but, in the case of coke, the complement is not a single type of distribution. B. Epstein and H. H. Lowry§ observed that broken coke could be represented by a Gaussian distribution, but did not carry their observations far enough to show the presence of fines outside this distribution. Epstein and Lowry also showed that on the basis of certain assumptions the Gaussian distribution would persist

SIZE DISTRIBUTION OF COKE IN BLAST FURNACE.

Fig. 1. TYPICAL COKE SCREENING IN ROSIN RAMMLER CO-ORDINATES.



for the case of repeated breakdown, such as occurs in the shatter test. In the case of coke broken down by normal handling, the Rosin-Rammler distribution seemed to fit the data rather better, although there is very little to choose between them. In the present investigation an examination of the screen-test data, therefore, was based on the Rosin-Rammler equation. This is

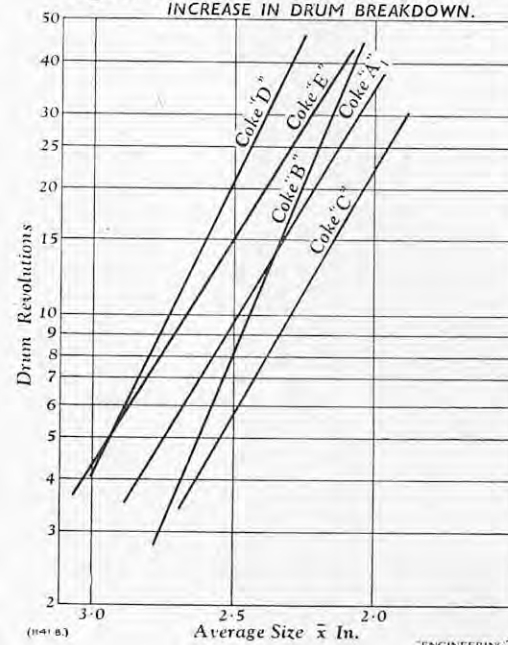
$$R = 100e^{-\left(\frac{x}{\bar{x}}\right)^n}$$

where R is the percentage retained on a screen size x and $\bar{x}$ and n are constants which are measures of average size and dispersion, respectively.

When plotted on special paper with co-ordinates of $\log \log \frac{100}{R}$ and $\log x$, distributions of this type give a straight-line graph. As observed, coke-screen analyses diverge from linearity as shown in Fig. 1, on this page. The first approach to the problem was to correct, by successive approximations, for excess "fines," so arriving at a straight Rosin-Rammler distribution plus a certain percentage of "fines." This method of analysis, however, was not continued for a number of reasons. One part of the present investigation has been devoted to following the breakdown of coke in passing through typical handling systems. The beginning and end of the handling system were taken to be the coke-oven grizzly and the discharge side of the blast-furnace storage bins. The latter point is often rather inconvenient and if several cokes are passing through the plant it is often quite impossible to separate one from the other. An attempt was made to simulate the handling breakdown in a test apparatus. A test drum, either the Micum or Cochrane, was used with a 100-lb. or 50-lb. charge, respectively. The results were virtually interchangeable; for example, 10 revolutions of the Micum were found to be equivalent to 40 revolutions of the Cochrane drum. Perhaps the Cochrane tends to give rather more fines for the same decrease in average size, but that was not certain. Representative samples were tested at different numbers of revolutions and the products analysed. By comparison with samples at the beginning and end of the handling system the equivalent number of revolutions to give the same degree of breakdown was determined. A consistent correlation was obtained for the residue, but that for the complement was rather variable. The severity of the handling for different systems could be compared in this manner and proved very similar in five cases for which the equivalent breakdown was 7 to 15 revolutions in the Micum drum. This was rather a surprise as, in two cases, transport was by belt and in the remainder by wagons.

The results obtained are shown in Table I. These figures are for samples of about 1,000 lb. taken in 20 increments or, in the case of the drum tests, the mean of six determinations. Even so, the propor-

Fig. 2. DECREASE IN MEAN SIZE WITH INCREASE IN DRUM BREAKDOWN.



tion of fines or complement is not very reproducible. In part, particularly for the blast-furnace bin sample, this may be ascribed to the difficulty of sampling under conditions in which a considerable degree of size segregation may be expected. Experience with the drum tests under the most rigidly controlled conditions, however, was equally unsatisfactory as regards the value for "fines." It can only be concluded that the amount of complement formed when a lump breaks is so variable that the sample

TABLE I.

Coke.	Sampling Position.	Residue Characteristic.		Complement, per cent.
		Mean Size, $\bar{x}$ in.	Dispersion Constant n .	
A ₁	Grizzly ..	2.95	3.15	1.4
	B.F. bin*	2.35	2.85	2.2
	Drum test..	2.3	2.85	2.9
A ₂	Grizzly ..	2.85	2.2	0.9
	Drum test..	2.3	2.05	2.0
A ₃	Grizzly ..	2.4	3.0	1.3
	Drum test..	1.95	2.45	2.1
A ₄	Grizzly ..	1.65	4.4	1.4
	Drum test..	1.45	3.25	4.6
B	Grizzly ..	2.9	3.05	0.8
	B.F. bin ..	2.35	2.9	4.1
	Drum test..	2.4	3.05	2.8
C	Grizzly ..	2.6	3.5	0.8
	B.F. bin ..	2.3	—	—
	Drum test..	2.3	3.1	2.9
D	Grizzly ..	3.2	3.7	2.0
	B.F. bin ..	2.65	3.1	3.2
	Drum test..	2.65	2.7	4.2
E	Grizzly ..	3.35	2.9	4.0
	B.F. bin ..	2.9	2.9	5.8
	Drum test..	2.9	2.5	5.5
F	Grizzly ..	3.05	3.3	0.5
	B.F. bin ..	2.75	3.1	3.1

* B.F. bin = Blast-furnace bin.

must contain a very large number of lumps in order to get a reliable mean value. In the usual drum tests more reproducible figures are obtained because the coke is broken down to a much greater extent, but it is not at all certain that the figures so obtained are a reliable guide to what happens under much milder conditions. It can be seen from Table I that, for most of the cokes, the degree of dispersion of the residue is steady and the n value is about 3.0. This was borne out by the results of the drum tests, and, in two cases, samples taken at intermediate points of the handling system. There was a tendency for a slight drop in n value immediately after the coke-oven grizzly sample, but, thereafter, it remained constant up to 100 or more drum revolutions. One coke of this group had a much lower n value, indicating a poorer grading, and two

* G. M. Isarov, *Coke and Chem.* (U.S.S.R.), vol. 9, pages 10 and 13 (1939). A. D. Zaslooskaya, *Coke and Chem.*, vol. 10, page 26 (1940).

† *Fuel*, vol. 6, page 245 (1927).

‡ J. Taylor, unpublished work.

§ American Inst. Min. Met., Blast-Furnace Conference, No. 3 (1948).

cokes differed from this group in that there was a very decided drop in the n value after the drum test. It is thought that these latter, one of which was a gas coke, represent the case where the natural "spread" had been drastically altered by screening and even relatively mild degradation caused a rapid reversion towards the natural value. The results with regard to the complement values must be treated with caution, but it may be observed that there is no evidence to suggest that cokes with an inherently poor residue grading also produce more complement.

A point of some fundamental interest is that single-stage crushing experiments were carried out on cokes A_1 and A_2 and one other not included in the present series. The product in such experiments can be separated into residue and complement and the dispersion coefficients of the residue distribution determined. These were found to be the same within experimental error and yet cokes A_1 and A_2 are considerably different after the multi-stage breakdown suffered in handling. Since the product of each act of breakage has the same characteristics, this can only mean that the probability of breakage of the different sizes in the mass samples are different, and, in fact, that relatively more of the smaller sizes are breaking down during handling in the case of coke A_2 . This agrees with the deductions made by Epstein and Lowry from the results of shatter tests on a number of American foundry cokes. They found that the determined screening analyses could be synthesised by assuming a constant single-stage fracture pattern and different probabilities of breakage. A point of general interest brought out by the samples taken at intermediate points in two of the belt-handling systems was that the most severe breakage occurred in dropping from the belt to the bin. Breakdown in passing through the bin was of comparatively minor importance. Moreover, there was no evidence to support the view that fines are produced in the latter case by abrasion. In all cases during these tests attention was paid to keeping the service bin as full as possible and these results confirm that this is the correct practice to minimise breakage.

TABLE II.

Coke.	Shatter Index.		
	+ 2 in.	+ 1½ in.	— ½ in.
A	74	82	5
B	73	84	3
C	65	79	3.5
D	73	84	3
E	72	83	3
F	84	91	2.5

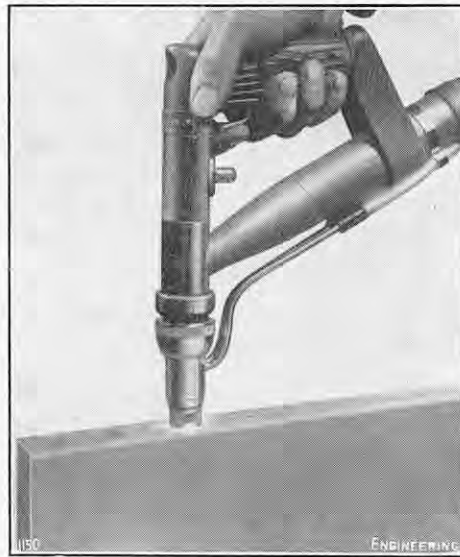
One further observation with regard to these experiments was that, in the drum-test series, the average size decreases linearly with the logarithm of the number of revolutions, as may be seen in Fig. 2, on page 806. This has already been commented upon by Epstein and Lowry although the exact significance is not clear. The slope of the graph is obviously related to the strength of the coke but whether it has any advantages over the more conventional methods of expression is doubtful. In this connection the shatter-test values for most of the cokes are quoted in Table II for information only. The data are too few to justify making comparisons. As regards the complement produced by breakdown in the drum test, no simple relation could be established between that value and number of revolutions.

(To be continued.)

POWER-STATION SIGNALLING SYSTEM.—A signalling system for transmitting routine orders between power-station control rooms and boiler and turbine houses has been devised by Standard Telephones and Cables, Ltd., Aldwych, London, W.C.2. It enables one of up to a total of ten orders to be selected by a rotary switch and initiated by pressing a knob. At the receiving end these orders are notified by audible and flashing visual signals. The receiver, of which there are a number of types, is fitted with an acceptance button which silences the audible alarm and converts the flashing signal into a steady illumination. At the same time, a flashing lamp in the switch knob in the control room becomes a steady glow. The system is operated by direct-current at 50 volts over multi-core telephone cables.

ARGON-ARC SPOT-WELDER.

A SPOT-WELDING process intended for use on stainless and other steels and alloys, and for tack-welding in assembly operations where access is obtainable from one side of the work only, has been introduced by the British Oxygen Company, Limited, Bridgewater House, Cleveland-row, St. James's, London, S.W.1. This, the Argonarc process, is used for making rapid flux-free spot welds on stainless steels, bright mild steel, magnesium, various copper-rich alloys, nickel-chromium alloys, and certain types of brasses and bronzes. By its means, the upper sheet in an assembly is fused to the material below it and the spot weld produced is of the characteristic circular form. An advantage of the process is that thin material may be joined to thick and, so long as the upper sheet is not more than ½ in. thick, the welding of one sheet to another, a sheet to a plate, or a sheet to a bar, angles or T-sections, can be satisfactorily carried out. The torch employed, which is shown in use in the accompanying illustration, utilises the heat derived from the low-current arc struck between a tungsten electrode and the work-piece, and the arc, electrode and spot-weld area are protected from the atmosphere by a shroud of argon gas. As the arc is screened by the nozzle of the torch, the operator need not wear goggles.



The automatic operation of the torch is provided by an electric timing unit which varies the duration of the arc over a wide range, usually from 0.8 to 5 seconds, according to the type and the thickness of the material to be welded. After the current and the arc time have been adjusted, the torch is held down over the point where the weld is to be made. The operator exerts pressure on the torch to bring the parts into intimate contact. The trigger is then pressed and the argon, cooling-water and high-frequency current are switched on in the correct sequence. After the pre-arranged interval, all supplies are cut off except the argon gas, which is allowed to flow until the tungsten electrode has cooled. The torch is then raised and the operations repeated at another point. The torch is fitted with a water-cooled copper shield and an insulated handle. The diameter of the tungsten electrode is ⅛ in. The welding transformer and the control cabinet are both mounted on wheels. The oil-immersed combined welding transformer and regulator is wound on the primary side for connection to either a single-phase or two lines of three-phase supply at from 175 to 550 volts, 50 cycles. The secondary striking voltage is 100 and current regulation is by two rotary selector switches, giving 49 settings between 20 and 250 amperes. The control cabinet contains a 300-ampere single-pole contactor, a high-frequency unit, and water, argon and current distributors for connection to the torch leads. On top of the cabinet is the unit which controls the spot-welding time and the after-weld flow of argon. A stand is provided to take a 165 cub. ft. cylinder of argon, the regulator for which is pre-set to a pressure of 10 lb. per square inch.

NOTES ON NEW BOOKS.

The Heat Treatment and Annealing of Aluminium and Its Alloys. Part I: Practice.

The Aluminium Development Association, 33, Grosvenor-street, London, W.1. [Price 2s.]

THE scope of this brochure is covered fairly succinctly by its title. It describes the main groups of alloys—"wrought" and "heat-treatable"—and the various processes of heat-treatment; and proceeds to deal with the annealing of wrought alloys, workshop practice, and the metallurgical principles of heat-treatment and annealing, with reference to the main specifications, more particularly those for the aircraft alloys. The "Practical Notes" are conveniently set out in parallel columns, headed "Do" and "Do Not," classified as "Heat Treatment" and "Annealing." There is a useful bibliography. Attention is drawn to the fact that the plant necessary for successful heat-treatment of the wrought aluminium alloys is described in a separate Information Bulletin (No. 4), obtainable from the same source.

Elementary Heat Power.

BY HARRY L. SOLBERG, ORVILLE C. CROMER and ALBERT H. SPALDING. Second Edition. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16. [Price 6.50 dols.] and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 52s. net.]

FIRST among the declared objects of the authors, who are all on the professorial staff of Purdue University, is to provide students with an understanding of the functions, principles of construction, and actual performance of heat-power machinery as a basis for a study of engineering thermodynamics. Hence, the book is mainly of a descriptive nature, with only calculations of the simplest kind. Although the academic units "slug" and "poundal" are introduced and defined in the first chapter, their existence is wisely ignored afterwards, so that the phraseology conforms with ordinary engineering language. The elementary nature of the treatment will be gathered from the fact that, while the First Law of Thermodynamics is emphasised by several examples of its application, the Second Law is dismissed in a couple of pages. After a discussion of fuels and combustion, the rest of the work is a general survey of the types of machinery used for developing power from heat, and for refrigeration purposes. The longest single chapter is devoted to internal-combustion engines, but furnaces, boiler-plant, steam turbines, reciprocating steam engines, gas turbines, refrigerators and heat pumps, together with fans, feed-heaters, condensers, pumps and other auxiliary apparatus all come under review.

The Origin and Development of Aveling-Barford, Limited.

Published by Aveling-Barford, Limited, Grantham and Newcastle-on-Tyne.

THE firm of Aveling-Barford, Limited, is an amalgamation of two famous engineering firms, both more than 100 years old, namely, Aveling and Porter, Limited, of Rochester, makers of the first steam roller, and Barford and Perkins, of Peterborough, originally makers of agricultural machinery, and later the pioneers of the motor-driven roller. Thomas Aveling (1824-81) was a native of Cambridgeshire who settled in Kent. He established his engineering business in Rochester in 1850 and there produced, in 1860, a "patent Locomotive Engine"—a four-wheeled vehicle steered by a fifth wheel projecting in front; it was illustrated in an advertisement which appeared in No. 1 of *ENGINEERING*, on January 5, 1866. The invention on which William Barford (1832-98) built up his business was a system of cable ploughing, using a portable steam engine to provide the power. The two firms amalgamated in 1933, under Mr. Edward Barford, M.C., as chairman, and were established in new works in Grantham in 1934. In 1946, an additional factory was acquired at Scotswood, Newcastle-upon-Tyne, where the smaller products are made, the Grantham works being employed on heavy rollers, graders, and larger-capacity dumpers. The history of the two firms singly and in combination is excellently set out in this well-illustrated book.

Du Pont: The Autobiography of an American Enterprise.

E. I. DU PONT DE NEMOURS AND COMPANY, Wilmington Delaware, U.S.A. Distributed by Charles Scribner's Sons, New York. [No Price indicated.]

THE more vociferous opponents of "big business" commonly exhibit two failings: firstly, that they do not know much about its operations, and secondly, that they are apt to forget that the vast majority of big businesses were once small businesses. It may be that some have grown by methods other than the principle of the Golden Rule, but of most it is probably correct to say that their survival is evidence that, on balance, they have contributed something to the world that the world needed. This handsomely produced volume, designed to commemorate the 150th anniversary of the foundation of the Du Pont Company by Eleuthère Irénée du Pont on July 19, 1802, may safely be left to tell its own tale. To the English reader, the present organisation may best be likened to that of Imperial Chemical Industries. Du Pont began as a maker of gunpowder; but, be it noted, for peaceful uses, good powder being a necessity to the early American settler. They still make explosives, for peace as well as war, but the list of their other products, and of the basic researches that they have sponsored and still sponsor, shows how essential their large-scale operations have become to the essentially large-scale nation which has fostered their development. A particularly instructive feature of the book is the succession of illustrations of the contemporary scene, domestic and social as well as scientific and industrial, accompanying the stages in the story of the firm's growth.

Structural Steelwork for Buildings.

By H. P. SMITH, B.Sc. (Eng.), M.I.Struct.E. Crosby Lockwood and Son, Limited, 39, Thurloe-street, London, S.W.7. [Price 7s. 6d.]

THIS is the third revised edition of a book on structural steelwork which was first published in 1937 in a series dealing with building and allied trades. Its object is to tell the student of building how steelwork is designed in accordance with current British Standards, particularly B.S.449 on "The Use of Structural Steel in Building" and B.S.153, on "Girder Bridges." The book is not intended for those who are training to become structural engineers; accordingly, theoretical discussion is limited to the minimum necessary to establish the rational basis of the practical rules used by designers in their calculations. The explanations, as far as they go, are clear and simple, and the chosen field is well covered by worked examples. The two final chapters deal with welded connections. It will be evident that the book is not addressed to historians, and the statement, on page 1, that "when such men as Galileo in 1588, Bernoulli and Euler in 1700, and others, first seriously investigated the way in which beams behaved when their shapes were altered, they only had training as general engineers to guide them," is merely incidental to the author's preface. When facts and figures are cited at all, however, they should be given correctly. Actually, Galileo's work on beams was published in 1638, Bernoulli's in 1705 and Euler's paper, from which the "moment of inertia" is derived, in 1778. Moreover, none of these mathematicians was trained as an engineer, nor did engineers pay much attention to their work till the Nineteenth Century was well advanced.

Colour Conscripton. How to Use Colour in Industry.

Second edition. British Paints, Limited, Portland-road, Newcastle-upon-Tyne, 2. [Price 10s. 6d.]

THE improvement of environment by an intelligent use of colours in the interior decoration of workshops and offices is the subject of this handbook. If a workshop requires to be repainted, it is only slightly more trouble to give some thought to the colour scheme, and even from a strictly utilitarian point of view the trouble will be worth while if it results in employees being stimulated as they enter their place of work. This handbook has been prepared for those who have not the time to study a highly technical treatise but who, nevertheless, seek a clear understanding of the principles involved.

TRADE PUBLICATIONS.

Electrical Engineering.—Messrs. Oerlikon Limited, Victoria House, Southampton-row, London, W.C.1, have sent us a copy of a brochure issued by their parent company, the Oerlikon Engineering Company, Zürich, Switzerland. The purpose of the brochure is to celebrate the 75th anniversary, last year, of the foundation of the firm in November, 1876, but, as a similar publication was issued on the occasion of the 50th anniversary, the present one deals mainly with the more outstanding events of the past 25 years. The departments covered include research and development, large and small generators and motors, motor-control gear, transformers, high-voltage equipment, rectifiers and electrolyzers, steam and gas turbines, and traction vehicles.

Air Compressors.—A well-illustrated 38-page catalogue dealing with their range of stationary air compressors has been issued by the Consolidated Pneumatic Tool Co., Ltd., 232, Dawes-road, London, S.W.6. Each class of compressor is introduced by a full description of its construction followed by specifications of each different size and typical examples of drives. Two-stage air-cooled single-stage single-acting, and double-acting water-cooled machines are described, together with air-receivers and after coolers.

Broaching Machines.—A bulletin containing a brief description of the American type "T" three-way broaching machine has been sent to us by the Rockwell Machine Tool Co., Ltd., Welsh Harp, Edgware-road, London, N.W.2. This machine, made to the design of the American Broach & Machine Co., Michigan, by the Coventry Gauge & Tool Co., Ltd., is made in three sizes, having maximum capacities of 6, 12 and 14 tons, respectively.

Fork-Lift Truck Operation.—A new manual entitled "How to Operate a Lift Truck" has been sent to us by the Hyster Company, 2902 N.E., Clackamas-street, Portland, Oregon, U.S.A.

Pulley-mounted Centrifugal Fans.—Details of their paddle rotor "Uniform" pulley-mounted fans are given in a publication received from The Standard and Pochin Bros., Ltd., Evington Valley-road, Leicester.

Diesel-Engine Cooling.—A booklet dealing with automatic temperature control as applied to the cooling of Diesel engines has been published by the Drayton Regulator and Instrument Co., Ltd., West Drayton, Middlesex. After describing the various types of cooling systems and temperature controllers, it explains how they should be used with open and closed cooling circuits. Oil cooling is also covered.

Constructional Materials.—A leaflet dealing with their range of Dexion constructional materials and accessories has been received from Dexion Ltd., Triumph House, 189, Regent-street, London, W.1. "Dexion" consists of standard 3-in. by 1½-in. slotted angle which can be cut into various lengths and bolted together to form storage racks, working platforms, light buildings and other structures.

Seed-Crushing Rolls.—A 16-page pamphlet giving details of their plant for crushing seeds and nuts for the purpose of oil-extraction has been received from Rose, Downs and Thompson, Ltd., Oil Foundry, Hull. It describes their preliminary reducing or breaker rolls, double-breaker rolls, Anglo-American rolls and horizontal flaking rolls.

Diesel-Engine Starting Batteries.—A booklet describing their Diesel-engine starting batteries has been sent to us by the D.P. Battery Co. Ltd., Bakewell, Derbyshire. It deals with the present range of a type of battery developed some years ago in collaboration with leading Diesel-engine locomotive builders and users.

Gas Scrubbers.—Brief details of Pease-Anthony gas scrubbers are given in a leaflet received from the Power-Gas Corporation Ltd., Stockton-on-Tees. The types described are the P-A cyclonic scrubber, which is used for micron-size ducts, and the P-A Venturi scrubber for use with sub-micron ducts, fumes and mists.

Maintenance of Electric Motor Control Gear.—The fundamental principles to be observed in maintaining electric control gear are dealt with in a booklet, entitled "Stitch in Time," received from Igranic Electric Co. Ltd., Bedford.

Fluorescent Lighting.—The second edition of the "Atlas Fluorescent Lighting Handbook," which we have received from Thorn Electrical Industries, Ltd., 105, Judd-street, London, W.C., gives details of their lighting units for industrial, commercial and domestic purposes.

Paddle-wheel Fans.—We have received from Keith Blackman, Ltd., Millhead-road, Tottenham, London, N.17, an illustrated catalogue containing particulars of their paddle-wheel type fans for industrial use, available in capacities from 500 to 30,000 cub. ft. per minute.

Driving Gear for Belt Conveyors.—An illustrated booklet has been issued by Mavor & Coulson, Ltd., Bridgeton, Glasgow, S.E., describing the mechanism of their driving gears for belt conveyors, which range from 7 h.p. to 200 h.p. Dimensions, weights, and belt speeds are given.

BOOKS RECEIVED.

The African Press and Advertising Annual. 1952-1953. Edited by CHAS. R. PASK and BARON V. M. FREDERICKSZ. 616, Boston House, Strand-street, Cape Town, South Africa. [Price 25s., post free.]

Applied Heat for Engineers. By DR. J.-B. O. SNEEDEN. Second edition. Blackie and Son, Ltd., 17, Stanhope-street, Glasgow, C.4. [Price 20s. net.]

Cutting Fluids. Esso Petroleum Company, Limited, 36, Queen Anne's-gate, London, S.W.1. [Price 7s. 6d.]

Lighting and Industry. British Electrical Development Association, 2, Savoy-hill, London, W.C.2. [Price 9s. post free.]

Memorandum on the Town Development Act. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 6d. net.]

Handbook of Engineering Fundamentals. Edited by OVID W. ESBACH. Second edition. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 10 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 80s. net.]

Metropolitan Water Board. Forty-Ninth Annual Report for the Year Ended 31st March, 1952. Staples Press, Limited, 14, Great Smith-street, London, S.W.1. [Price 5s.]

The British Electrical and Allied Industries Research Association. Technical Report G/T 256. The Performance of A.C. Fuses with Small Over-Currents at 11 kV. By H. W. BAXTER and M. T. CREE. [Price 6s.] No. G/T 265. *Flameproof Enclosure of Electrical Apparatus. Gaseous Explosions in Communicating Compartments; the Influence of Turbulence and Pressure Piling.* By J. A. B. HORSLEY. [Price 6s.] No. L/T252. *The Measurement of Permittivity at High Frequencies.* By E. RUSHTON. [Price 6s.] No. S/T57. *The Measurement of Lightning Currents. A Survey of the Present State of Knowledge.* By R. H. GOLDE and T. J. BROWN. [Price 12s.] No. S/T 60. *Statistical Survey of Overvoltages Observed During Switching Tests on a 66-kV System with Arc-Suppression Coil and with Resistor Earthing.* [Price 3s.] No. Z/T 89. *Fuel Cells. A Non-Technical Outline of their Development.* By A. P. PATON. [Price 4s. 6d.] Offices of the Association, Thorncroft Manor, Dorking-road, Leatherhead, Surrey.

Interim Rules for the Evaluation of Restriking Voltage Severity. The Association of Short-Circuit Testing Authorities, 36 and 38, Kingsway, London, W.C.2. [Price 5s.]

Ministry of Civil Aviation. Civil Aircraft Accident. Report on the Accident to Proctor 4 G-AJMX which Occurred on 13th July, 1952, near Rochester Aerodrome, Kent. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1s. net.]

Mechanical World Year Book. 1953. Emmott and Company, Limited, 31, King-street West, Manchester, 3. [Price 3s. 6d. net]

Heat Transfer Phenomena. By DR. R. C. L. BOSWORTH. Associated General Publications Pty., Limited, Sydney, New South Wales, Australia; and Pergamon Press, Limited, 2, 3 and 5, Studio-place, Kinnerton-street, London, S.W.1. [Price 2 guineas.]

Welding Practice. Edited by E. FUCHS and H. BRADLEY. Vol. II. *Welding of Ferrous Metals.* Published in association with Imperial Chemical Industries, Limited, by Butterworth's Scientific Publications, Limited, Bell-yard, Temple Bar, London, W.C.2. [Price 22s. 6d.]

Prestressed Concrete. By PROFESSOR KURT BILLIG. Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 36s. net.]

CONTRACTS.

The associated Kuwait company of JOHN HOWARD & Co., LTD., civil engineering contractors, 13, Buckingham Gate, London, S.W.1, have received a contract from the Kuwait Government for the construction of a technical training college to accommodate 1,000 students. The contract is worth 2,000,000l., and the college will take two years to complete.

THE GENERAL ELECTRIC CO. LTD., Kingsway, London, W.C.2, announce that a contract has been placed with their Fraser and Chalmers Engineering Works for an electrically-driven winding engine for the No. 2 Area of the South-Western Division of the National Coal Board. The equipment is to be installed at the Glynceorwg Colliery and will replace a steam winding engine. It will raise 270 tons of coal an hour from a depth of 1,800 ft. and the weight of coal brought up at each wind will be 6 tons. The motor and switch-gear will be provided from the General Electric factory at Witton, Birmingham.