

THE ESSO OIL REFINERY, FAWLEY.

THE opening of the new Esso oil refinery at Fawley, Hampshire, by the Prime Minister on Friday, September 14, marked an important stage in the development of the British oil industry, as in addition to promoting national self-sufficiency in the supply of refined products, its inception represents a great saving in dollar imports estimated at two million dollars a week. At present, the British oil industry is going through what is probably the most important period of development and expansion in its history, for, in place of the old idea of marketing products obtained from overseas, big new refineries are being erected in various parts of the country which, when completed, will satisfy the home demand almost entirely. This expansion programme represents the investment of some

125,000,000/., and the new refineries under construction, when finished, will raise the country's total refined petroleum production to approximately 20,000,000 tons per annum in 1953 compared with 3,500,000 tons in 1948.

The Fawley project is, undoubtedly, the most ambitious single project in the refinery-expansion programme, having cost more than 37,500,000/.. Already, it is the largest oil refinery in Europe and, when in full production, will supply some 6,500,000 tons of petroleum products a year, including a daily output of 1,000,000 gallons of high-quality motor spirit. Other products, the quantities of which will be adjusted to meet market requirements, will include white spirit, tractor fuel, turbo-jet fuel, kerosene, high-speed Diesel oil, marine Diesel oil, lubricants, bunker fuels, mainly for shipping, and liquid-petroleum gases, to mention but a few. The major units comprise two pipe-stills, a catalytic-cracking plant with light ends and polymerisation

facilities, an Edeleanu plant for the treatment of kerosene and gas oil, a copper sweetening plant for petrol, and various units for the treatment of the lubricating-oil fractions such as a propane de-asphalting unit, a phenol extraction plant for the removal of aromatics, a propane de-waxing plant and the usual clay-treatment plant. These units, together with the storage tanks, etc., occupy an area of some 450 acres near the village of Fawley, on Southampton Water. This was an obvious choice of site as the company already had a refinery in this locality, and the unique double tides and slow-moving current of Southampton Water enable fully-laden tankers of the largest size to swing, berth and unberth at any time of the day or night. In an emergency, therefore, tankers could leave the berths at any state of the tide.

To conserve dollar expenditure, the crude oil will come from the Middle-East oilfields. Fortunately, considerable developments have taken place in that

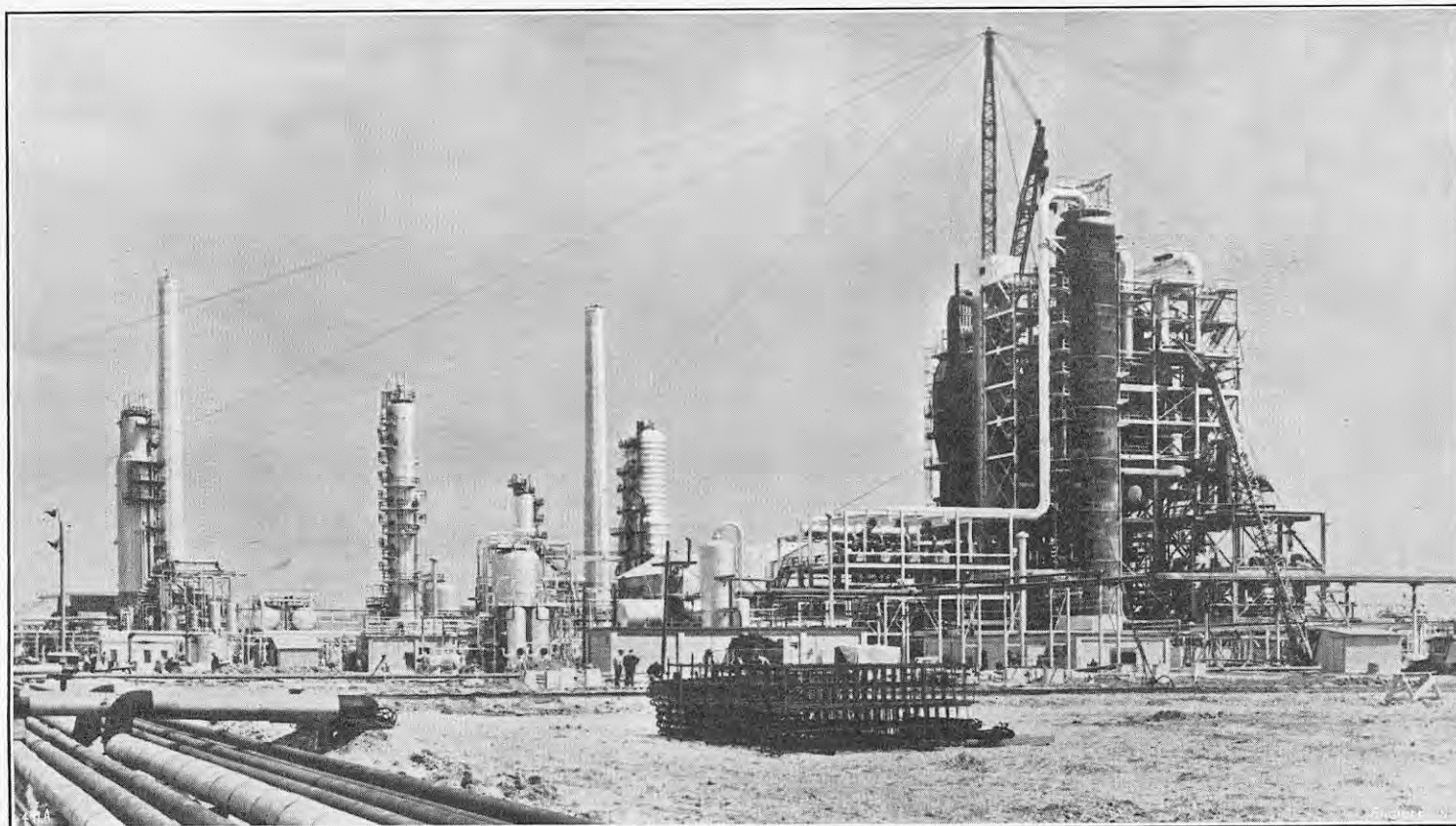


FIG. 1. GENERAL VIEW OF MAIN REFINERY UNITS.



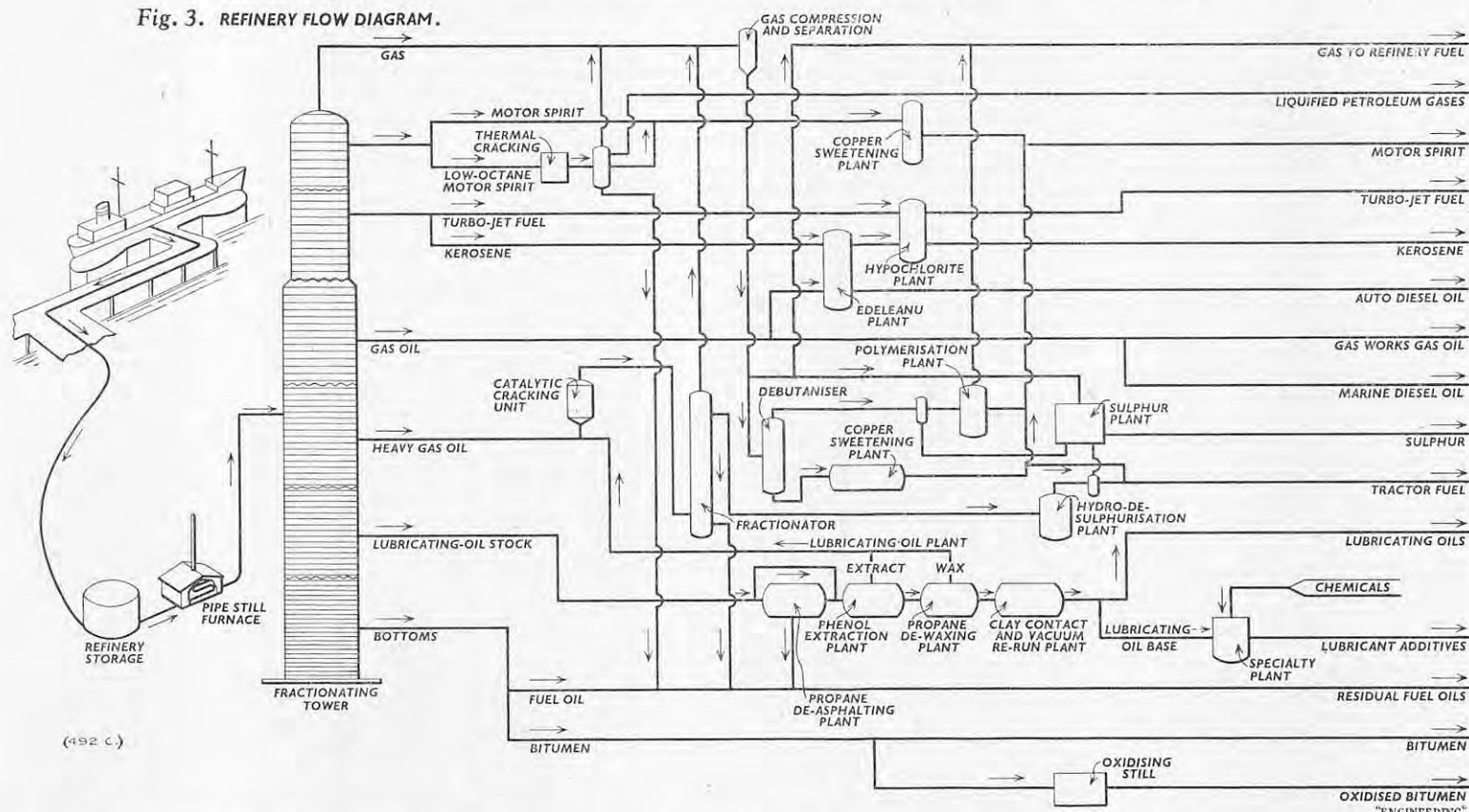
FIG. 2. JETTY UNDER CONSTRUCTION.

area during recent years; Kuwait, for example, produced practically no oil in 1938, but by 1950 the output had reached 17,000,000 tons. Saudi Arabia may be quoted as another example, as only 67,500 tons of crude oil were produced in 1938 compared with 23,000,000 tons in 1950. The crude oil will be brought to Fawley in the Company's own fleet of tankers, which will berth at a new marine terminal built to accommodate vessels of 39,000 tons; it was designed and constructed by Messrs. Christiani and Nielsen, Limited, 54, Victoria-street, London, S.W.1. The jetty is shown under construction in Fig. 2, on this page, and part of the completed jetty, with a tanker alongside, in Fig. 4, on Plate XXVI. The jetty is joined to the refinery by a reinforced-concrete approach, 2,000 ft. long, built across the salt marshes, for which more than 630 piles 71 ft. long and of 16 in. by 14 in. cross section, were used. This approach carries a large number of oil and steam pipes arranged in two tiers, as well as a 4-ft. diameter salt-water pipeline.

At the site of the berths, there was 30 ft. of mud overlying 10 ft. of gravel and beneath this 300 ft. of stiff clay, known as Barton clay. Dredging, therefore, proved relatively simple and economical, as only the mud had to be removed to obtain the depth of water required. In fact, only 400,000 cub. yds. of mud had to be dredged to give a 34-ft. depth of water at low tide. For the construction of the jetty, five hundred hollow cylindrical

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Fig. 3. REFINERY FLOW DIAGRAM.



concrete piles, having a length of 75 ft., an external diameter of 2 ft. 8 in. and a wall thickness of $5\frac{1}{2}$ in., were used. The weight of each pile is approximately 20 tons and they were driven into position by means of two floating pile drivers specially constructed for the purpose, each of which was fitted with a steam hammer of $8\frac{1}{2}$ tons falling weight. Pile driving was rendered somewhat difficult due to a considerable swell but fortunately the gravel and clay make excellent foundations for the piles which will support more than 50 tons. Four T-shaped breasting islands have been built for berthing the tankers, each of which will rest against two dolphins or caissons. These are reinforced-concrete cylindrical shells of 40 ft. diameter filled with sand and situated at each end of the breasting islands.

The crude oil is pumped from the tankers to one of several tanks situated in the storage area, the capacity of which is sufficient to permit the operation of the refinery for two weeks. Part of the piping and associated valves of the units handling the crude oil can be seen in the photograph reproduced in Fig. 5, on Plate XXVI, and some of the storage tanks can be seen in Fig. 17, on page 387. As previously mentioned, the main refinery units comprise two distillation units, a catalytic-cracking plant and an Edeleanu plant. These, together with some of the other units, can be seen in Fig. 1, on page 385, and in Fig. 8, on Plate XXVII, the latter illustration showing a panorama of the complete refinery, while an idea as to the many different units incorporated in the refinery and the various processes involved can be gained from the abridged flow diagram reproduced in Fig. 3, above. Of the two distilling units, one is a single-stage atmospheric unit and the other a combined two-stage atmospheric and vacuum unit. Photographs of the two distilling units are reproduced in Fig. 6, on Plate XXVI, and Fig. 9, on Plate XXVII, from which it will be seen that they are situated in the same area of the refinery, the single tower of the single-stage unit being towards the left and the two towers of the combined atmospheric and vacuum unit towards the right of the illustrations, respectively. General views of the single-stage unit are shown separately in Figs. 10 and 11, on Plate XXVII. The fractionating column is 124 ft. high and has a diameter of 21 ft. It is fitted with 35 trays, each of which is provided with a number of the usual form of bubble caps and, so as to avoid excessive

corrosion, the interior surface is lined with stainless steel. In accordance with the usual practice, the gasoline products are taken from the top of the column and the heavier products are extracted progressively lower down, reflux to the trays being provided by a system of pumps. The interior of the pipe-still furnace is shown in the photograph reproduced in Fig. 7, on Plate XXVI; it operates on the two-flow system and is provided with two convection- and two radiant-heating banks, the heating capacity being in the neighbourhood of 250,000,000 B.Th.U. per hour. The unit is provided with the usual range of heat exchangers which, together with the pumps, are located in the open.

The pipe-still for the atmospheric and vacuum two-stage plant is a double-furnace unit, the first section, which works in conjunction with the atmospheric column, being similar to that used with the single-stage plant. The second section, however, has single convection- and radiant-heating banks and has a heating capacity of 85,000,000 B.Th.U. per hour as compared with 156,000,000 B.Th.U. per hour for the first section. The atmospheric column and vacuum tower are illustrated in Fig. 12, on Plate XXVII, the former being to the left and the latter to the right of the illustration. The atmospheric column is 90 ft. high with internal diameters of 15 ft. 6 in. and 13 ft., while the vacuum tower is 130 ft. high, the diameter in this case being 28 ft. As in the case of the single-stage unit, both towers are lined internally with anti-corrosive materials and the two units are provided with an extensive system of heat exchangers, which, together with the pumps, are situated in the open.

The most impressive installation in the refinery is, undoubtedly, the catalytic cracking plant. The theory of catalytic cracking was covered extensively by Mr. Robert Price Russell when he delivered the second Cadman Memorial Lecture before a meeting of the Institute of Petroleum in London in June, 1947, a report of which appeared in *ENGINEERING*, vol. 163, page 507. According to the lecture, it was discovered some time previously that by carrying out cracking in the presence of catalysts consisting of clays and related solid synthetic materials, the cracking process could be operated at lower pressures and temperatures with better overall yields and improved products. When catalytic cracking was first applied on a large scale, it was used in stationary beds over which the vapours were passed. This

method, however, gave rise to several practical difficulties and the development of a continuous process seemed desirable. Eventually these problems were overcome by introducing a new process known as fluid catalytic cracking in which the catalyst is so finely divided that it behaves like a fluid, and it is this type of cracking plant which has been constructed at Fawley. It is illustrated in Figs. 13 and 14, on Plate XXVIII, and as will be seen from the flow diagram, Fig. 3, is fed with heavy gas oil from the fractionating columns of the distillation units. In operation, the heated oil vapour from the distillation units enters a reaction chamber carrying with it the catalytic material as a suspended powder. Owing to the decreased velocity of the vapours passing through the reactor, which is 70 ft. high and 35 ft. in diameter, the suspended powder settles out to form a relatively dense bubbling bed and cracking takes place as the rising oil vapour makes contact with the catalyst. On leaving the reactor, the cracked oil vapours pass through a series of cyclones for the removal of any entrained catalyst and then enter a fractionating column where they are separated into the desired fractions. The bed of catalyst in the reactor is automatically maintained at a constant level and any "spent" catalyst, that is, those particles covered by a coating of carbon, is delivered by an air stream to the regenerator, a vessel 70 ft. high and 55 ft. in diameter. Because of the decreased velocity of the air in the regenerator, another violently bubbling bed is formed in this vessel and the carbon deposited on the catalyst while it is in the reactor is burnt off, the catalyst being returned subsequently to the reactor. The flue gases leaving the regenerator first pass through a series of cyclones to remove the entrained catalyst and then to waste-heat boilers, the steam generated being used for process work in the refinery.

Petroleum products resulting from distillation or cracking require, of course, further treatment before they are fit for general use. Several treatment plants have been installed and these include the Edeleanu plant, previously referred to, a debutaniser tower, a copper sweetening unit and a hypochlorite plant. In the Edeleanu plant, kerosene from the fractionating columns is treated chemically to improve its burning qualities. This plant employs a sulphur-dioxide solvent extraction process and, in addition to treating kerosene, will be

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(For Description, see Page 385.)



FIG. 4. TANKER UNLOADING AT NEW JETTY.

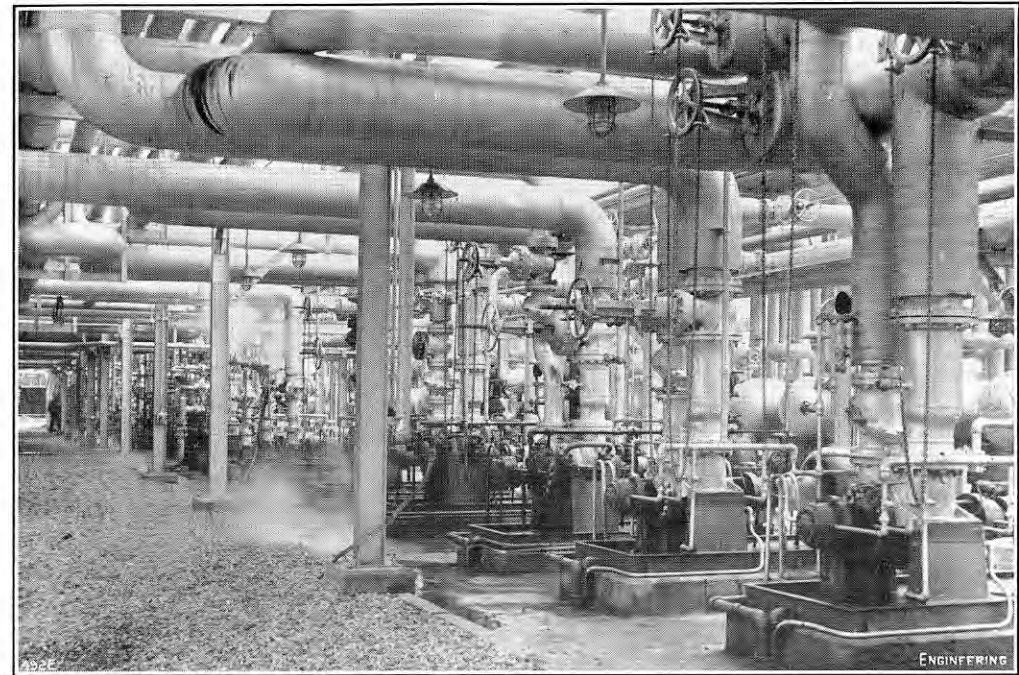


FIG. 5. VALVES AND PIPING FOR HANDLING CRUDE OIL.

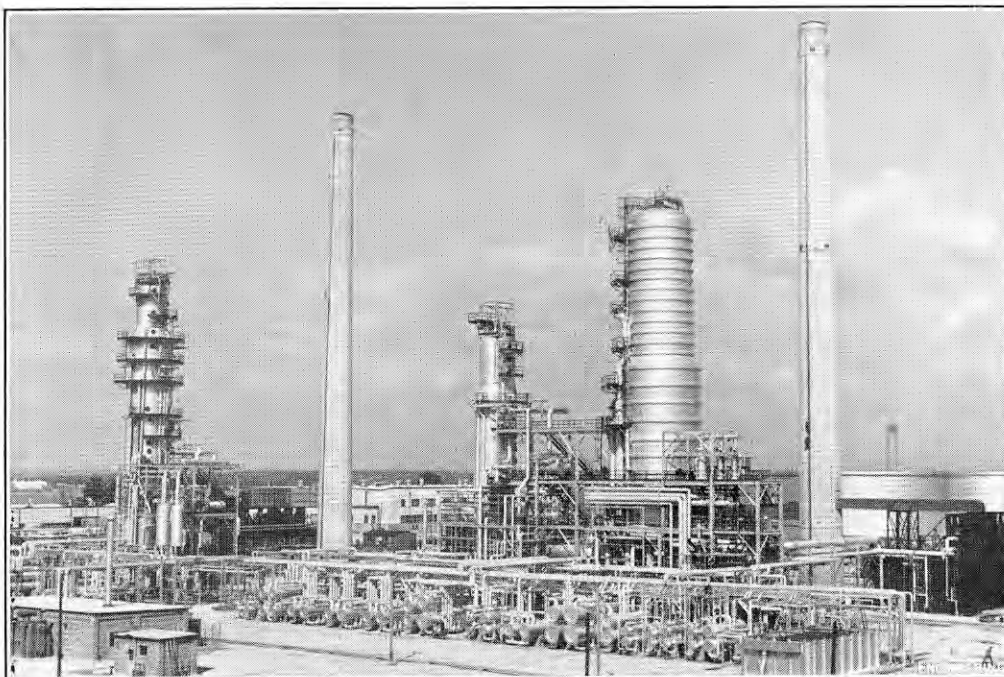


FIG. 6. ONE-STAGE AND TWO-STAGE DISTILLING UNITS.

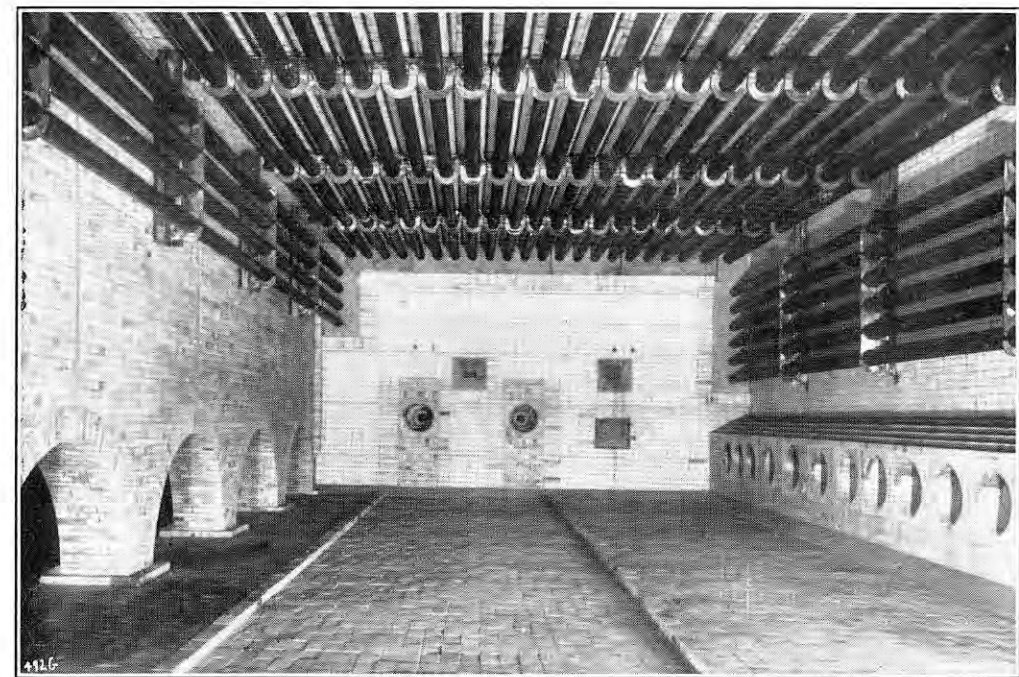


FIG. 7. INTERIOR OF SINGLE-STAGE PIPE-STILL FURNACE.

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FIG. 8. GENERAL VIEW OF REFINERY AREA, SHOWING BOILER-HOUSE,



FIG. 9. CRUDE-OIL UNITS WITH HEAT EXCHANGERS IN FOREGROUND.



FIG. 10. SINGLE-STAGE ATMOSPHERIC UNIT.

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(page 385.)



UNITS, CATALYTIC-CRACKING PLANT, STORAGE TANKS AND FLARE TOWER.



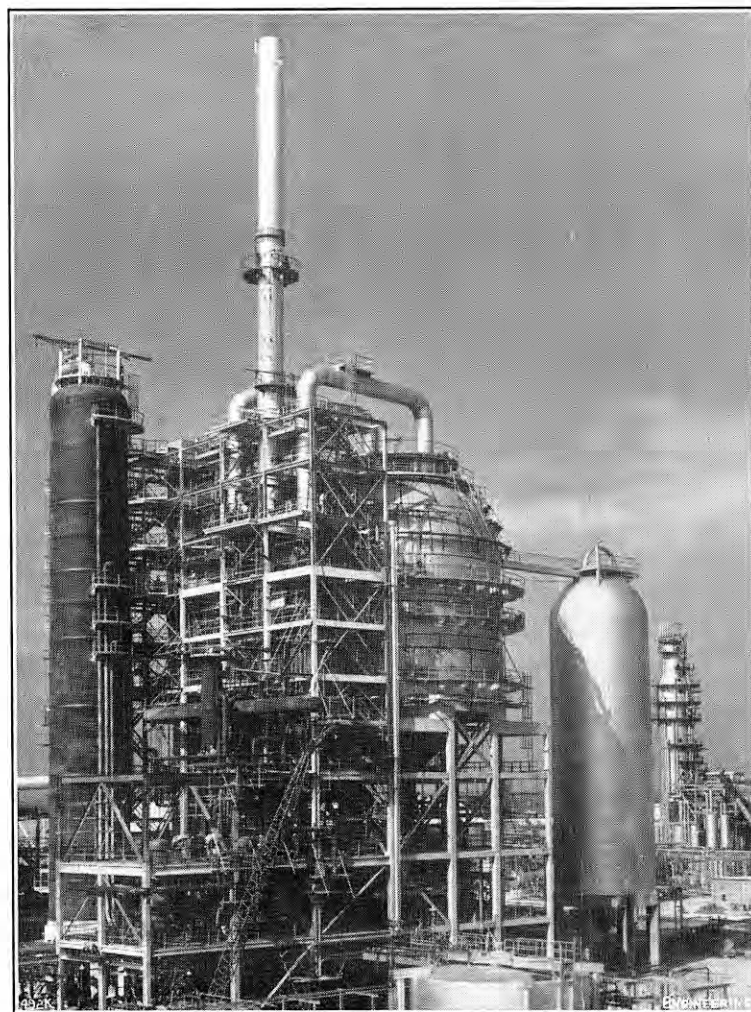
FIG. 11. SINGLE-STAGE FRACTIONATING COLUMN.



FIG. 12. TWO-STAGE ATMOSPHERIC AND VACUUM UNIT.

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(For Description, see Page 385.)



FIGS. 13 AND 14. CATALYTIC-CRACKING PLANT.



FIG. 15 DEBUTANISER TOWER.



FIG. 16. PIPING FOR CRUDE-OIL UNITS.

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FIG. 17. STORAGE AREA, WITH LABORATORY IN FOREGROUND.

employed for treating gas oil so as to reduce its sulphur content. The debutaniser tower, a photograph of which is reproduced in Fig. 15, on Plate XXVIII, is 113 ft. high and weighs 135 tons; it was delivered as a complete unit and was the largest single piece of equipment supplied to Fawley. It has been designed for a working pressure of 250 lb. per square inch and its function is to remove butane and other light gases from motor spirit so that the product meets the required vapour-pressure specifications. The copper sweetening unit operates with copper chloride, the motor spirit from the fractionating columns being diverted to this unit for the removal of corrosive compounds and unpleasant vapours, the product subsequently being blended with high-octane spirit from the catalytic-cracking plant. Turbo-jet fuels and kerosene will be further treated in the hypochlorite plant for the removal of evil-smelling sulphur compounds.

Other plants which should be mentioned are the oxidising plant and hydro-desulphurisation plant. In the former, air is blown through bitumen to produce a rubber-like substance suitable for such uses as roofing, while the hydro-desulphurisation plant is used to remove the sulphur content of tractor fuel. This is accomplished by treating it with hydrogen in the presence of a catalyst. Eventually, the hydrogen sulphide resulting from this process will be fed to the sulphur plant, now being installed. It is claimed that, when this plant is in operation, it will convert the hydrogen sulphide into 99.5 per cent. chemically-pure rock sulphur at a rate of 12,000 tons per annum. Heavy lubricating oil from the fractionating columns is treated successively in four plants, namely, a propane de-asphalting unit for the removal of the asphaltic content, a phenol-extraction plant for the removal of the aromatics, a propane de-waxing plant and the usual form of clay-treatment plant.

Extensive services, of course, have had to be provided. As well as the waste-heat boilers at the catalytic-cracking plant, there are four Babcock and Wilcox water-tube boilers designed for a working pressure of 150 lb. per square inch and a steam temperature of 465 deg. F. They have a rated

capacity of 95,000 lb. of steam per hour and are arranged for both gas and oil firing. Cooling water for process work is being taken from Southampton Water, the pump-house for this purpose being located on the shore side of the jetty. The pumps will deliver 50,000 gallons of salt water a minute, which will be conveyed to a storage tank in the refinery before being delivered by further pumps to the service lines. Before it is returned to the sea, the used water passes through a separator which effectively removes any entrained oil. Fresh water is obtained partly from the Southampton Corporation Water Works and partly from wells, several of which have been sunk on the site to a depth of 600 ft. by the International Water Corporation.

Electrical power is taken entirely from the national grid, no generators being installed in the refinery area. Originally, the contract for all electrical equipment was placed in the United States, it having been considered at that time that British manufacturers could meet neither the constructional programme nor the specifications which were based on American oil-refining experience. This view was opposed by the Metropolitan-Vickers Electrical Company, Limited, who eventually succeeded in negotiating an agreement whereby they undertook to supply all electrical equipment for phase A of the project except that which was too far advanced in construction. Phase A covered the crude distillation units, which went on stream on August 1, 1951, the catalytic-cracking plant and debutaniser unit, and the sulphur-dioxide Edeleanu plant. As a result of this agreement, the Company supplied over 70 per cent. of the electrical equipment for phase A and are now supplying that for phase B, which covers the polymerisation, tractor-fuel and light-oils and sulphur-recovery plant, scheduled to go on stream by the end of 1953. The equipment already supplied includes a variety of switchgear, transformers, motors, etc., installed during site preparation, 132-kV and 11-kV switchboards for the Southern Electricity Board's substation in the refinery area, five main-unit 11/3.3-kV substations, eleven secondary unit 3,300/415-volt substations, approximately 140 motors, the majority of which are totally-enclosed flameproof units, and a large

quantity of subsidiary equipment such as lighting fixtures, distribution transformers, instruments, etc. Each substation has an automatic-transfer scheme arranged so that if a fault occurs on one 'bus-bar, a duplicate is brought in automatically to prevent interruption of the supply.

Although the main contract for the supply of the major units and their erection was placed with the Foster Wheeler Corporation, 165, Broadway, New York, U.S.A., the actual work was executed by their British affiliated company, Messrs. Foster Wheeler, Limited, Ixworth-place, London, S.W.3, who placed large sub-contracts in the United Kingdom. It proved necessary, however, to obtain the major units, such as the catalytic-cracking plant, the pipe stills, the Edeleanu plant and some of the feed plant from the United States whose petroleum-equipment manufacturers alone had the special knowledge and capacity for its production. No Marshall Aid was involved in financing the project as the parent firm, the Standard Oil Company, New Jersey, U.S.A., reinvested considerable funds and provided a substantial amount of new capital.

The new refinery was built on a virgin site and work in the field commenced in August, 1949. Its completion by early September, four months ahead of schedule, represents, therefore, a remarkable achievement, particularly in mind the severity of the last two winters is borne in mind. The initial operations consisted mainly of land clearance and grading, the installation of a central concrete and aggregate plant, the laying down of railway tracks and the erection of a permanent steel-framed combined workshop and warehouse. The excavating work required, which proved to be considerable, was carried out by Messrs. George Wimpey and Company, Limited, Hammersmith-grove, London, W.6. The combined workshop and warehouse was erected during the early stages so that it could be used for accommodating construction materials and reduce to a minimum the need for erecting temporary huts. It is 800 ft. long and 180 ft. wide and, in addition to being equipped with travelling cranes, incorporates a modern workshop. Two railway lines run directly into the building and part is laid out for foremen's offices. Other permanent build-

ings on the site include the administrative offices, laboratories and a social club, the last named being situated just outside the boundary. Care has been taken to preserve the local amenities and although it is not feasible to screen the plant from the seaward direction, a wide belt of trees and flowering shrubs has been planted to screen it from the road on the landward side.

LITERATURE.

Classical Mechanics.

By PROFESSOR H. C. CORBEN and PROFESSOR P. STEHLE. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 6.50 dols.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 52s. net.]

IDEAS concerning molecular and atomic phenomena have undergone great changes in recent years as a consequence of the advances in experimental and theoretical physics, awakening in wide circles a lively interest in the subject. There are many who lack the time or the preliminary knowledge necessary for the study of original papers and treatises on the dynamical side of the matter. Such students may desire an exposition which, while modern in treatment and outlook and not too comprehensive, would enable them to grasp the transition from classical mechanics to quantum or relativity mechanics. In their book, Dr. Corben and his colleague provide such an exposition in a form eminently suitable for use as a text-book in more advanced courses of study.

Of the 18 chapters in the book, the first four deal with the preliminary topics of the kinematics of particles, the laws of motion, conservative systems with one degree of freedom, and miscellaneous theorems on systems of particles. From this point onwards the reader gradually realises that classical mechanics has a vast realm of validity, and that the development of quantum mechanics has been guided to a great extent by the "correspondence principle," which asserts that quantum mechanics must yield the same results as classical mechanics when applied to problems where the classical theory is known from experience to give the correct description of events. The procedure involves reorientation of ideas at several points. For example, the treatment of Lagrange's equations of motion, in Chapter 5, is arranged so as to remind the reader constantly of the distinction between co-variant and contra-variant components of vectors and tensors. This method of formulating these equations is of utility for two reasons: it eliminates the necessity of evaluating the Christoffel symbols explicitly, and it provides a convenient means of calculating Christoffel symbols of the second kind in a simpler manner than by the direct method. Again, in the next chapter, on applications of Lagrange's equations, the problem of central motion is discussed with more than usual emphasis on scattering problems, so that the reader here finds discussions on the nature of a cross-section, Rutherford's formula, and the transformation connecting centre of mass and laboratory co-ordinate systems. Following a chapter on linear space-vectors, the authors next proceed to the consideration of small oscillations of conservative systems, in the exemplification of which is included the eigen-vibrations of the molecule of which the prototype is ammonia. The kinematics of rigid bodies is then discussed in detail by means of quaternions and orthogonal matrices, thus completing the more elementary part of the treatment.

The more advanced topics start in Chapter 10, with the Hamilton theory of motion, and, though little of this and the succeeding chapters is of practical use in the solution of specific problems in non-relativistic classical mechanics, the underlying transformation theory cannot be dismissed by the physicist as useless mathematical juggling. In the first place, this theory affords a deep insight into equations of motion of a mechanical system which can be specified by a Lagrangian function, making it possible to write these equations in a very attractive form. Secondly, the Hamilton-Jacobi partial-differential equation is, in fact, of real use in solving complicated dynamical problems. Finally, the generalisations of the theory to that of relativity

and, more particularly, to quantum and to statistical mechanics, are of fundamental importance in these branches of theoretical physics. The authors accordingly pay due attention to the transformation theory in dynamics by devoting six chapters, rather less than one-third of the book, to contact transformations and allied topics. Here the serious student will find a mass of useful information on several points of interest: Fermat's principle, contact transformations which simplify the equations of motion, infinitesimal transformations of this type, perturbation theory, the utility of Poisson's brackets in quantum mechanics, and an instructive analogy between thermodynamics and contact transformation theory in which the mathematical structure of the theory is exhibited in a familiar context. The foregoing, together with chapters on the formal aspects of relativity mechanics, including a brief discussion of the Thomas precession of a charged particle, and on applications of the theory to the motion of ions in the present-day high energy accelerators, concludes the work. It is, indeed, an excellent book, by reason of the order of presentation, character of the illustrative examples, and method of exposition generally.

Heat and Thermodynamics.

By J. K. ROBERTS, Sc.D., F.R.S., revised by A. R. MILLER, Ph.D., F.Inst.P. Blackie and Son, Limited, 16-18, William IV-street, Charing Cross, London, W.C.2, and 17, Stanhope-street, Glasgow. [Price 35s. net.]

ALTHOUGH thermodynamics was originally confined to the subject of heat engines, its laws are now recognised as underlying so vast a range of natural phenomena that it may be fairly regarded as the most fundamental of the sciences. Engineers need not be surprised, therefore, to find that the aspects of thermodynamics with which they are practically concerned are given a very small place in a treatise designed, like the present one, as a text-book for university students taking an honours course in physics. Indeed, such matters as power and refrigerating cycles, steam and internal-combustion engines, turbines, and the theory of jets are all disposed of in a single chapter of 32 pages, which the student is told he may ignore if he so desires. The present edition of the book—the first edition appeared in 1928—has again been brought up to date by including references to work published as recently as last year, and its modernity is shown by the adoption of the joule or watt-second as the unit of heat instead of the calorie, and by calling the Centigrade thermometric scale the Celsius scale in accordance with international agreement. Also, the name "enthalpy" is used in the index, though the function to which it refers is always called by the more familiar name of "total heat" in the book itself.

The new material is mainly concerned with low-temperature phenomena, particularly the thermodynamic properties of liquid helium and the superconductivity of metals. Another matter connected with very low temperatures is the Nernst heat theorem, which, as in some other modern books, has now been raised, in a modified form, to the dignity of a Third Law of Thermodynamics. The theorem, as usually enunciated, asserts that the entropy of a pure crystalline substance is zero at the absolute zero of temperature. The new Third Law, as proclaimed in italics by the authors, states that "The contribution to the entropy due to each factor with respect to which the system is in internal thermodynamical equilibrium vanishes as the absolute zero is approached." This Law is said to be equivalent to the statement that the absolute zero is unattainable, provided that the usual assumption is made, that the specific heats tend to zero along with the temperature. As the next sentence asserts that this condition means that the entropy has a finite value at the absolute zero of temperature, a cynical reader might be tempted to say that, if a Third Law of Thermodynamics is really needed, it had better be confined for the present to the simple proposition that, at the absolute zero of temperature, the entropy either does, or does not, become equal to zero.

The emphasis throughout the book on the laboratory methods employed by various investigators

may seem excessive to readers who are more interested in the data secured than in the means of obtaining them. Over a score of pages, for example, are devoted to experiments on the value of the mechanical equivalent of heat, while determinations of specific heats and their ratios, vapour pressures, thermal conductivities, low-temperature effects, etc., are also dealt with at greater or less length from the experimental point of view. Though there may be arguments in favour of this method of teaching, it is more difficult to justify the sequences of some of the subjects. The quantum theory of specific heats for instance, is discussed in considerable detail in Chapter VI, but the reader is recommended in a footnote to master Chapters XXI and XXII first. Again, cooling by adiabatic demagnetisation, in Chapter V, is provided with another footnote of the same kind; which is perhaps just as well, because the mathematical argument involves the conception of entropy, which is not defined at all until the Second Law of Thermodynamics is discussed in Chapter XII. Though the volume is not likely to be of much direct use to students of engineering, its comprehensiveness will appeal to those who regard thermodynamics with a wider outlook. To derive the greatest value from it, the reader should not only be equipped with a good knowledge of mathematics, but should also have access to a first-class technical library containing the specialised publications on particular subjects recommended to him in innumerable footnotes. There is an algebraical slip on page 504, resulting in an error in the expression for the mean energy of the vibrators in a plane polarised system; but, fortunately, wherever the expression is made use of, it appears to be given in a correct form. Also, in the statement of Dulong and Petit's Law, the atomic heat of a gramme-atom is given as 25.94 joules per degree, though the correct value of 24.94 is used elsewhere.

Proceedings of the Fourth Empire Mining and Metallurgical Congress, 1949.

Edited by F. HIGHAM, A.R.S.M., M.Sc., M.I.M.M., and published (in two parts) at the offices of the Congress, 436, Salisbury House, Finsbury Circus, London, E.C.2. [Price 20s. per part.]

THE Empire Council of Mining and Metallurgical Institutions was founded in 1924 to convene successive Congresses and to foster a high level of technical efficiency. The Fourth Congress was held in Great Britain from July 9 to 23, 1949, and the printed *Proceedings* are now available. Part I has an introductory report by the organising committee, the presidential address by Sir Henry T. Tizard, and reports of the speeches at the banquet at Guildhall. Thereafter, the papers and discussions at the first five technical sessions are given in full. The subject matter dealt with includes a comprehensive account of the mineral resources of the Empire, modern methods of mineral exploration, six papers on physiological and psychological effects of heat and humidity on workers in deep mines and metallurgical works, and two papers on drilling and production practice in oilfields. This volume of 550 pages is the most up to date and authoritative publication available on the subjects dealt with. The second part of the *Proceedings* will probably be of more interest to readers of *ENGINEERING*, since the technical sessions recorded therein are on coal, present-day trends in mineral dressing, and metallurgy and metallurgical industries. Useful papers in the last section cover such subjects as developments in copper pyrometallurgy, zinc smelting and the electrolytic-zinc industry, lead-sintering practice, the nickel industry, the alloying and fabrication of magnesium, future trends in the British iron and steel industry, research and development in Canadian foundry practice, and the cold working of metals. All metallurgists will find something of interest in this 600-page report. Evening lectures by Sir John D. Cockcroft, K.C.B., on "Metallurgical and Mining Problems in Atomic Energy," and by Dr. W. Hume-Rothery, F.R.S., on the "Theory of Metals and Alloys," are appended to the second part of the *Proceedings*. The two volumes, which are clearly printed and amply illustrated, constitute a worthy record of a successful and useful congress.

CRITICAL REYNOLDS NUMBERS FOR STEADY AND PULSATING FLOW.

By PROFESSOR L. J. KASTNER and DR. S. H. SHIH.

MANY investigations have been carried out dealing with the passage of a fluid through a pipe or channel and it has been established that there is a limiting value of the Reynolds number, R_c , below which laminar flow will always be maintained. The experiments of Reynolds,* Ruckes,† Stanton and Pannell,‡ and Barnes and Coker,§ have established that, for circular pipes in which the fluid is either air or water and is flowing at a constant rate, the value of the critical Reynolds number, $R_{c,c}$ is about 2,000; but for rectangular or square pipes there is less information available and $R_{c,c}$ is quoted at values between 1,600 (Schiller||) and 2,800 (White and Davies¶). It is to be noted, however, that the phenomena occurring in a pipe or channel are influenced by the conditions at entry, and, if the fluid is exceptionally free from any disturbance before entering the test section, the critical Reynolds number may be much higher than the above, as has been determined by Reynolds himself, and by others, in experiments in which great care was taken to remove any sources of irregularity of flow at entrance.

Conversely, in special circumstances, including cases where the flow at entry is particularly disturbed, certain investigators (e.g., Sorkau,** Carothers,†† and Grindley and Gibson‡‡) have found that very low Reynolds numbers are necessary to guarantee viscous flow, and values from about 200 to 400 have been quoted. Such cases, however, as well as those in which abnormally high values of $R_{c,c}$ have been found, are usually considered to be quite exceptional.

When the rate of flow of the fluid is not constant but is subject to regular pulsations, the problem of investigating the resistance of a narrow passage of given form becomes more complicated and does not appear to have attracted the notice of experimenters. The investigation to be described was undertaken with the object of obtaining additional information as to the critical Reynolds number for closed narrow passages under steady and pulsating conditions of flow, most of the work being concerned with the isothermal motion of a pulsating stream of air through a narrow rectangular channel.

Transition Lengths.—When a fluid flows through a channel under conditions of low Reynolds number, laminar flow will, in general, only be achieved at a certain distance downstream from the entrance and will again be lost at a certain distance upstream of the exit cross-section.

According to Schiller,§§ the distance from the entrance required for practically complete transition is given by $L = 0.0575 r R_c$, in which r is the radius of the (circular) pipe and R_c is the Reynolds number. The theory of Boussinesq,||| experimentally verified by Nikuradse,¶¶ is based on the assumption that the entrance disturbance may be considered to become negligible when the ratio of the maximum to the mean velocity is within 1 per cent. of the normal value of 2. This gives a length about double that accepted by Schiller, leading to an expression $L = 0.13 r R_c$.

For flow in a rectangular channel, or between parallel plates, no information as to the magnitude of the transition length appears to be available. An attempt was made to calculate this magnitude

by applying Schiller's theory and by assuming that the plates by which the flow is confined are so wide that flow in the transition region may be regarded as being two-dimensional. If the distance between the plates is $2b$, the transition length given by the calculation is $L = 0.0259 b R_c$. The calculation can only be very approximate, since Schiller's assumptions of a central flow uninfluenced by velocity, and of a parabolic fall in velocity toward the walls, are valid only near the entrance, as shown by Nikuradse. For the latter part of the transition region, a definite core flow independent of friction apparently does not exist. The results of Davies and White for the flow of water through rectangular pipes of large width-depth ratio can be correlated with the calculated expression $L = 0.0259 b R_c$, and it appears that, for small Reynolds numbers, say, $R_c < 400$, the transition lengths as calculated are larger than the experimental ones, but are smaller for $R_c > 400$. The conditions at entrance in the two cases are, however, not truly comparable.

As far as can be ascertained, no information appears to be available regarding the magnitude of the transition length at exit, but it is supposed that, in most cases, this is not greater than the transition length at entrance. If, however, the flow is unsteady and subject to pulsations, the problem is further complicated and the estimation of a true value for the transition length, either at entrance or exit, becomes very difficult. In such a case, it is clearly advisable to use a very considerable factor of safety and to site the pressure tapings some way from the entrance or exit of the channel as was done in the experiments with parallel-sided passages which are described below.

Effect of Side Boundaries.—In many problems concerned with viscous flow through rectangular channels of comparatively large width-depth ratio, the influence of the side walls on the fluid stream may be ignored, but, for a required degree of accuracy, there must be a limiting value of the width-depth ratio below which the effect of the lateral boundaries cannot be neglected. Analysis suggests that a convenient way of allowing for the influence of the side walls is by comparing the flows through channels of infinite and finite width, the calculation resulting in a correction factor which can be applied to the relatively simple equations determining the pressure drop across, or the flow through, an infinitely wide channel, to make these equations appropriate to the case of a rectangular pipe of any width-depth ratio. It appears, as shown by Equation (12), on page 391, that the influence of the boundaries on the mean flow of an oscillating motion is the same as if the flow were steady. The use of the following equations is therefore permissible in considering the mean flow of a pulsating motion.

The problem of steady flow through a rectangular passage appears first to have been solved by Boussinesq.* If the width and depth of the passage are $2a$ and $2b$, respectively, if x is the dimension in the direction of motion, and if p and μ refer to pressure and viscosity, the equation for the discharge, in Boussinesq's form, is

$$Q_1 = -\frac{2}{\mu} \frac{dp}{dx} \frac{a^3 b^3}{a^2 + b^2} \left\{ \frac{1}{2} + \frac{2}{K'} \sum_{K'=0}^{\infty} \frac{1}{K^3} \left(1 - \frac{2}{K^2} \right) \times \left[\frac{b}{a} \cdot \frac{K^a}{e^{\frac{K^a}{b}} - e^{-\frac{K^a}{b}}} - \frac{K^a}{b} \cdot \frac{K^b}{e^{\frac{K^b}{a}} - e^{-\frac{K^b}{a}}} \right] \right\} \quad (1)$$

where K' is any positive integer and $K = (2K' + 1)\frac{\pi}{2}$. By a somewhat lengthy transformation, equation (1) may be shown to be exactly equivalent, for all values of $\frac{a}{b}$, to the alternative and more convenient form

$$Q_1 = \frac{4}{3} \frac{a b^3}{\mu} \frac{(\Delta p)_1}{l} \left\{ 1 - \frac{192 b}{\pi^5 a} \sum_{n=1,3,5,\dots}^{\infty} \frac{1}{n^5} \tanh \frac{n \pi a}{2 b} \right\} \quad (2)$$

in which $(\Delta p)_1$ is the pressure drop across a length l in the direction of motion and the number n is

* *Journal de Math. Pures et Appliquées*, vol. 13, 2me série, page 377 (1868).

always odd. Making

$$\psi = \frac{192}{\pi^5} \sum_{n=1,3,5,\dots}^{\infty} \frac{1}{n^5} \tanh \frac{n \pi a}{2 b}$$

the discharge becomes

$$Q_1 = \frac{4}{3} \frac{a b^3}{\mu} \frac{(\Delta p)_1}{l} \left(1 - \psi \frac{b}{a} \right);$$

but the discharge through a corresponding area $2a \cdot 2b$ of an infinitely wide passage is given by the familiar expression

$$Q_2 = \frac{4}{3} \frac{a b^3}{\mu} \frac{(\Delta p)_2}{l},$$

$(\Delta p)_2$ being again the pressure drop across a length l ; so, for equal discharges through corresponding areas of an infinitely wide passage and the rectangular passage of finite width,

$$Q_2 = Q_1$$

or

$$(\Delta p)_2 = (\Delta p)_1 \left(1 - \frac{\psi}{a/b} \right).$$

Calculation shows that ψ changes very little, $\frac{a}{b} > 3$ so, for rectangular passages in which the width-depth ratio exceeds this figure,

$$(\Delta p)_2 = (\Delta p)_1 \left(1 - \frac{0.63}{a/b} \right).$$

very nearly. The significance of this expression is demonstrated graphically by Fig. 1, on page 390, which enables the pressure drop calculated for an infinitely wide passage to be corrected for the influence of side boundaries. It will be noticed that, for values of $\frac{a}{b} > 20$, the influence of the side boundaries is always less than 4 per cent.

In the experiments to be described the method outlined above was used to obtain a comparison between ideal and measured flows, and the agreement was found to be good.

Experimental Investigation.—The first part of the experimental investigation was carried out by using closed rectangular channels of approximately equal width-depth ratio and of depths 0.0215 in., 0.035 in., and 0.044 in., respectively. The channels were formed in the space between two brass plates which were each $\frac{3}{16}$ in. thick and were separated at their edges by thin brass shims, the plates being carefully checked for parallelism and flatness. The length of channel over which measurements of pressure drop were made varied from 6 in. to 9 in., but this test length was preceded and followed by $4\frac{1}{2}$ -in. lengths of passage, to eliminate as far as possible the influence of transition effects both at entrance and at exit. The greatest transition length, according to the modified Schiller formula, would be less than $1\frac{1}{2}$ in. for the deepest channel tested, assuming $R_c \gg 2,500$. It is considered, therefore, that there is an adequate factor of safety.

The general layout of apparatus is shown in Fig. 2, page 390. Air is drawn through the narrow channel by a displacement method, using the horizontal drum of a Babcock and Wilcox water-tube boiler as a reservoir. Water flows from the drum at A and is collected at the water outlet B, air flowing in through C to take its place. Thus, the rate of air flow is controlled by the valve at B. Since the amount of air which flows through the channel is very small—varying from about 0.1 cub. ft. to 1.2 cub. ft. per minute—and since the drum is of over 160 cub. ft. capacity and situated about 17 ft. 6 in. above the level of the control valve, the head of water and, consequently, the air velocity, remained sensibly constant during the course of a test. This method of inducing and measuring the air flow through the channel was adopted after an extensive series of trials in which, first, a water-driven and, later, an air-driven ejector were employed to induce the air flow, air quantities being measured by a vane-type gas meter. Under conditions of pulsating flow, the latter method did not prove satisfactory. It will be appreciated that an orifice method of measuring flow would be difficult to adopt here in view of the small quantities of air involved.

To provide a pulsating flow, a flow-interrupting disc, driven by a small variable-speed direct-current

* *Phil. Trans.*, vol. 174, pages 935-982 (1883).

† *Ann. d. Phys.* (4), vol. 25, pages 983-1021 (1908).

‡ *Phil. Trans. A*, vol. 214, pages 199-224 (1914).

§ *Proc. Roy. Soc. A*, vol. 74, pages 341-356 (1905).

|| *Zeitschr. f. Angew. Math. u. Mech.*, vol. 3, pages 2-13 (1932).

¶ *Proc. Roy. Soc. A*, vol. 119, pages 92-107 (1928).

** *Phys. Z.*, vol. 14, page 759 (1913).

†† *Roy. Soc. Proc. A*, vol. 87, page 154 (1912).

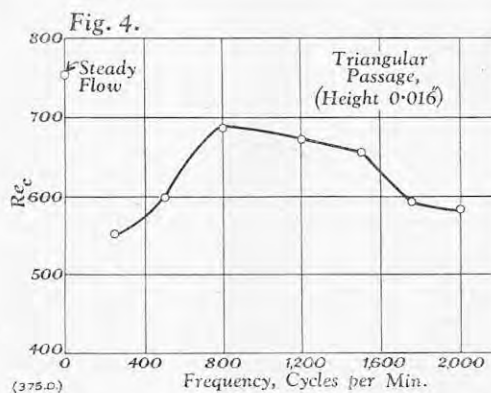
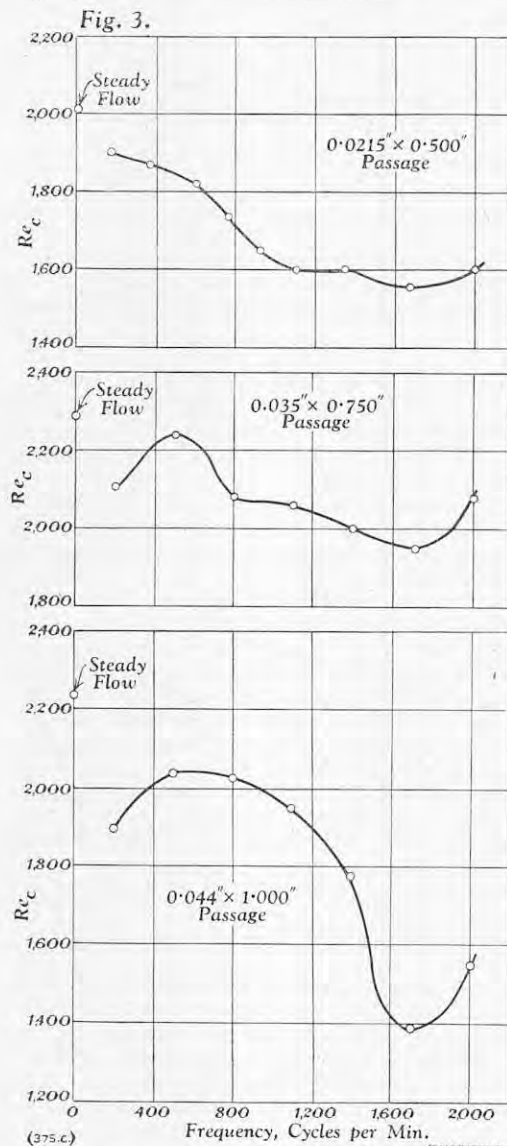
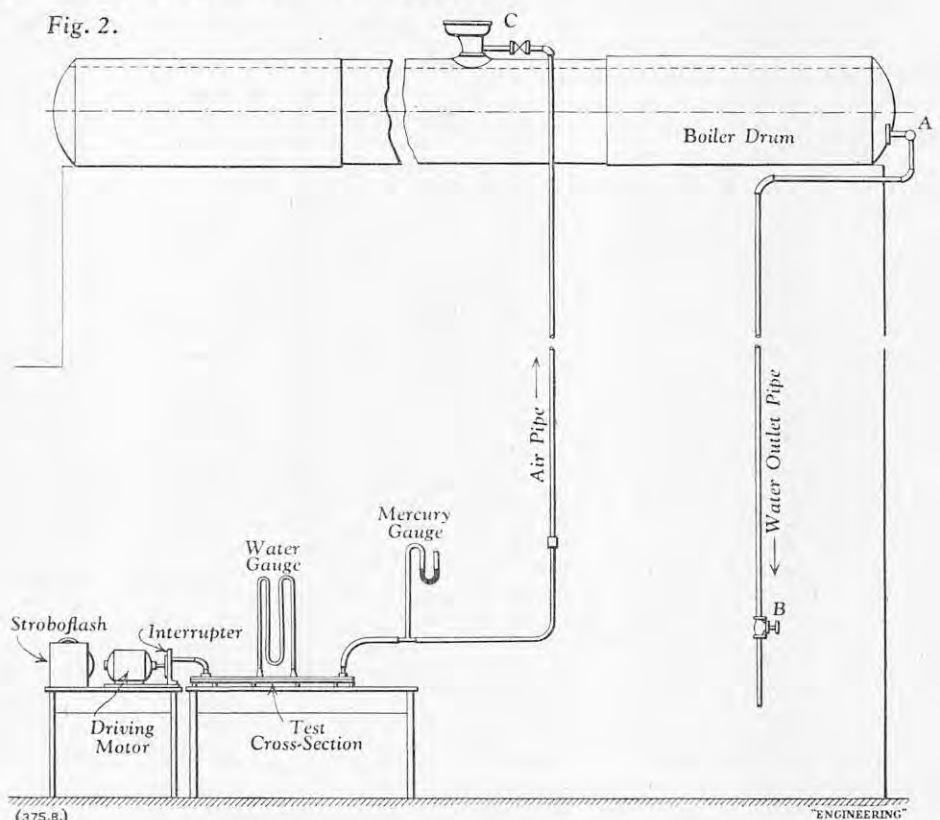
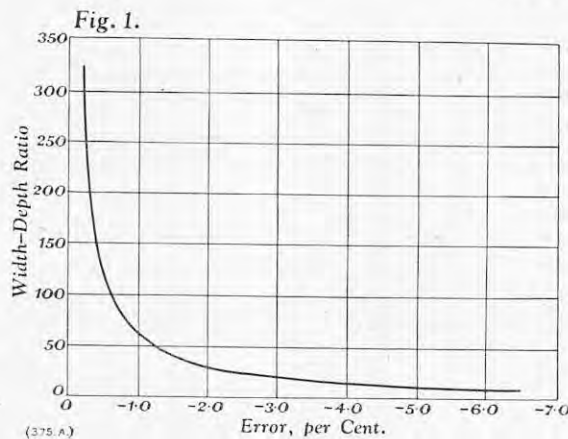
‡‡ *Roy. Soc. Proc. A*, vol. 80, page 114 (1908).

§§ *Forschung. V.D.I.*, vol. 248 (1922); *Z. Angew. Math. und Mech.*, vol. 2, page 96 (1922).

||| *Comptes Rendus*, vol. 113, pages 9-49 (1891).

¶¶ *Applied Hydromechanics and Aeromechanics*, by L. Prandtl and O. G. Tietjens, first edition, pages 25 and 26 (1934).

CRITICAL REYNOLDS NUMBERS.



The critical Reynolds numbers for steady flow in rectangular passages of approximately the same width-depth ratio, but with different dimensions of cross-section, as found in the present series of tests, are given in Table I; it will be seen that they fall in the neighbourhood of $Re_c = 2,000$, as might have been expected. The fact that Re_c for the passage of smallest depth is somewhat less than for the other two passages is possibly due to the relatively high pressure drop, approaching 12 in. of water, across the 6 in. long channel which was employed. With such a comparatively large change of pressure, compressibility may be beginning to have some influence.

TABLE I.—Critical Reynolds Numbers for Steady Flow in Rectangular Passages.

Passage Dimensions, in.	Width-Depth Ratio.	Re_c , (Critical).
0.0215 by 0.500	23.2	2010
0.035 by 0.750	21.7	2290
0.044 by 1.000	22.7	2240

Fluctuating Flow.—The apparatus used for the trials on fluctuating flow did not give any control over waveform or amplitude, and merely permitted controlled variations in frequency. The results obtained must therefore be considered with this point in mind.

Fig. 3 illustrates the variation in mean critical Reynolds number with frequency, obtained experimentally for three rectangular channels of approximately constant width-depth ratio, but of different cross-sectional areas. It will be observed that the three curves are similar in shape, displaying a fall in critical Reynolds number both at low frequencies and at high ones, but the maximum critical Reynolds number is somewhat less than that applying to steady flow. Puzzling features are the greater prominence of frequency effects displayed for spacings of 0.0215 in. and 0.044 in. than for the intermediate spacing, and the apparent recovery displayed by each of the three curves at the highest frequency of interruption. The interrupter disc would not maintain good speed regulation below 200 r.p.m. or above 2,000 r.p.m., and it is evident that extended trials outside this range would yield interesting results.

A series of experiments was also carried out with a channel composed of a number of equilateral triangular passages arranged in parallel. This

boiler drum. The volume of air obtained by weighing the displaced water could therefore be corrected to atmospheric conditions.

A water manometer was used to measure the pressure drop across the test-section, and, during all trials with pulsating flow, felt pads were inserted in the manometer connections to minimise errors due to pressure fluctuations.

Experimental Results: Steady Flow.—For each of the passages tested, a careful determination of the critical Reynolds number for steady (uninterrupted) flow was first made before any trials with fluctuating flow were attempted. The procedure, both with steady and with interrupted flow, was to control the quantity of air passing through the channel by varying the discharge of water from the boiler drum, and the pressure drop across the experimental section could thus be governed within close limits. Pressure drop was then plotted against discharge, an adequate number of readings being obtained so that the point at which viscous flow broke down could be determined with sufficient accuracy. Great care was taken to ensure that conditions were quite steady before a reading was taken, and the necessity for this made the experiments somewhat slow to perform. Plotting to a large scale was employed in determining the point of transition from viscous to turbulent flow, and the transition Reynolds number was calculated from the expression $Re_c = \frac{4 v_{\text{mean}} D}{\nu}$, in which D is the hydraulic mean depth

$$\left(D = \frac{ab}{a+b} \text{ for the rectangular passage} \right).$$

motor, was provided on the intake side of the narrow channel. The revolving disc, in which was cut a $\frac{1}{2}$ -in. slot extending over 180 deg. of arc, acted as a shutter, and the air intake therefore remained open for half of each cycle; it is not claimed, of course, that a "square" waveform was obtained. The disc ran in a bearing formed in the face of a vertical plate, and, if this face were lightly greased, it was found that the disc would run steadily anywhere in the range from 200 to 2,000 r.p.m. A short copper pipe, $\frac{1}{2}$ in. in diameter, led from the air intake in the face of the vertical plate to the channel under test. Since the usual type of tachometer was found to interfere with the speed regulation of the electric motor, a Stroboflash was employed for the measurement of speed. The pressure in the pipe on the downstream side of the test section was measured by a mercury gauge, this pressure being assumed to equal, with sufficient accuracy, the pressure in the air space within the

channel was formed by enclosing between two $\frac{5}{8}$ -in. copper-plated steel plates (in the inner surface of one of which a shallow rectangular depression was cut) a piece of crimped cupro-nickel foil, the crimpings being saw-toothed and 0.021 in. high. The total effective width of the channel was $1\frac{1}{8}$ in., its length was 3 in., and the number of rectangular passages was 54.

By cutting two slots in the upper plate and building small sheet-metal boxes round them, these boxes being fitted with nipples for the manometer connections, the pressure difference was measured over a length of 2 in. only, leaving a $\frac{1}{2}$ -in. clear length at entrance and exit. It was not possible to construct a longer channel, since the foil was not available with crimpings more than 3 in. long. The steel plates forming the upper and lower boundaries of the channel were $7\frac{1}{4}$ in. long; and, as the channel was disposed centrally, the air flowed along a narrow rectangular section before reaching the triangular passages, and left in a similar manner. The effective height of each equilateral triangular passage was 0.016 in. when the thickness of the metal foil was allowed for.

As before, the critical Reynolds number under conditions of steady flow was first measured, and a series of determinations of R_{ec} was then made for conditions of pulsating flow, the frequency being increased in steps up to a maximum of 2,000 cycles per minute. The Reynolds number was again calculated from the expression $R_e = \frac{4 u_{mean} D}{\nu}$,

D equalling one-sixth of the height of the equilateral triangular passage. It will be seen from Fig. 4, opposite, that the values of R_{ec} found in this manner for the triangular passage are only about one-third of those found for the rectangular passages, the highest value—that applying to steady flow—being 750 only. The curve demonstrates to a marked degree the reduction of R_{ec} below the "steady flow" value at low frequencies, and it also shows a falling off at high frequencies as in the case of the rectangular passage. It is not claimed that the results for the rectangular and triangular passages are directly comparable, owing to the uncertain validity of the hydraulic mean depth as a basis of calculation.

Theoretical Concepts.—The following analysis relates to a viscous motion which may be regarded as consisting of a steady flow with a fluctuating flow, of mean value zero, superposed on it.

For flow between two parallel plates of infinite width, the basic Navier-Stokes equations reduce to

$$\frac{\partial u}{\partial t} + \frac{1}{\rho} \frac{\partial p}{\partial x} = \nu \frac{\partial^2 u}{\partial y^2} \quad (3)$$

$$\frac{\partial p}{\partial y} = 0, \quad \frac{\partial p}{\partial z} = 0,$$

where u is the velocity in the x -direction, p is the difference of the actual pressure from the hydrostatic pressure, t is the time, and ρ and ν , respectively, are the density and kinematic viscosity of the fluid. The vertical and horizontal axes in the plane at right angles to the direction of motion are denoted by y and z .

To solve (3) it is assumed that both $\frac{\partial p}{\partial x}$ and u are periodic functions of t and can be expressed by the Fourier series

$$\frac{\partial p}{\partial x} = A_0 + \sum_{n=1}^{\infty} A_n \cos n \omega t + \sum_{n=1}^{\infty} B_n \sin n \omega t, \quad (4)$$

in which A_0, A_n, B_n are constants and $\omega = 2\pi f$, f being the frequency, and

$$u = \alpha_0(y) + \sum_{n=1}^{\infty} \alpha_n(y) \cos n \omega t + \sum_{n=1}^{\infty} \beta_n(y) \sin n \omega t \quad (5)$$

where $\alpha_0(y), \alpha_n(y), \beta_n(y)$ are functions of y .

Substituting in (1) and equating coefficients of corresponding terms, we obtain

$$\frac{A_0}{\rho} = \nu \frac{d^2}{dy^2} \alpha_0(y) \quad (6)$$

$$-n \omega \alpha_n(y) + \frac{B_n}{\rho} = \nu \frac{d^2}{dy^2} \beta_n(y) \quad (7)$$

$$n \omega \beta_n(y) + \frac{A_n}{\rho} = \nu \frac{d^2}{dy^2} \alpha_n(y) \quad (8)$$

Assuming no slip at the boundaries, the solutions of (4), (5) and (6) are given by

$$\alpha_0(y) = -\frac{A_0}{2\mu} (b^2 - y^2) \quad (9)$$

$$\alpha_n(y) = \frac{1}{2\mu} [A_n S_n(y) + B_n C_n(y)] \quad (10)$$

$$\beta_n(y) = -\frac{1}{2\mu} [B_n S_n(y) - A_n C_n(y)] \quad (11)$$

where

$$S_n(y) = \frac{\sin q(b+y) \sinh q(b-y) + \sin q(b-y) \sinh q(b+y)}{q^2 (\cos 2qb + \cosh 2qb)}$$

$$C_n(y) = \frac{\cos q(b+y) \cosh q(b-y) + \cos q(b-y) \cosh q(b+y) - \cos 2qb - \cosh 2qb}{q^2 (\cos 2qb + \cosh 2qb)}$$

$$q = \sqrt{\frac{n\omega}{2\nu}}, \quad \mu = \rho\nu,$$

and b = half the distance between the plates.

It will be seen that (9) is Poiseuille's equation for steady flow between two parallel boundaries. Since A_0 and $\alpha_0(y)$ are, respectively, the mean values of the series (4) and (5) over a cycle, (9) represents the mean value of the periodic viscous flow.

Substituting (9), (10) and (11) in (5), we obtain the solution of (3) for the forced motion

$$u = -\frac{A_0}{2\mu} (b^2 - y^2) - \frac{1}{2\mu} \sum_{n=1}^{\infty} \{ [A_n S_n(y) + B_n C_n(y)] \times \cos n\omega t + [B_n S_n(y) - A_n C_n(y)] \sin n\omega t \}, \quad (12)$$

which indicates that the velocity distribution is made up of two parts—a Poiseuille distribution of the mean flow, and a pulsating distribution given by the infinite series.

In the experiments described above, the amplitude of the pulsations was only of the order of an inch or so of water, and the problem of obtaining their waveform would have been extremely difficult to solve experimentally and was not attempted. In cases where the pressure fluctuations may have amplitudes of a few inches of mercury, the problem of indicating them is not insuperable and it should be possible to determine with reasonable accuracy the form of $\frac{\partial p}{\partial x}$, and thence the approximate form of

$\frac{\partial p}{\partial x}$, since $\frac{\partial p}{\partial t} = -c \frac{\partial p}{\partial x}$, where c is the propagation velocity. This would allow a consideration of the Fourier coefficients A_n, B_n , leading to an approximate evaluation of the magnitude of the "fluctuating" term of equation (10) in relation to the "steady flow" term. If this relative magnitude is small the effect of pulsations on the velocity distribution remains unimportant. It is possible, perhaps, that deviation from the strict parabolic form may have some influence in promoting instability of flow.

The experiments described above represent a part of an investigation into the characteristics of a viscous-flow air meter for piston-type internal-combustion engines, carried out in the Department of Engineering, University College, Swansea. Though these experiments to determine the critical R_e for conditions of pulsating flow cover only a narrow field of review, it is thought that their results, though necessarily of very restricted value, may be of some interest.

GERMAN EXHIBITION OF CHEMICAL APPARATUS.—Achema X, the international exhibition of chemical apparatus, is to be held at Frankfurt-on-Main, Germany, from May 18 to 25, 1952. It is being organised by Dechema Deutsche Gesellschaft für Chemisches Apparatewesen E.V., Frankfurt. A chemical-engineering conference will be held at the same time, as well as technical meetings of several scientific societies.

ELECTRICITY SUPPLY IN NORTHERN IRELAND.—A new generating set was set to work at Ballylumford power station, Northern Ireland, on September 20, bringing the capacity of the station up to 124,500 kW. The Northern Ireland Electricity Board last year sold 252 million kWh., or 41 per cent. of the total for the country. A new generating set is nearly completed at Belfast Harbour power station, and it will be followed by a new station at Victoria Channel, Belfast. The capacity of Londonderry power stations is being increased by 6,000 kW, and sites outside Belfast are being considered for additional plant in the future, including possible hydro-electric schemes on the rivers Bann and Mourne, investigations into which are now well advanced.

FLYING DISPLAY OF BRITISH AIRCRAFT.

(Concluded from page 355.)

WE conclude below our description of some of the exhibits at the 12th annual display of the Society of British Aircraft Constructors, which was held at the aerodrome of the Royal Aircraft Establishment, South Farnborough, Hampshire, from September 11 to 15.

The Canberra bomber aeroplane, which was first demonstrated two years ago at the 10th display, and described subsequently on page 584 of our 168th volume (1949), has clearly justified the enthusiasm that it aroused on that occasion. It is in production in this country, in Australia, and in the United States. A Canberra B Mark 2 tactical bomber, similar to the machine flown in last year's display, but equipped with additional fuel tanks, recently established an international record for the east-to-west Atlantic crossing by flying from Aldergrove, Northern Ireland, to Gander, Newfoundland, at an average speed of 480 m.p.h. against headwinds ranging from 20 to 80 knots. The designers of the Canberra, the English Electric Company, Limited, Warton Aerodrome, near Preston, Lancashire, demonstrated two versions which had not been seen previously at Farnborough—the PR Mark 3 photographic-reconnaissance aeroplane, flown on September 11 and 12, and a new bomber, the B Mark 5, on September 13 to 16. Externally, both these aircraft differ only slightly from the B Mark 2 tactical bomber described briefly on page 217 of our 170th volume (1950); the fuselage of the P.R. Mark 3, which is illustrated in Fig. 13, page 392, is slightly longer and accommodates cameras and flares. It has a transparent nose without the flat bomb-aimer's window of the B. Mark 2. The B. Mark 5 has an opaque nose with a larger bomb-aimer's panel. As mentioned on page 343, *ante*, British-built and Australian-built Canberras are powered at present by two Rolls-Royce Avons.

In the United States, however, the Canberra aircraft, which are being built under licence by the Glenn L. Martin Company, Baltimore, are to be powered by Sapphire axial turbojets, also being built under licence in the United States, by the Curtiss-Wright Corporation, New Jersey. American visitors to the display, therefore, must have been particularly interested in the demonstration of the Sapphire Canberra sponsored by the designers of the Sapphire, Messrs. Armstrong Siddeley Motors, Limited, Coventry. A brief description of the Sapphire, which was demonstrated for the first time in last year's display, installed in a Meteor aeroplane, was given on page 238 of our 170th volume (1950). It may be recalled that it is a particularly compact engine and is stated to have a sea-level static thrust of 7,220 lb., a net dry weight of 2,500 lb., and a specific fuel consumption of 0.916 lb. per lb.-thrust per hour. The Sapphire Meteor experimental aircraft recently established four international climbing-speed records (subject to confirmation by the Fédération Aéronautique Internationale) during a climb to 12,000 m. (39,370 ft.), which it accomplished in 3 minutes 7 seconds. As announced recently in *ENGINEERING*, the Armstrong Siddeley Sapphire engine is to be produced at Hucclecote, Gloucestershire, by Brockworth Engineering, Limited, a company formed for the purpose by the Hawker Siddeley Group.

An interesting development demonstrated by de Havilland Propellers, Limited, Hatfield, Hertfordshire, were the constant-speed negative-thrust propellers fitted to a Handley-Page Mamba-Marathon, believed to be the first power-on braking propeller-turbine installation in the world. In the Armstrong Siddeley Mamba propeller-turbine engines, it may be recalled, both stages of the turbine drive the compressor shaft which is coupled, through reduction gearing, to the propeller shaft. Messrs. de Havilland have found that braking propellers of the type fitted to piston engines, in which the blades are held against a fixed negative-pitch stop during the landing run, are not suitable for "solid-shaft" propeller turbines such as the Mamba because the engines must operate within a fairly narrow range

AIRCRAFT AT FARNBOROUGH DISPLAY.

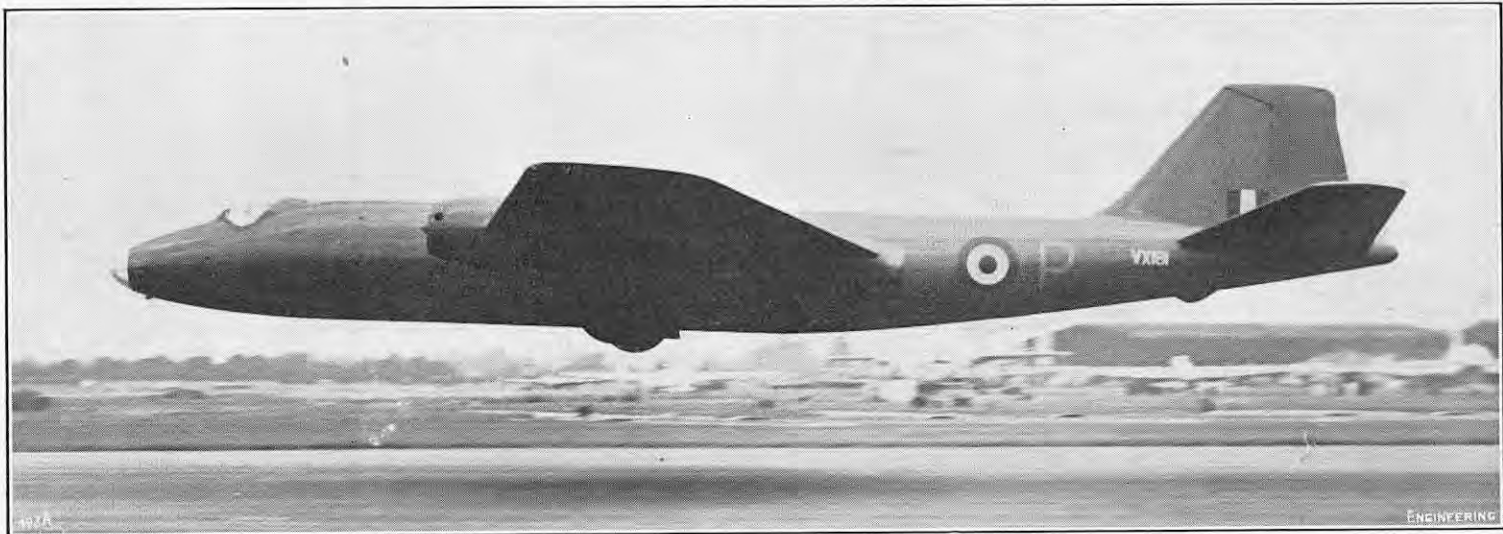


FIG. 13 "CANBERRA" PR MARK 3 BOMBER; ENGLISH ELECTRIC COMPANY, LIMITED.

of rotational speed to avoid engine stalling or overheating. The firm have therefore modified the normal constant speed unit to allow constant-speed operation in reverse pitch; this is accomplished by a solenoid-operated valve which reverses the connections to the propeller coarse-pitch and fine-pitch oil lines.

The negative-thrust propeller is provided with a non-retractable coarse-pitch stop in the feathering position, a mechanically-retractable flight fine-pitch stop, an electrically-actuated super-fine pitch "stop" for providing a fine positive blade setting for starting the engines, and a non-retractable negative-pitch stop. During the approach at reduced power, the rotational speed selected is high and the blade will be at or slightly above the fine-pitch stop. As the aircraft touches down, a micro-switch is operated by the undercarriage legs and a solenoid is energised which withdraws the flight fine-pitch stop and allows the propeller pitch to decrease until, at the starting fine-pitch angle, a cam on the blade root actuates a micro-switch energising the coarse-pitch solenoid valve which directs oil to the coarse-pitch line to increase the blade angle; a hunting condition is then set up at the starting pitch.

When it is required to set the propeller in negative pitch, the pilot pulls the single engine-control lever back into a reversing quadrant beyond the idling position. This interrupts the electrical supply through the starting-pitch micro-switch to the coarse-pitch solenoid and, in effect, "retracts" the starting fine-pitch stop. The movement also energises the reverse-pitch solenoid and the coarse-pitch solenoid so that the blades are moved into negative pitch. A second cam-operated micro-switch on the blade roots is arranged to break the circuit to the coarse-pitch solenoid as the blade pitch passes beyond a low negative setting; this leaves the propeller free to run at constant speed in negative pitch. The engine power can be increased as desired for braking during the landing run by backward movement of the control lever in the reverse quadrant. The sequence of switching operations in entering negative pitch and returning to positive pitch is simply carried out by a drum switch operated by the pilot's engine-control lever. The landing run of the Mamba-Marathon, it is claimed, is reduced by about 50 per cent. with the constant-speed reverse-thrust propellers in action.

The Hermes 5 air liner, the largest propeller-turbine air liner yet flying, constructed by Messrs. Handley Page, Limited, Cricklewood, London, N.W.2, has been fitted with Dunlop plate brakes, described on page 83 of our 169th volume (1950), and Dunlop Maxaret automatic hydraulically-operated brake control which prevents the wheels from locking and skidding; during the landing run the pilot of the Hermes 5 demonstrated the action of the new brakes. The Maxaret unit incorporates a small flywheel, driven by the main landing wheel, which acts as a governor, and automatically releases

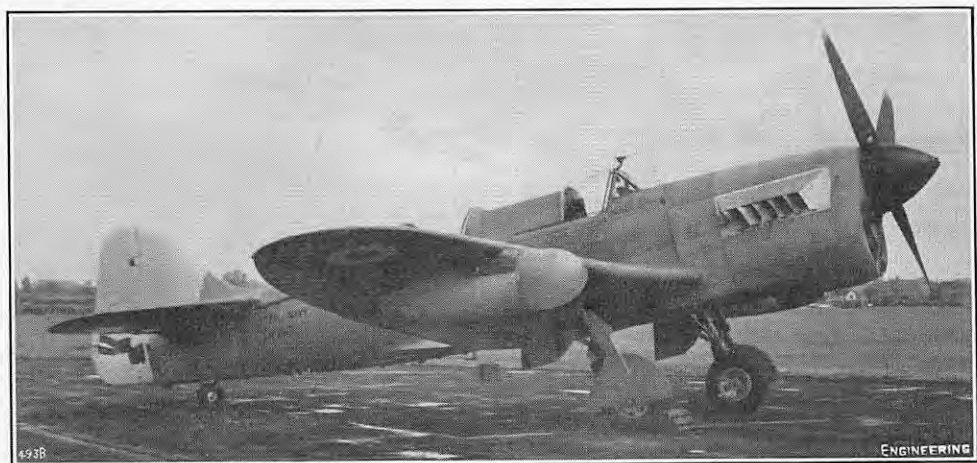


FIG. 14. "FIREFLY" MARK 7 ANTI-SUBMARINE AIRCRAFT; FAIREY AVIATION COMPANY, LIMITED.

the brake pressure if the landing wheel decelerates too rapidly. It also prevents the application of brake pressure before the landing wheels touch down. The braking efficiency is considerably increased by the non-skid unit, and tyre wear is greatly reduced.

Two more developments for the Navy should be mentioned. The latest variant of the Firefly, the Mark 7, three-seater carrier-borne anti-submarine aircraft, which first flew in March of this year, was demonstrated, carrying sonobuoys and fuel tanks under the wings. A photograph of the Firefly Mark 7 is reproduced in Fig. 14. It is built by the Fairey Aviation Company, Limited, Hayes, Middlesex, and is powered by a Rolls-Royce Griffon engine; it is in production for the Royal Navy. The span of the wing has been increased from 41 ft. 2 in. to 44 ft. 6 in., and the overall length is 37 ft. 11 in. No performance details have yet been released. The other new naval aircraft, a prototype single-speed high-speed fighter, is the naval version of the P.1052 aeroplane, designed and constructed by Messrs. Hawker Aircraft, Limited, Canbury Park-road, Kingston-on-Thames, Surrey. The P.1052 land-based aeroplane was first demonstrated at the display two years ago. It has a swept-back wing with a span of 31 ft. 6 in., and is powered by a Rolls-Royce Nene jet engine with bifurcated air intakes and jet exhausts at the wing roots.

Among the lighter aircraft, three new developments were demonstrated by Auster Aircraft, Limited, Rearsby Aerodrome, Leicestershire, all of them of the familiar high-wing braced monoplane configuration. The Auster Model S has been built for the Army, and is undergoing trials as an air-observation post. The aircraft has a span of 32 ft., and is powered by a Blackburn Bombardier 702 piston engine developing 180 h.p. It is interesting to note that this engine is the first employing

direct petrol injection to pass the approval tests of the Air Registration Board. The same power unit is employed in the Auster ambulance freighter aircraft, in which the tailplane is supported by a tail boom in order to allow access to the removable loading door at the rear of the fuselage. The aircraft has a span of 37 ft., an overall length of 24 ft. 8 in., an all-up weight of 2,600 lb., and can carry a payload of 560 lb. The range is 300 miles at a cruising speed of about 105 m.p.h. The third Auster machine demonstrated was the two-seat Aiglet elementary trainer, which is powered by a 130-h.p. de Havilland Gypsy Major piston engine. It has a span of 32 ft. and an overall length of 23 ft. 3 in. All these aircraft are intended for operation from small fields, and are particularly noteworthy for their excellent slow-flying characteristics.

Among the aircraft which have taken part in previous displays may be mentioned the large GAL-60 prototype military freighter aircraft built by Messrs. Blackburn and General Aircraft, Limited, Brough, East Yorkshire. To demonstrate the capacity of the hold, the GAL-60 was flown to Farnborough carrying a large caravan and a jeep. On arriving at Farnborough the hydraulically-operated loading ramp and fairing doors were lowered and the jeep drove off towing the caravan. Fig. 15, opposite, shows a similar operation being carried out. The GAL-60 is powered by four Bristol Hercules engines, and has a wing span of 162 ft. with a length of 99 ft. 2 in. Last year the main undercarriage units had single wheels, but they have now been replaced by four-wheel bogie units, each wheel being provided with disc-type brakes which, in conjunction with the reversing propellers fitted, give a remarkable short landing run. The capacity of this machine for carrying bulky and

AIRCRAFT AT FARNBOROUGH DISPLAY.

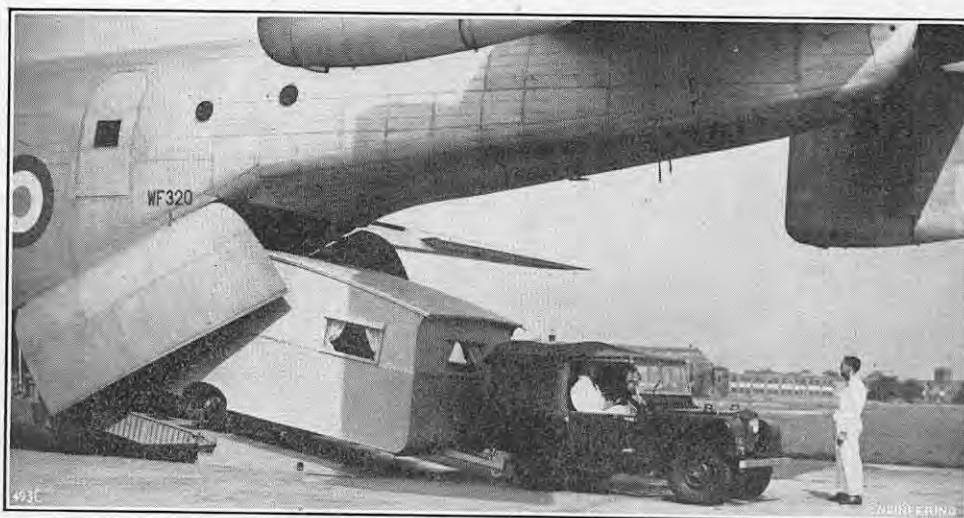


FIG. 15. UNLOADING GAL-60 FREIGHTER AIRCRAFT; BLACKBURN AND GENERAL AIRCRAFT, LIMITED.

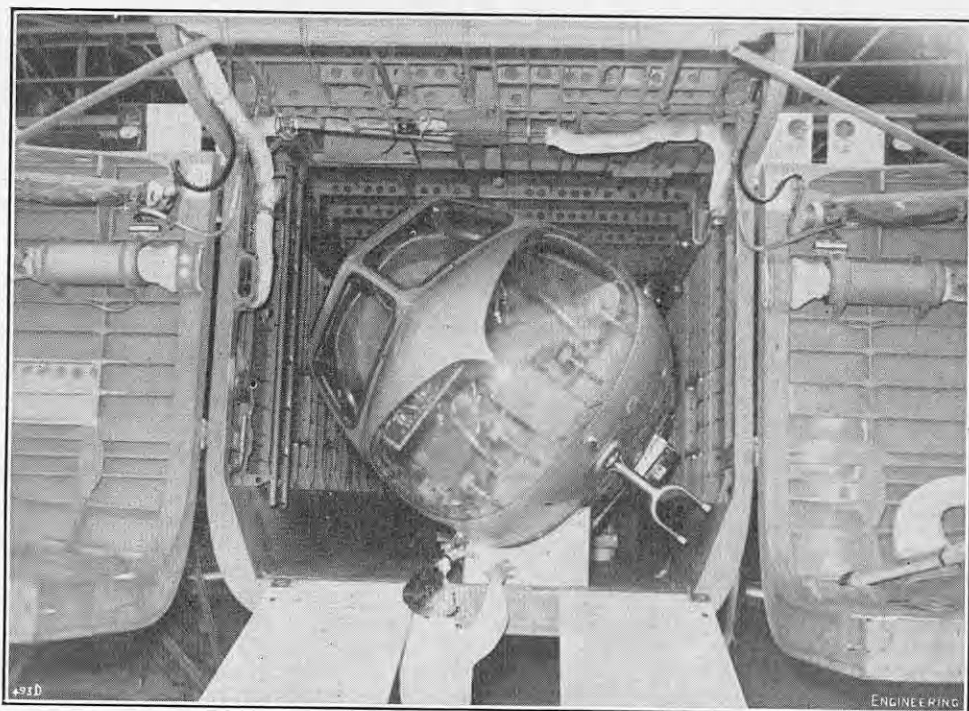


FIG. 16. BRISTOL 171 MARK 3 HELICOPTER STOWED IN BRISTOL 170 MARK 31 FREIGHTER; BRISTOL AEROPLANE COMPANY, LIMITED.

heavy loads and for operating from restricted areas with rudimentary maintenance facilities should render it of great value in both the military and civil fields. It is interesting to note that the firm are designing a civil development of the aircraft, to be powered by four Bristol Centaurus engines, each developing 2,940 h.p. at take-off revolutions per minute at sea level, which will increase both the cruising speed and the disposable load. A design all-up weight of 127,000 lb. has been quoted for this project. The rear fuselage is to be replaced by a tubular tail boom, in which it will be possible to carry 19 passengers; clamshell loading doors will be fitted.

The Bristol Freighter aeroplane, designed and constructed by the Bristol Aeroplane Company, Filton House, Bristol, is well known and has seen several years of civil and military operation, carrying loads ranging from beef carcasses to helicopters. In the latter capacity, a Bristol 170 Freighter Mark 31 was on view in the static park, as illustrated in Fig. 16, which actually shows a Bristol 171 Mark 3 helicopter loaded into the Freighter in June last, for transport to Khartoum, where the helicopter has been undergoing tropical trials. The Bristol 170 Mark 31 is powered by two Bristol Hercules 734

engines, each developing 1,980 h.p. at take-off revolutions per minute at sea level; it has an all-up weight of 42,000 lb., a maximum still-air range of 1,400 miles, and a maximum disposable load of 15,335 lb.

This concludes our description of some of the aircraft and engines included in the Society of British Aircraft Constructors' annual display. Other notable aircraft which appeared at Farnborough but have not been included in this review have been described in earlier volumes of *ENGINEERING*. Every year the items of interest at Farnborough are more numerous than in the preceding display; but although most visitors are interested mainly in the flying display and in examining the aircraft in the static park, it should be mentioned that there is also an excellent exhibition of components and equipment. The majority of visitors are only able to spend a single day at the show, and in the short time available it is impossible for them to make more than a cursory inspection of this exhibition. It may therefore be suggested that the Society of British Aircraft Constructors should consider whether the time has not come to consider holding the flying display and the static exhibition separately, possibly in alternate years.

THE PASSENGER AND CARGO LINER "KENYA."

THE 15,000-ton twin-screw passenger and cargo liner Kenya, which is the latest and largest addition to the fleet of the British India Steam Navigation Company, Limited, is now on her maiden voyage to East Africa, having left London on August 25. She was built and engined by Barclay, Curle and Company, Limited, at their yard at Whiteinch, Glasgow, which she left on July 12, after running trials in the Firth of Clyde, making the passage to London via the north of Scotland and the Pentland Firth. We were afforded the opportunity to come round to the Thames in the ship, which carried a party of the owners' guests, and the following description has been prepared, therefore, with the advantage of a fairly detailed acquaintance with the vessel.

Although the main business of the British India Steam Navigation Company, which was founded in 1856, has been with India, as the title indicates, their fleet has played an important part in developing trade with East Africa, since the Suez Canal was opened in 1869. The company was founded in Calcutta by William (afterwards Sir William) Mackinnon and his partner, Robert Mackenzie, and by 1862 had established services from India to Rangoon, Singapore and the Persian Gulf. In 1873, they began to trade with Zanzibar, obtaining the favour of the then Sultan to such an extent that Mackinnon was offered a concession for 70 years to administer his dominions, including the mainland territory under the control of the Sultan, and to collect the customs dues. It was not, however, until German traders opened up what became German East Africa that the British Government could be persuaded to support the proposal, and Sir William was enabled, in 1887 to accept the concession and to form the British East Africa Association. From that time onward the British India Company's services to East Africa developed steadily, until now, including the Kenya, they maintain 14 or 15 ships on that route. Another vessel, the Uganda, a sister ship to the Kenya, is rapidly approaching completion for the same service, and, like her, will carry both first-class and tourist passengers. This represents an innovation on this run, where previous ships have carried only one class of passengers. It may be remarked that the Kenya is the 58th vessel built for or acquired by the company since the outbreak of war in 1939.

The general appearance of the Kenya will be seen from the illustration, Fig. 1, on the next page; an air photograph taken as she was steaming up the Thames estuary on July 15, on delivery from the builders' yard. Figs. 2 to 5, on Plate XXIX, show some of the public rooms provided for the first-class passengers; a profile and deck plans are given in Figs. 6 to 15, on Plate XXX; and other illustrations of the first-class accommodation, with two of the tourist-class public rooms, are reproduced in Figs. 16 to 19, on Plate XXXI. Provision is made for 174 first-class passengers and 99 in the tourist class. The principal dimensions are as follows: length, overall, 540 ft. 0 in., and between perpendiculars, 517 ft. 6 in.; breadth moulded, 71 ft.; depth moulded, to B deck, 38 ft. 6 in. Propulsion is by two sets of Parsons turbines, driving the twin screws through double-helical gearing and taking steam from three Babcock and Wilcox boilers. Full particulars of the main and auxiliary machinery will follow our description of the ship. The service speed is 16 knots.

As will be seen from the arrangement drawings reproduced on Plate XXX, the passenger accommodation is on the promenade deck and on A, B and C decks. The promenade deck is devoted entirely to first-class public rooms, and the dining saloons for both classes of passenger are on C deck. The whole of B deck is occupied by cabins, as also is A deck except for the tourist-class entrance hall, lounge and smoking room, at the after end. For the first-class passengers there are 16 single-berth and 31 two-berth cabins on A deck, and also two single-berth and two double-berth cabins which are designated "special" and provide rather greater space and various other extra amenities; they are situated at the forward end, under the first-class

PASSENGER AND CARGO LINER "KENYA."

BARCLAY, CURLE AND COMPANY, LIMITED, GLASGOW.

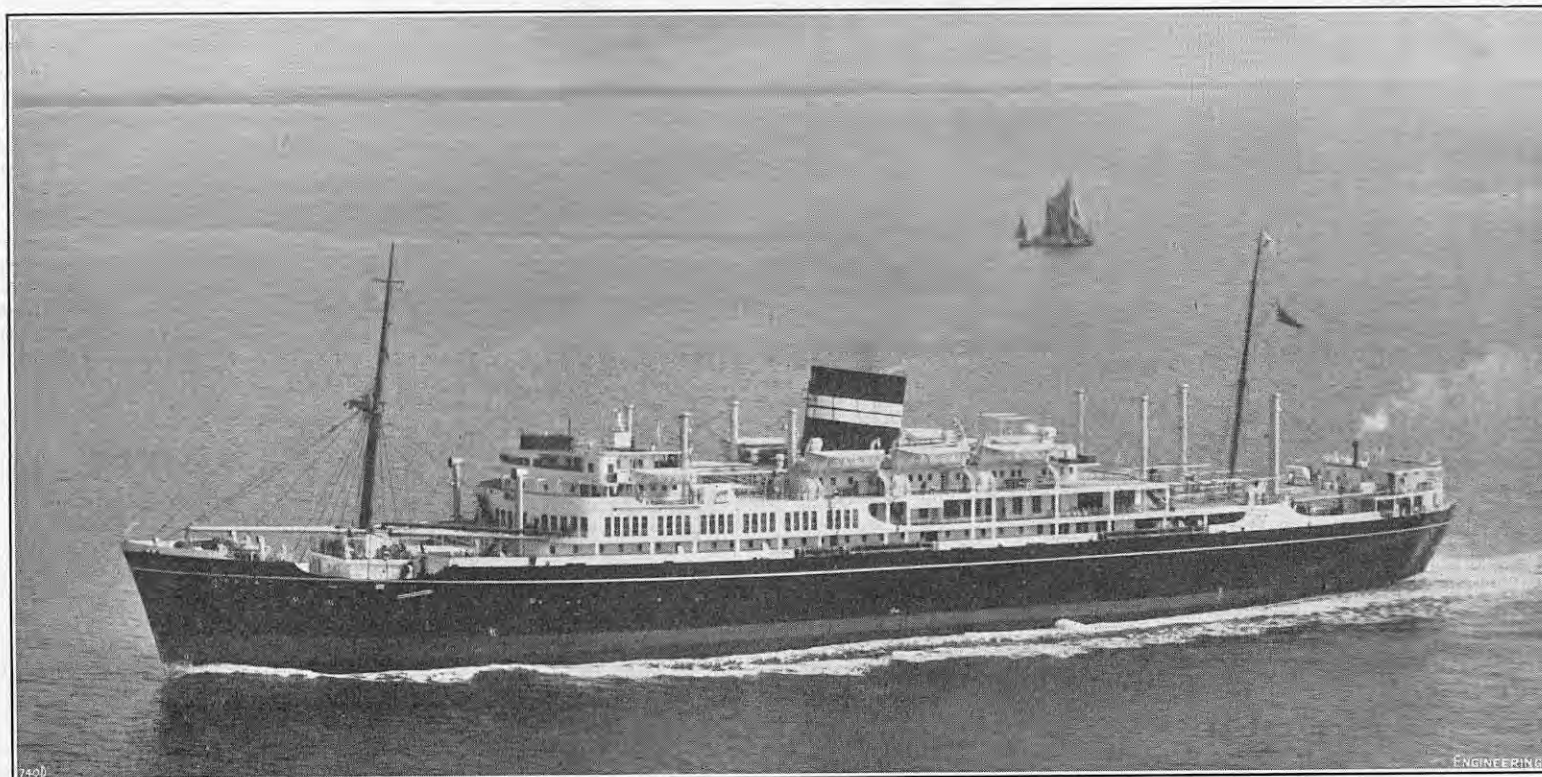


FIG. 1. S.S. KENYA ENTERING THE THAMES.

lounge. On B deck there are four of these special cabins with single berths and four with two berths, and 35 ordinary first-class cabins, 16 with one berth each and 19 with two berths. All of the tourist-class cabins are situated on B deck; they comprise four with two berths, 21 with three berths, and 13 with four berths each.

The first-class public rooms comprise the dining saloon, a children's dining room (which can be converted, if desired, into three small private dining rooms), the lounge, writing room, card room, smoking room, cocktail bar, and veranda ballroom. The tourist-class public rooms are the dining saloon, smoking room, and lounge. There is also a children's nursery for the first class, and another for the tourist class, suitably equipped. The air-conditioned first-class dining saloon, towards the forward end of C deck, extends for the full width of the ship and has seating for 176 persons at small tables. In the centre, the ceiling is raised through B deck, giving a spacious appearance to the room and facilitating lighting, which is of the fluorescent type. The panelling is in figured silver birch, relieved with Nigerian cherry. Aft of the main saloon, on the port side, is the children's dining room, mentioned above, which seats 40.

The first-class lounge, at the forward end of the promenade deck, is of unusual form, the main floor being roughly elliptical in plan, with the long axis athwartship. The forward curve of the ellipse conforms to that of the bridge front, and at the sides the room projects slightly, in two shallow bays, on to the covered forward end of the promenade, which continues round the front of the superstructure, under the bridge. At the forward end of the lounge, there is a slightly raised false deck, wide enough to accommodate several tables, settees, etc., and a grand piano; thus it can be used either as an observation gallery, or as a dais for concerts, etc. The lay-out of the lounge can be seen from Fig. 11, on Plate XXX; and Fig. 2, on Plate XXIX, gives a general view of the room. Aft of it, on the port side, is the card room, shown in Fig. 4, on Plate XXIX; and on the starboard side is a wide corridor connecting the lounge with the entrance hall, with the writing room on its outboard side. The writing room is illustrated in Fig. 5, on Plate XXIX; the folding doors at the forward end, which can be seen in Fig. 5, conceal

an altar, as this room is intended to be used also for church services.

From the entrance hall, a wide central staircase leads to the decks below, and corridors, to port and starboard, lead aft to the first-class smoking room, which extends across the superstructure between the boiler casing and the engine casing, as can be seen from the plan in Fig. 12, on Plate XXX. On the port side, it is in communication, through the cocktail bar, with the veranda ballroom. On the starboard side, there is an exit into a vestibule from which stairs lead to the decks above and below. The ballroom has a close-boarded dance floor in oak, teak and maple, and is provided with a shallow proscenium at the forward end, with a cinema screen, and a low platform for the orchestra, as can be seen in Fig. 16, on Plate XXXI. Both sides of the ballroom are fitted with sliding and folding glazed screens. At the after end of the promenade deck is the first-class swimming pool.

The tourist-class dining saloon is on C deck and seats 126 persons. At the after end of it is a staircase, rising through B deck to the tourist-class smoking room on the port side of A deck and the lounge on the starboard side. The tourist-class swimming pool is also on A deck.

Of the first-class cabins, six single-berth rooms and six two-berth rooms have private bathrooms, and all of the other rooms are fitted with hot and cold running fresh water. Mechanical ventilation on the Thermotank system and separately controllable heating are provided in all cabins of both classes. The upper berths in the tourist-class three-berth and four-berth cabins can be removed if not required. Twenty-four of the tourist-class cabins on B deck, on the port side and adjacent to the first-class accommodation, can be converted to first-class cabins if necessary. Ironing and drying rooms are provided for the use of passengers in both classes of the accommodation; and on B deck there is a shop and also a hairdressing saloon. Hospitals for male and female patients are situated amidships on B deck, on the starboard side. An isolation hospital and a separate hospital for the crew are provided on the poop, on the level of the promenade deck.

Most of the equipment in the galleys is electric, though steam-heating is also available, should it be required. The main galley has an electric range

containing six ovens, a deep fat-fryer and an electric grill. Electric mincing and slicing machines are provided in the butcher's shop, and there is an electric potato-peeler with a capacity of 56 lb. of potatoes per minute. In the bakery, there is an electric oven, dough-mixer and other equipment necessary to produce bread in batches of 180 lb.; and adjoining this department is a freezer and cold storage container for ice cream, together with an emulsifier for the production of milk and cream. The milk-producing plant has an output of 15 gallons an hour. The electric dish-washer can deal with 3,000 pieces per hour. The all-electric laundry will handle the whole of the ship's washing.

For protection against fire, the cargo holds are fitted with a Pyrene combined smoke-detecting plant and CO₂ extinguishing system: the warning signals are given both on the bridge and in the officers' quarters, visually and by alarm bells. Automatic sprinklers and fire-alarms are fitted throughout the passenger accommodation and the crew's quarters—representing, incidentally, an addition of some 50 tons to the ship's displacement, including the water in the system; and there is a mechanical foam installation in the boiler room.

(To be continued.)

SOUTH LONDON TRAM-CONVERSION SCHEME.—London Transport are to introduce stage V of the scheme for converting South London tram routes to 'bus routes on the night of October 6. The routes from which 99 tram-cars will be withdrawn are numbers 56 and 84 between Peckham Rye and Victoria Embankment, via Westminster and Blackfriars-bridges, respectively; 58 between Blackwall Tunnel and Victoria, 60 between Dulwich Library and the City, 62 between Forest Hill and the Victoria Embankment, 66 between Forest Hill and Victoria, and 7 between New Cross Gate and the Victoria Embankment. They will be replaced by 109 bus vehicles on the following new routes: Nos. 184 between Brockley Station and the Victoria Embankment; 185 between Blackwall Tunnel and Victoria; 176A, on weekdays only, between Dulwich (The Plough) and Cannon-street station; 176, on weekdays only, between Forest Hill and the Victoria Embankment, 36A, on weekdays only, between Brockley Rise and West Kilburn; 286, an all-night route, between New Cross Gate and Charing Cross underground station; and 180, on weekdays only, between Woolwich and Catford. The total number of trams withdrawn during stages I to V is 414; they have been replaced by 487 buses.

TWIN-SCREW PASSENGER AND CARGO LINER "KENYA."

BARCLAY, CURLE AND COMPANY, LIMITED, GLASGOW.

(For Description, see Page 393.)



FIG. 2. FIRST-CLASS LOUNGE.



FIG. 3. FIRST-CLASS SMOKING ROOM.



FIG. 4. CARD ROOM.



FIG. 5. WRITING ROOM.

TWIN-SCREW PASSENGER AND CARGO LINER "KENYA."

BARCLAY, CURLE AND COMPANY, LIMITED. GLASGOW.

(For Description, see Page 393.)

Fig. 6.
RIGGING PROFILE

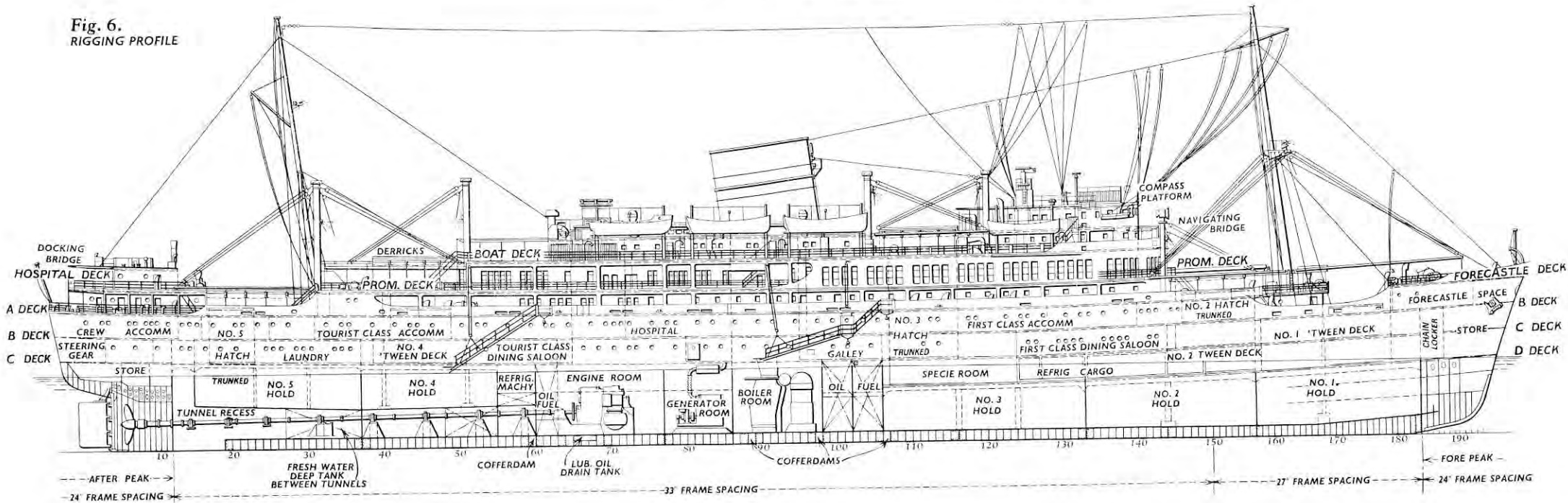


Fig. 7.
TOP OF ENGINEERS' HOUSE

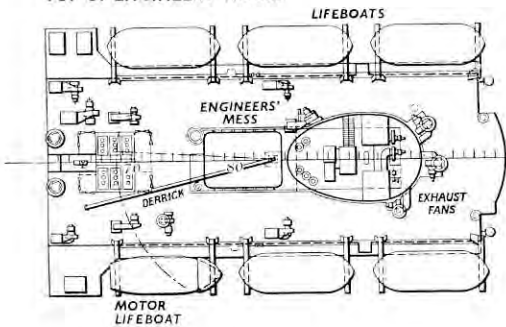


Fig. 8. BOAT DECK

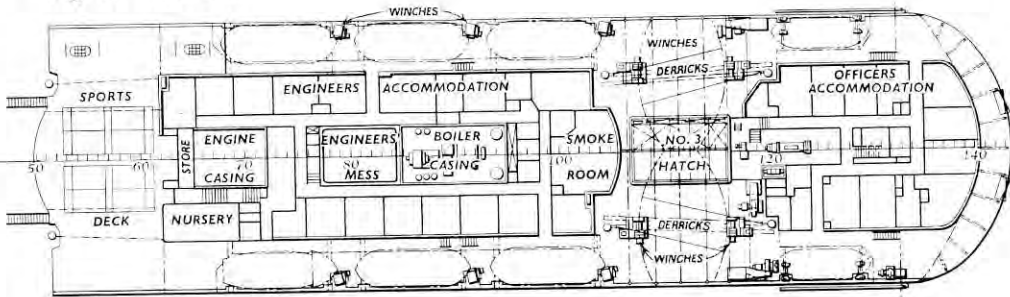


Fig. 9.
NAVIGATING BRIDGE

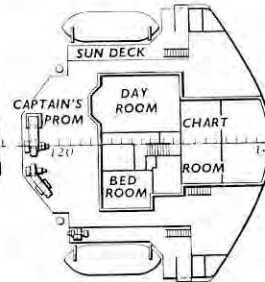


Fig. 10.
COMPASS PLATFORM

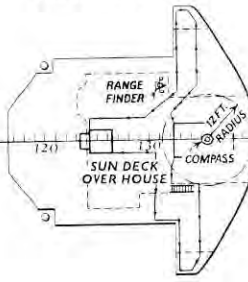
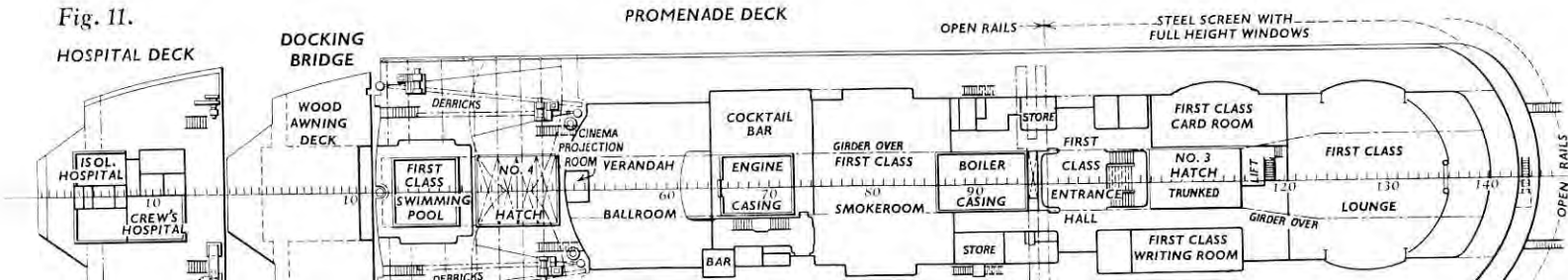
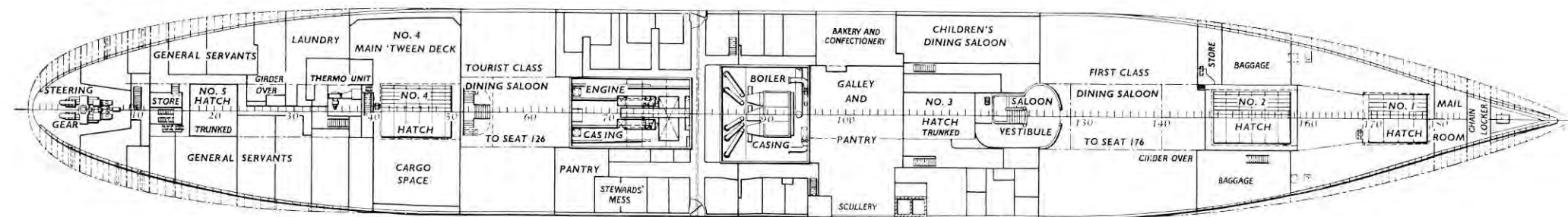
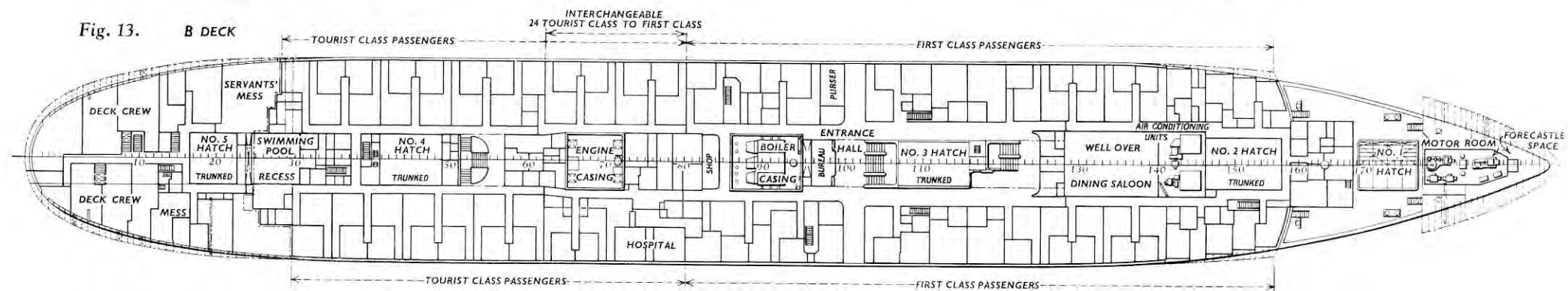
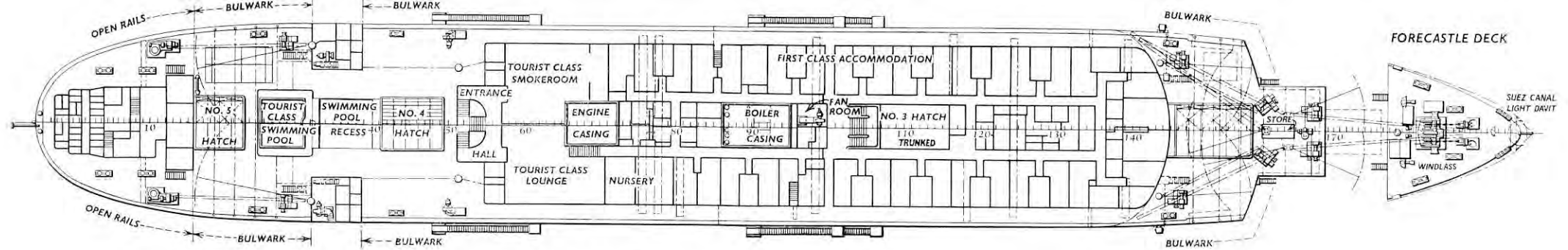


Fig. 11.
HOSPITAL DECK





TWIN-SCREW PASSENGER AND CARGO LINER "KENYA."

BARCLAY, CURLE AND COMPANY, LIMITED, GLASGOW.

(For Description, see Page 393).



FIG. 16. VERANDAH BALLROOM.



FIG. 17. FIRST-CLASS SWIMMING POOL.



FIG. 18. TOURIST-CLASS LOUNGE.



FIG. 19. TOURIST-CLASS SMOKING ROOM.

LEVEL GANGWAY AT HOLYHEAD HARBOUR.

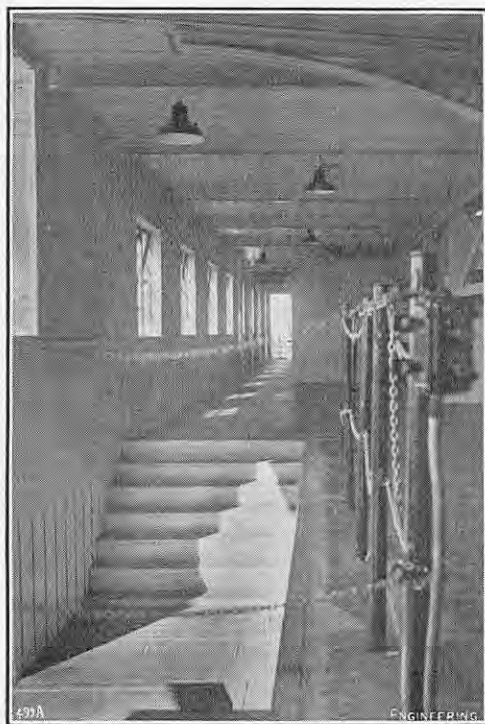


FIG. 1. PLATFORM AND STEPS.

LEVEL GANGWAY FOR TIDAL WHARF.

An amenity which is much appreciated by passengers on the Irish Mail route between Holyhead and Dun Laoghaire (Queenstown) was introduced at Holyhead harbour in June this year by British Railways (London Midland Region). The inconvenience of a steeply-sloping gangway between ship and shore has been eliminated by providing two platforms at the Customs building which are adjustable in height over a range of 6 ft. 9 in. to suit the state of the tide. Each gangway is laid from one of the platforms to the ship, and the platform is reached from the building by a flight of steps, as shown in Fig. 1, herewith. The novelty of the arrangement consists in the method of varying the number of steps in the flight to suit the setting of the platform.

The underside of the platform can be seen in Fig. 2 in its highest position. Its deck actually consists of a series of independent steps, so that when the frame of the platform is lowered the steps are laid in turn on stone pads built into the enclosing walls. Fig. 1 shows the platform at about the mid-height position, with the six upper steps in use as such and the lower steps forming a short level platform giving access to the gangway (off to the left of Fig. 1). Each platform has a timber deck, 10 ft. by 9 ft. 6 in., which projects 4 ft. beyond the face of the Customs building, and 12 independent steps which are constructed of timber protected with steel kicking plates and treads. The steps are held in position by guides which run in vertical channels recessed in the walls.

The frame of each platform was constructed of two 12-in. by 6-in. welded steel beams 20 ft. 6 in. long, braced together 4 ft. apart and supported at their ends by four bronze nuts which work on four vertical square-thread screws. The screws are carried on thrust bearings at their upper ends to ensure that they are always in tension due to the weight of the platform. Each screw is between two vertical rolled-steel channels which serve as guides for maintaining the platform in position horizontally (Fig. 2). The screws are rotated simultaneously by means of a 5-h.p. electric motor, the drive being through a worm reduction unit and bevel gears and shafts. The whole of this gear is on a foundation below the platform at its lowest position. An electro-mechanical brake is fitted to bring the driving gear to rest and to hold the platform in the desired position. The platform is controlled by push-buttons on the upper deck of the customs building (the push-buttons can be seen on the right of Fig. 1) and overrun in either direction is prevented by limit switches. Before a vessel is due to arrive at Holyhead, the two platforms are adjusted to suit the average height of the tide during the disembarkation period and they are retained in this position until all passengers have landed.

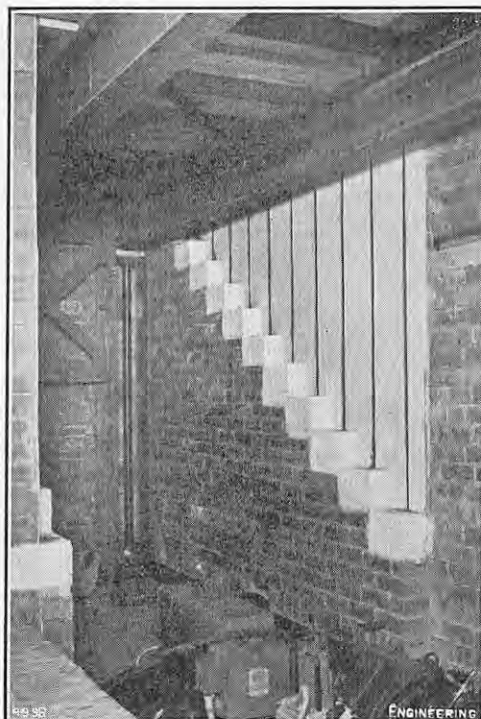


FIG. 2. UNDERSIDE OF PLATFORM, SHOWING PAD-STONES.

ATHLONE FELLOWSHIPS.

The first Canadian engineering graduates to receive awards under the Athlone Fellowship scheme have arrived recently in this country. Each year 38 fellowships are to be awarded by H.M. Government to enable Canadian engineering graduates to take a two-year post-graduate training course in the United Kingdom; the cost of transport, fees and maintenance will be covered. The fellowships have been named after Princess Alice of Athlone, the wife of the Earl of Athlone who was at one time Governor-General of Canada. The two years may be spent in works training in approved industrial organisations, or post-graduate study in a university, college, or research establishment, or a combination of works training and academic studies; or they may be devoted to research in a university, leading to a higher degree.

Of the first 38 fellowship holders, 28 are newly-qualified graduates and 10 are graduates from industry. Eighteen are to spend their two years at a university or college, four of them in research and the others on post-graduate studies. Ten have selected a mixed course of academic studies and works training, and seven are to enter industry for two years. The subjects chosen include general mechanical and electrical engineering, chemical engineering, aeronautics, gas turbines, automobile engineering, machine tools and production engineering, steel production, metallurgy, electro-chemistry, rubber technology, open-cast mining, structural analysis, concrete structures, soil mechanics, river-flow studies, hydraulic engineering, control mechanisms, electronics, and nuclear engineering. The academic and technological institutions to which the Canadian graduates will go include the Imperial College of Science and Technology; the University of Birmingham; Cambridge University; University College, London; the University of Aberdeen; the Royal Technical College, Glasgow; and the College of Aeronautics, Cranfield. In industry, the students have elected to train with the Production Engineering Research Association, the British Electricity Authority and, possibly, the National Gas Turbine Establishment and the Telecommunications Research Establishment; as well as eleven well-known manufacturers and consulting engineers.

STOKE-ON-TRENT ASSOCIATION OF ENGINEERS.—As announced on page 399, the Reginald Mitchell Memorial Gold Medal for 1951 of the Stoke-on-Trent Association of Engineers has been awarded to Professor Sir Wm. Lawrence Bragg, F.R.S., and the presentation has been arranged to take place at a public meeting to be held in the Victoria Hall, Hanley, Stoke-on-Trent, on Friday, October 5, commencing at 7 p.m. Sir Lawrence will afterwards deliver the Reginald Mitchell Lecture on "Atomic Patterns in Everyday Life." The presentation will be made by the President, Mr. G. F. Barnes.

LAUNCHES AND TRIAL TRIPS.

M.S. "BENNY SKOU."—Single-screw cargo liner, carrying twelve passengers, built and engined by Burmeister & Wain, Copenhagen, for D/S Ove Skou A/S & D/S af 1937 A/S, Copenhagen, Denmark. Main dimensions: 390 ft. between perpendiculars by 55 ft. 6 in. by 35 ft. 6 in.; deadweight capacity, 6,950 tons on a draught of 24 ft. 4 in.; gross tonnage, 4,248. B. & W. eight-cylinder single-acting oil engine, developing 7,000 b.h.p. at 125 r.p.m. Speed, 17 knots. Trial trip, August 23.

M.S. "BERNHARD HANSEN."—Single-screw oil tanker, built and engined by William Gray & Co., Ltd., West Hartlepool, for Skibsaktieselskapet Athos (Managers: Bernhard Hansen & Co.), Flekkefjord, Norway. Main dimensions: 470 ft. between perpendiculars by 62 ft. 9 in. by 35 ft. 6 in. to upper deck; deadweight capacity, 12,505 tons on a mean draught of 28 ft. Two Gray-Polarsix-cylinder Diesel engines, together developing 4,720 b.h.p. at 250 r.p.m., coupled to a single shaft through Vulcan hydraulic clutches and reduction gearing supplied by David Brown & Sons (Huddersfield), Ltd., Huddersfield. Speed on trials, fully loaded, 12½ knots. Trial trip, August 31.

M.S. "BUESTEN."—Single-screw oil tanker, built by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend-on-Tyne, for Tonsbergs Rederiaktieselskab (Managers: Rafen & Loennechen), Tonsberg, Norway. Main dimensions: 500 ft. between perpendiculars by 65 ft. 6 in. by 37 ft. 6 in.; deadweight capacity, 15,620 tons on a draught of 29 ft. 2 in.; gross tonnage, 10,268; capacity of oil-cargo tanks, 712,400 cub. ft. Wallsend-Doxford five-cylinder opposed-piston two-stroke Diesel engine, developing 5,100 b.h.p. at 105 r.p.m., constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne. Service speed, 13 knots. Trial trip, September 11.

S.S. "TOFO."—Single-screw ore-carrying vessel, built and engined by William Gray & Co., Ltd., West Hartlepool, for Compania Sud-Americana de Vapores, Valparaiso, Chile. First vessel of an order for two. Main dimensions: 415 ft. between perpendiculars by 57 ft. 6 in. by 34 ft. to upper deck; deadweight capacity, about 8,800 tons on a draught of 25 ft. Triple-expansion steam engines and two forced-draught oil-fired boilers, developing 1,835 i.h.p. at 69.5 r.p.m. Service speed, 10½ knots. Launch, September 14.

M.S. "LONDON VICTORY."—Single-screw oil tanker, built by the Furness Shipbuilding Co., Ltd., Haverton Hill, County Durham, for the London and Overseas Freighters, Ltd., London, W.1. Third vessel constructed for these owners. Main dimensions: 525 ft. between perpendiculars by 71 ft. by 39 ft. 3 in.; deadweight capacity about 18,200 tons on a summer draught of 30 ft. 6 in. N.E.M.-Doxford six-cylinder opposed-piston single-acting two-stroke reversible oil engine, developing 6,800 b.h.p. at 119 r.p.m. in service, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Speed, 15 knots. Launch, September 18.

M.S. "BRITISH PIONEER."—Single-screw oil tanker, built by the Blythwood Shipbuilding Co., Ltd., Scotstoun, Glasgow, for the British Tanker Co., Ltd., London, E.C.2. Main dimensions: 463 ft. between perpendiculars by 61 ft. 6 in. by 34 ft.; deadweight capacity, about 12,500 tons on a summer draught of 27 ft. 6 in. Six-cylinder four-stroke single-acting Burmeister and Wain Diesel engine, developing 3,200 b.h.p. at 115 r.p.m., constructed by John G. Kincaid & Co., Ltd., Greenock. Speed on trials, about 12½ knots. Trial trip, September 18.

M.S. "IRVANA."—Single-screw trawler, built by Cook, Welton and Gemmell, Ltd., Beverley, Yorkshire, for J. Marr & Son, Ltd., Fleetwood. Third vessel of a series of four. Main dimensions: 123 ft. 6 in. between perpendiculars by 26 ft. 6 in. by 13 ft.; gross tonnage, about 330; fishroom capacity, 7,000 cub. ft. Mirreles seven-cylinder Diesel engine, developing 700 b.h.p. at 228 r.p.m., constructed by Mirreles, Bickerton and Day, Ltd., Stockport, Cheshire, and installed by Charles D. Holmes & Co., Ltd., Hull. Launch, September 19.

S.S. "GARLINGE."—Single-screw cargo vessel, built and engined by William Gray & Co., Ltd., West Hartlepool, for Constants (South Wales), Ltd., London, E.C.2. Main dimensions: 320 ft. between perpendiculars by 46 ft. 4 in. by 24 ft. 3 in. to shelter deck; deadweight capacity, about 4,650 tons on a draught of 20 ft. 5½ in. Triple-expansion steam engines and two oil-fired forced-draught boilers. Speed in service, 10½ knots. Launch, September 19.

M.S. "CALTEX KENYA."—Single-screw oil tanker, built and engined by William Doxford & Sons, Ltd., Sunderland, for the Overseas Tankship (U.K.), Ltd., London, W.1. First vessel of an order for four. Main dimensions: 490 ft. overall by 61 ft. 9 in. by 36 ft. 3 in.; deadweight capacity, about 12,000 tons on a draught of 28 ft. 2½ in. Doxford five-cylinder opposed-piston balanced oil engine, developing 5,150 b.h.p. at 108 r.p.m. Speed, 13½ knots, loaded. Launch, September 19.

CONCRETE RESERVOIR TANK PRESTRESSED BY "PRELOAD" SYSTEM.

PRELOAD (GREAT BRITAIN), LIMITED, LONDON.

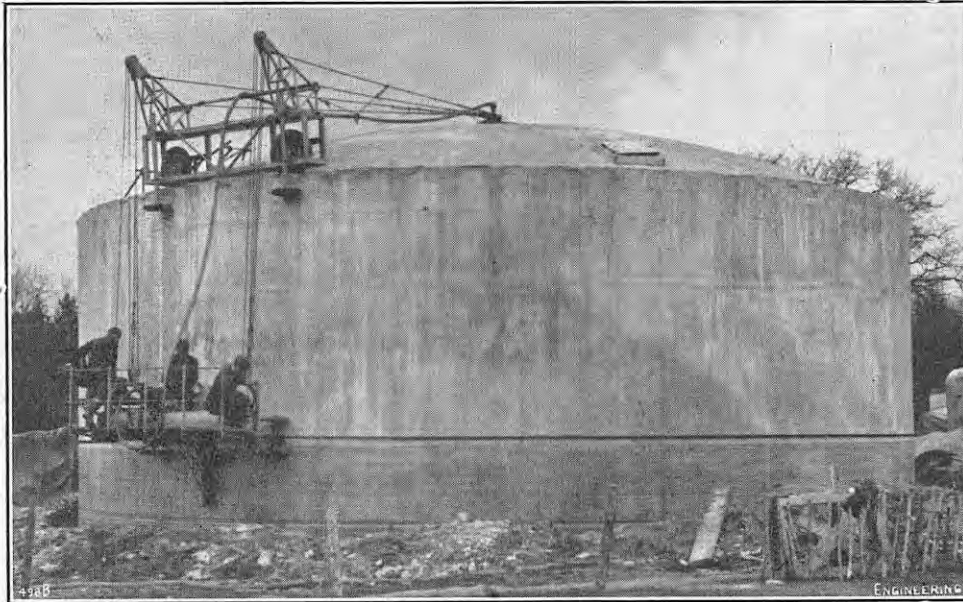


FIG. 1. PRESTRESSING WIRES BEING APPLIED.

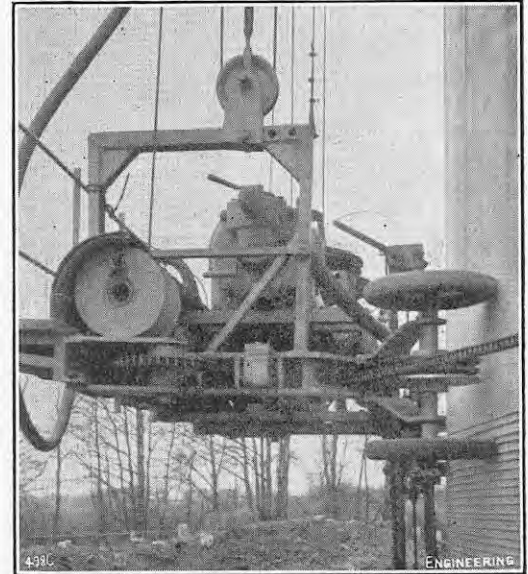


FIG. 4. "MERRY-GO-ROUND."

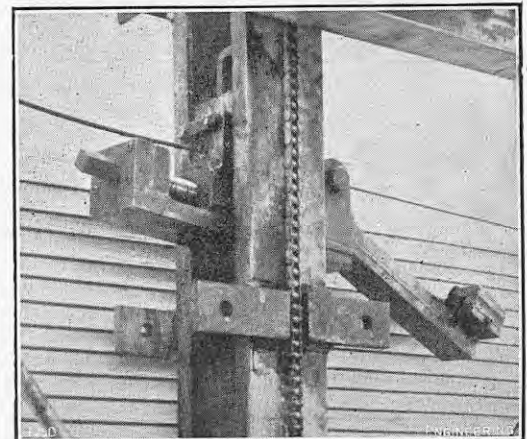
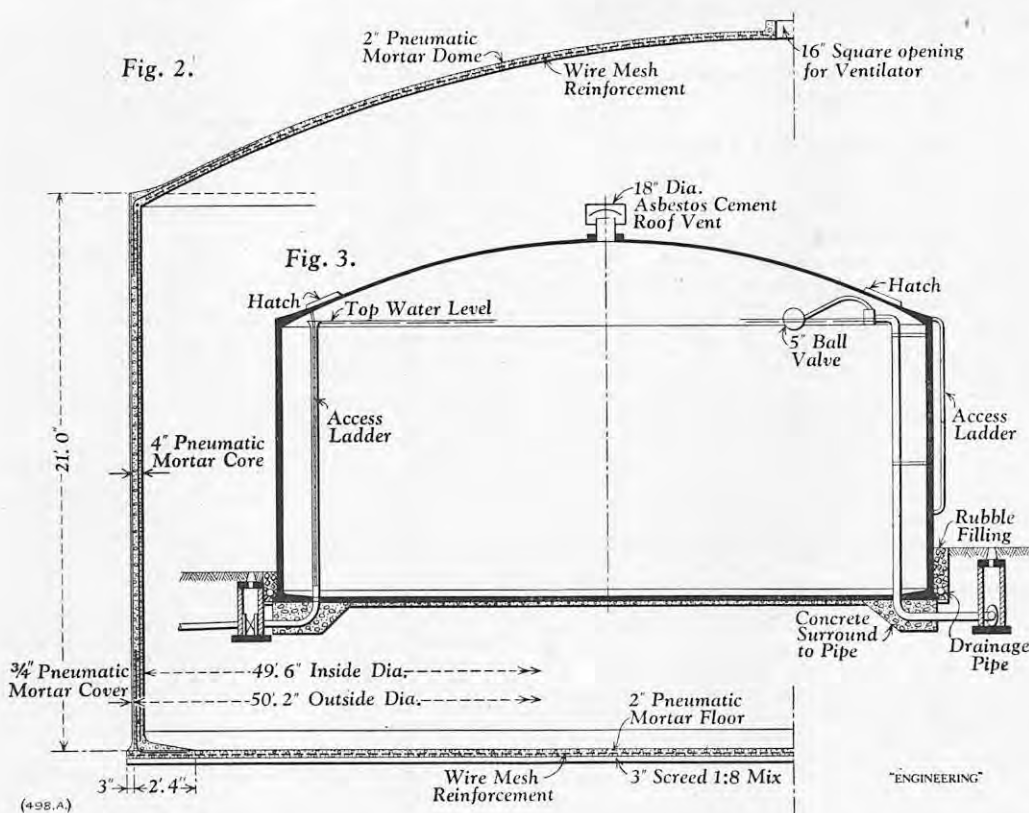


FIG. 5. WIREDRAWING DIE ON "MERRY-GO-ROUND."

CONCRETE RESERVOIR TANK PRESTRESSED BY "PRELOAD" SYSTEM.

AN American method of prestressing cylindrical concrete structures has recently been applied to a reservoir tank at Crawley New Town. Circumferential prestressing is obtained by continuously wrapping high-tensile steel wire round the reservoir, considerable tension being induced in the wire by drawing it through a die which is mounted on a travelling cradle or "merry-go-round." Prestressing is shown in progress in Fig. 1, herewith, and Figs. 2 and 3 illustrate the chief features of the construction. The following details of the construction have been supplied by the Cement and Concrete Association, 52, Grosvenor-gardens, London, S.W.1.

The Pease Pottage reservoir, as it is known, is part of a scheme for supplying water to the town. It is the first to be constructed in this country on the Preload system, and was built by Preload (Great Britain), Limited, to the instruction of the chief engineer to the Crawley Development Corporation (Mr. A. J. W. McIntosh, B.Sc., M.I.C.E.). It has a

capacity of 250,000 gallons and is 50 ft. in diameter, with a wall height of 21 ft. and a domed roof rising 6 ft. 3 in. The wall has been prestressed circumferentially and vertically so that under all conditions of loading there is a residual compressive stress in the concrete. The wall, floor and roof were concreted in pneumatic mortar applied with a cement gun. The mortar used was a machine-made mixture of dry sand and cement which was carried in suspension in a stream of compressed air through a flexible hose to a nozzle approximately at the point of deposit. The water of hydration was introduced into the suspended material and air stream at the nozzle. The cement and sand in the mortar were used in the proportion of one part of cement to four of sand, based on the dry loose volume. The amount of water injected was such that the surface of the material when placed had a rich, smooth appearance. On vertical surfaces the amount of water used was adjusted so that material with a maximum thickness of approximately $\frac{3}{4}$ in. would adhere without support.

As no concentrated loads were involved, the only requirements for the tank floor were that it should be watertight yet sufficiently flexible to deform slightly

with any settlement that might occur in the sub-base. It consists of 2 in. of monolithic pneumatic mortar reinforced with standard wire-mesh, laid on a rough 3-in. base of 1-to-8 mix concrete. There is no expansion joint between the floor and wall—the two are rigidly tied together by $\frac{1}{2}$ -in. dowel bars at 12-in. centres—but to minimise differential shrinkage between them the floor was kept continuously moist until the wall was complete. The wall consists of a 4-in. pneumatic mortar core, of approximately 1-to-3½ cement-to-sand ratio, with a $\frac{3}{4}$ -in. pneumatic mortar layer added outside to give cover to the circumferential prestressing wires. Formwork, which was used only to the outer face of the wall, extended for the full length and height. The mortar was placed from the inside so that the outside surface had a smooth finish which facilitated the placing of the circumferential wires.

The wire used for all the prestressing was 0.2-in. diameter high-tensile steel, with a minimum ultimate tensile strength of 210,000 lb. per square inch and a minimum stress at 1 per cent. proof stress of 180,000 lb. per square inch. For the vertical prestressing, the wires are grouped in units of four and were placed into keys preformed in the concrete, the keys extending the full wall height at 2-ft. intervals on the outer face. When the concrete had reached a sufficient strength and the wires had been tensioned, the keys were filled with pneumatic mortar which protects the wires and bonds them finally to the structure. The hydraulic jack used for the vertical stressing was of a pattern developed by the Ministry of Works. It consists of four jacks automatically compensated so that the tension on each wire is the same. After vertical prestressing, the formwork for the dome was erected and the dome cast. It consists of a 2-in. layer of pneumatic mortar of the same mix as that used for the wall, but reinforced with normal wire mesh. The circumferential stressing of the wall was then carried out by the self-propelled machine, or "merry-go-round" (Fig. 4),

ELEVEN-ROLL LEVELLING MACHINE.

BRONX ENGINEERING COMPANY, LIMITED, LYE, NEAR STOURBRIDGE.

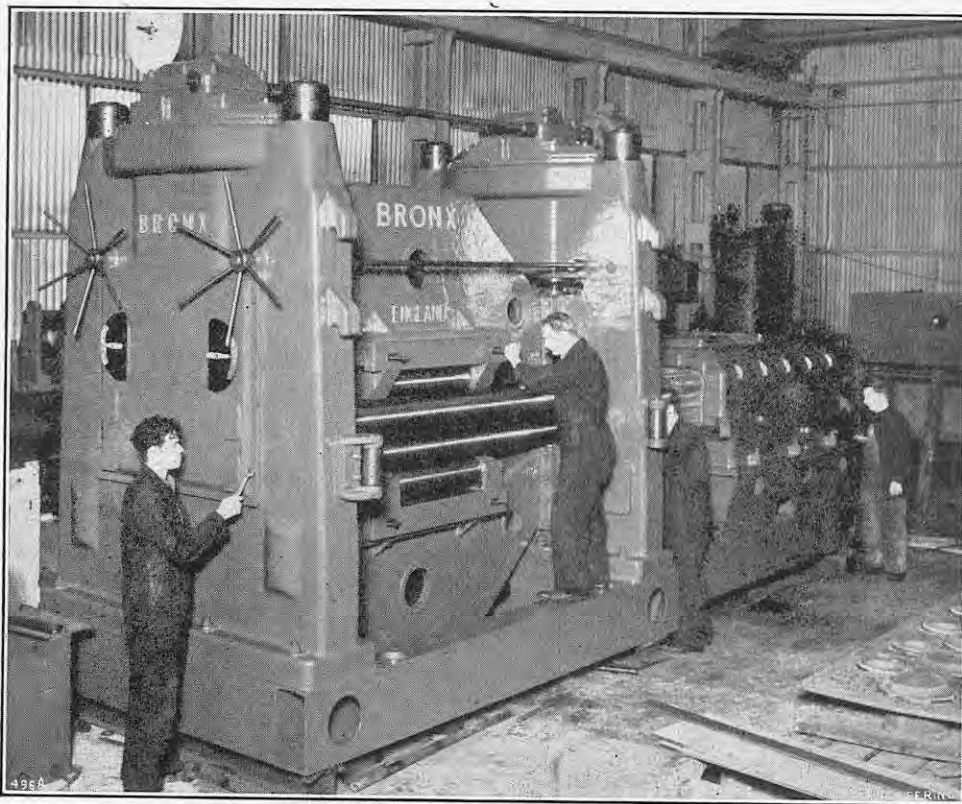


FIG. 1. GENERAL VIEW OF MACHINE.



FIG. 2. GEARBOX, SHOWING OIL GALLERY.

which wound the wire round the wall in a continuous operation, at the same time accurately stressing it within specified limits and spacing it correctly in helical form. The merry-go-round consists of a cradle, slung from a trolley which runs round and round the tank on the top edge of the wall. A motor on the cradle picks up a continuous chain which encircles the tank and propels the cradle along. The prestressing wire, which is fed from a coil on the cradle, passes through a hardened steel die which pays it out at a predetermined tension, as shown in Fig. 5. For this tank the diameter of the wire was initially 0.200 in., and that of the die 0.177 in., and the stress in the wire after it had cooled was 140,000 lb. per square inch.

As the merry-go-round circulated the tank it was raised gradually by the supporting trolley so that the wire formed a continuous helix on the surface of the

concrete. The raising of the cradle was controlled so as to give the correct spacing of the wires, which varied from 14 per linear foot at the base of the wall to 4 per linear foot at the top. Vertical adjustment of the die was possible either by raising the cradle relative to the trolley or by raising or lowering the die relative to the cradle. The second of these two adjustments was necessary for placing the wires near the bottom of the tank, where the die had to be supported below the cradle, and also at the top, where it was above the cradle. At the top of the wall, 17 circumferential wires were placed close together in a 10-in. deep ring to provide an inward thrust at the base of the dome.

Winding commenced from the bottom. After attaching the end of the wire firmly to the wall by steel collets in a special anchorage, the winding proceeded steadily upwards, the dome ring being wound last. The end

of the wire in the dome ring was fixed to the tank by another anchorage unit similar to that at the base. For joining a new coil of wire to the end of a previous coil, a special torpedo splice was used by which the ends of both wires were gripped in tapered holes by steel collets. In case the wire should break during the winding process, it was positively attached at set intervals to the tank wall by anchorages. In this way, breakage of the wire would not involve the rewinding of the whole tank, but only a small portion of it. When stressing was complete, the dome formwork was stripped and the cover coat applied to the outer face of the wall. All exposed outward-facing surfaces were left with a natural gun finish which was treated with cement paint to give the structure a clean uniform appearance. No special finish was required on the inside, other than minor items of "making-good." Pipes to the tank were run under the wall and the connections made to a sump in the floor. This is usually the most economical method of connecting pipes, although openings can readily be left for them in the walls of Preload tanks.

The tank was designed to give a maximum compressive stress in the wall concrete of 1,500 lb. per square inch, when the wire was wound on at its initial stress of 140,000 lb. per square inch. Owing to shrinkage and creep, this initial stress in the steel will decrease slightly with time to 100,000 lb. per square inch, or thereabouts, and give an estimated minimum working stress in the concrete, when the tank is empty, of 720 lb. per square inch and, when full, a minimum residual compressive stress of 50 lb. per square inch.

ELEVEN-ROLL PLATE-LEVELLING MACHINE.

IN last week's issue of *ENGINEERING*, on page 366, *ante*, we recorded that the Bronx Engineering Company, Limited, Lye, near Stourbridge, had despatched to France an eleven-roll plate-levelling machine which was claimed to be the largest yet made in that district. Herewith, in Figs. 1 and 2, we reproduce two photographs of the machine, and append below some details of its construction.

The machine, which is of the backed-up type, has been designed and constructed to the specification of a French steelworks, the *Acieries Marine d'Homecourt*, and is of rather unusual adaptability; it will handle a range of sheet and plate in thicknesses from $\frac{1}{8}$ in. to $\frac{1}{2}$ in., and widths up to 2,500 mm. (8 ft. 2 in.). The drive is by an electric motor of 100 h.p. through a flexible coupling to a totally-enclosed three-tier cast-iron gearbox. The gears are alloy-steel forgings and all are of the double-helical type. The gearbox is in two compartments, one containing the high-speed reduction gears, which are carried in roller bearings, and the other containing the slow-speed shafts, each of which drives one of the eleven levelling rolls. The 48 bearings in the gearbox are oil-lubricated from a gallery round the inside top tier, to which oil is fed from the high-speed gears; from the gallery, which can be seen in Fig. 2, the oil is piped individually to the roll bearings.

The drive from the gearbox to the rolls, which are arranged six on top and five below, is by means of mill-type universal couplings and coupling spindles. The universal couplings have half-moon bearings of laminated plastic, individually grease-lubricated. The levelling unit consists of two split housings of semi-steel, mounted on a welded steel fabricated baseplate. The bottom support-roll bridge is an iron casting which extends below the level of the baseplate. The top support-roll bridge, of similar construction, is bolted to the top roll-chock housings. The support-roll blocks are adjustable by means of a four-point taper wedge to pre-load the top and bottom levelling rolls as required.

For setting or other purposes, the plate can be reversed by the machine and levelled in either direction. For this reason, both the ingoing and outgoing top levelling rolls are not supported, their necessary stiffness being ensured by making them of greater diameter than the supported levelling rolls. These unsupported top rolls are individually adjustable; and the whole bank of top rolls, with the support bridge, can be adjusted as a unit by a separate motor, mounted on a fabricated steel bracket which is bolted to the right-hand frame housing. The worm gearing for adjusting the rolls is totally enclosed and runs in oil. A large dial indicator, to be seen in Fig. 1, shows the position of the top bank of levelling rolls; and individual pointers indicate on a graduated scale the position of the top ingoing and outgoing rolls in relation to the four supported top rolls. Vertical idlers, which also can be seen in Fig. 1, are fitted to the ingoing and outgoing sides of the machine to prevent extra wide plates from fouling the housings. The weight of the machine is 53 tons; not 64 tons, as stated in our previous reference. Our paragraph also credited it with the ability to straighten plates up to $\frac{3}{4}$ in. thick; the correct capacity, however, is as given above.

NOTES FROM THE INDUSTRIAL CENTRES

SCOTLAND.

EXTENSION OF ALUMINIUM-ROLLING MILL.—Permission was granted at Falkirk Dean of Guild Court on September 20 for the erection of extensions and subsidiary buildings, to include a laboratory, at the rolling mills of the British Aluminium Company at Falkirk.

MR. T. A. CROWE, M.Sc.—The North British Locomotive Co., Ltd., Glasgow, have appointed Mr. T. A. Crowe, M.Sc. (Durham), a managing director. Mr. Crowe was until recently engineering director of John Brown & Co., Ltd., Clydebank. He is a vice-president of the Institution of Engineers and Shipbuilders in Scotland, and a member of Council of the Institution of Mechanical Engineers, and of the Institution of Naval Architects.

SMITH'S ENGLISH CLOCKS, LTD.—Mr. G. R. Strauss, Minister of Supply, was presented with the 9,000,000th alarm clock manufactured in Scotland by Smith's English Clocks, Ltd., when he officially opened a new factory for the firm at Gowkthrapple, near Wishaw, on September 20. The watch and clock industry, he claimed, had made more rapid technical advances than any branch of engineering in the country. Gowkthrapple may ultimately employ 1,500 persons and produce 4,000,000 alarm clocks a year.

WARNINGS OF POWER CUTS.—The South-West Scotland Electricity Board are exploring the possibilities of a new short-wave transmitter, which, if successful, might be used to warn industrial consumers of impending power cuts. The transmitter is at the Port Dundas offices, and industrial consumers would require to have receivers installed. A test of the signal was made on September 21.

CLEVELAND AND THE NORTHERN COUNTIES.

NEW COAL STAITHES AT NORTH SHIELDS.—Subject to the approval of the Treasury and the Ministry of Transport, the Tyne Improvement Commissioners propose to construct two coal-shipping staithes at Whitehill Point, North Shields. One will be on the site of the former No. 2 staith, destroyed by fire in 1938, and the other partly on the site of the present Nos. 1 and 2A staithes. Each will have two radial-arm loaders, enabling two holds of a vessel to be filled simultaneously. Wagon tipplers will be provided to load washed small coal into hoppers, from which it will be transferred by electrically-driven belt conveyors to the radial loaders. The estimated cost of the work is 600,000*l.* Additional wagon sidings are also to be provided.

THE IRON AND STEEL POSITION.—Although more ore is now coming in, Tees-side iron and steel producers are compelled to keep plants operating at considerably below capacity at a time when more and more specifications are being issued for material for priority purposes, with the result that there is a growing inconvenient shortage of sections urgently needed for ordinary commercial requirements. The scarcity of coke is retarding the much-desired increase in pig iron output, and a more liberal fuel supply is essential to accelerate blast-furnace activity. An outstanding hopeful factor in the generally unsatisfactory situation is the position in regard to iron ore. Heavy deliveries have enabled consumers to accumulate large reserve supplies and, indeed, to restore stocks almost to normal level. Imports of foreign ores are being maintained on a substantial scale and supplies from home mines continue good.

LANCASHIRE AND SOUTH YORKSHIRE.

FOREMEN IN CONFERENCE.—One of the addresses to be given to steelworks and toolroom foremen at the conferences at Hope, Derbyshire, referred to on page 366, *ante*, is on costs; Mr. F. Pickworth, managing director of the English Steel Corporation, is to deal with costing in steelworks. He is chairman of the Costs Committee of the Iron and Steel Federation, which is sponsoring the series of conferences. There will be talks on law as it affects industry, the role of trade unions, the management of men, joint consultation, and other topics. Opportunity will be given for the foremen to express their views on the various subjects and their opinions of the value of the conferences. Two conferences are to be held in October.

ELECTRICITY TARIFFS.—The new electricity tariffs in the East Midlands, to come into operation next year,

will affect more than 12,000 industrial concerns. It is stated that many of the industrial tariffs throughout the area have not been revised since the war and have been rendered completely uneconomic by the continuous rise in costs since 1945, particularly for supplies given under block tariffs which did not incorporate a fuel clause. The new tariffs will replace numerous tariffs of the 33 separate undertakings now vested in the East Midland Electricity Board.

PROFESSOR W. E. S. TURNER.—On his 70th birthday, on September 22, Emeritus Professor W. E. S. Turner, the first head of Sheffield University's Department of Glass Technology, founded by him in 1915 and the first of its kind in the world, was presented with a volume, dedicated to him, tracing the history of the glass industry. Illuminated addresses from Sweden, the United States, Spain, India, Belgium and Germany were also handed to him, as well as messages of goodwill from India, Denmark and France. The company at the presentations came from all parts of Britain and from four other countries.

TRANSPORT USERS' CONSULTATIVE COMMITTEE FOR THE YORKSHIRE AREA.—The Minister of Transport, the Rt. Hon. Alfred Barnes, has formally appointed the Transport Users' Consultative Committee for the Yorkshire area, under the chairmanship of Professor A. N. SHIMMIN. The committee members are Mr. H. S. WOOD, representing agriculture; MESSRS. H. BRADLEY, K. CAMPBELL-CULLEN, A. B. SHIPLEY, and W. COLE, representing industry and commerce; Mr. W. BARR, representing shipping; MESSRS. F. STOTT and F. ROBINSON, representing labour; COUNCILLOR H. J. CRAVEN, ALDERMAN H. A. B. GRAY, C.B.E., COUNCILLOR J. RAFFERTY and COUNCILLOR S. I. DYSON, representing the local authorities; and MESSRS. E. W. ARKLE and W. M. HITCHCOCK, representing the British Transport Commission. The committee secretary is Mr. J. Horsfield, of the Railway Executive, North-Eastern Region. Six more members are still to be appointed.

BULK CONVEYANCE OF CEMENT BY RAIL.—The North Eastern Region of British Railways have undertaken the conveyance, in bulk containers, of 40,000 tons of cement from the Ferriby works of G. & T. Earle, Ltd., Hull, to the site of a new reservoir for Wakefield Corporation, which is being constructed at Baitings, near Sowerby Bridge. The cylindrical containers used, which hold 5½ tons each, were made during the recent war, for the Ministry of Supply, for the carriage of magnesium oxide.

THE MIDLANDS.

ELECTRICITY LOAD-SHEDDING PLANS.—Plans have been made for load-shedding during the coming winter, in the area covered by the Midlands Electricity Board. As in the winter of 1950-51, voltage reduction or temporary withdrawal of supplies will be on a district rota basis, the principal difference being that the days on which power will be cut will be changed. Thus, for example, some districts which previously had cuts on a Monday will now be affected on Fridays. It is expected that a list of districts, with the days on which power cuts can be expected during peak-load periods, will be available shortly.

THE NEW CONVEYOR COMPANY, LTD.—An agreement has been reached whereby Tube Investments, Ltd., of Birmingham, will acquire the assets of the New Conveyor Co., Ltd., of Smethwick and West Bromwich. The New Conveyor Co. will continue to operate as a separate concern, and the management and products will remain as before the merger. Mr. W. R. Purnell, the present vice-chairman of the New Conveyor Co., will become chairman, and will continue his duties as managing director of that company.

PLANS APPROVED FOR A NEW COLLIERY.—Rugeley Urban District Council have approved plans for a new colliery near that town. The new pit is planned for an eventual output of 1,500,000 tons a year, and ultimately will replace the existing Brereton Colliery, which has now only a limited remaining life. Large reserves of coal have recently been proved in the neighbourhood.

TRAINING BOILER FIREMEN.—The Ministry of Fuel and Power is running a series of instructional courses in the Midlands for boiler firemen. Ten training centres have been established and courses will be held once a week. The regional fuel engineer, Mr. A. H. Pinder, has appealed to Midland industrialists to support the Ministry's campaign for fuel economy by sending their boiler-room staffs for training in modern methods of firing. He estimates that 12,000 tons of coal and coke a week could be saved in the Midlands by the application of modern methods. Details of the scheme can be obtained from the Regional Fuel Engineer, Ministry of Fuel and Power, Hagley-road West, Birmingham, 17.

PROGRESS ON THE RIVER AVON NAVIGATION.—The Lower Avon Navigation Trust, a non-profit-making concern which was formed to restore the River Avon navigation from Tewkesbury to Evesham, has repaired Strensham Lock, about five miles from Tewkesbury, and has now entered on the second part of its work. Nafford Lock, about three miles up the river from Strensham, is being repaired, and an order has been placed for the repair of the Avon Lock at Tewkesbury, which gives access to the River Severn. The river is now open as far as Pershore, and can be used by pleasure or commercial craft.

PIT PROPS FROM MIDLAND FORESTS.—During the felling season, which begins on October 1, it is expected that a million cubic feet of timber suitable for pit props will be obtained from forests in the Midlands. The timber will come from both Forestry Commission property and private woodlands, the owners of the latter being assisted by a grant from the State for timber thinning.

REDUCTION OF STEEL OUTPUT.—Shortage of labour has resulted in a reduction of output from two Midland steel-rolling mills belonging to Richard Thomas and Baldwins, Ltd. The plants affected are the Wilden works, near Stourport, and the Stour Vale works, near Kidderminster. Steel sheets are produced at these works, and at present only eight out of eleven hot mills can be operated.

SOUTH-WEST ENGLAND AND SOUTH WALES.

NEW CRANES AT NEWPORT DOCKS.—Six new 10-ton grabbing cranes have been installed at Newport docks for the rapid handling of iron-ore cargoes. During the past five years, an average of over 470,000 tons of iron ore a year has been received at Newport. The new cranes are convertible for general cargo use. They have been supplied and erected by Stothert and Pitt, Ltd., Bath. The foundation and reinforced-concrete work was carried out by Christiani and Nielsen, Ltd., Westminster.

NANTGARW COKE-OVEN PLANT.—A development of importance to South Wales and the country was the start of production at the National Coal Board's new 3,000,000*l.* coke oven and by-product plant at Nantgarw on Thursday of last week. The ceremony was performed by Mr. Philip Noel-Baker, Minister of Fuel and Power, who pressed a button to operate the first discharge of coke from the ovens. Mr. Noel-Baker described the plant as the focal point of the new gas grid that the Wales Gas Board are constructing in the eastern part of the coalfield, the largest under construction in the country. The new plant will produce 1,100 tons of coke, 2,700 gallons of motor spirit, and 18,000,000 cub. ft. of gas a day, as well as other carbonisation products. It was originally intended that the King should open the plant, and a message expressing His Majesty's regret at not being able to be present was read by Mr. G. E. Aeron-Thomas, chairman of the South Western Division of the National Coal Board. A plaque to commemorate the opening was unveiled by Lord Hyndley. The project was initiated by the Powell Duffryn Co., before the nationalisation of the gas industry.

HOME-GROWN PIT PROPS.—Thinnings from forests in Wales for the twelve months to the end of this month will be worth 200,000*l.*, according to estimates by the Conservators of Forests for South and North Wales. This represents about 1,500,000 cub. ft. of timber, most of which goes as pit props to the South Wales collieries.

INDUSTRIAL PROGRESS IN SOUTH WALES.—Sir Percy Thomas, chairman of the Welsh Board for Industry, praised the co-operation between the Board and Government Departments when he spoke at the inaugural meeting of the East Wales District Committee of the Board, held at Newport on September 18. A representative of the Ministry of Works told the meeting that licences granted in Wales were of an average value of 600,000*l.* monthly. The value of those rejected each month was about 200,000*l.* For the Admiralty, it was stated that 22 naval ships were in the repair yards of South Wales, and the Ministry of Supply representative spoke of efforts made to secure more defence work for Welsh factories. The Ministry of Labour reported a record low unemployment figure of 13,000.

LOSS OF M.V. "TWILIT WATERS."—The Ministry of Transport announces that the formal investigation into the loss with all hands of the M.V. Twilit Waters, on or about April 11, 1951, has been fixed for hearing at the Magistrate's Court, Brixham, Devon, on Tuesday, October 16, 1951, at 10.30 a.m.

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.

SOCIETY OF ENGINEERS.—Monday, October 1, 5.30 p.m., Geological Society's Apartments, Burlington House, Piccadilly, W.1. "The Application of Electronic Instruments to Industry," by Mr. S. F. Smith.

ILLUMINATING ENGINEERING SOCIETY.—*Sheffield Centre*: Monday, October 1, 6.30 p.m., The University, Western Bank, Sheffield, 10. Chairman's Address, by Mr. G. L. Tomlinson. *Newcastle Centre*: Wednesday, October 3, 6.15 p.m., Minor Durrant Hall, Oxford-street, Newcastle-upon-Tyne, 1. Chairman's Address, by Mr. W. H. Dodgson. *Leicester Centre*: Thursday, October 4, 6.30 p.m., Offices of the East Midlands Electricity Board, Charles-street, Leicester. Discussion on "The Lighting of the New House of Commons."

INSTITUTION OF ELECTRICAL ENGINEERS.—*Mersey and North Wales Centre*: Monday, October 1, 6.30 p.m., Royal Institution, Colquitt-street, Liverpool. Chairman's Address, by Mr. E. W. Ashby. *North-Western Centre*: Tuesday, October 2, 6.30 p.m., Engineers' Club, Albert-square, Manchester. Chairman's Address, by Mr. G. R. Polgreen. *Southern Centre*: Wednesday, October 3, 6.30 p.m., British Electricity House, 111, High-street, Portsmouth. Chairman's Address, by Mr. A. L. Ashton. *District Meeting*: Monday, October 8, 7.30 p.m., The Royal Hotel, Norwich. "Some Electrical Methods of Measuring Mechanical Quantities," by Mr. F. J. Woodcock.

INSTITUTION OF WORKS MANAGERS.—*Notts and Derby Branch*: Monday, October 1, 7.30 p.m., The Welbeck Hotel, Nottingham. "My Own Experience in America," by Mr. J. A. Warner. *Wolverhampton Branch*: Tuesday, October 2, 7 p.m., The Star and Garter Royal Hotel, Wolverhampton. "Industrial Relations Under Present Circumstances," by Mr. J. Leask. *Sheffield Branch*: Tuesday, October 2, 7.30 p.m., The Grand Hotel, Sheffield. "Some Aspects of Motion and Time Study," by Mr. D. D. W. Usalis. *Teesside Branch*: Thursday, October 4, 7.30 p.m., The Vane Arms Hotel, Stockton. "Law in Industry," by Mr. Norman Scott. *London Branch*: Friday, October 5, 6.45 for 7.30 p.m., St. Ermin's Hotel, Westminster, S.W.1. Annual General Meeting. *Merseyside Branch*: Tuesday, October 9, 6.30 p.m., Adelphi Hotel, Liverpool. "Why Nationalised Industry Cannot be Efficient," by Mr. Lewis C. Ord.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Sheffield Branch*: Monday, October 1, 7.30 p.m., Royal Victoria Station Hotel, Sheffield. Presidential Address on "The Training of Foundry Technicians," by Mr. W. J. Colton. *North-East Scottish Section*: Wednesday, October 3, 7.30 p.m., The Imperial Hotel, Keptie-street, Arbroath. "Cast Iron as an Engineering Material," by Dr. H. T. Angus. *Wales and Monmouth Branch*: Saturday, October 6, 6 p.m., South Wales Institute of Engineers, Park-place, Cardiff. Film Display. *Slough Section*: Tuesday, October 9, 7.30 p.m., High Duty Alloys, Ltd., Slough. "The Running and Feeding of Castings," by Mr. H. B. Farmer.

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—*Scottish Centre*: Monday, October 1, 7.30 p.m., Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow, C.2. "The Heating and Ventilation of Public-Service and Heavy-Goods Vehicles," by Mr. F. Duncombe. *Eastern Group*: Tuesday, October 2, 7 p.m., The University Arms Hotel, Cambridge. Inaugural Meeting. *Institute*: Wednesday, October 3, 6.30 p.m., Central Hall, Broadway, Westminster, S.W.1. Sixth Annual General Meeting. *Western Group*: Tuesday, October 9, 7.30 p.m., The Grand Hotel, Bristol. Opening Meeting of the 1951-52 Session. *East Midlands Centre*: Wednesday, October 10, 7.30 p.m., Mechanics Institute, Nottingham. "The Art of Welding," by Mr. M. Allender.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*Leeds Branch*: Monday, October 1, 7.30 p.m., Lighting Service Bureau, Leeds. "Research on Lamps and Lighting," by Mr. R. V. Mills. *Sheffield Branch*: Monday, October 1, 7.30 p.m., The Royal Victoria Station Hotel, Sheffield. "Television," by Mr. C. O. Birtles. *North-East London Branch*: Monday, October 1, 8 p.m., The Angel Hotel, Ilford. "Modern Installations," by Mr. W. F. Parker. *West London Branch*: Tuesday, October 2, 7.30 p.m., The Windsor Castle Hotel, Hammersmith. "Automatic Power Factor Correction," by Mr. J. Orr. *South London Branch*: Thursday, October 4, 8 p.m., Café Royal, North End, Croydon. "Gyroscopes," by Mr. W. J. Spencer.

INSTITUTE OF MARINE ENGINEERS.—Tuesday, October 2, 5.30 p.m., 85, The Minories, E.C.3. Presidential Address, by Dr. S. F. Dorey, F.R.S. Tuesday, October 9, 5.30 p.m., 85, The Minories, E.C.3. "Refractory Materials for Marine Boilers," by Mr. F. H. Clews.

INCORPORATED PLANT ENGINEERS.—*London Branch*: Tuesday, October 2, 7 p.m., The Electric Light Manufacturers' Association, 2, Savoy-hill, W.C.2. "Planned Maintenance," by Mr. J. T. Bromley. *Southampton Branch*: Wednesday, October 3, 7.30 p.m., Polygon Hotel, Southampton. "How the Institution Functions," by Mr. L. G. Northcroft. *Peterborough Branch*: Thursday, October 4, 7.30 p.m., Eastern Gas Board's Offices, Church-street, Peterborough. Discussion on "The Manufacture of Electric Lighting Fittings." *South Wales Branch*: Tuesday, October 9, 7.15 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Gears," by Mr. G. B. Ashton. *East Lancashire Branch*: Tuesday, October 9, 7.15 p.m., Engineers' Club, Albert-square, Manchester. "Manufacture, Development and Application of Brake-Lining Material," by Mr. G. E. Taylor.

INSTITUTION OF PRODUCTION ENGINEERS.—*Reading Section*: Tuesday, October 2, 7.15 p.m., Great Western Hotel, Reading. "Industrial Incentives," by Mr. R. N. Marland. *Nottingham Section*: Wednesday, October 3, 7 p.m., Victoria Station Hotel, Nottingham. "Fatigue of Metals," by Professor J. A. Pope. *South Essex Section*: Wednesday, October 3, 7.30 p.m., South East Essex Technical College, Barking. "The Problems of Management," by Mr. Lewis C. Ord. *Institution*: Thursday, October 4, 7 p.m., Royal Empire Society, Northumberland-avenue, W.C.2. "Increased Productivity by the Use of Compressed Air," by Mr. N. P. Watts. *West Wales Section*: Friday, October 5, 7.30 p.m., Central Library, Alexandra-road, Swansea. "History and Development of the Tube Industry," by Mr. W. Goldsworthy.

INSTITUTE OF PETROLEUM.—Wednesday, October 3, 5.30 p.m., Manson House, 26, Portland-place, W.1. Redwood Lecture on "The Training of a Technologist," by Professor F. H. Garner.

LIVERPOOL ENGINEERING SOCIETY.—Wednesday, October 3, 6 p.m., 9, The Temple, 24, Dale-street, Liverpool. Presidential Address, by Mr. E. Walker Elliott.

INSTITUTION OF SANITARY ENGINEERS.—Wednesday, October 3, 6 p.m., Caxton Hall, Westminster, S.W.1. "Concrete Lining of Corroded Water Mains," by Mr. R. Petherbridge.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—*East Midlands Branch*: Wednesday, October 3, 6.30 p.m., The Victoria Station Hotel, Nottingham. "Refrigeration, with Special Reference to Air Conditioning," by Mr. F. L. Pettman. *South Western Branch*: Tuesday, October 9, 6.30 p.m., G.E.C. Building, Cathays Park, Cardiff. Films: "Reciprocating Pumps" and "Submersible Pumps."

ROYAL AERONAUTICAL SOCIETY.—Thursday, October 4, 6 p.m., Institution of Civil Engineers, Great George-street, S.W.1. Seventh Commonwealth Lecture on "Air Transport in New Zealand and the South Pacific," by Air Vice-Marshal Sir L. M. Isitt.

INSTITUTION OF MECHANICAL ENGINEERS.—*North Western Branch*: Thursday, October 4, 6.45 p.m., Engineers' Club, Albert-square, Manchester. "Industrial Design and Its relation to Machine Design," by Mr. H. G. Conway. *Institution*: Friday, October 5, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. Special General Meeting (Open to corporate members of the Institution only). **AUTOMOBILE DIVISION**: Tuesday, October 9, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. Annual General Meeting and Chairman's Address.

INSTITUTE OF METALS.—*London Local Section*: Thursday, October 4, 7 p.m., 4, Grosvenor-gardens, S.W.1. "Pressure Welding," by Mr. R. F. Tylecote.

LEEDS METALLURGICAL SOCIETY.—Thursday, October 4, 7 p.m., Chemistry Department, The University, Leeds. "Statistical Control in the Steel Industry," by Mr. N. H. Bacon.

ROYAL SANITARY INSTITUTE.—Friday, October 5, 10.30 a.m., Town Hall, Hastings. (i) "Problems of Hastings Water Supply, with Particular Reference to Darwell Reservoir," by Mr. S. Little. (ii) "A Prospect of Public Health in a Cinque Port," by Mr. W. G. McDonald.

INSTITUTE OF FUEL.—*South Wales Section*: Friday, October 5, 6 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Fuel Efficiency in the Oil Industry," by Mr. M. J. Stradling.

MANCHESTER ASSOCIATION OF ENGINEERS.—Friday, October 5, 6.30 p.m., Engineers' Club, Manchester. Presidential Address, by Mr. F. Buckingham.

INSTITUTION OF CHEMICAL ENGINEERS.—Tuesday, October 9, 5.30 p.m., Geological Society's Apartments, Burlington House, Piccadilly, W.1. Discussion on "The Education of the Chemical Engineer by Part-Time Study."

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, October 9, 6.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. Presidential Address, by Sir Andrew McCance, F.R.S.

PERSONAL.

SIR ERIC RIDEAL, D.Sc. (Lond.), Ph.D. (Bonn), F.R.S., F.R.I.C., Professor of Physical Chemistry at King's College, University of London, has been appointed by the Lord President of the Council to be a member of the Advisory Council for Scientific and Industrial Research, with effect from October 1 next. PROFESSOR H. W. MELVILLE, D.Sc. (Edin.), Ph.D. (Cantab.), F.R.S., F.R.I.C., will retire from the Council as from September 30, on the completion of his period of service.

SIR WM. LAWRENCE BRAGG, O.B.E., M.C., F.R.S., M.A., Cavendish Professor of Experimental Physics, Cambridge, has been awarded the Reginald Mitchell Memorial Gold Medal for 1951 of the Stoke-on-Trent Association of Engineers. The presentation will take place on October 5.

VICE-ADMIRAL W. Y. LA R. BEVERLEY, C.B., C.B.E., Admiral Superintendent, H.M. Dockyard, Portsmouth, has been appointed Director of Dockyards, in succession to ADMIRAL SIR CLAUD B. BARRY, K.B.E., C.B., D.S.O. The appointment will take effect in December.

DR. W. I. PUMPHREY, M.Sc., F.R.S.A., has been appointed research manager of Murex Welding Processes, Ltd., Waltham Cross, Hertfordshire, in succession to Dr. E. C. ROLLASON, M.Sc. (Birm.), F.I.M., who, as stated on page 403 of our issue of April 6, 1951, has been appointed to the Henry Bell Wortley professorship of metallurgy at the University of Liverpool. Dr. Rollason will take up this appointment on October 1.

DR. HENRY E. MERRITT, M.B.E., D.Sc. (Eng.), chief research officer to the British Transport Commission, has been appointed chief administrative engineer for the Coventry factories of the Rootes group of companies, Devonshire House, Piccadilly, London, W.1. The Commission have agreed to release Dr. Merritt from his present post, to enable him to accept the new appointment.

MR. R. H. GRAY, O.B.E., M.A., M.I.Mech.E., has been appointed deputy chief inspector in the Inspectorate of Fighting Vehicles, War Office.

MR. J. T. A. BROOKS, F.R.I.C.S., assistant chief quantity surveyor to the Ministry of Works, has been appointed chief quantity surveyor, in succession to the late Mr. C. A. MORRISON, C.B.E.

SIR RICHARD E. YEABSLEY, C.B.E., F.C.A., F.S.S., has been appointed a director of F. Perkins, Ltd., Queen-street, Peterborough.

MR. G. DANIEL, C.B.E., chief ship surveyor of the Ministry of Transport, is retiring at his own request on November 30, and will be succeeded by Mr. H. E. STEEL, deputy chief ship surveyor to the Ministry.

CAPTAIN G. P. CLARIDGE, R.N. (ret'd.), has been appointed chief executive of the Council of British Manufacturers of Petroleum Equipment, 79, Buckingham Palace-road, London, S.W.1.

MR. C. R. ANLEY, formerly a designer draughtsman with the Brush Electrical Engineering Co., Ltd., has been appointed a development engineer for the Foster switch-gear division of Crypton Equipment, Ltd., Bridgewater, a member of the Lancashire Dynamo group of companies.

MR. R. STEVENSON, mechanical inspector at the Derby carriage and wagon works of the London Midland Region, British Railways, has been appointed manager of the Bromsgrove wagon works of the same Region in Worcestershire, in succession to Mr. T. R. HOWARD, who has retired.

MR. J. T. MARLER has been appointed manager of the operating division of the Marconi International Marine Communication Co., Ltd., Chelmsford, Essex, in succession to Mr. S. STANSBRIDGE, who retired recently.

MR. L. BRUCE ARCHER has been appointed honorary proctor of the Institution of Engineering Draughtsmen and Designers, Grand Buildings, Trafalgar-square, London, W.C.2, in succession to Mr. R. R. OSBORNE.

THE NORTHERN ALUMINIUM CO., LTD., announce that, as from October 1 next, the address of their head office and London area sales office will be Bush House, Aldwych, London, W.C.2. (Telephone: TEMple Bar 8430; Telegraphic Address: Noraluco, Estrand, London.)

The new office buildings of BOULTON AND PAUL, LTD., at their Riverside Works, Norwich, were opened on September 19, by the Lord Mayor of Norwich.

POWELL DUFFRYN, LTD., 40, Lime-street, London, E.C.3, have announced the centralisation of the coal exporting, bunkering and chartering activities of their two wholly-owned subsidiary companies, CORY BROTHERS & CO., LTD., and GUERET, LLEWELLYN AND MERRETT, LTD. As a result of this reorganisation, Cory Brothers will carry on the activities of both subsidiaries.

M.T.E. CONTROL GEAR, LTD., Leigh-on-Sea, Essex, have opened a branch office at 47, Warwick-road, Coventry (Telephone: Coventry 64561), to deal with M.T.E. control equipment in the Midlands area, including Gloucestershire and Cheshire. Mr. J. A. FISHPOOL is in charge of the new office.

ENGINEERING, MARINE AND WELDING EXHIBITION AT OLYMPIA.

(For Description, see Page 404.)

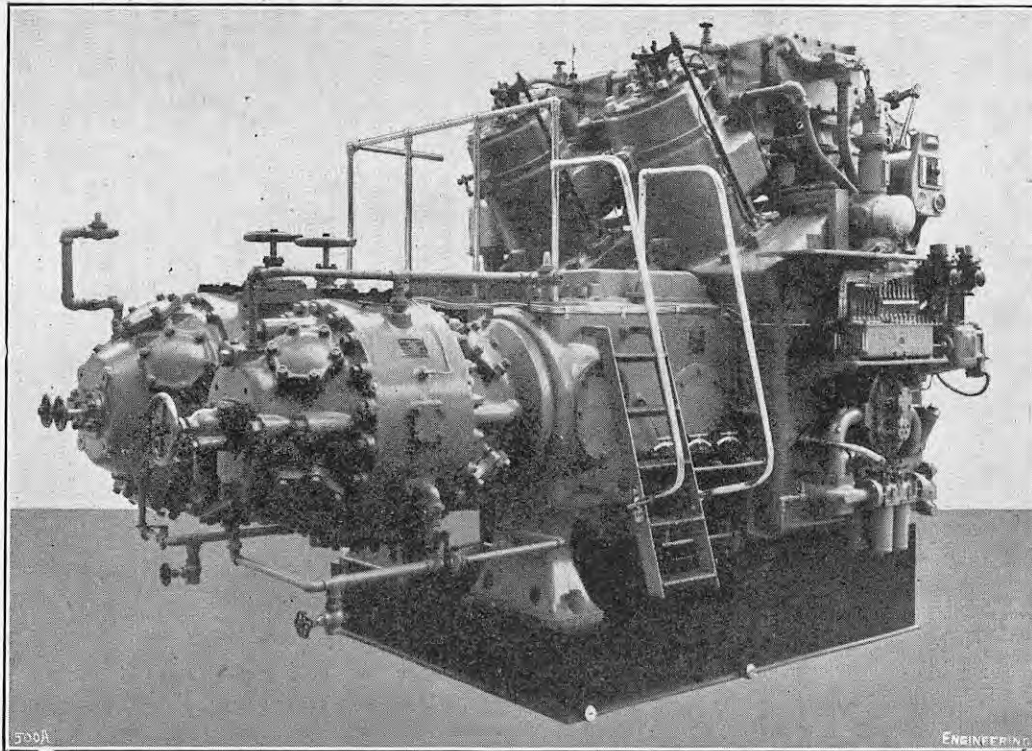


FIG. 104. GAS-ENGINE DRIVEN COMPRESSOR; HARLAND AND WOLFF, LIMITED.

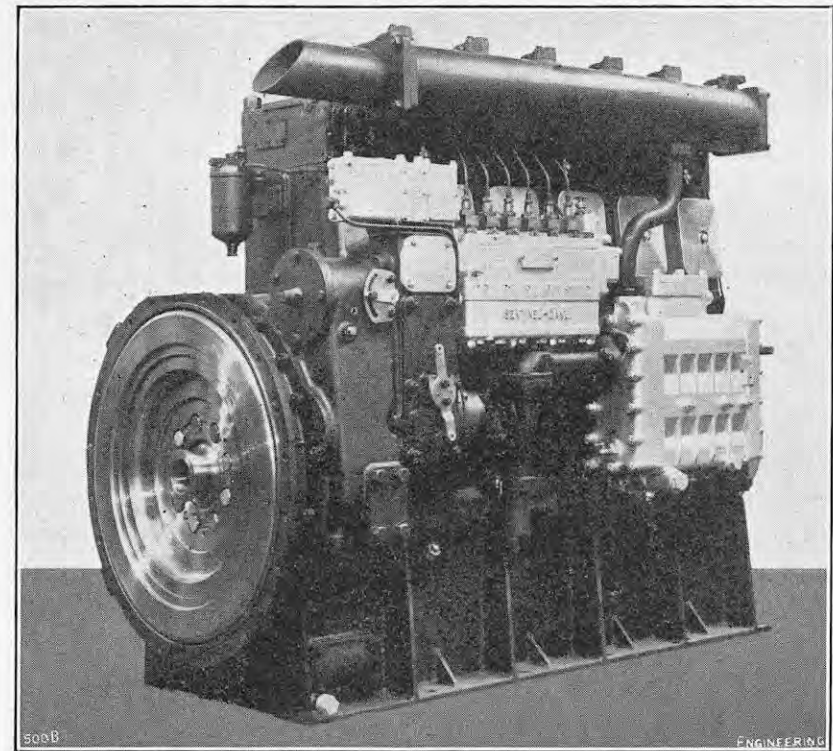


FIG. 106. SENTINEL-GANZ 240-B.H.P. DIESEL ENGINE; SENTINEL (SHREWSBURY), LIMITED.

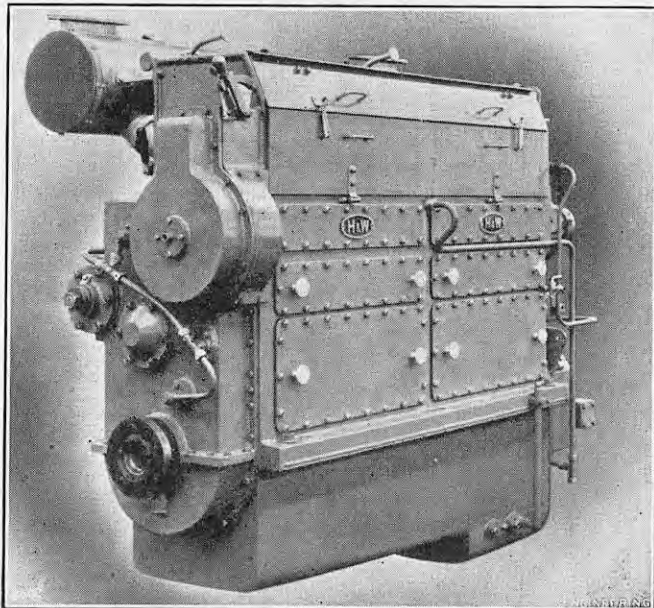


FIG. 105. 300-B.H.P. RAIL-TRACTION ENGINE; HARLAND AND WOLFF, LIMITED.

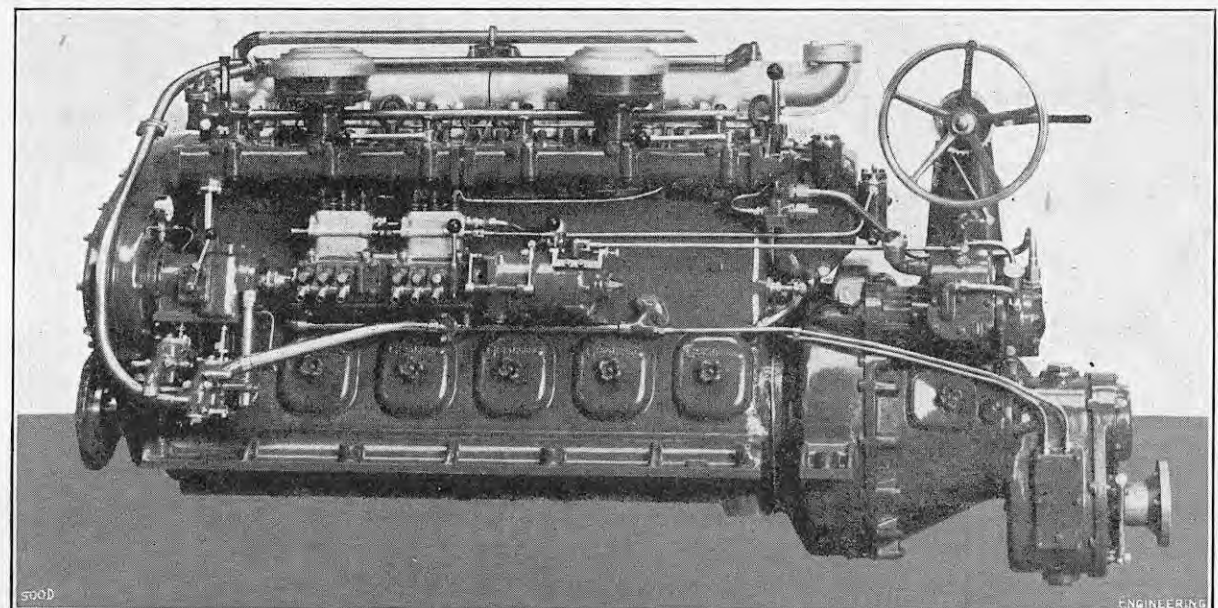


FIG. 107. 120-B.H.P. MARINE DIESEL ENGINE; GLENIFFER ENGINES, LIMITED.

ENGINEERING,

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

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

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"ENGINEERING," LESQUARE, LONDON.

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SUBSCRIPTIONS.

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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 on the green art paper wrapper, on the inside black and white pages and in the buff art paper two-colour supplement, as well as for insets, 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 at least 10 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

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

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PASSENGER AND CARGO LINER "KENYA."

ENGINEERING

FRIDAY, SEPTEMBER 28, 1951.

VOL. 172.

No. 4470.

HIGHER TECHNOLOGICAL EDUCATION.

THE Government's policy for the development of higher technological education was announced in a White Paper* which was published last week. The text of it runs to about 1,100 words, many of which are employed to advance an argument which will be familiar to readers of ENGINEERING, while others are used to enunciate platitudes. Its contents can, therefore, be concisely summarised. Between 1938-39 and 1949-50, the numbers of full-time technological students at British universities increased from 5,288 to 10,933; and the numbers of post-graduate students from 662 to 1,539 in the same period. Accommodation for these students is inadequate and will have to be increased if undergraduate courses are to be lengthened and more post-graduate courses instituted. Additional staff of the requisite quality will also have to be recruited. Provision under both these headings is, it is felt, limited at the present time for financial reasons. Further, the available resources of manpower, accommodation and equipment are so strained in the current economic circumstances that the alternative of establishing a technological university (to cater for at least 3,000 students) would not be in the national interest to adopt. It is promised, however, that the establishment of such a Temple of Technology will be considered on its merits when the situation improves.

Having thus disposed of the role assignable to

* Higher Technological Education: Statement of Government Policy for the Development of Higher Technological Education in Great Britain (Cmd. 8357). H.M. Stationery Office, York House, Kingsway, London, W.C.2. [Price 3d. net.]

the universities, the White Paper turns next to the technical colleges, where, it is estimated, about 5,000 full-time students are currently working for the London University external degree in engineering. The recommendation* of the National Advisory Council on Education for Industry and Commerce, that increased financial assistance should be given to such of these colleges as are engaged in advanced technology, is accepted; and it is stated that proposals for implementing this policy will be announced shortly. In addition, the Government accept the recommendation that a College of Technologists should be established to encourage the development of courses at the "first award" and "post-graduate" levels, and to make suitable awards for that purpose. It is implied, though not specifically stated, that, as also recommended by the National Advisory Council, this body would not be a teaching or examining institution, its sole functions being to approve courses, the conditions under which they are being conducted, and the arrangements for examining the students. Finally, the hope is expressed that the Government will have the co-operation of all concerned in guiding the next stage of development along the lines indicated.

Such co-operation, however, is not likely to be promoted by the very general nature of these proposals; for, while there will be practically unanimous agreement that higher technological education in this country should receive adequate assistance, there will be many opinions whether the course suggested is the best that could be devised, and still more regarding the most efficient way of implementing the plan. A further, if temporary, difficulty is that, although the White Paper may be taken as representing the views of the present Government on the subject, it may not necessarily be in accordance with the views of the one that is to succeed in the near future. It is unlikely, therefore, that any immediate steps will be taken to carry out what has been suggested. In itself, however, this need not be a disadvantage, since it would afford a further chance, the proposals and all that they imply. If it is argued that the matter has already been sufficiently discussed without much result, we can only say that a few crystals are now beginning to emerge from a confused solution.

In the first place, the parts that the universities on the one hand, and the technical colleges on the other, should play in the development of higher technological education must be decided in a more definite manner than has emerged thus far—and that will not be easy. The White Paper lays down the proposition that the function of universities is to concern themselves with the more fundamental aspects of technology and that the departments dealing with these subjects must therefore be closely associated with those dealing with pure science. Technical colleges, on the other hand, while paying adequate attention to the fundamental sciences, should cater for students whose outlook is more practical and should be more closely connected with industry. Technical colleges are also considered to be particularly appropriate institutions for students who come to full-time courses at university level after they have been engaged in part-time study, coupled with employment in industry.

From this perhaps it may be deduced, not unfairly, that it is intended that the education given both at the universities and the technical colleges should be of equally high standards, but that it would differ in that at one the treatment will be predominantly theoretical and at the other it would have a practical bias. University education has, however, another important function, that of training a pro-

* See The Future Development of Higher Technological Education: Report of the National Advisory Council on Education for Industry and Commerce. H.M. Stationery Office. [Price 1s. net.] Also ENGINEERING, vol. 170, page 537 (1950).

portion of each rising generation in the arts of thinking independently and of continuing to learn, so that those concerned may contribute something to the advancement of human knowledge. To ensure that this function is performed, pure theory must be alloyed with some element of the "humanities." This admixture is also necessary from the material point of view, since the university graduate must subsequently be able to earn a living, of a kind that will induce in him a reasonable contentment of mind.

Independent thought and a capacity for continuing to learn are, however, no less useful attributes for the student at a technical college to acquire. It is important, therefore, that in arranging the courses at these institutions the outlook of the College of Technologists, eventually operating with all the prestige of a Royal Charter, should not be purely utilitarian; and should never lose sight of the truth that, even under present social conditions, "man does not live by bread alone." This is particularly essential because one of the main difficulties of the new organisation will be to ensure that students, employers and, above all, the professional institutions, do not succumb to the temptation of drawing invidious distinctions between the two types of qualification. It would, in fact, be highly undesirable if a student, because he was the holder of a first university degree, were to be automatically considered a more (or a less) useful member of technical society than one who possessed the diploma of the new college. To ensure that this does not occur, it will be necessary, not only that the courses shall be of equally high standard, but that they shall be generally recognised as being such. It must also be recognised that the possession of a degree or, alternatively, of a diploma indicates rather that the holder has been educated along parallel lines on an equal level than at different levels. Such recognition will not be obtained automatically, but, unless it is obtained, the scheme is more likely to fail than to succeed.

In the discussions which have taken place on this subject, a good deal of stress has been laid on the necessity for closer co-ordination between the universities and industry. That such co-ordination will be even more necessary between the technical colleges of the new dispensation and industry will hardly be denied. It will, in fact, be one of the first and most important tasks of the new college to develop this association. Perhaps one of the best ways in which this can be done is by the seconding of selected members of the staff of the appropriate firms to the technical institutions for teaching duties. This would ensure not only that instruction was conducted on practical lines, but that a useful outlet was provided for those who, while desiring to teach, are attracted by the more glittering prizes available in industry. In fact, the staffing problem is not likely to be the least of the problems of the new body.

The White Paper states that, in formulating their policy, the Government have taken into account the views of the University Grants Committee, the National Advisory Council on Education for Commerce and Industry, the Advisory Council on Education in Scotland, and the Advisory Council on Scientific Policy, "together with the views expressed publicly by other bodies and persons." Presumably, the last-named include the professional engineering institutions. It appears a little doubtful, however, whether these societies can be expected to regard the proposals with any real enthusiasm. Their present membership consists very largely of men who have sought election, with all the expense that it entails, solely for the sake of "letters after their names," and the institution of a qualification ranking at least as highly in the minds of prospective employers, but involving no annual outlay for subscriptions, may easily result in a serious diminution in the number of applicants for admission.

INCENTIVES.

MANY, probably most, of the reports prepared by the productivity teams which have visited the United States have attributed the higher output of American labour, as compared with British, to better works layout and arrangements for handling materials and to the fact that workpeople are prepared to make full use of labour-saving machines. The absence of the rigid demarcation insisted on by British organised labour is an important factor in the high outputs which are attained. The American worker has to contend with a highly-inflated cost of living, but is prepared to meet that cost by his own efforts. He realises that high wages can be paid only by prosperous industry and does his best to ensure that the firm by which he is employed shall attain and maintain prosperity. Basically, the position is that he wants high wages to sustain his standard of living and recognises the conditions necessary for high wages to be paid.

Piece-work arrangements and other incentive systems appear to be comparatively rare in the United States; presumably, the mental attitude of labour makes them unnecessary. As the general adoption of that attitude seems unlikely in this country, at any rate in the immediate future, the most promising way to increase output appears to be the employment of incentive in some form or other. The British workman may not realise to what extent prosperity depends on his own procedure, but he is in no way indifferent to more money. An example of this is furnished by the Saturday shifts which are being worked in many coal mines. These are frequently represented as an expression of patriotism on the part of the miners; actually, they are fully explained by the special rates paid on Saturdays. This indication of a desire for more money is natural and commendable, so long as it is accompanied by a realisation that more money should be earned by more output. Special rates for Saturday working are not usual in industry generally, but incentive schemes of one kind or another are relatively common. They have not always been successful and at various times trouble has been caused by the introduction of piece rates based on what was little more than guessing.

This matter bears on one of the points made by the productivity teams. High output depends not only on the mental attitude of the employee, but also on shop arrangement and work flow, while incentive schemes, to be successful, must be based on a proper analysis of shop methods and procedure. Two recent and useful* booklets deal with this subject of method study and work measurement in some detail. Both contain sections dealing with incentives in which such matters as the relation of bonus payments to base rates, and the relative advantages and disadvantages of bonus payments to individuals or groups, are considered.

Both these books are concerned with incentives to workpeople, but Mr. Speakman in a section entitled "Psychology of Incentives" writes "We can offer increased remuneration in proportion to the amount of extra effort—or responsibility—involved." The word "responsibility" in this statement presumably has reference to foremen or charge hands, but it has a wider application which those who have been responsible for the government of this country in recent years are either unaware of, or ignore. It is not only workpeople who benefit from incentives to improve their performances. A few weeks ago, the Federation of British Industries submitted a memorandum to the Royal Commission on the Taxation of Profits and

Income, in which it was pointed out that the high marginal rates of income tax, including surtax, were now such that rewards for the highest posts in industry and other activities, which demanded unusual ability and carried heavy responsibility, were reduced to a level little or no higher than those awarded to relative mediocrity. The disincentive now applied to the highest ability could not but reflect unfavourably on the efficiency and progress of British industry.

This contention by the Federation of British Industries had particular reference to the higher executives, but its implications have a wider application. The careful organisation of American factories and the working out of handling arrangements and other production-aiding features are carried out by a technical staff and not by the workpeople. The important part played by this class of worker in raising the efficiency of industry was put in a striking way by the late Michael Roberts in a recent book*, wherein he pointed out that, "between 1900 and 1940, through the effort and ingenuity of a few hundred men, the efficiency of the steam-turbine was more than doubled, with the result that more than 120 million tons of coal are saved every year in the production of electrical energy: the few hundred engineers have contributed more to the world's well-being than half a million miners."

There are incentive schemes in existence, in the form, for instance, of a bonus based on profits, which do benefit technical staffs, but in general those who provide the brains of industry are deemed to require no incentive to make them do their best. To their credit, this is usually correct. No permanent good, however, can come from the application of what are in effect disincentives to those on whom the efficiency of industry depends. A worker of this class might, for instance, be permitted to build himself a house, for which he is prepared to pay, rather than expect someone else to do it for him and let it to him at a figure well below the economic rent. The discouragement of the higher executive staff, referred to by the Federation of British Industries, reflects also on technical staffs. The two classes work closely together in industrial planning, and a policy which refuses any reward for special effort or the assumption of added responsibility cannot assist industrial progress.

This article is entitled "incentives," but it has turned to a discussion of the opposite. The most striking industrial disincentive which has recently been proposed is the limitation of company dividends. This is a matter with which members of the higher executives are closely concerned. Technical staffs may put forward proposals for extensive and costly new plant, and examination may suggest that they would probably lead to increased output and a lowering of costs. There is, however, necessarily a certain amount of uncertainty and risk in the matter and it may be argued quite reasonably that the risk is not worth taking if any advantage accruing is not to come to those who have provided the money. All those who buy shares in industrial companies face the risk that they may get little reward, or may even lose their money, and if the risk is not accompanied by the possibility of an adequate or attractive return, they may well refrain from any further purchases of the kind. The only source of capital expenditure is savings, and if savings are not adequately remunerated they will cease to be made. There is a school of thought, or thoughtlessness, which appears to suppose that, if an industry is nationalised, it will no longer be dependent on the investor. This is not correct; the investor is the sole source of capital and it is just as important to offer him incentives as it is to devise attractive bonus schemes for application in the workshop.

* *Work Study*, by R. M. Currie. British Institute of Management, Management House, 8, Hill-street, London, W.1. [Price 3s. 6d.] *Work Study and Incentives*, by A. J. Speakman, Emmott & Co., Ltd., 31, King-street West, Manchester, and 21, Bedford-street, Strand, London, W.C.2. [Price 4s. net.]

* *The Estate of Man*, page 77.

NOTES.

THE CITY AND GUILDS OF LONDON INSTITUTE.

It is announced by the City and Guilds Institute that H.R.H. the Duke of Edinburgh, K.G., F.R.S., has accepted the office of President of the Institute, to which he was duly elected at a meeting of the members on September 21. By so doing, His Royal Highness renews and continues a long connection of the Royal Family with the Institute, which began in 1881, when the Duke of Albany laid the foundation stone of the Finsbury Technical College. In the same year, the Prince of Wales (afterwards King Edward VII) became the first President and, in that capacity, laid the foundation stone of the City and Guilds Engineering College in Exhibition-road, South Kensington. Three years later, he also performed the opening ceremony at the College. In 1900, the Institute was granted a Royal Charter by Queen Victoria. On his accession to the throne in 1901, King Edward VII became Visitor and Patron of the Institute, in accordance with the terms of the Royal Charter, relinquishing the office of President, which remained vacant until, as stated, the Duke of Edinburgh was elected to the Presidency. Since 1926, when the Finsbury College was closed, the engineering instruction of the Institute has been concentrated in the City and Guilds College, which is administered by a Delegation representing the Imperial College, the City and Guilds of London Institute, the Goldsmiths' Company and the Clothworkers' Company.

RAILWAY ACCIDENT AT WEEDON.

The Ministry of Transport inquiry into the passenger-train derailment which occurred at Weedon, Northamptonshire, on September 21, was opened at Euston Station yesterday, Thursday. The accident occurred at 11.25 a.m. about 400 yards south of the Stowehill tunnel, though, according to reports, the derailment began 600 yards north of the tunnel, which is 500 yards long. Eight persons were killed outright and seven have since died. The train was the 8.20 a.m. Liverpool to Euston express, consisting of 15 coaches hauled by Class-7 4-6-2 locomotive No. 46207, which is one of the early Pacific engines of the former London Midland and Scottish Railway. The engine and ten of the coaches crashed down a shallow embankment, and as there were 700 passengers in the train it is probably very fortunate that the train had left the tunnel before the final stage of the derailment occurred. As it was, the first coach was telescoped and the second was cut in two by the third. The driver and fireman had remarkable escapes, though the driver was buried under coal and ashes, which had to be dug away to free him. The fireman ran to the nearest signal box to give warning, but it appears that the signalman had already put the signals at danger to stop the down Royal Scot, which was due a few minutes after the accident. Main-line traffic was diverted via Northampton while the wreckage was being cleared, and the two tracks were opened to traffic at 5.30 p.m. on Saturday, though a restriction of 15 miles an hour was imposed on up trains. Some trains were still being sent through Northampton on Sunday.

CRAMPTON'S TELEGRAPH CABLE TO FRANCE.

September 25 marked the centenary of an event of some importance in the history of telegraphic communication, as it was on that date, in 1851, that Thomas Russell Crampton—more widely known, perhaps, as a designer of railway locomotives—successfully laid the first sheathed telegraph cable, between England and France. The story was told in our issue of August 21, 1885 (vol. 40, page 171), in our report of the Inventions Exhibition in that year, in which a portion of the cable was shown by Mr. Crampton. He had previously laid a cross-Channel wire, covered with guttapercha, but this was not successful; the sheathed cable, however, was still working perfectly when our report was prepared. The Government had supported the cross-Channel telegraph project to the extent of offering naval ships to aid in the laying, but none of the steam vessels then in the Navy could provide stowage for the cable. Even-

tually, Crampton selected the gunboat *Blazer*, from which the engines had been removed, and had her towed to Millwall, where she took the cable on board, and thence to Dover, where laying began at dawn on September 25—the last day but one of the concession granted for the construction of the submarine telegraph to France. Unfortunately, the weather worsened seriously and in mid-Channel the vessel broke away from the tug. To quote our report: "The brakes were screwed down in the hope that she would ride to the cable as an anchor, but they were not sufficiently powerful and the ship slowly drifted down Channel, paying out the line as she went. . . . Another hawser was passed to the tug, and the voyage resumed, this time more successfully. Four miles of extra cable had been provided to allow for slack, but this was more than exhausted by the unlooked-for detour and, when within half a mile of the shore, near Cape Grisnez, it was found that practically all the cable was paid out, and that darkness was coming on, with the whole squadron lying off a lee shore." The *Blazer* was anchored, and next morning, the wind having abated, a temporary length of guttapercha-covered wire was spliced on and carried ashore; "thus telegraphic communication between England and the Continent was completed within the specified time, and in face of enormous difficulties." P. W. Barlow, engineer of the London, Chatham and Dover Railway, who was on board the *Blazer*, sent a telegram to his wife as the last of the cable was being paid out: "Two miles off the coast of France. Shall not be home to-night." It was duly transmitted to London over the telegraph system of the South-Eastern Railway. The form delivered to Mrs. Barlow is to be one of the historical items in the Festival of Britain exhibition to be held by the Junior Institution of Engineers on October 24 to 26, at 39, Victoria-street, London, S.W.1.

REORGANISATION OF SOUTH WALES STEEL FIRMS.

The Iron and Steel Corporation of Great Britain have decided to reconstitute the boards of Guest, Keen and Baldwins Iron and Steel Company, Limited, and Guest, Keen and Nettlefolds (South Wales), Limited. The latter firm was previously a wholly-owned subsidiary of Guest, Keen and Nettlefolds, Limited, and prior to nationalisation it was "hived off" from the parent company. Under the Iron and Steel Act, Guest, Keen and Baldwins Iron and Steel Company, Limited, and Guest, Keen and Nettlefolds (South Wales), Limited, passed into public ownership. The directorates of both companies were mainly nominees of Guest, Keen and Nettlefolds, Limited. In the reconstituted boards, three part-time directors will retire from Guest, Keen and Baldwins Iron and Steel Company, Limited, and six from Guest, Keen and Nettlefolds (South Wales), Limited, but all the full-time executive directors remain. The full-time executive directors of Guest, Keen and Baldwins Iron and Steel Company, Limited, will be: Mr. C. R. Wheeler and Mr. T. Jolly (joint managing directors), Mr. E. H. Lever, Mr. H. F. Spencer and Mr. J. S. Hollings, C.B.E. The full-time executive directors of Guest, Keen and Nettlefolds (South Wales), Limited, will be Mr. N. R. Brook (general manager), Mr. G. A. Phipps (works manager) and Mr. E. Brown (commercial manager). The management of the two companies will become closely associated with that of Richard Thomas and Baldwins, Limited. These changes, the Corporation state, are a logical consequence of the public ownership of the companies and are a step in the integration and economic working of the steel industry in South Wales.

DISCUSSION ON METAL ECONOMICS.

The Institute of Metals have issued a pamphlet on the general discussion on metal economics which is to be held at the Park Lane Hotel, Piccadilly, London, W.1, from 10 a.m. to 5 p.m., on Wednesday, October 17. It gives synopses of the following papers which are to be presented. Mr. R. Lewis Stubbs is to speak on "The World Supply of Non-Ferrous Metals, including the Light Metals"; Professor S. Zuckerman, C.B., F.R.S., on "Metals as Natural Resources"; Dr. T. P. Colclough, C.B.E., on "Iron Ore: World Demand and Re-

sources"; Mr. C. A. Bristow, Mr. A. J. Sidery and Dr. H. Sutton on "The Scope for Conservation of Metals, Ferrous and Non-Ferrous"; Mr. C. Dinsdale on "Economy by Standardisation of Alloys and of the Method of Reclamation of Scrap Metals"; Mr. F. Hudson on "The Influence of Specifications on Productivity and the Economic Utilisation of Ferrous and Non-Ferrous Metals"; Mr. E. H. Jones on "Secondary Heavy Metals"; and Colonel W. C. Devereux, C.B.E., on "Secondary Aluminium and Magnesium."

OBITUARY.

MR. FRED CLEMENTS, WH.EX.

ALTHOUGH he had been living in retirement for several years, the name of Mr. Fred Clements is well remembered among those whose business is with the design, construction and operation of blast-furnace plant, and the news of his sudden death at his home in Eastbourne, on September 19, has caused widespread regret, especially in Sheffield and district.

Mr. Clements, who was born in Chesterfield on January 4, 1882, was educated in a local elementary school and at Dronfield grammar school, which he left in 1896 to serve an engineering apprenticeship with Markham and Company, Limited, Chesterfield. Concurrently, he attended evening classes in Chesterfield. He remained with Markham and Company until 1904, and then took up an appointment in the drawing office of the Park Gate Iron and Steel Company, Limited, Rotherham, which enabled him to continue his engineering studies at the University of Sheffield, with the assistance of the Whitworth Exhibition which he obtained in 1905. Two years later, he became chief draughtsman of the Park Gate Company, with whom the rest of his working life was spent. He was appointed successively to the positions of engineer, consulting engineer and general manager of the Park Gate works, and eventually was appointed a director and then, at the end of June, 1937, chairman and managing director, in succession to Mr. Percy Fawcett. He continued in those offices until December 31, 1945. During his long service with the firm, he was for extensive reconstructions of the plant, and was consulted also regarding the design of equipment for other iron and steel works.

Throughout his life, Mr. Clements was a keen student of the technology of steel production, and contributed a number of informative papers to various professional societies; but his *magnum opus* was his three-volume treatise on *Blast Furnace Practice*, published in 1929, probably the most comprehensive work on the subject that has yet appeared. He was a member of the Institution of Civil Engineers, the Institution of Mechanical Engineers, and the Iron and Steel Institute, and an associate member of the Institution of Electrical Engineers, and had served on the Council of the Institution of Mechanical Engineers when chairman of the Yorkshire Branch of that Institution. He served also for a number of years on the Council of the Iron and Steel Institute, and was the recipient, in 1936, of the Institute's Bessemer Gold Medal. He was a freeman of the Company of Cutlers in Hallamshire, and was Master Cutler in 1939-40. He was also a keen amateur astronomer, and a Fellow of the Royal Astronomical Society; this activity he continued to pursue in his retirement at Eastbourne until increasing infirmity compelled him to relinquish it, and also to give up his other hobby, his well-equipped private workshop. For some time before his death, he had been able to walk only with the aid of sticks. We understand that the slipping of one of his sticks on a stair, by which he fell heavily, was the immediate cause of his death.

INDUSTRIAL EMPLOYMENT IN CAITHNESS.—Employment prospects in Caithness were described yesterday as fairly good, in a report made to Caithness and Sutherland Local Employment Committee. Information on the availability of labour was given to representatives of a firm of manufacturing chemists and to a shoe company, who may establish light industries in the area.

LETTERS TO THE EDITOR.

PRECISION MEASUREMENT OF ROCKWELL HARDNESS DIAMOND PENETRATORS.

TO THE EDITOR OF ENGINEERING.

SIR,—Your correspondent, Mr. P. Grodzinski, asks, on page 180, *ante*, why Mr. Tolmon and Mrs. Wood have failed to illustrate a good Rockwell indenter tip by an interferogram, to compare with that of the steel ball shown. A reason for this is to be found in the object of the measurements, namely, to demonstrate, if only by inference, how far short of the ideal form many of the indenters in current use must fall.

The indenters measured, which were employed in the hardness testing investigation previously reported, were carefully prepared, and the best of these yielded interferograms approaching in regularity that illustrated by Mr. Grodzinski. However, the illustrations on page 89 were chosen not so much to exhibit the best forms as to demonstrate the sensitivity of one possible method of inspection.

Mr. Grodzinski is to be congratulated on the symmetry of the tip of the Rockwell cone indenter he has produced, and it is greatly to be regretted that he was unable to give particulars of the radius of curvature of the tip and the included angle of the cone. These details can, if he so desires, be obtained by measurement at the National Physical Laboratory in the manner described by the above authors.

It is interesting to note that Mr. Grodzinski, in his second paragraph, refers to "attempts to produce Rockwell cones of better shapes"; a form of wording which suggests that he would not disagree with the conclusions drawn in the paper by the writer and Mr. Phillips.

Yours faithfully,

A. J. FENNER.

Ministry of Supply,
Division of Atomic Energy (P),
Culcheth, near Warrington.
September 19, 1951.

WATER TURBINES FOR HYDRO-ELECTRIC PROJECTS.

TO THE EDITOR OF ENGINEERING.

SIR,—In their paper on the above subject, presented to the British Association, as printed in your issues of August 10 (on page 184, *ante*), and August 17 (page 217), the authors, Mr. R. W. Weekes and Mr. A. Feiner, make certain general statements regarding valves on which I should like to comment.

Taking first the butterfly type: its shortcomings are, as stated, that it presents a permanent obstruction to flow and does not close drop-tight, but in justice it should also be said that it is less likely to cause water hammer than any of the other types mentioned. For equal uniform operating speeds, it takes about 70 per cent. longer to make the last 10 per cent. of the closing stroke than the rotary or the spectacle eye types, and about 100 per cent. longer for the last 5 per cent. of travel—important gains from the water-hammer point of view.

The Larner-Johnson type is condemned for its costliness, its length between flanges and, with certain exceptions, its tendency to slam. There is, however, evidence to show that it can compete successfully with the rotary type on a price basis, and as far as overall length is concerned it can be constructed in such a way that the greater part of its length becomes, in effect, part of the penstock or pipeline. In regard to slamming propensities, Johnson's earliest designs did show tendencies in this direction, but that was before the time when Larner and Johnson combined and the valve became known as the Larner-Johnson valve. Any valve to which the latter designation could be applied would be immune from that failing, and as there have been several patented designs to which that immunity would apply, it is untrue to say that all Larner-Johnson valves, with the exception of one patented design, tend to slam.

In regard to the high head loss for which the

conventional sluice valve is said to be responsible, a valve of this type, of the same diameter as the penstock and working on an average installation under a head of 200 ft. and a penstock velocity of 12 ft. per second, would lower the overall efficiency of the plant by something like 0.1 per cent. This can hardly be described as a high loss, and it is even doubtful whether its capitalised value would cover the additional cost of the rotary type valve to which the authors give so unqualified a blessing.

Yours faithfully,

F. A. KLOUMAN, Director.

J. Blakeborough and Sons, Limited.

Brighouse, Yorkshire.

September 19, 1951.

BOILER AND TURBINE TESTING.

TO THE EDITOR OF ENGINEERING.

SIR,—I have read the abridged version of my paper on "Boiler and Turbine Testing" in your issue of August 31, on page 285, *ante*. There is one paragraph which I might bring to your notice, in that the abridgment has altered the sense. It is on page 286, in the centre column, beginning "The Naval Wing of the National Gas Turbine Establishment possesses equipment . . . and 18,000 r.p.m. for testing compressors." The original reads "Arrangements have been made with the Ministry of Supply for the Naval Wing to have full access to all the facilities of the National Gas Turbine Establishment. These include . . ."

The abridgment implies the possession by the Naval Wing of certain equipment which actually belongs to the National Gas Turbine Establishment and the Ministry of Supply, and to which the Naval Wing has access. To avoid any misconception in the public mind and possible questions as to duplication in possession of important testing facilities, I would be glad if you could publish a correction.

Yours faithfully,

L. A. B. PELLE,

Captain (E), Royal Navy.

Admiralty,
Bath.

September 19, 1951.

TO THE EDITOR OF ENGINEERING.

SIR,—The interesting paper which has been appearing in your columns, on "Boiler and Turbine Testing" reminds me of a story current on the North Eastern Circuit, to which I belonged when in practice at the Bar. It may be new to your readers. A case at the Leeds Assizes involved an inquiry into the method of testing a boiler. John Waugh, an engineer in practice at Bradford, was called as a witness. He was cross-examined by a youthful barrister who probably knew more about law than he did about the laws of physics. Counsel inquired of the witness: "It is not the proper way to test a boiler to do it by steam under pressure?"

Witness: "No, Mister. It is always done by water under pressure."

Counsel: "Have you never heard of a boiler being tested under steam?"

Witness: "I know of one man who did it."

Counsel: "Ah! I thought it was sometimes done. Is your friend coming here as a witness?"

Witness: "I don't think so, Mister. He was last seen going through the roof!"

I might add that John Waugh was a man who required careful handling when in the witness box. He had a brother, William Waugh, who was leader of the Circuit for many years, being a most capable advocate. We juniors took care to be in court if ever William had to cross-examine John—knowing there would be some fun. On one occasion, William propounded a question bearing on a technical matter. John paused for a moment, and then said: "Na, Wully, tha knows that's a very silly question!"

Both brothers have long since gone to their rest. They were beloved by every member of the old Circuit.

Yours faithfully,

W. VALENTINE BALL.

18, Holland-street,
Kensington, W.8.
September 22, 1951.

ENGINEERING, MARINE AND WELDING EXHIBITION AT OLYMPIA.

(Continued from page 364.)

IN the concluding article on the Engineering, Marine and Welding Exhibition, which was held at Olympia from August 30 to September 13, we describe several Diesel engines, as well as an improved safety valve, feed pumps and a refrigerating compressor.

Messrs. Dewrance and Company, Limited, Great Dover-street, London, S.E.1, exhibited representative fittings for high-pressure high-temperature service and industrial steam installations. A demonstration unit, prepared for exhibition purposes, showed the operation of three systems of water-level indication, namely a Dewrance-Yarway remote indicator, a high and low water whistle alarm, and a patent bi-colour illuminated water-level indicator. An electromagnetic relief valve shown was a full-lift valve with a capacity considerably in excess of the conventional safety valve and large enough to make it unnecessary for the spring-loaded valves to blow, except in an emergency, thus reducing operating wear of the safety valves. The electromagnetic valve head is held on its seat by the full boiler pressure, unlike a conventional safety valve, which is held only by the pressure differential; thus, it cannot simmer or chatter. It is wide open or closed tight by unbalanced pressures and its action is governed by positive electrical control.

One of the most interesting exhibits on Messrs. Dewrance's stand was a sectional model of the Dewrance-Consolidated full-lift safety valve, which has been developed to meet the exacting requirements of high-pressure service from 600 lb. to 2,000 lb. per square inch. Early high-pressure safety valves of conventional design, which gave excellent service at 600 lb. per square inch, developed undesirable characteristics at pressures from 900 lb. to 2,000 lb. per square inch. Among other difficulties, consistently tight closure was difficult to obtain, and cracking of the metal was frequently observed in discs and seats. Metallurgy provided only part of the solution. When a safety valve reseats after a pop, a small amount of leakage occurs momentarily between the seat and the disc before the valve becomes tight. This leakage (actually an expansion of gas across an orifice) creates a refrigeration effect which sets up a temperature differential between the point of leakage and the remainder of the circumferential seat contact. These differences in temperature create severe thermal stresses, resulting in warping of the seat contact surfaces, which further aggravate the leakage. At the lower pressure ranges this is not serious, but tests carried out at 1,200 lb. per square inch showed temperature differences of 300 deg. F. and higher around the seat contact circumference, due to the cooling effect of leakage at localised points. In addition, the portion of the disc inside the seat contact surface is exposed to full operating temperatures, whereas the guiding portion of the disc remains comparatively cool and frequently causes cracks to develop in the outer guiding surfaces of the disc. Thus, it became apparent that the solution lay in a design which would accomplish the following three objects: a type of seat which would permit the rapid equalisation of temperature differentials around the seating surfaces; a separation of the seating portion of the disc from the large metal mass of the guiding portion of the disc; and a positive closing action which would result in a clean, sharp cut-off without wiredrawing or dragging of the seat surfaces on closing. The new design of valve, which is in service in a number of installations for pressures up to 2,700 lb. per square inch, incorporates these features and provides a new standard of tightness never before obtained in high-pressure safety valves.

The valve itself is a separate and replaceable unit, and can therefore be made of the most suitable material for the valve face. It is recessed underneath so that a thin lip forms the actual seating part. Steam under pressure behind the seating surfaces permits rapid heat flow through the contact area, thus compensating for the refrigerating effect

mentioned earlier. Thermal stresses are reduced to a minimum and cracking is eliminated by the method of mounting the valve itself in its shell. Rapid and positive closing of the safety valve is ensured by designing the valve so that, as it closes, some of the steam flowing above the valve is momentarily trapped: this boosts the pressure tending to close the valve, which thereupon closes sharply.

The outstanding exhibit on the stand of Messrs. Harland and Wolff, Limited, Belfast, was undoubtedly the gas-engine driven compressor illustrated in Fig. 104, on page 400. This represents a range of gas engine and motor-driven compressors having outputs of from 150 h.p. to 2,750 h.p. which are manufactured by Harland and Wolff, Limited, under licence from the Cooper-Bessemer Corporation, Ohio, U.S.A. The unit illustrated is a four-cylinder 400-brake horse-power spark-ignition gas engine arranged to drive a two-stage compressor. A notable feature of the design is the mounting of the gas-engine and compressor cylinders on a common crankcase so that a single crankshaft can be employed for transmitting the power from the gas engine to the pistons of the compressor. The cylinders of the gas engine are arranged in two banks of two in V formation with two connecting rods joined to a common crankpin bearing. Each crankpin bearing, however, also forms the big-end for the connecting rod of a compressor piston, so that two cylinders of the gas engine drive the low-pressure piston of the compressor and the other two cylinders the high-pressure piston of the compressor. These operate in cylinders arranged in the horizontal plane and bolted to the side of the engine crankcase. The engine works on the two-stroke cycle, induction and exhaust taking place through ports in the cylinder wall in the normal manner. Scavenge air is supplied by two single-acting pumps, one for each crank-throw, the scavenge-pump pistons being formed integrally with the crossheads for the compressor, the cylinder walls serving as crosshead guides. The fuel is not mixed with the ingoing air but is injected into the cylinders at a pressure of approximately 32 lb. per square inch gauge through poppet valves arranged centrally in the cylinder heads and operated through push rods and rocking levers from cams on the crankshaft, the timing being such that injection occurs immediately scavenging is completed.

Other exhibits on the stand of Messrs. Harland and Wolff, Limited, included a six-cylinder dual-fuel engine suitable for coupling to generators, pumping sets, etc., and a rail-traction engine. The latter unit, which is illustrated in Fig. 105, on page 400, has six cylinders with a bore and stroke of 150 mm. and 220 mm., respectively, and develops 330 h.p. on the one-hour rating. It is of the vertical-trunk type and operates on the two-stroke cycle, scavenge air being delivered to the cylinders by a rotary blower through ports in the cylinder walls and exhaust effected through four valves in each cylinder cover. It is claimed that this arrangement gives a brake mean effective pressure comparable with that of a four-stroke cycle engine. This engine is one of a series developed specifically for rail-traction service and is, therefore, of sturdy construction so as to reduce maintenance to a minimum. The bedplate and frame are fabricated-steel structures, the latter incorporating the crankcase, scavenge spaces and the cylinder-cooling jacket. The crankshaft is machined from a solid forging in 3 per cent. nickel-chromium steel and is supported by white-metal-lined steel-backed bearings. Cast-iron cylinder liners are installed and these are machined all over and incorporate the ports for admittance of the scavenge air. Cast-iron or aluminium-alloy pistons can be fitted; they are joined to the crankshaft through forged-steel connecting rods provided with steel-backed whitmetal-lined big ends and phosphor-bronze little ends. A common camshaft is used for operating the exhaust valves and fuel pumps and this is driven from the crankshaft through spur gearing with ground teeth. Individual fuel pumps are provided, one for each cylinder, and they are supplied with fuel under pressure from a booster pump. Forced lubrication is, of course, employed throughout, a gear-type pump delivering the oil through a full-flow filter to the main bearings and then by drillings in the

crankshaft and connecting rods to the big and little ends. For its output the engine is particularly compact, the overall length only being 6 ft. 11½ in. while the height and width are 5 ft. 10½ in. and 3 ft. 2¼ in., respectively.

The exhibits on the stand of Messrs. Sentinel (Shrewsbury), Limited, Shrewsbury, included the Sentinel-Ganz VIJaT Diesel engine, illustrated in Fig. 106, on page 400. It was shown fitted with a heavy-duty power take-off and clutch assembly, but is equally suitable for use in railcars or for such duties as the driving of generators, alternators, etc. It has a bore and stroke of 170 mm. and 24 mm. respectively, and develops 240 brake horse-power at 1,250 r.p.m. on the 12-hour rating with a fuel consumption of 0.402 lb. per brake horse-power per hour. The unit is of robust construction and in view of the comparatively slow speed, should have a long life. The crankcase is an iron casting which is designed to carry the crankshaft in underslung main bearings. The crankshaft with integral driving flange is machined from a high-tensile steel

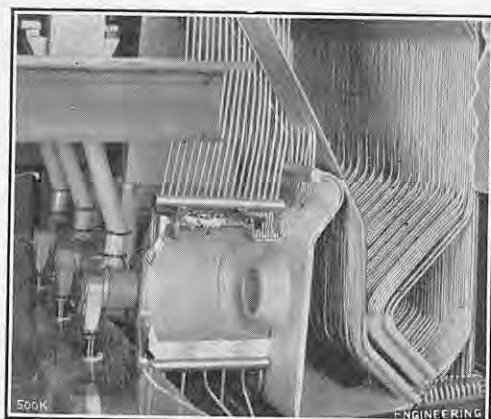


FIG. 108. MODEL OF CYCLONE FURNACE; BABCOCK AND WILCOX, LIMITED.

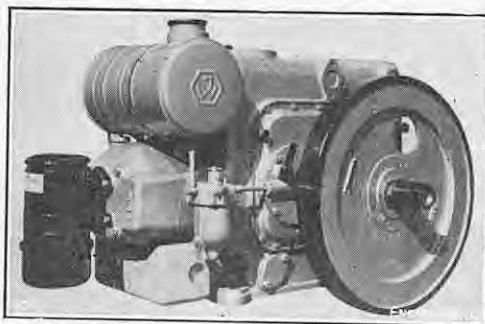


FIG. 109. 15-B.H.P. JENBACH DIESEL ENGINE; GILBERT J. MCCAUL AND COMPANY, LIMITED.

forging, the main journals and crankpins being hollow, but closed by suitable plugs. There are seven main bearings, the top halves of which are lined with whitmetal and the lower halves with a copper-lead alloy. Copper-lead bearings are also used in the big-ends of the connecting rods, which are machined from drop forgings. The pistons are of aluminium Y-alloy and each is provided with three compression and two oil-scraping rings. Fully-floating gudgeon pins are employed and the lubrication system is arranged so that the piston crowns are cooled by jets of oil escaping from the tops of the connecting rods.

Pearlitic cast iron is used for the cylinder blocks, which are cast in pairs and designed so that they may be removed separately from the crankcase. The camshaft is driven through spur gearing from the flywheel end of the crankshaft and the inlet cams have triple profiles which provide for decompression, starting and normal running, respectively, the appropriate cams being brought into the correct positions by moving the shaft axially. This is accomplished by means of a hand lever, the camshaft being retained in the running position by a strong spring. Like the cylinder blocks, the cylinder heads are cast in pairs and each is fitted with an ante-chamber, an injector and the overhead inlet and

exhaust valves, the last-named being operated through push rods and rocking levers in the usual manner. A governor of the centrifugal type is fitted and this operates directly on the fuel-pump control rod. The outstanding features of the engine are probably the design of the combustion chambers and the Sentinel-Ganz fuel pump. Each combustion chamber consists of an ante-chamber which, as previously mentioned, is located in the cylinder head and this communicates through several orifices with a depression formed in the piston crown so that, on injection, the fuel passes through the ante-chamber and through one of the orifices to impinge against a boss on the piston crown. The impact of the fuel on this boss disperses it efficiently throughout the combustion chamber and the partial combustion of the particles of fuel in the ante-chamber causes a rise of pressure which also assists in the uniform distribution of the fuel in the combustion chamber.

In the injection pump, the plunger is only operated by the engine during its suction stroke, the delivery stroke being accomplished by a strong spring held under constant tension regardless of engine speed, and which is released at the correct instant by the cam of the fuel pump. As a consequence, the injection pressure, duration of injection, fuel velocity, etc., depend entirely on the tension of the injection springs and not on the speed of the engine; combustion, therefore, is equally efficient at both low and high speeds. Furthermore, as the pressure developed during the injection period is limited by the dimensions of the springs, no overloading of the fuel pump can occur and excessive stresses cannot be imposed even in the unlikely case of a blocked tube.

All bearings are fed with oil delivered under pressure by a submerged gear-type pump. Primary and secondary filters are incorporated in the lubrication system and, on leaving the secondary filter, the oil passes through a cooler before reaching the main bearings, etc. Cooling water is circulated by a centrifugal pump having a cast-iron body and a bronze impeller driven from the timing gears, the water passing through the oil cooler and exhaust manifold before reaching the cylinder blocks and heads. Starting is accomplished by means of two electric motors, the pinions of which engage a toothed ring on the flywheel in accordance with normal automobile practice; alternatively, the engine can be arranged for compressed-air starting.

Recently, Gleniffer Engines, Limited, Anniesland, Glasgow, W.3, added a new 120-h.p. unit to their range of marine Diesel engines. It was only to be expected, therefore, that the new unit would form the major exhibit on their stand. Actually, a "handed" pair of engines was being shown, each of which was arranged to drive an outboard-turning propeller through a 2-to-1 reducing gearbox. The new engine, a photograph of which is reproduced in Fig. 107, on page 400, is a six-cylinder unit having a bore and stroke of 6 in. and 7 in., respectively, and developing 120 brake horse-power at 900 r.p.m., with a fuel consumption of 0.42 lb. per brake horse-power per hour. In general, the design follows the firm's established practice, being of sturdy but compact construction. An iron casting forms the bedplate, which is designed to accommodate the main bearings. An iron casting is used also for the combined cylinder block and crankcase, which is bolted to the bedplate so that the complete unit can be raised should access be required to the main bearings, etc. For routine inspection and maintenance, however, substantial doors are provided in the sides of the crankcase portion of the casting. The cylinder block is fitted with wet-type liners of cast iron, and these are sealed at the lower end by rubber rings in the usual manner. Aluminium Y-alloy pistons are used, which are joined to the crankshaft by H-section connecting rods drilled centrally to convey oil to the little-end bearings. Separate cylinder heads are fitted, each being equipped with the exhaust and inlet valves, and the fuel injector. The valves are disposed horizontally with a spherical combustion chamber arranged between the valve heads, to which the fuel is delivered by a centrally-placed injector. Each inlet valve is located in a detachable cage, which, when dismantled, enables the exhaust valve to be removed and, although the valves are arranged on opposite sides of the head,

ENGINEERING, MARINE AND WELDING EXHIBITION AT OLYMPIA.

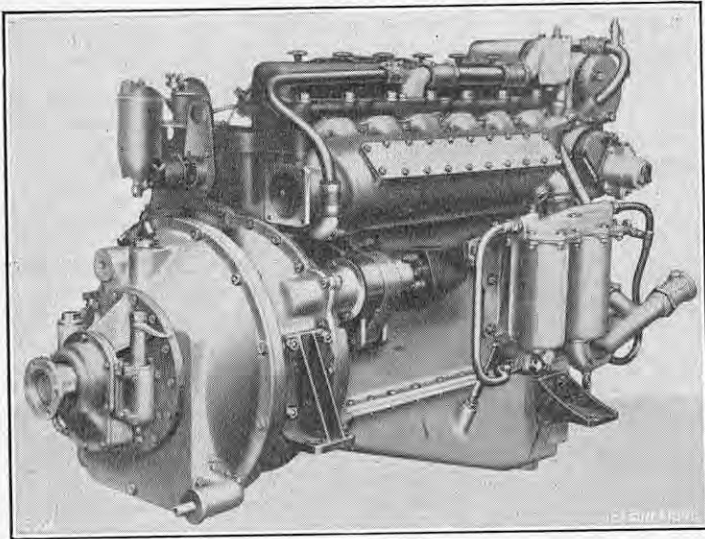


FIG. 110. 120-H.P. MARINE DIESEL ENGINE; FODENS, LIMITED.

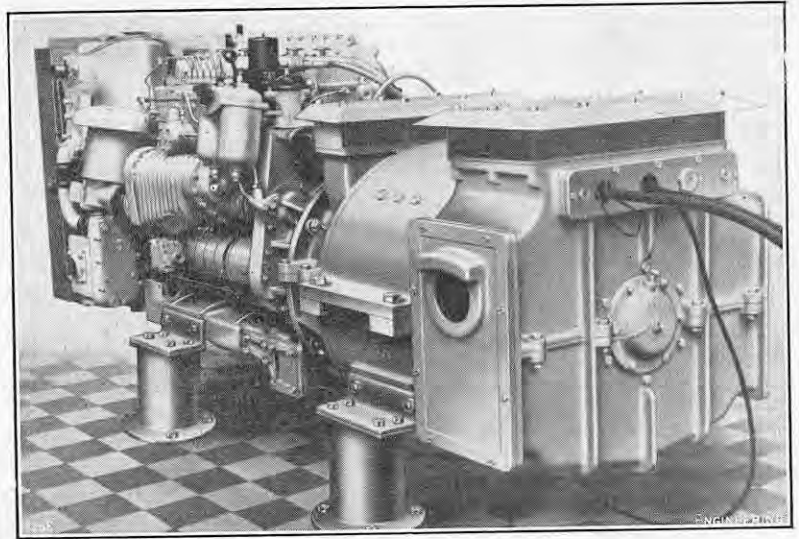


FIG. 111. AUXILIARY GENERATING SET; FODENS, LIMITED.

only a single camshaft is used. This is located high up along one side of the engine and the motion is transferred directly to the exhaust valve by a rocking lever and to the inlet valve by a similar rocker designed to operate a tension rod which, in turn, is connected to the valve tappet. C.A.V. fuel-injection pumps are used, but they are operated by Gleniffer-designed cams and rocker gear arranged so that each pump can be put out of action at will; this permits one cylinder to be used for charging the air bottle used in connection with the air starting motor normally fitted to the engine. Forced lubrication is employed throughout, a plunger pump drawing the oil from the sump and delivering it to a separate tank, while a further plunger pump draws the oil from the tank and delivers it to the crankshaft main bearings, etc.

Messrs. Babcock and Wilcox, Limited, Farringdon-street, London, E.C.4, showed several models of their boilers and associated plant, as well as two exhibits of their subsidiary firm, the Clarkson Thimble Tube Boiler Company, Limited, 15, Fetter-lane, London, E.C.4. The latter consisted of an exhaust-gas heater and a model of an exhaust-gas and simultaneous oil-fired vertical boiler. The exhaust-gas heater, type HEGAR/11, had a heating surface of 11 sq. ft. and was sectioned so that the internal construction could be examined. This unit was designed for use with a number of small lighting sets of 20 to 25 kW, and has also been used at technical colleges for experimental use as an exhaust-gas calorimeter. It is capable of recovering heat up to 30,000 B.Th.U. per hour. The model shown was of a Clarkson boiler designed to utilise the exhaust gases of a ship's Diesel engine so as to supply steam for the "hotel" requirements of the vessel. Using exhaust gas alone, the boiler will supply about 1,200 lb. of steam per hour at 100 lb. per square inch. The same quantity of steam can be obtained by burning oil alone, but if the two methods of heating are used a total output of up to 2,500 lb. of steam per hour can be achieved.

The Babcock and Wilcox exhibits were mainly models of their land and marine boilers and associated plant, including a cyclone steam separator. In this separator, the steam and water mixture from the generator tubes enters steam cyclones tangentially; from there the steam passes out of the top, where corrugated scrubber plates effect the final removal of moisture from the steam. Meanwhile, the water moves downward in a helical path and leaves through vanes that are shaped so as to use the kinetic energy in overcoming the head of water outside the separator. The water level in the drum does not affect the proper functioning of the cyclone and it is therefore possible to carry a higher water level, thus giving more storage capacity.

Another model on this stand was of a Babcock two-drum integral-furnace marine boiler with a

large furnace at the side having stud water walls. The amount of heat absorbed in each section is controlled by partly covering the tubes with chrome ore, thereby ensuring that the flame is not over-cooled at any load. Inferior grades of oil can be burned efficiently even at low ratings.

Fig. 108, on page 405, shows a model of a Babcock Cyclone furnace which was displayed at the exhibition. The Cyclone furnace comprises a completely water-cooled cylindrical chamber in which crushed coal, maintained in a swirling vortex by primary and secondary air streams, is burned efficiently and at high rates of combustion with very low excess air and high ash recovery. The ash is tapped off in a molten state into a water-filled slag tank. This novel method of firing has been fully tested and proved under practical service conditions, and Messrs. Babcock and Wilcox are now constructing a large Radiant boiler designed for firing by means of Cyclone furnaces.

Messrs. Gilbert J. McCaul and Company, Limited, 16, St. James's-street, London, S.W.1, showed a number of Diesel engines made by Jenbacher Werke, Jenbach, Austria, for whom they are agents. The engines included the JW 15, shown in Fig. 109, on page 405, the characteristics and performance of which were the subject of an article by Professor S. J. Davies, which appeared in *ENGINEERING*, vol. 168, pages 465 and 493 (1949). This engine is used for many purposes, including the driving of machinery, dynamos, pumps, etc.; as a fixed or portable unit for agricultural machines; in building and constructional work for driving concrete mixers etc.; and in small locomotives, tractors and other vehicles. There is one four-stroke cylinder, 115-mm. bore and 145-mm. stroke, which is evaporative-cooled, and the output of the engine is from 8 h.p. to 15 h.p. for speeds from 800 r.p.m. to 1,500 r.p.m. The total weight is approximately 814 lb. The fuel consumption is from 0.42 lb. to 0.44 lb. per brake horse-power per hour, and the lubricating-oil consumption is about 0.01 lb. per brake horse-power per hour.

Messrs. Fodens Limited, Elworth Works, Sandbach, Cheshire, were represented at the exhibition for the first time and were showing a 75/120-h.p. marine-propulsion oil engine and a 35/60-kW generating unit powered by the same engine. The Foden marine-propulsion unit is illustrated in Fig. 110, herewith. There are six cylinders with a bore and stroke of 85 mm. and 120 mm., respectively, and for the intermittent rating it develops 120 brake horse-power at 2,000 r.p.m. For continuous duty the rating is 102 brake horse-power at 1,800 r.p.m. and for heavy duty, 75 brake horse-power at 1,500 r.p.m. The design is based on the heavy-duty road-transport engine developed by this company during the last few years and described from time to time in *ENGINEERING*. It is a super-

charged uniflow-scavenged two-stroke cycle compression-ignition engine with the design based on the Kadenacy principle. A low-pressure Root's-type blower delivers the scavenging air to a common air chest from which it flows into the cylinders through a series of ports formed in the liners and designed so that they impart a high degree of swirl to the air. Exhaust valves are located in the cylinder head, there being two valves to each cylinder, and they are operated by push rods and rocking levers in the usual way. Although of comparatively light weight, the engine is of robust construction, considerable use being made of light alloys; the combined crankcase and cylinder block, for example, is cast from an aluminium alloy. A unit type of fuel pump is used; this is fitted with a hydraulic governor and delivers the fuel to single-hole injectors located in the cylinder heads. Engine cooling is accomplished by a fresh-water closed system, in conjunction with a Serck heat exchanger, the fresh water being circulated by a centrifugal pump and the seawater by a Megator triple-shoe self-priming pump. The Serck heat exchanger is a dual unit, being used for cooling the lubricating oil as well as the fresh water. The reverse gear is a standard unit as manufactured by the Self-Changing Gear Company, Coventry, and incorporates this firm's system of hydraulic operation. Equipment supplied with the engine includes 24-volt electrical starting gear, and provision is made for installing a bilge pump should this be required.

The generating set is illustrated in Fig. 111, herewith. It is fitted with the same type of engine as that just described, which can be arranged for cooling either by means of a heat exchanger or a radiator, the cooling of the lubricating oil forming an integral part of each system. Assuming a generator efficiency of 90 per cent., units developing up to 60 kW direct current at 1,800 r.p.m. and 50 kW alternating current at 1,500 r.p.m. can be supplied. Both generators and alternators are of the single-bearing type, flange-mounted to the engine flywheel casing, and resilient mountings for the bearing feet can be provided if required. The unit is governed hydraulically in conformity with B.S.S. 649 and an automatic shut-down device can be supplied as an extra fitting. This is incorporated in the control panel and set so that any variation outside predetermined limits of engine speed, oil pressure and coolant temperature causes the engine to be stopped. The causes of stoppage are indicated by warning lights.

Messrs. G. and J. Weir, Limited, Cathcart, Glasgow, S.4, exhibited a pair of modern direct-acting feed pumps; a turbine-driven feed pump, the compactness of which was in direct contrast to an old pair of feed pumps, shown alongside on the stand, which were removed from the Aquitania after she had steamed about 3,000,000 miles; also

ENGINEERING, MARINE AND WELDING EXHIBITION AT OLYMPIA.

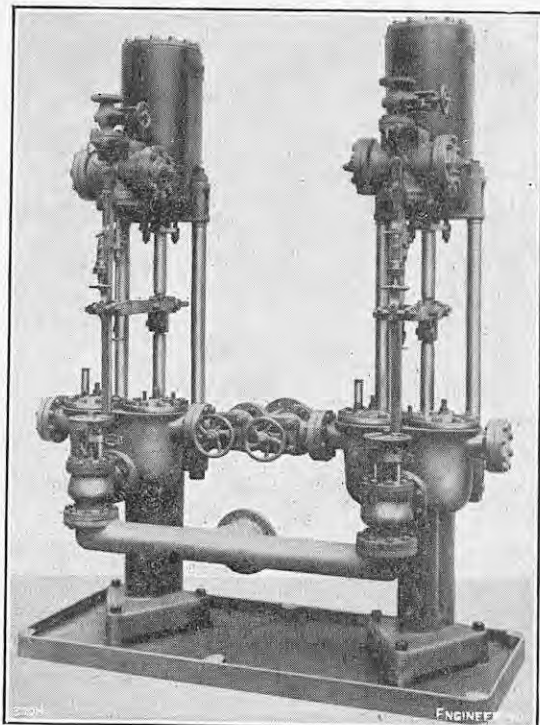


FIG. 112. PAIR OF BOILER FEED PUMPS; G. AND J. WEIR, LIMITED.

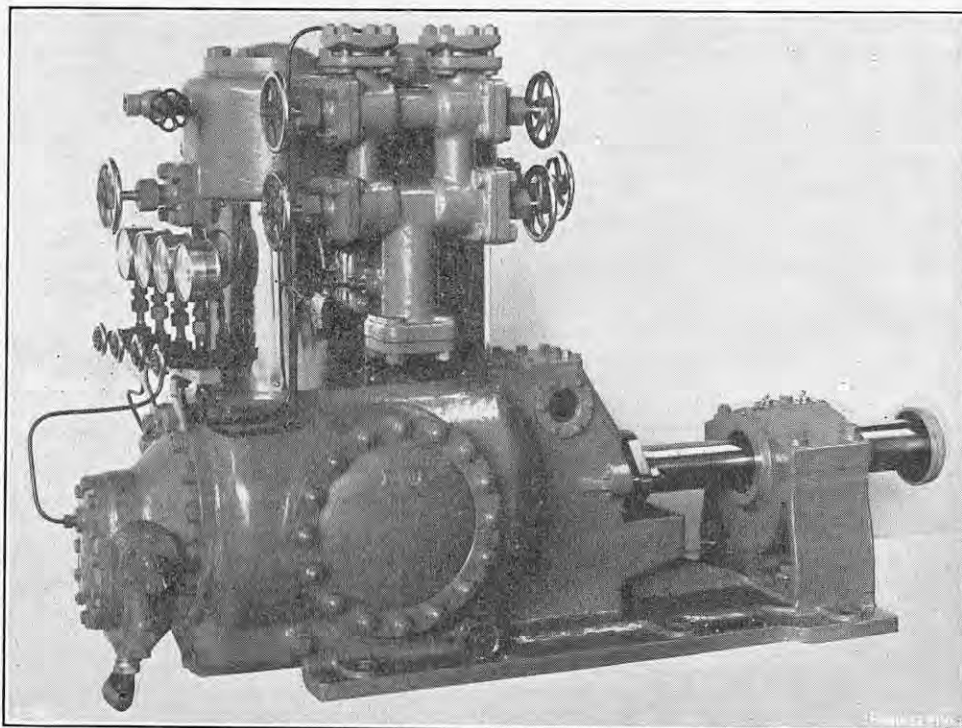


FIG. 113. TWIN AMMONIA COMPRESSOR; G. AND J. WEIR, LIMITED.

a motor-driven air compressor and an ammonia compressor for refrigeration service. The direct-acting feed pumps, shown in Fig. 112, herewith, were of the firm's standard design. Each pump has a single steam cylinder and a double-acting water end. The valve gear is positive, i.e., the steam valve can never be in such a position that the pump will not start immediately steam is turned on. The only position in which the steam valve can rest is at full travel, for either an up or a down stroke of the piston. The steam cylinder is of cast iron, lagged and covered with planished sheet steel. The pump is also of cast iron, but with a gunmetal liner. The construction of the rod depends on the size of the pump: for the smaller sizes it is in one piece of rolled naval brass; for the 5-in. by 12-in. pump it is in one piece of stainless steel; and for larger sizes it is in two pieces, i.e., a piston rod of mild steel and a pump rod of stainless steel, joined by a forged steel crosshead. The materials of the valves, valve seats and steam pistons also depend on the size of the pump; in all cases, however, the water piston is of gunmetal and is fitted with ebomite packing rings. These Weir pumps are suitable for pump-discharge pressures up to 300 lb. per square inch and boiler pressures up to 250 lb. per square inch. They will normally operate with and against pressures down to 40 lb. per square inch, though they can be supplied for a minimum pressure of 25 lb. per square inch.

The refrigerating compressor, illustrated in Fig. 113, herewith, was a standard 6-in. by 6-in. twin-cylinder unit fitted with 50 per cent. capacity reduction valves. Under standard conditions, i.e., 5 deg. F. evaporation temperature and 86 deg. F. condensing temperature, and running at its maximum speed of 400 r.p.m., the machine will handle 216,000 B.Th.U. per hour at 28 brake horse-power; and under normal conditions, condensing at 90 deg. F. and evaporating at 0 deg. F., its output is 180,000 B.Th.U. per hour and it will deal comfortably with 50,000 cub. ft. The compressor is particularly suitable for small cargo spaces and for the provision rooms on large ships such as the Himalaya class. The compressor can also be supplied for operating on Freon 12; with a maximum speed of 600 r.p.m. and under standard conditions (5 deg. F. evaporation and 86 deg. F. condensing), its output is then 144,000 B.Th.U. per hour at 24 h.p. Alternatively, if the machine is evaporating at 0 deg. F. and condensing at 90 deg. F. its output is 127,000 B.Th.U. per hour.

FORTHCOMING EXHIBITIONS AND CONFERENCES.

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

9TH INTERNATIONAL ROAD CONGRESS.—Monday, September 24, to Monday, October 8, at Lisbon. Sponsored by the Permanent International Association of Road Congresses, 24, Rue de l'Université, Paris. Apply to the joint honorary secretary, British organising committee, International Road Congress, Berkeley Square House, London, S.W.1. (Telephone: MAYfair 9494.)

BIRMINGHAM MIDLANDS IDEAL HOME EXHIBITION.—Wednesday, September 26, to Saturday, October 20, at Bingley Hall, Birmingham. Organisers: Herbert Daniel Exhibitions, Ltd., 15, Dover-street, London, W.1. (Telephone: MAYfair 5846.)

INTERNATIONAL NAUTICAL EXHIBITION (MARITIME AND INLAND WATERWAYS INDUSTRIES).—Saturday, September 29, to Sunday, October 14, at Paris. Organised by the Chambre Syndicale des Industries Nautiques, 8, Rue Jean-Goujon, Paris, 8e.

PACKING EXHIBITION.—Thursday, October 4, to Sunday, October 14, at Paris. Details obtainable from the secretary, Salon de l'Emballage, 40, Rue du Colisée, Paris, 8e.

INTERNATIONAL MOTOR-CAR, CYCLE, AND SPORTS EXHIBITION.—Thursday, October 4, to Sunday, October 14, at Paris. Details obtainable from the secretary, Chambre Syndicale des Constructeurs d'Automobiles, Grand Palais, 111, Avenue Alexandre, Paris, 8e.

ASLIB ANNUAL CONFERENCE.—Friday, October 5, to Monday, October 8, at Ashorne Hill, near Leamington Spa. Apply to the secretary, Aslib, 4, Palace-gate, London, W.8. (Telephone: WESTern 6321.) See also our issue of March 23, page 350.

CONFERENCE ON FUEL AND POWER SHORTAGE.—Tuesday and Wednesday, October 9 and 10, at the Dorchester Hotel, Park-lane, London, W.1. Organised by the Combustion Engineering Association, 6, Duke-street, St. James's, London, S.W.1. (Telephone: WHITEhall 5536.) See also page 329, *ante*.

33RD NATIONAL METAL CONGRESS AND EXPOSITION.—Thursday, October 11, to Saturday, October 20, at Detroit, Michigan, U.S.A. Apply to Mr. W. H. Eisenman, secretary, American Society for Metals, 7301, Euclid-avenue, Cleveland 3, Ohio, U.S.A. See also our issue of January 19, page 79.

WORLD METALLURGICAL CONGRESS.—Monday, October 15, to Friday, October 19, at Detroit, Michigan, U.S.A., under the auspices of the American Society for Metals. Apply to Mr. W. H. Eisenman, secretary, American Society for Metals, 7301, Euclid-avenue,

Cleveland, 3, Ohio, U.S.A. See also our issue of January 19, page 79.

FOURTH LONDON REGIONAL DISPLAY.—Tuesday and Wednesday, October 16 and 17, at the Royal Horticultural Society's new hall, Greycoat-street, London, S.W.1. Organised by the Engineering Industries Association, 9, Seymour-street, London, W.1. (Telephone: WELbeck 2241.)

SUSSEX INDUSTRIES EXHIBITION AND TRADE FAIR.—Wednesday, October 17, to Saturday, October 27, at the Corn Exchange, Brighton. Organisers: Federation of Sussex Industries, 3, Marlborough-place, Brighton. (Telephone: Brighton 26189.)

ECONOMICS OF METALS.—Wednesday and Thursday, October 17 and 18, at the Park Lane Hotel, Piccadilly, London, W.1. See page 403.

INTERNATIONAL MOTOR EXHIBITION.—Wednesday, October 17, to Saturday, October 27, at Earl's Court, London, S.W.5. Organised by the Society of Motor Manufacturers and Traders, Ltd., 148, Piccadilly, London, W.1. (Telephone: GROsvenor 4040.)

INTERNATIONAL CYCLE AND MOTOR-CYCLE SHOW.—Sunday, October 28, to Sunday, November 4, at Frankfurt. Organised by the Internationale Fahrrad- und Motorrad Ausstellung, Frankfurt-am-Main.

26TH INTERNATIONAL CYCLE AND MOTOR-CYCLE SHOW.—Saturday, November 10, to Saturday, November 17, at Earl's Court, London, S.W.5. Organisers: British Cycle and Motor-Cycle Manufacturers' and Traders' Union, Ltd., The Towers, Warwick-road, Coventry. (Telephone: Coventry 62511.)

BUILDING EXHIBITION.—Wednesday, November 14, to Wednesday, November 28, at Olympia, London, W.14. Organised by the Building Trades Exhibition, Ltd., 4, Vernon-place, London, W.C.1. (Tel.: HOLborn 8146.)

INTERNATIONAL SYMPOSIUM ON ABRASION.—Wednesday and Thursday, November 14 and 15, at Rubber-Stichting, Oostsingel, Delft, Holland. Apply to the secretary of the symposium, Rubber-Stichting, Postbox 66, Delft. See also page 243, *ante*.

INTERNATIONAL CYCLE AND MOTOR-CYCLE EXHIBITION.—Saturday, December 1, to Monday, December 10, at Milan. Organised by the National Association of Cycle, Motor Cycle and Accessories Manufacturers, Via Macchi 32, Milan, Italy.

SMITHFIELD SHOW AND AGRICULTURAL MACHINERY EXHIBITION.—Monday, December 3, to Friday, December 7, at Earl's Court, London, S.W.5. Organised by the Smithfield Show Joint committee, 148, Piccadilly, London, W.1. (Telephone: GROsvenor 4040.)

SYMPOSIUM ON CORROSION OF BURIED METALS.—Wednesday, December 12, at 4, Grosvenor-gardens, Westminster, London, S.W.1. Organised by the Iron and Steel Institute. Apply to the secretary of the Institute at the address given above. (Telephone: SLOane 0061.) See also page 190, *ante*.

NEW BUILDING MATERIALS AND TECHNIQUES EXHIBITION.—Friday and Saturday, January 18 and 19, 1952, at the Royal York Hotel, Toronto. *Agents:* Tides, Ltd., 1, Hanover-square, London, W.1. (Telephone: MAYfair 1101.)

INTERNATIONAL AGRICULTURAL MACHINERY EXHIBITION.—Sunday, February 17, to Sunday, February 24, 1952, at Brussels. Apply to the secretary, Société de Mécanique et d'Industries Agricoles, S.A., 29 Rue de Spa, Brussels, Belgium.

GERMAN INDUSTRIES FAIRS, HANOVER.—*Light Industries:* Wednesday, February 27, to Sunday, March 2, 1952, at Hanover. *Heavy Industries:* Sunday, April 27, to Tuesday, May 6, 1952, at Hanover. *Agents:* Schenkers, Ltd., 27, Chancery-lane, London, W.C.2. (Telephone: HOLborn 5595.)

INTERNATIONAL AGRICULTURAL MACHINERY EXHIBITION.—Tuesday, March 4, to Sunday, March 9, 1952, at the Parc des Expositions. Organised by the Union des Expositants des Machines et d'Outillages Agricoles, 38 Rue de Chateaudun, Paris 9e.

VIENNA SPRING FAIR.—Sunday, March 9, to Sunday, March 16, 1952. *Agents:* British Austrian Chamber of Commerce, 29, Dorset-square, London, N.W.1. (Telephone: PADdington 7646.)

MANCHESTER BUILDING TRADES EXHIBITION.—Tuesday, March 25, to Saturday, April 5, 1952, at the City Hall, Deansgate, Manchester. Apply to Provincial Exhibitions, Ltd., City Hall, Deansgate, Manchester. (Telephone: Deansgate 6363), or to the London agent at 167, Oakhill-road, Putney, London, S.W.15. (Telephone: VANDyke 5635.)

FIRST SUPERVISING ELECTRICAL ENGINEERS NATIONAL EXHIBITION.—Friday and Saturday, March 28 and 29, 1952, at the Royal Horticultural Society's new hall, Greycoat-street, Westminster, London, S.W.1. For further information, apply to the conference secretary, Mr. P. A. Thorogood, 35, Gibbs-green, Edgware, Middlesex. See also page 266.

EXHIBITION OF BRITISH COMPONENTS, VALVES AND TEST GEAR FOR THE RADIO, TELEVISION, ELECTRONIC AND TELECOMMUNICATION INDUSTRIES.—Monday to Wednesday, April 7 to 9, 1952, at Grosvenor House, Park-lane, London, W.1. Organised by the Radio and Electronic Component Manufacturers' Federation, 22, Surrey-street, Strand, London, W.C.2. (Telephone: TEMple Bar 6740.)

SWISS INDUSTRIES FAIR.—Saturday, April 19, to Tuesday, April 29, 1952, at Basle. Apply to the Division Economique, Swiss Legation, 18, Montague-place, London, W.1. (Telephone: PADdington 0701.)

ROYAL SANITARY INSTITUTE HEALTH CONGRESS.—Tuesday, April 22, to Friday, April 25, 1952, at Margate. Apply to the secretary, the Royal Sanitary Institute, 90, Buckingham Palace-road, Westminster, London, S.W.1. (Telephone: SLOane 5134.)

TELEVISION CONVENTION.—Monday, April 28, to Saturday, May 3, 1952, at Savoy-place, Victoria-embankment, London, W.C.2. Organised by the Radio Section of the Institution of Electrical Engineers. Apply to the secretary of the Institution at the address given above. (Telephone: TEMple Bar 7676.) See also pages 265 and 371, ante.

BRITISH INDUSTRIES FAIR.—Monday, May 5, to Friday, May 16, 1952, at Earl's Court, London, S.W.5, and Olympia, London, W.14; and Castle Bromwich, Birmingham. Particulars from the director, British Industries Fair, Board of Trade, Lacon House, Theobald's-road, London, W.C.1. (Telephone: CHAncery 4411); or the general manager, British Industries Fair, 95, New-street, Birmingham, 2.

INTERNATIONAL EXHIBITION OF ELECTRICAL APPLIANCES.—Tuesday, May 13, to Tuesday, May 27, 1952, at Bologna. Apply to the Ente Autonomo Fiera di Bologna, via Farina 6, Bologna.

ELECTRICAL ASSOCIATION FOR WOMEN, 27TH ANNUAL CONFERENCE.—Monday, May 19, to Saturday, May 24, 1952, at Scarborough. Apply to the director, the Electrical Association for Women, 35, Grosvenor-place, London, S.W.1. (Telephone: SLOane 0401.)

CANADIAN INTERNATIONAL TRADE FAIR.—Monday, June 2, to Friday, June 13, 1952, at Toronto. Apply to Miss M. A. Armstrong, Canadian Government Exhibition Commission, Canada House, Trafalgar-square, London, S.W.1. (Telephone: WHItchall 8701.)

MECHANICAL HANDLING EXHIBITION.—Wednesday, June 4, to Saturday, June 14, 1952, at Olympia, London, W.14. Apply to the Exhibition organisers, Iliffe and Sons, Ltd., Dorset House, Stamford-street, London, S.E.1. (Telephone: WATerloo 3333.)

ROYAL AGRICULTURAL SHOW.—Tuesday, July 1, to Friday, July 4, 1952, at Newton Abbot. Organised by the Royal Agricultural Society of England, 16, Bedford-square, London, W.C.1. (Telephone: MUSeum 5905.)

EXHIBITION OF CHEMICAL APPARATUS, FRANKFURT.—See page 391.

LABOUR NOTES.

CLAIMS for substantial increases in wages, which, if granted in full, would add many millions of pounds to the nation's total wage bill, continue to be presented. Negotiations on a number of such claims have been in progress during the last few days. The joint demands of the three major railway unions for an all-round increase of 10 per cent. for railway operating staffs were further discussed at the adjourned meeting of the Railway Staff National Council on September 21. The meeting of the Council commenced on the previous Tuesday and was adjourned until September 21, to enable the unions concerned to reconsider their attitude. Little advance towards a settlement of the claims appears to have been made at the adjourned meeting, however, and it was eventually agreed that the claims should be referred to the Railway Staff National Tribunal for arbitration.

It may be recalled that the unions' claims were rejected by the Railway Executive and that the Executive later presented a counter offer, which would have provided increases varying from 4s. 6d. to 15s. weekly for the operating staff, and of up to 50l. a year for employees in the salaried grades. The National Union of Railwaymen estimated that these increases would amount to an average for all members of the three unions of less than 5 per cent., and considered that such a small increase was quite insufficient. The other two unions concerned, the Associated Society of Locomotive Engineers and Firemen and the Transport Salaried Staffs' Association, were equally firm in their refusal of the Executive's offer. The reference of the claims to the Railway Staff National Tribunal for arbitration usually marks the final stage in negotiations on railway wage claims, but Mr. J. B. Figgins, the general secretary of the N.U.R., at the close of the adjourned meeting of the Railway Staff National Council, expressed the opinion that the Tribunal's findings would not be binding on the unions, which would be free to accept or reject them. The hearings before the Tribunal will commence at an early date and will take place in public.

Negotiations on the wage claim of some 250,000 employees in the shipbuilding and ship-repairing industries for an overall increase of 20s. a week were commenced in London on Tuesday last at a meeting between officials of the Confederation of Shipbuilding and Engineering Unions and representatives of the Shipbuilding Employers' Federation. The meeting is understood to have been largely occupied in hearing the case for the men, which the Confederation presented. Among other requests, the Confederation asked that merit craft rates and district differentials should be maintained. The Federation undertook to give careful consideration to the Confederation's case and a further meeting of representatives of the two sides will be held in the near future to receive the Federation's reply. The Federation, in the meanwhile, will consult its constituent associations.

The claim of the shipbuilding and ship-repairing employees is one of three demands, which together cover all workpeople, men and women, employed in the engineering, shipbuilding, and ship-repairing industries. Collectively, the claims are applicable to some 2,500,000 persons and it is estimated that they would add about 125l. million a year to the nation's wage bill, if granted in full. The other two claims, the one on behalf of men employees in the engineering industry, and the other on behalf of women, will be discussed at meetings between representatives of the Engineering and Allied Employers' National Federation and the Confederation of Shipbuilding and Engineering Unions, at an early date. The claim on behalf of the men employees in engineering is expected to be presented to the employers on October 10.

Other claims, in addition to the demand for a wage increase, were considered at the meeting on Tuesday last between the Confederation and the Shipbuilding Employers' Federation. The employers gave their reply to a request that a five-day week should be worked all through the year, which had been put forward by the Confederation at an earlier joint meeting, and felt that this claim must be rejected. At present, a five-day week is worked in the shipbuilding and ship-repairing industry between March and October, but, during the winter months, a five-and-a-half day week is the rule. The Confederation officials were informed, however, that the employers would reconsider the recent claim for an additional week's annual holiday with pay, which it had been the original intention of the Federation to reject.

Wage claims, complementary to those presented on behalf of railway operating staffs and employees in the engineering industry, have been put forward for a

"substantial" increase in the wage rates paid to men engaged in the railway workshops. It is estimated that the number of railway shopmen involved in this claim is about 130,000. Preliminary consideration was given to these demands at a meeting of the two sides of the Railway Shopmen's National Council in London on Tuesday last. The Council comprises members of the Railway Executive and of the two unions, the National Union of Railwaymen and the Confederation of Shipbuilding and Engineering Unions, to which the shopmen belong. It was announced subsequently that negotiations on the claim would be continued at a further meeting of the Council to be held shortly.

Scientific assistants in the engineering industry are to be granted minimum rates of pay, in accordance with the terms of an award by the Industrial Disputes Tribunal, which was announced on Tuesday last. The new rates will range from 6l. to 7l. 15s. a week, according to the age of the person concerned and the district in which he is employed. This is the first time that minimum rates have been made applicable to adult scientific assistants in engineering, and some 8,000 persons will benefit from the award.

A special conference of unions interested in the welfare of clerical employees has been organised by the National Federation of Professional Workers, and is due to take place in London on October 12. The main objects of the conference, as expressed by the Federation, are to consider the possibility of pooling the Union's resources respecting the collection of information relating to salaries and conditions of service of clerical workers, correlating standards of remuneration, and establishing machinery for consultation among themselves. The conference is intended to be exploratory only, but there appears to be some expectation that it may be the first step towards the setting up of permanent joint machinery, for the consideration of problems concerning clerical employees generally.

References to the demands made by the Government's rearmament programme on the services of the working population of Great Britain were made by Mr. Alfred Robens, the Minister of Labour, in a speech at Whitley Bay, Northumberland, on Tuesday last. He expressed the opinion that, if the aims of the Government respecting rearmament were to be fulfilled, it would be necessary to transfer about half-a-million persons, during the course of the next three years, from their present tasks to work in connection with production for the defence programme. That was the problem that had to be solved. He had rejected the compulsory direction of labour, as a possible means of overcoming the difficulties associated with transferring workpeople from industry to industry and from district to district, because such direction was generally disliked. Mr. Robens said that he considered that the introduction of between five and ten thousand Italian workers and the greater use of part-time women employees would contribute towards a solution. Industrialists should explore the possibility of employing more women for part-time duties in their works, but care should be taken not to invite mothers with young children.

The decline in colliery man-power continues to give cause for some concern. Although the decrease in the number of men employed at the coal face was not so prominent during the week before last, as it has been in some of the preceding weeks, statistics issued by the Ministry of Fuel and Power show that the total number of miners in Great Britain declined from 696,700 on September 8, to 696,100 on September 15, a loss of six hundred men in one week. Face workers, however, declined in number by one hundred only, from 286,300 on September 8, to 286,200 on September 15. The average weekly attendance of miners at the pits during the 37 weeks ended September 15, 1951, was 699,900, of whom 287,700 were employed at the coal face. The average weekly attendance during the corresponding period last year was 700,800, of whom 289,600 were employed at the coal face.

The average number of shifts worked per colliery wage earner improved from 4.65 for the period ended September 16, 1950, to 4.73 for the period ended September 15, 1951. Absenteeism increased during the same corresponding periods, from a total of 12.11 per cent. (voluntary absenteeism 5.10 per cent.) for 1950, to a total of 12.31 per cent. (voluntary absenteeism 5.60 per cent.) for 1951. Output per manshift rose from 3.09 tons at the coal face (1.18 tons overall) in 1950, to 3.16 tons at the coal face (1.21 tons overall) in 1951. The amount of saleable coal produced during the first 38 weeks of 1951 totalled 160,159,000 tons, of which 151,975,000 tons were deep-mined and 8,184,000 tons opencast. The comparative figures for the corresponding period in 1950 were 156,331,000 tons produced in all, of which 146,988,000 tons were deep-mined and 9,343,000 tons were opencast.

A THEORY OF IMPERFECTION FOR THE VIBRATIONS OF ELASTIC BODIES OF REVOLUTION.*

By S. A. TOBIAS, Ph.D.

WHENEVER the attempt is made to formulate a mathematical theory to describe a natural phenomenon, certain initial assumptions have to be made. These can be divided into two categories which are derived by the process of classification and the process of abstraction. Phenomena have to be classified according to their common attributes and their essential qualities must be abstracted, even at the loss of their uniqueness or individuality, if a mathematical treatment is to be made possible. It has been pointed out that "mathematics can never tell us what is, only what would be if . . ."

In the theory of vibration the process of classification normally involves the assumption of "small" vibrations, which obviously neglects the fact that at reson-

ance, such a condition is not even approximated. The process of abstraction results in the assumption of a certain perfection of the system under investigation. Since, in bodies which occur in normal practice, the density, the elastic properties, etc., vary little, it is assumed that they are constant throughout the body. A further important and not sufficiently recognised assumption is made, namely, that dimensions can be kept with mathematical accuracy. Whereas for experimental purposes in the laboratory this can be approximated even if not achieved, in the normal engineering practice almost always a compromise has to be made between the desire for dimensional accuracy and the accompanying increase in productive costs.

The process depicted above is not only characteristic of the scientific method but of the working of the human mind on any problem in general. A better approximation in the description of phenomena encounters two difficulties. The first difficulty is technical and manifests itself in an increase in the number of variables affecting phenomena. Mathematically speaking, it results in the difficulty of setting up the equations describing phenomena and in finding a solution for them.

The second difficulty is fundamental and no improvement of the mathematical apparatus can overcome it. It is due to the fact that some variables are not only uncontrollable, but the way in which they vary is unknown and varies from one specific case to another. For instance, it is known that the density or the elastic properties are not uniform in any body. However, little practical advantage can be achieved by solving the problem of a vibrating rod with varying density or varying elasticity, by introducing these characteristics as new variables, since some assumption regarding the function according to which they vary has to be made. The number of these functions is

inevitably limited, whereas in reality an infinite variety, itself never repeating, is encountered. At this stage a distinction has to be made. Laws of nature have two aspects, a quantitative and a qualitative. When the aforesaid difficulty is encountered it must be realised that there is a limit to the quantitative approximation obtainable and that beyond a certain stage qualitative prediction is all the investigator can hope for. Thus, if the necessity arises to consider the effect of the variation of density or elasticity, etc., upon the vibrations of a rod, the investigator must realise the impossibility of calculating the natural frequencies and the modes with a great degree of accuracy and should primarily concern himself with the question whether or not the neglecting of these variables will alter the phenomenon qualitatively.

In general, for statical problems, a high degree of approximation is unnecessary. Consider, for instance, a cylindrical rod being strained by two forces acting at each end. It is realised that, contrary to the mathe-

a large variety of seemingly entirely different systems, the simplest of which is the string, the most complicated the bell. Any combinations of these elemental types, which conform with the criteria of cylindrical symmetry, are included in the theory (to be published later). The mathematical part of the present theory is based upon the fact that the amplitude expressions of flexural and some other types of vibration of each member of the class are fundamentally of the same form. This relationship is due to the common criterion of cylindrical symmetry, as a consequence of which the members can be regarded as being generated from each other by a gradual change of curvature and dimensions.

Before we describe the phenomena due to imperfections, we must define the concepts of "mathematical perfection" and "dynamical perfection." A body is mathematically perfect if its dimensions and physical characteristics conform with the mathematical assumptions made in its theoretical treatment. In the theory of vibration this means, in general, that the physical

Fig. 1. Circular Plates

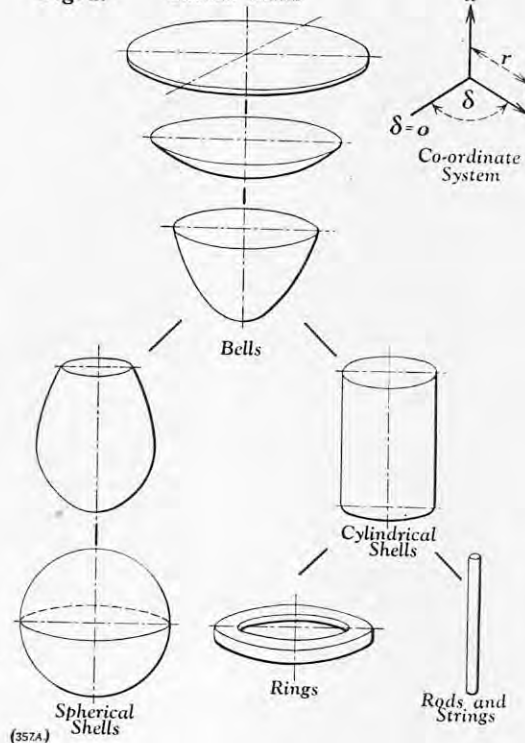


Fig. 2.



Fig. 3.

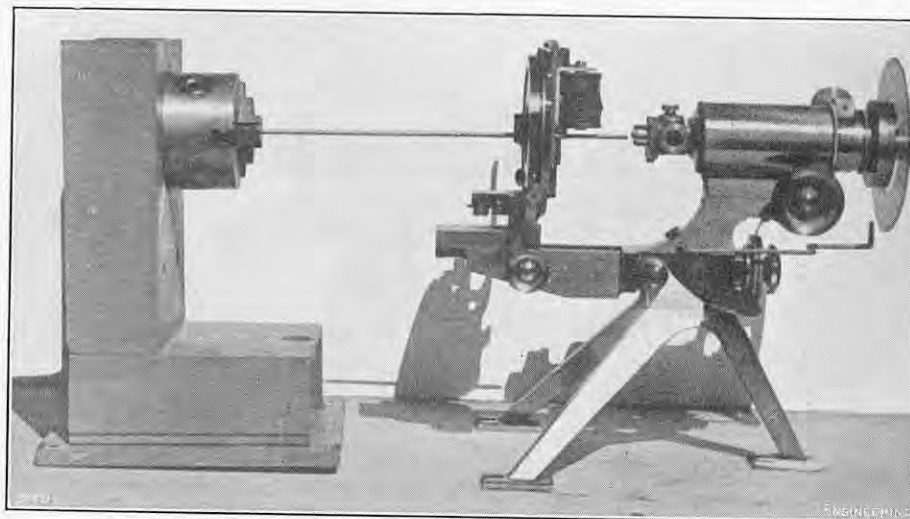
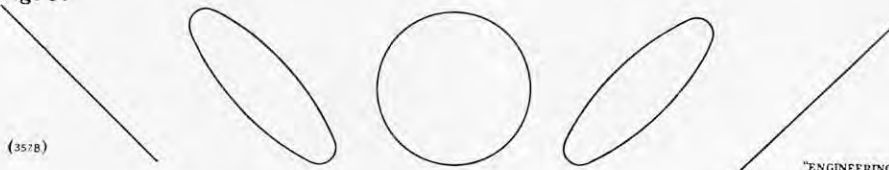


FIG. 4. EXPERIMENTAL APPARATUS.

mathematical assumptions, the strain-stress distribution over any cross-section is not uniform, that the rod is not dimensionally perfect, that the surface will not be free from irregularities; or, in short, that the rod is "imperfect." All these imperfections make little difference to the reliability of the calculations. However, if we come to dynamical problems we might encounter new phenomena which are due to the imperfections and then the initial assumptions ought to be re-examined. Thus, in our example, if we are concerned with varying forces the problem of fatigue arises and then dimensional or surface imperfections will make a considerable difference between calculated and practical results. In cases like these, even a qualitative solution only might be of great help, especially if, with a suitable statistical analysis of experimental results, the probability whether a certain phenomenon is likely to occur can be predicted.

Various observations and preliminary experiments have shown that the effect of imperfections upon the vibrations of bodies of revolution cannot be neglected. Owing to the possibility of applying the Lagrange equation, the influence of the imperfections could be traced through the kinetic energy, the potential energy and the dissipation function. Although the fundamental difficulty of the uncertainty of certain variables was not eliminated, this procedure permitted at least the making of general qualitative statements as to the behaviour of the system if imperfections are present.

Fig. 1 shows the more important members of the class of the bodies of revolution. The class comprises

characteristics are uniform throughout. In the case of dynamical perfection, the dimensions and/or physical characteristics need not conform with the mathematical assumptions made, but their deviation is such that they do not alter qualitatively the ensuing phenomenon. Practically speaking, a body of revolution is dynamically perfect as long as the symmetry of revolution is maintained, that is, as long as the "imperfections" are a function of x and/or r but are independent of the angle δ (Fig. 1).

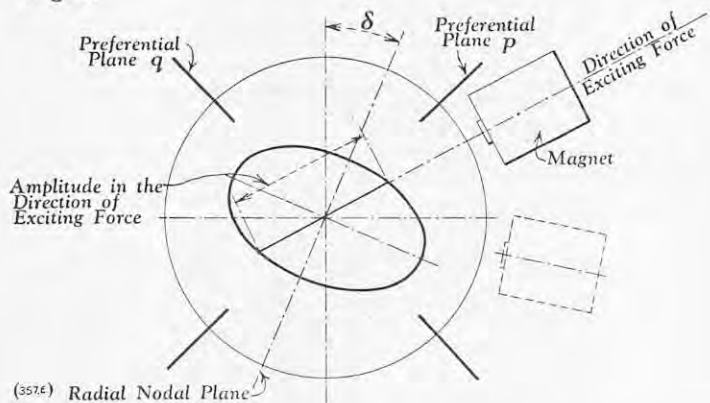
Fig. 2 shows the lowest mode of vibration of rods clamped at one end. According to the conventional theory, these vibrations will be confined to a single plane until, owing to friction, they subside. However, if we investigate "real" rods or strings, even if they have been manufactured with the greatest possible care regarding their uniformity and accuracy, we shall observe, that in general, the vibrations are not confined to one plane only. The end of the rod "will commence as a line, almost immediately open up into an ellipse, the lesser axis of which will gradually extend as the larger axis diminishes, until it becomes a circle; what was before the lesser will then become the larger axis; and thus the motion will alternate until, from their decreasing magnitudes, they cease to be visible." (Wheatstone, 1827). (See Fig. 3.)

The phenomenon becomes even more interesting if we consider forced vibrations. Fig. 4 shows the experimental apparatus. The rod, clamped in a chuck, is set into forced vibration with the aid of a small electromagnet which is fixed to the turntable of a

* Paper read before Section G of the British Association at Edinburgh on Tuesday, August 14, 1951. Abridged.

VIBRATIONS OF ELASTIC BODIES.

Fig. 5.



microscope. Through the microscope we watch the movement of the end of the rod. Fig. 5 shows that the vibrations will not confine themselves to the plane in which the exciting force is acting, but that, in general, every part of the rod will describe an elliptical path. As the exciting frequency is varied, the ratio between the large and small axes of the ellipse and the angle which the small axis forms with the vertical varies. If we define the plane in which the amplitudes are a minimum, that is, the plane which the small axis of the ellipse forms with the axis of symmetry, as a "radial nodal plane," we can say that by varying the exciting frequency the radial nodal plane will oscillate.

The amplitudes measured in the direction of the exciting force plotted as a function of the exciting frequency give a resonance curve which, in general, will have two resonance peaks (Fig. 6, curve A). After moving the magnet into a neighbouring angular position we repeat the experiment; we observe that there are two directions for the exciting force in which the ensuing vibrations confine themselves to the plane of excitation. Resonance curves belonging to these directions have one resonance peak only (Fig. 6, curves B and C); however, the resonance frequencies are not the same. These two directions form two planes with the axis of symmetry called the "preferential planes." Vibrations which have been started in either of these planes confine themselves to them; vibrations started in any other plane will behave in the way described above.

Fundamentally the same phenomena are observed with all bodies of revolution. Fig. 7 represents a cross-section of the apparatus used to investigate the vibrations of cylindrical shells. The vibrations were measured with the aid of an electronic vibration pick-up and were displayed on the screen of a cathode-ray oscilloscope. Fig. 8, opposite, shows the top view of a vibrating cylinder as it may be expected to vibrate according to the conventional theories. There is an even number of points at rest on the circumference of the tube, called the nodal points. Any point of the cylinder can be a nodal point depending only upon the way in which the vibrations were started.

Experiments were carried out with "real" tubes on similar lines as in the case of rods, that is, the vibration pick-up was set opposite the exciting magnet and, while varying the exciting frequency, the movement of the nodes was observed and the amplitudes measured. It was observed that there are, in general, no points upon the circumference which have zero radial amplitudes, only points which have an amplitude minimum compared with others. In every other respect they are like nodes, for their number is even and as long as the imperfections are small they are equally distributed round the circumference. The planes passing through these "relative nodes" are called the "radial nodal planes." As we alter the exciting frequency the radial nodal planes will not remain stationary but will oscillate, similarly to the way we observed with rods.

The measured resonance curves have in general two resonance peaks (Fig. 9, curve A). Here, too, there are directions which determine the preferential planes, in which the exciting force will produce a resonance curve which has one resonance peak only (Fig. 9, curves B and C). If we turn the exciting magnet into one of the preferential planes the resulting nodal configuration is called the "preferential configuration" corresponding to the preferential plane under investigation (Fig. 10). In most cases, depending on the kind and size of the imperfections present, the nodes of the two preferential configurations are symmetrically situated to each other. If the exciting force acts outside the preferential planes both configurations are excited at the same time and the amplitudes we

Fig. 6.

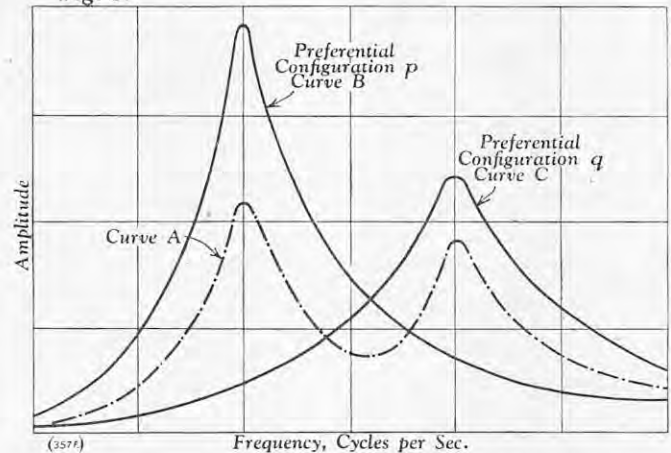
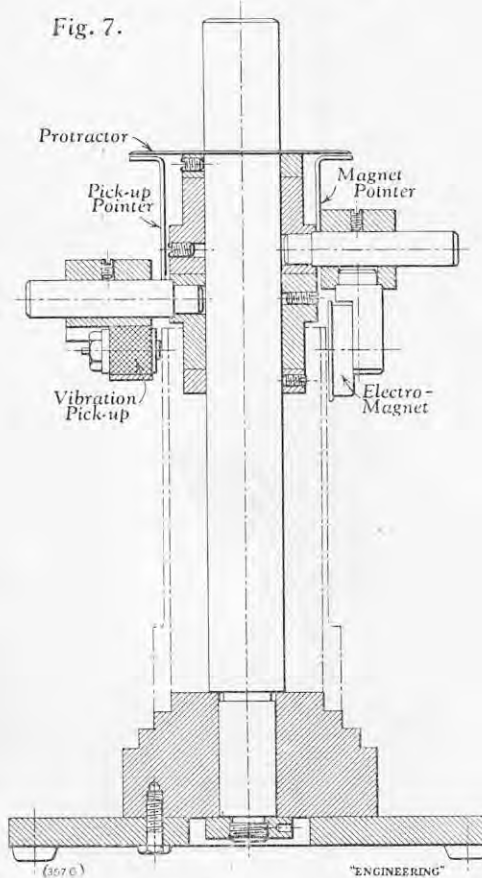


Fig. 7.



measure are due to a superimposition of both preferential configurations with regard to their phase angles relative to the exciting force (Fig. 9).

As long as the imperfections are small, any part of the circumference of the cylinder may become a relative node. If, however, the imperfections are large, the preferential frequencies are very far from each other and the two preferential configurations cannot be excited any more with the same frequency and consequently the nodes become practically fixed. Fig. 11 shows a resonance curve of a cylinder produced with the greatest possible care regarding dimensional accuracy, and Fig. 12 one for a cylinder which has deliberately been made imperfect. In the first case it was possible to produce relative modes at any part of the cylinder; in the second case, the nodes were fixed. The radial amplitudes for the two preferential configurations of a cylinder which contained large imperfections is shown in Fig. 13. As can be seen, owing to the considerable size of the imperfections the symmetry of the amplitude distribution is disturbed.

Experiments made with circular discs, conducted on similar lines as those described for rods and tubes, gave exactly the same results. Based upon these experiments, the subsequent theoretical investigation proved that the effect of imperfections upon the flexural vibrations of bodies of revolution can be stated in the following general terms: (a) The appearance of imperfections eliminates the indeterminacy of the angular position of the radial nodal planes, that is, the angular position of the radial nodes will, in general, be definitely determined by the imperfections of the

body. (b) For each mode of vibration there are two nodal configurations, the preferential configurations, which, in general, possess different natural frequencies. (c) The difference between these two frequencies is to some extent a measure of the imperfections present; for dynamically perfect bodies these two frequencies are equal and for highly imperfect bodies they are far apart.

It might appear that the problem of imperfections is only of theoretical interest and has no importance for the engineer. However, considering the wide application of bodies of revolution in engineering practice as stationary and rotating machine components, it is obvious that there is a great field in which it is worthwhile to re-examine the results that were obtained with the assumption that bodies can be produced with mathematical perfection. This is already in progress for the problem of rotating discs, which have a wide application in the field of turbine rotors and gearing. The investigations have shown a possible way to eliminate certain types of vibration of these components which, in practice, prove to be undesirable.

The work is being done at the Engineering Department of the University of Edinburgh under the supervision of Professor R. N. Arnold.

DESIGN OF DISTRICT-HEATING SCHEMES.*

THE object of these notes is to provide a basis for the preparation of preliminary reports on projected schemes. Many of the data which follow are of a tentative nature, and may require modification in the light of further experience, or to suit local circumstances. The figures given will serve for the preparation of preliminary schemes, but detailed estimates of heat requirements should be prepared when more accurate particulars of the various buildings and their heat demands are known. Reports on district-heating proposals should be accompanied by the consulting engineer's observations on the advisability in the particular circumstances of such a proposal. He will, no doubt, give his views on, *inter alia*, the extent of the reduction of smoke, bearing in mind that steps may have to be taken to avoid grit emission from the boiler-house; the efficiency of burning fuel in a central boiler-house, making due allowance for heat losses from mains, compared with other forms of heating by the latest solid-fuel appliances; the qualities of solid fuel that can be used with district heating compared with other appliances; the comparison of fuel delivery, and of ash and garbage disposal problems; the value of space and additional construction compared with loss of the housing space occupied by the boiler-house and auxiliary plant; the value to the tenants of ample heat all over the house and of ample hot water, but at an inflexible weekly charge; and the comparison of fire risks with local and district heating, respectively. The availability of unrestricted supplies of hot water at a fixed charge can give rise to greatly increased consumption.

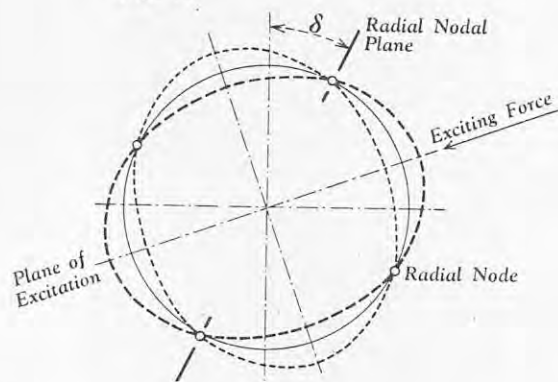
When district heating service is provided, gas, electricity or solid fuel will still be necessary for cooking. District heating will increase the number of services to be carried below the ground. In many cases, district heating will increase the dependence of the community

* Abstract (abridged) from *Notes on the Preparation of Schemes for the District Heating of Housing Estates*, prepared by the District Heating Sub-Committee of the Interdepartmental Committee on Domestic Heating. Published by the Ministry of Fuel and Power, Fuel Efficiency Branch, Queen Anne's Chambers, Dean Farrar-street, London, S.W.1.

VIBRATIONS OF ELASTIC BODIES.

(For Description, see Opposite Page.)

Fig. 8.



(357.4)

Fig. 9.

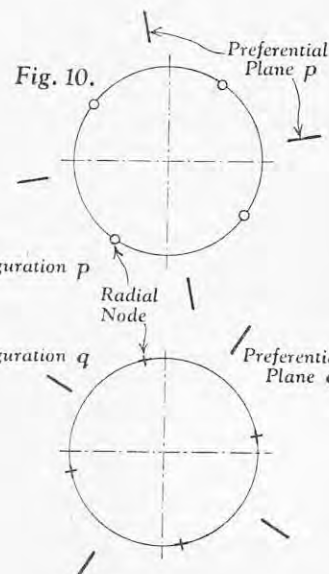
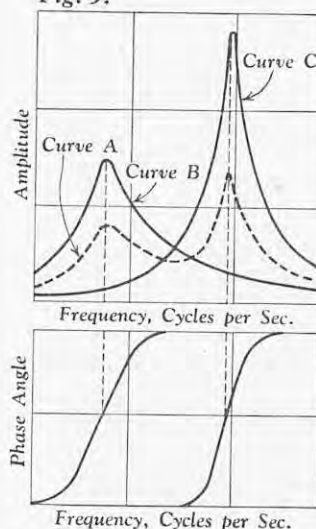
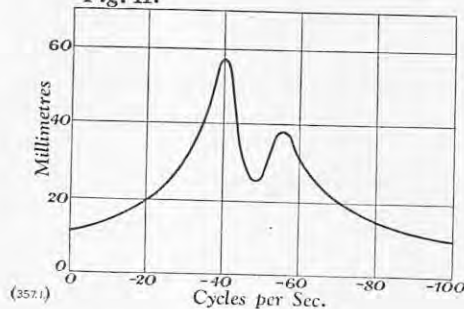
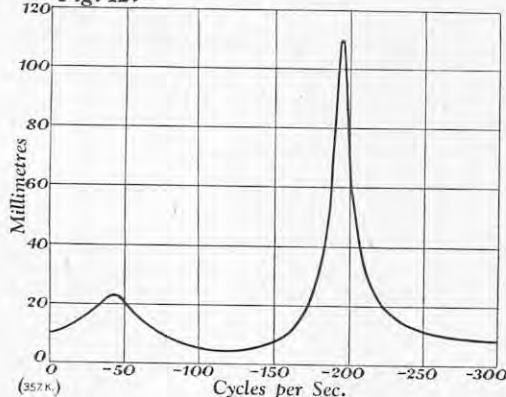


Fig. 11.



(357.1)

Fig. 12.

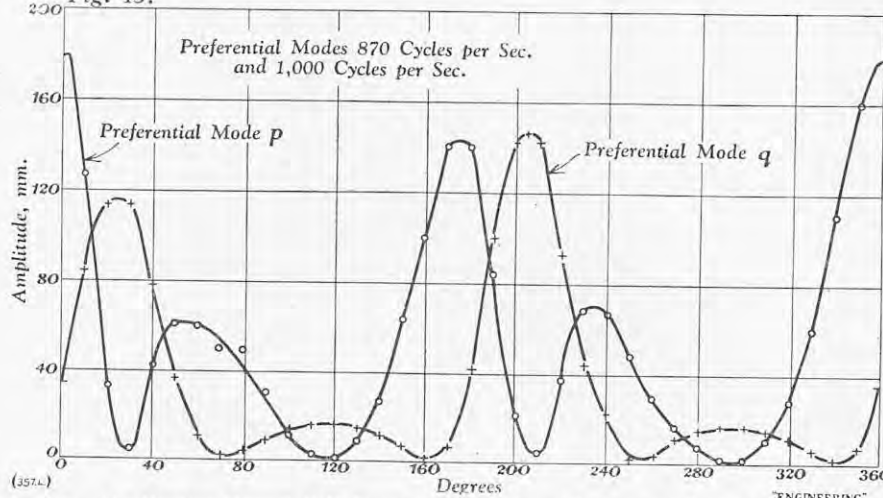


(357.4)

on central stations, but, with adequate design and maintenance, the risk of breakdown of a district-heating service will be small. The efficiency of boilers for district-heating schemes will, in general, be higher than those of small boilers serving central heating in individual public buildings, blocks of flats, etc. When mains losses are taken into account, the efficiency of heat utilisation is approximately the same with both systems, but district-heating boilers will burn lower grades of fuel than are suitable for small individual plants. The main disadvantage of district heating is the extra initial capital outlay necessary before a new estate is fully developed and connected to the system. There may be several years in which the loan charges cannot be met by the average economic charges. Losses during the development period can be partly avoided by the use of group heating, i.e., by providing temporary or permanent smaller separate boiler-houses dealing with groups of buildings as they are erected. Experience abroad, however, indicates that permanent group heating by separate boilers is much less efficient and more expensive in operation than heating from a single boiler-house. When temporary boilers are used in the initial stages of a scheme, part of the cost may be recoverable when they are no longer required.

The minimum basis of design for a district-heating service should be the maintenance of a temperature of 65 deg. F. in the living room and 60 deg. F. in the dining space and kitchen (or hall). Some auxiliary provision must be made for heating, for use if heat is required at times when the district heating system is

Fig. 13.



(357.4)

not in operation. The *Housing Manual*, 1949,* contains the recommendation, on page 171, that "Gas and electricity should be used for intermittent and auxiliary service." When considering district-heating schemes, it is necessary to estimate the maximum demand for heat which will occur at any time, and the total amount of heat which will be required during the year. Assumptions must be made as to the design temperature, the total connected load, the diversity factor and the load factor. The requirements of various classes of buildings can be conveniently grouped as for domestic (houses and flats), commercial, communal, and industrial buildings, respectively. Ordinary central-heating systems for individual buildings are usually designed on the basis of an external temperature of 30 deg. or 32 deg. F., and a margin of capacity is provided in the boiler to deal with colder conditions. Records at Greenwich for 100 years show that there were 49 periods, totalling 205 days, during which the temperature was continuously below 32 deg. F., but only 16 days on which the temperature did not exceed 25 deg. F. The design temperature (20 deg. F. to 30 deg. F.) appropriate to the locality should be observed when a district-heating scheme is being designed. [Data for the estimation of loads are given in the *Notes*, together with examples.—ED., E.]

The area supplied by the system should be zoned, and the buildings in the zones grouped together so that long lengths of mains to serve isolated buildings are not necessary. In planning, the aim should be to ensure that the consumers' load factor for each length of main is as high as possible. The present tendency to build houses in large groups is to be encouraged from the point of view of district-heating economics. Planning which requires fairly frequent right-angled bends or offsets in the mains is advantageous, as these bends, etc., enable expansion to be taken up without the necessity for special devices.

The ideal position for the boiler is at the "centre of gravity" of the heat load, but it is often impracticable for aesthetic and other reasons. The boiler house should be designed so as to be as inconspicuous as

possible, with due regard to facilities for fuel delivery and ash removal, and to the direction of the prevailing wind. The avoidance of complaints about smoke and grit is important, and the height of the chimney, particularly in residential areas, should not be less than $2\frac{1}{2}$ times the height of the tallest neighbouring building. In most cases grit arresters are essential, particularly in larger plants where mechanical firing is employed. If site conditions permit, all fuel and ash should be handled mechanically, advantage being taken of gravity feeding wherever possible. Boiler-house labour costs tend to be a high proportion of the total operating costs and a high degree of mechanisation is usually economic; the number of men required is reduced, lower grade fuels can be used with success, and greater efficiency is obtained than is possible with hand firing.

The boiler capacity provided must not be less than the maximum demand which can be foreseen, bearing in mind that in many cases extensions to the system will be required as time proceeds. In all cases it is desirable that two or more boilers should be provided; not only does this course eliminate the possibility of failure of service due to a boiler fault, but it enables the plant to be operated efficiently, and in accordance with changing seasonal demands. Boilers can be provided capable of dealing with the combined space-heating and domestic hot-water load in winter, but a separate boiler for hot-water service in summer will operate at higher efficiency than a large boiler running under reduced load. The variable nature of the load, both for space heating and for domestic hot water, does not favour the operation of boilers at consistently high efficiency, and the following average figures are suggested as applying to district heating schemes with solid-fuel boilers: stoker-fired, 70 per cent., and hand-fired, 60 per cent. When boilers large enough for the combined space-heating and hot-water load are used for hot-water service only during the summer months, the above figures should be reduced, for summer working, to 65 per cent. and 55 per cent., respectively.

The use of steam for distribution has many advantages; variations of head due to an undulating or a steeply-sloping site do not affect the system, and no circulating pumps are required, though on some sites

* Issued by the Ministry of Health: now obtainable from the Ministry of Local Government and Planning.

it may be necessary to use pumps to return the condensate. Metering, either of steam or of condensate, is relatively simple; the steam is at a sufficient temperature at all times to provide domestic hot water; and if industrial demands for steam are met from the district plant this will assist the economics of the scheme. The disadvantages of steam are that the return of the condensate may cause corrosion, and steam traps require frequent attention; the high temperature of steam mains may increase the heat losses; and make-up water will generally require chemical or other treatment. In most cases, and particularly for domestic heating, hot-water heating is preferred, and with steam service this necessitates the provision of heat exchangers. The temperature of steam cannot be regulated easily unless a vacuum system is employed, requiring vacuum pumps, and constituting a potential source of trouble through the in-leakage of air. In this country, hot water is generally considered to be the better medium for heating purposes. The principles are well understood, and hot water allows flexible operation, with the temperatures of the heating surfaces adjusted in accordance with the requirements. It may be used in low-pressure systems (up to 200 deg. F.), medium-pressure (200 to 250 deg. F.) or high-pressure (250 to 400 deg. F.) systems. Circulating pumps are necessary, but temperatures can easily be controlled at the boiler-house and sub-stations to suit the weather conditions. The metering of small individual space-heating loads may present some difficulty. In some cases, it may be economic to generate steam or high-pressure hot water at the boiler-house and to convert, through heat exchangers, to low-pressure hot water at sub-stations. Medium-pressure hot water can be used directly for heating, but in these cases it is desirable to use convectors instead of normal radiators in houses.

Boiler-house practice and the heating of buildings are both well established, and the vitally important factor in district heating is distribution. The success of a district-heating scheme will depend largely upon the selection of the most suitable system of distribution and its efficient installation. In deciding systems of distribution, an important factor is the necessity for supplying domestic hot water throughout the year, whereas space heating is normally required during the winter months only. (When some space heating is required at all times, e.g., in clinics, this can be arranged by connecting the heating appliances to the domestic hot-water system.) Distribution to consumers can be by the two-pipe, four-pipe, or three-pipe system.

The two-pipe system is shown in Fig. 1. In this system, a single pair of mains serves both space heating and domestic hot water. Domestic hot water must be supplied indirectly, with storage calorifiers in each building or block of buildings; preferably, calorifiers of 30 to 40 gallons capacity should be installed in individual dwellings. The temperature of the circulating water must be high enough at all times to provide domestic hot water at a temperature of about 140 deg. F. at the consumers' taps; this restricts the range of temperature regulation possible, and may result in overheating of radiators, etc., in mild weather unless local automatic controls are provided in consumers' premises. Conversely, in very cold weather, when the flow temperature, in a low-pressure hot-water system, may be 180 deg. F. or more, the domestic hot water may be overheated unless a thermostatically-controlled valve is fitted on each calorifier.

Ducts for a two-pipe system are small, as only one pair of pipes has to be accommodated. The ratio of heat loss in transmission to effective heat load is low in winter, as loss occurs from the surface of one pair of mains only; the necessity of maintaining a high flow temperature, however, tends to increase the loss. The heat-loss ratio is comparatively high in summer, when the mains are large in relation to the load carried. On the other hand, pumping costs are reduced in summer, and it is desirable to install separate pumps for winter and for summer service, so that each seasonal load can be supplied by a pump working at high efficiency. It is advantageous to install pumps in the flow main, so that pressure is maintained throughout the system.

The four-pipe system is shown in Fig. 2. Separate pairs of mains serve space-heating and domestic hot water, and each pair may be operated independently at the temperature required. Hot water can be heated in bulk, in storage calorifiers at the central station or sub-stations, or in individual buildings. Hot water is usually supplied directly from the secondary mains, and the district-heating authority is thus in the position of supplying both water and heat. This may involve some difficulties of an administrative nature, and there is some possibility of cross connections being inadvertently made between heating and hot-water mains. If hot water becomes contaminated in transmission, serious results may ensue, as some consumers may use water from the hot taps for culinary purposes. Water undertakings may raise objections to the use of mixing devices connected to both the hot and cold water pipes. As an alternative to direct supply,

Fig. 1. TWO-PIPE SYSTEM

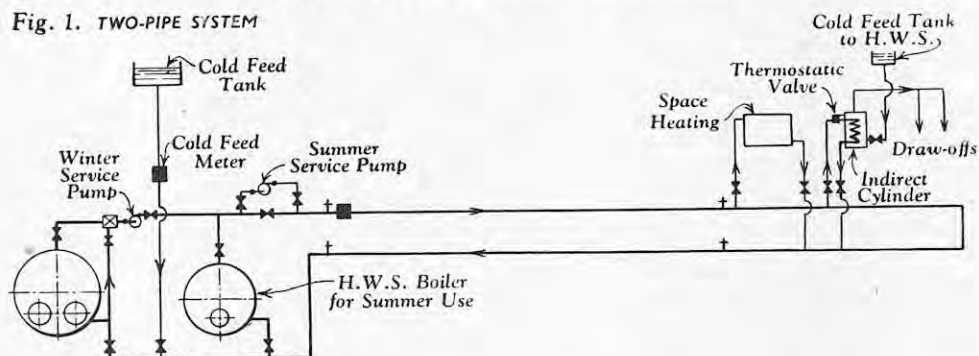


Fig. 2. FOUR-PIPE SYSTEM

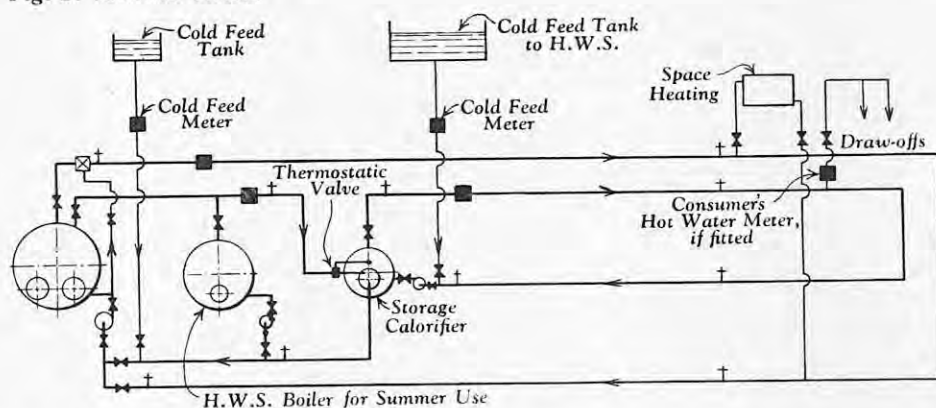
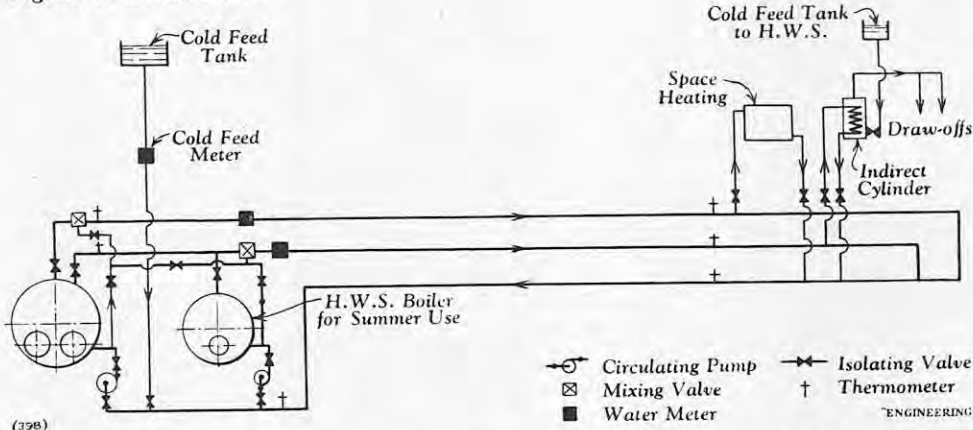


Fig. 3. THREE-PIPE SYSTEM



(198)

—○— Circulating Pump —+— Isolating Valve
 —X— Mixing Valve —+— Thermometer
 ■ Water Meter

individual calorifiers can be installed in dwellings, but their provision would add appreciably to the capital cost of the system, even though, unlike the two-pipe system, thermostatic controls on the individual calorifiers would not be required, as the temperature in the hot-water flow main would be suitably regulated. The flow temperature, however, would require to be higher than with direct supply. The four-pipe system requires large ducts. The heat-loss ratio is high in winter, owing to the large surface of the four pipes, but is low in summer, as the hot-water service mains are correctly sized for their duty. Two separate pumps are required for winter service, and pumping costs in general will be higher than with the two-pipe system.

The three-pipe system is shown in Fig. 3. Separate flow mains are used for space heating and for domestic hot water, and the system has the same flexibility as the four-pipe system, as the temperature for each service can be regulated in accordance with requirements. The return main is common to both services. As with the two-pipe system, domestic hot water must be supplied indirectly, but local thermostatic controls are unnecessary. The cost of ducts, mains and insulation with the three-pipe system is intermediate between those of the two-pipe and four-pipe systems. The large common return main will increase the heat-loss ratio in summer, but, in general, for the same service, the annual heat losses from a three-pipe system are not much greater than those from a two-pipe system, and are less than those for a four-pipe system. Separate pumps should be provided for winter and for summer service, and should be installed in the return main.

There is no universal criterion as to the best system of distribution to adopt. A number of combinations as possible and each scheme must be investigated on

its merits, taking into account the capital costs of the mains, of calorifiers and of storage vessels. Before the most satisfactory system can be selected, estimates must be made of the cost of operation, including the costs of heat losses and of pumping. It is of great importance that a thorough investigation be made of the technicalities and economics of the alternative systems so that a sound decision can be reached. In many cases, the balance of advantage will be found to lie with the three-pipe system. Whatever system of distribution is adopted, it is important that means of regulating and balancing the flow of water to the houses shall be provided, and that the process shall not entail entering individual houses. In some cases, difficulties have arisen in regulation as new sections of the estate were connected to the system.

District-heating mains are usually of mild steel, Class C. Pipes of 3-in. diameter and upwards should be welded, as flanged joints necessitate large ducts. Smaller pipes can be screwed, but welding is preferable in all cases. Most of the completed work will be out of sight and all welding must therefore be of the highest order. Wherever possible, mains should be routed through the basements of buildings; inspection and maintenance are thereby facilitated and the heat lost from the mains will be used to advantage. Outside the buildings the mains may be taken through private grounds or beneath pavements or roads. If the slabs covering the trenches are incorporated in pavements or paths, this will tend to keep them dry and free from snow and ice. Mains networks should as far as possible be "ringed" so that, should faults develop, they can be isolated for repair with the minimum disturbance to other sections of the service. In cases where the water is corrosive it may be necessary to run the secondary

hot-water service in copper throughout. Where mild-steel and copper pipes are run in the same duct, precautions to avoid electrolytic corrosion must be taken; pipes of different metals should not be carried in direct contact with the same metal brackets or hangers.

The ducts required for a district-heating system may comprise tunnels not less than 6 ft. 6 in. high, in which "upright" access is provided, or small tunnels not less than 3 ft. 6 in. high in which "crawl-way" access is provided; buried ducts; and shallow trenches with cover slabs level with the ground or the floors of buildings (British Standard Sub-Code 304.105, entitled "Design and Construction of Pipe Ducts"). It is particularly important to ensure that the ducts are thoroughly watertight. To guard against the accumulation of water, by leakage or otherwise, great care must be taken to form the duct with a fall to gullies connected to the drainage system. In water-logged or wet soil a complete underdrain is necessary.

The most satisfactory method of providing for expansion in district-heating mains is to run the mains with offsets or changes in direction, preferably at intervals of not more than 100 ft. In the planning of housing estates, blocks of houses are usually arranged in broken alignment; this is favourable to the layout of district-heating mains. Offsets of reasonable size should be provided at convenient positions. If considered necessary, expansion loops of straight-U or long-radius type can be employed; the former are the cheaper, both as regards the pipe work and the duct construction. Loops of any kind increase the resistance of the flow of water, and, therefore, the costs of pumping. If it is not possible to take up expansion by means of offsets or loops, provision must be made by means of expansion joints of sliding or bellows type; these joints must be readily accessible for inspection and maintenance. All mains must be securely anchored in accordance with usual pipework practice. Between points of anchorage, pipes must be free to expand or contract. Roller bracket supports are generally used, but in tunnels, hangers, which allow the pipes to swing freely, are preferable. It is necessary to ensure that branch pipes are not subject to undue strain by the expansion of the main, and wherever possible branches should be taken off near a point of anchorage.

The heat losses from insulated pipes in ducts will vary with the type of soil and in most cases with the season. The disposition and number of pipes in a duct will also affect the heat loss. An approximate estimate of the heat loss can be made by allowing an emission of 0.25 B.Th.U. per hour per square foot of the exterior surface of the pipe, per 1 deg. F. difference between the temperature of the water or steam in the pipe and the temperature of the ground; the latter can be assumed to be 50 deg. F. throughout the year. Until factual data can be obtained, it is suggested that heat losses from pipes, calculated on the above basis and shown in the following Table, should be used.

Heat Loss from Insulated Pipes in Ducts, in Therms per 100 ft. of pipe per 1,000 hours.

Nominal Bore, in.	Temperature of Water or Steam.			
	150 deg. F.	200 deg. F.	250 deg. F.	300 deg. F.
1	8.7	13.0	17.3	21.6
2	15.6	23.3	31.1	38.9
3	22.9	34.4	45.8	57.3
4	29.4	44.1	58.8	73.4
5	36.0	54.0	72.0	90.0
6	42.5	63.8	85.0	106.3
8	55.5	83.3	111.0	138.8
10	68.8	103.1	137.5	171.9
12	81.8	122.6	163.5	204.4

As previously indicated, domestic hot water is an important factor in district heating. With bulk storage and direct supply, there is little or no limitation of the amount of hot water which can be drawn off by individual consumers. For this and for other reasons, the supply of hot water to domestic consumers should be indirect, a separate calorifier being installed in each dwelling, with a heating-up period of three hours. Bulk storage, if used, may be installed at the central station or substations, or in various blocks of buildings. The secondary mains will have considerable capacity, which should be taken into account when estimating the size of the storage calorifier required. The total amount stored should not be less than 10 gallons per dwelling; in local bulk storage for small blocks of 10 or 12 dwellings this should be increased to 15 gallons. The heating coils in the bulk-storage calorifier should be so sized that the number of gallons per hour raised through 100 deg. F. is about 15 per dwelling for small schemes of the order of 100 houses, reducing to about half this figure in large schemes.

A number of instruments are required for the efficient operation of a district-heating system, and should be provided as an integral part of the installation. Some instruments are essential for efficient boiler operation, and other equipment is necessary to control the amount of heat generated in accordance with hour-to-hour

requirements, and to ensure that heat is distributed efficiently. Various meters should be provided to enable adequate records of operation to be kept.

For each boiler, a recording flue thermograph, with daily or weekly charts, should be regarded as the minimum provision. In addition, a CO₂ recorder or indicator enables an estimate to be made of the heat loss in the flue gases, and, by inference, the efficiency of the boiler. If CO₂ recorders are installed, they should preferably be of the same pattern as the thermographs, as the charts can then be superimposed for examination by the supervising engineer. Draught indicators are desirable, and, if fitted to a range of boilers, enable each boiler to operate under the same conditions and take its fair share of the load. Coal meters enable fuel consumption to be recorded automatically.

In addition to the boiler equipment, the following are required. (a) An outside temperature recorder, preferably of a continuous recording type, but alternatively maximum and minimum thermometers may be provided. The instruments should be located in a position where they will not be affected by direct sunshine or by heat from buildings, and should preferably be housed in a Stevenson or similar screen. It is a great advantage if the outside temperature at all times is clearly indicated in the boiler-house; a large-scale dial thermometer with remote bulb is very suitable for this purpose. (b) Thermometers showing the temperature in each flow and return main at the central station and substations. These should preferably be of the recording type, with weekly charts. Thermometers of ordinary indicating type at the consumers' ends of mains are of value in ensuring that water reaches consumers' premises at the correct temperature, and in enabling an estimate to be made of transmission losses; the latter would also reveal any failure of mains insulation.

(c) Water meters should be provided in mains at the central station and substations as follows: (i) For heating mains, a meter in each flow main. (ii) For hot-water supply mains with direct supply (four-pipe system), a meter on each primary and secondary flow main; in this case the cold-water feed meter will indicate the hot-water consumption. (iii) For hot-water supply mains with indirect supply (three-pipe or four-pipe system) a meter in each flow main. These meters should preferably record the cumulative flow in gallons. Alternatively, rate-of-flow indicators of Venturi-throat type may be used, or an approximate estimate can be made from the working head of each circulating pump and the characteristic curves supplied by the pump makers. (iv) A water meter should record the cold-water make-up to each pair of mains (to the return main in a three-pipe system). (v) Where domestic hot water is heated in bulk at the central station, substations, or consumers' premises, a water meter should record the cold-water make-up to each storage calorifier.

(e) Electricity meters should record the consumption for lighting and power at the central station and each substation. For steam schemes, steam-flow meters would replace some of the water meters enumerated above. Cold-feed recorders should also be fitted, in accordance with standard steam-boiler practice. Steam-pressure recorders, with daily or weekly charts, are desirable on the main steam header, with pressure gauges on each flow main. Condensate, if returned, should be metered.

Suitable types of automatic control will effect substantial fuel savings, and are very desirable to ensure that the temperature of water for space heating is regulated in accordance with the climatic conditions, and that the temperature of domestic hot-water supply is not excessive. For space heating, an outside element can regulate the temperature of the circulating water by means of a mixing valve, which diverts part of the return water into the flow main. Alternatively, elements can be arranged to control the operation of the mechanical stoker and the draught equipment. A combination of methods gives the most satisfactory results. For domestic hot water, the control should ensure that water leaves the consumers' taps at about 140 deg. F. This can be effected, with bulk storage, by a thermostat in each calorifier, controlling a valve or mixing valve in the primary flow. With individual hot-water calorifiers in dwellings, the temperature in the flow main must be controlled. All thermostats should have adjustable ranges.

Meters should be provided to record steam, space-heat or domestic hot-water, supplied in bulk to any industrial or other large building. For individual dwellings, space-heat meters are at present impracticable, but in cases where domestic hot water is supplied direct from the district-heating authority's mains, several types of hot-water meters are available, and their installation will tend to reduce hot-water consumption. If it is decided to install such meters, connections must be arranged so that they can be removed and replaced without difficulty, and suitable testing and calibration equipment must be provided at the central station.

NOTES ON NEW BOOKS.

The Northampton Sand Ironstone.

By S. E. HOLLINGWORTH, Ph.D., M.A., B.Sc., M.I.M.M., Department of Scientific and Industrial Research, Memoirs of the Geological Survey of Great Britain, H.M. Stationery Office, York House, Kingsway, London, W.C.2. [Price 17s. 6d. net.]

WITH the gradual exhaustion of the hematite deposits in the carboniferous limestone and the diminished productivity of the clay band and blackband iron ores from the coal measures, a position has now been reached where the mesozoic ironstones provide virtually the whole of this country's reserves of home ore. The 1939-45 war led to greatly increased production in the Northampton sand field, and 55 opencast pits and three underground mines were working during that period. In 1942, the field produced the record output of over 10½ million tons, and over the six war years it was responsible for considerably more than half the total British production of iron ore. The ore field extends through Northamptonshire, Rutland, East Leicestershire and Lincolnshire, and is being worked in all these counties. Its persistence over extensive areas as a relatively thick flat-lying bed, at no great depth below the surface, has favoured its exploitation at low cost in large opencast excavations. Though richer in iron than other British bedded ironstones, the Northampton sand is low-grade in comparison with many imported ores. In general, the iron content in the workable stone ranges from 28 to 35 per cent., silica from 6 to 18 per cent., and lime from 2 to 10 per cent. The phosphoric nature of the ore, at an average of 0.7 per cent. phosphorus, renders it suitable only for the basic steel-making processes. At the present rate of production of some 7 million tons per annum, the field has reserves for about 175 years, and 50 per cent. of the total tonnage is available for opencast working by present-day methods. This 211-page memoir deals concisely with the stratigraphy, structure and reserves of the field, and also discusses its history and describes the methods of prospecting, sampling and working in common use.

Steam Turbine Theory and Practice.

By PROFESSOR WILLIAM J. KEARTON, D.Eng. Sixth edition. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 35s. net.]

THE sixth edition of this well-known text-book resembles the previous edition of 1949 so closely that a new preface of only three lines serves to call attention to the difference. This amounts to little more than the inclusion of a description of the Westinghouse system of governing steam turbines by the variation of fluid pressure produced by a centrifugal pump on the turbine shaft, which replaces the usual mechanical type of governor. A similar principle, it may be remembered, was employed by Sir Charles Parsons for the speed regulation of his very earliest steam turbines, though he used a fan to create a vacuum for operating the throttle valve. As the changes are so slight, no detailed review of the book is necessary; it is sufficient to say that it provides about as good a course of instruction on the design of land turbines as any student could wish for. He will be brought to realise that the mechanical problems of turbine design are fully as important as the thermodynamic considerations, and that much more than a knowledge of the behaviour of steam is required to produce a machine that can be relied on not to give trouble in operation. As a well-written and lucid combination of theoretical and practical information on turbine design, the book is one that can be recommended without reserve.

Some Wallis and Stevens Traction Engines and Steam Wagons.

By R. C. WALLIS and J. P. MULLETT. Obtainable from J. P. Mullett, "Westcroft," Northchurch Common, near Berkhamsted, Hertfordshire. [Price 4s.; by post, 4s. 3d.]

THE principal contents of this brochure comprises 24 illustrations of traction engines and four steam wagons, made by the firm of Wallis and Stevens at their North Hants Ironworks, Basingstoke, between 1877 (the date of their first traction engine) and 1920, when they discontinued the construction of steam wagons. The letterpress consists of no more than an introduction, and a short description under each illustration. As it is stated that Messrs. Wallis and Stevens, Limited, "no longer have available any data concerning the subjects described," we might point out that the woodcuts of the 1877 engine and of its 1879 successor are reproductions from *ENGINEERING* of August 24, 1877 (vol. 24, page 142) and February 13, 1880 (vol. 29, page 135), respectively. These references are not given in the brochure, nor are the sources of any of the illustrations.

PNEUMATIC COMPARATOR.

Fig. 1.

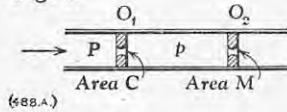
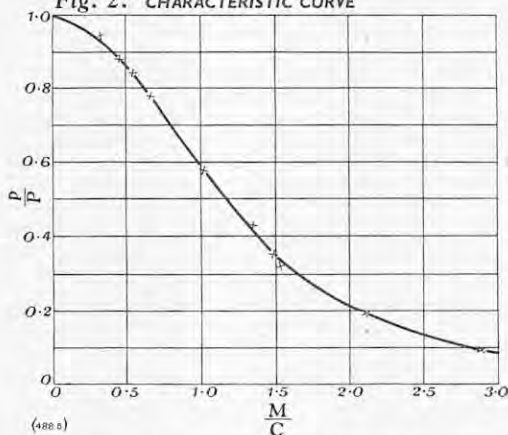


Fig. 2. CHARACTERISTIC CURVE



PNEUMATIC COMPARATOR OF HIGH SENSITIVITY.*

By M. GRANEK, B.Eng., A.M.I.E.E., and J. C. EVANS, B.Sc., Ph.D.

THE last decade or so has seen a marked increase in the use of pneumatic gauging in precision engineering, in workshops as well as in inspection and standards rooms. This technique has special advantages for some applications, as, for example, the measurement of fine bores, and has the particular merit that high sensitivity may be obtained with relatively simple apparatus. Increase of sensitivity, however, has in general been attained only at an undue expense in speed of response, the resulting sluggishness being often a drawback even when measuring a constant dimension, and becoming a serious disadvantage when measuring one which is changing fairly rapidly. The authors have described elsewhere† apparatus developed for measuring and recording a rapidly changing quantity, such as the area of cross-section of a textile yarn during production. By further development of the principles used in that work, a comparator having very high sensitivity and good speed of response has been devised in a compact and robust form, and this instrument is described here.

It will be useful to consider first the principle of the particular form of pneumatic gauging employed and the factors which determine the working characteristics of an instrument based upon it. The principle is shown schematically in Fig. 1. Air from a constant-pressure source is supplied first to an orifice O_1 and thence to an orifice O_2 through which it escapes to the atmosphere. P represents the pressure upstream of the first orifice and p that between the two orifices, both pressures being referred to atmospheric pressure as datum. For a given value of P , the magnitude of p depends on the relative sizes of O_1 and O_2 . If C and M are the effective escapement areas of O_1 and O_2 , respectively, the relationship between $\frac{p}{P}$ and $\frac{M}{C}$ is

given by a characteristic curve of the form shown in Fig. 2. This particular curve was obtained experimentally using an orifice O_1 of fixed diameter equal to 0.033 in. and a constant value of P equal to 15 lb. per square inch. It is of interest to note that it agrees quite closely with the equation $\left(\frac{M}{C}\right)^2 = \frac{P}{p} - \frac{p}{P}$, an approximation which may be derived from theoretical considerations.

For values of $\frac{p}{P}$ between 0.4 and 0.9 the characteristic curve in Fig. 2 differs little from the straight line represented by the equation

$$\frac{p}{P} = 1.10 - 0.50 \frac{M}{C}, \quad (1)$$

so that within these limits, and for constant values of P and C , p may be regarded as a linear function of M . If the effective area of escapement of O_2 is arranged to

Fig. 3.

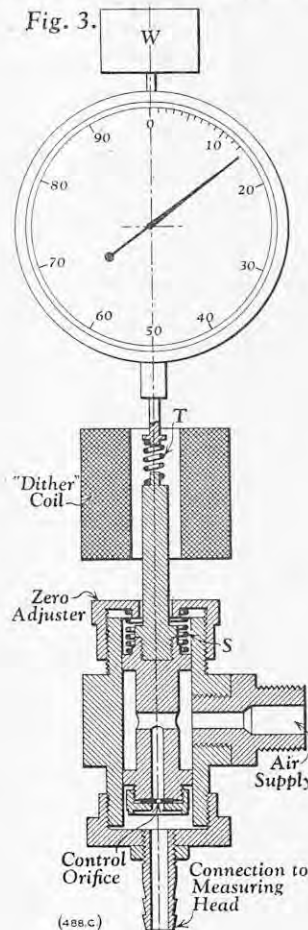
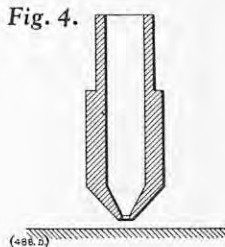


Fig. 4.



depend on a dimensional quantity A in such a manner that alteration of A produces a proportional alteration of M , then changes in A may be determined by measuring the corresponding changes in p .

The rate of change of p with M is given by the equation

$$\frac{dp}{dM} = -0.50 \frac{P}{C} \quad (2)$$

and hence, for a given value of P , is greatest when C is least. The largest value of $\frac{M}{C}$ within the linear range is that corresponding to $\frac{p}{P}$ equal to 0.4, and, by equation (1), is equal to 1.40. For maximum sensitivity, therefore, C should be chosen so as to satisfy the relationship

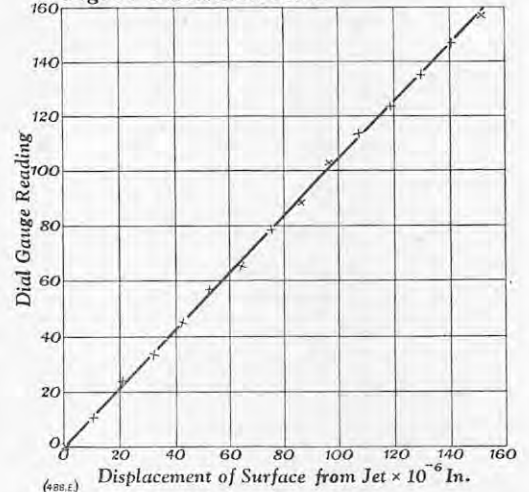
$$C = \frac{M_{\max}}{1.40} = 0.7 M_{\max} \quad (3)$$

where $M_{\max}$ is the maximum value of the effective escapement area of O_2 . The overall sensitivity of an instrument based on this principle will, of course, depend also on the sensitiveness of the device used for measuring p . This device should preferably be linear in terms of p and, in view of the requirement

$0.4 < \frac{p}{P} < 0.9$, it should be fitted with means for suppressing the zero so that the zero of the scale corresponds to a pressure p equal to 0.4 P . Within this range, the indications of the instrument will then be linear in terms of A . It is, of course, necessary that P should be kept constant in order to maintain consistency of calibration.

The speed of response of the instrument will depend on several factors, the chief of which are the value of P , the area C of the first orifice, and the volume V between the two orifices; the response improves when P or C is increased or V diminished. It has been seen that for high sensitivity C should be kept small, so that, in the determination of the optimum size of O_1 , high

Fig. 5. CALIBRATION CURVE



sensitivity and quick response are conflicting demands. With C determined by the sensitivity requirement, improved response must be sought by reducing V to a minimum and making P as large as is conveniently practicable.

The instrument, shown in Fig. 3, consists of a hollow double piston which is an air-tight sliding fit inside a cylinder of $\frac{1}{4}$ in. bore, the radial clearance being only about 0.0001 in. Compressed air, maintained at constant pressure by a precision pressure regulator, is supplied to the centre of the cylinder, whence it flows downwards through the hollow piston to the control orifice. This orifice is simply a small hole drilled in a thin metal disc held in place on the bottom of the piston by means of a screw cap, an arrangement which enables the orifice to be changed easily when it is desired to alter the sensitivity of the instrument. After flowing through the control orifice, the air passes to the lower part of the cylinder, from which a connection is taken by means of a short length of small-bore flexible tubing to the measuring head. When the measurement to be made is the displacement of a surface, a simple jet, Fig. 4, may be used as the measuring head, the gap between jet and surface determining the effective escapement area for the air. The volume which determines the time constant of the instrument is that of the space in the cylinder below the piston plus the capacity of the flexible tube and measuring head. The total effective volume is, therefore, small and the speed of response correspondingly high.

The piston is loaded by means of a compression spring S , Fig. 3. The initial compression of this spring is set by the "zero adjuster" screw so that with a supply pressure of 15 lb. per square inch, say, the piston just moves away from its lowest position when the pressure beneath the piston is 6 lb. per square inch, i.e., 0.4 P . Any further increase in the pressure p will produce a proportional upward movement of the piston. The effective escapement area at the measuring head is dependent on the air gap, and experiment has shown that the movement of the piston is directly proportional to the displacement of the surface from the measuring jet within the limits set by the condition that p lies between 6 lb. per square inch (0.4 P) and 13½ lb. per square inch (0.9 P). By suitable choice of control orifice and compression spring in the cylinder, the ratio of movement of piston to displacement at the measuring jet may readily be made equal to 1,000:1.

The movement of the piston is indicated on a 2-in. diameter dial gauge of ordinary pattern, the pointer of which makes one revolution for a spindle movement of 0.1 in. The magnification provided by the dial gauge is, therefore, about 60:1, so that a total magnification of the order of 60,000:1 for the complete unit may be achieved. With this sensitivity, using a dial gauge having a scale of 100 divisions, each corresponding to a spindle movement of 0.001 in., one scale division would represent a relative displacement between measuring jet and surface of one millionth of an inch.

To overcome the effect of static friction between piston and cylinder, an extension rod of mild steel fitted to the top of the piston is arranged to project into a solenoid supplied with half-wave rectified alternating current. This produces a "dither" of the moving parts of small amplitude (about 0.001 in.) at mains frequency and completely eliminates the possibility of the piston sticking at any point in the cylinder. Half-wave rectification is used because the heating effect of the current in the coil, for a given maximum pull on the plunger, is thereby reduced by about 50 per cent. so that a smaller dither coil can be used than would otherwise be required. As it is necessary

* Communication from the National Physical Laboratory.

† J. C. Evans, M. Graneek and H. G. Loe, "Continuous Pneumatic Gauging of Material in Thread or Wire Form," *Trans. Soc. Instrum. Tech.*, vol. 2, No. 2, page 34 (1950). Also British Prov. Pat. No. 28719/49, cog. 1471/50.

PNEUMATIC COMPARATOR.

Fig. 6.

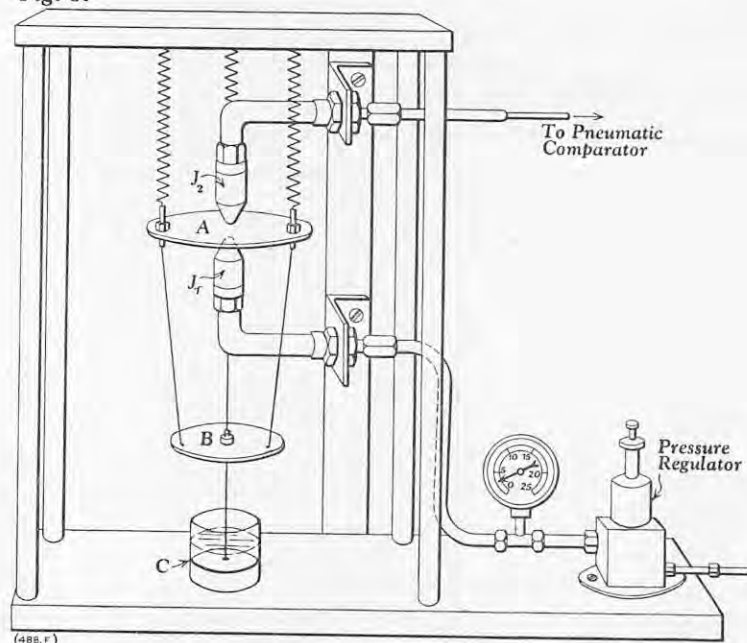


Fig. 7.

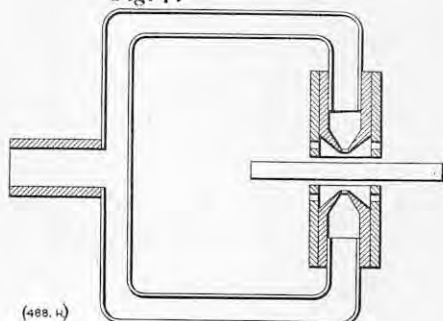
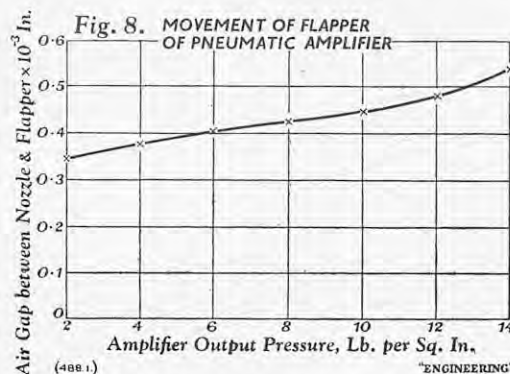
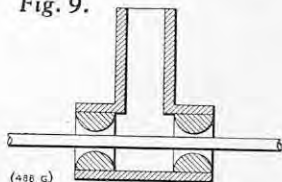


Fig. 9.



direct weighing, the aluminium disc B, which is suspended from A by three wires, serving as a scale pan, while the dash-pot C provides sufficient damping to make the system aperiodic.

The comparator, in association with a jet J_2 fixed just above disc A, provides a criterion for judging when the correct weights have been added to the scale pan, the procedure being as follows. Commencing with no air supply to J_1 , the position of J_2 in relation to A is chosen so as to give some convenient reading on the dial gauge of the comparator. The air supply to J_1 is then adjusted until the required pressure is attained and weights are added to B until the dial gauge reading is restored to its original value. Readings can be taken quickly and easily, so that a set of observations covering different pressures and different distances of J_1 from A can readily be obtained. As an example of the results obtained from these tests it may be quoted that the force on a surface due to a jet of air at a pressure of 10 lb. per square inch from an orifice of diameter 0.040 in. at a distance of 0.001 in. from the surface is 0.2 oz. weight.

Mention has been made of the use of a simple jet, Fig. 4, as a suitable measuring head for the direct measurement of the displacement of a surface. Fig. 9 shows a sectional view of an alternative measuring head suitable for gauging the cross-sectional area of thread or wire. It is of box-like form with a shaped orifice in each of two opposite faces and is connected to the comparator by the tube entering the upper face. With properly dimensioned orifices, "cross-cornering" of the wire in the head has no appreciable effect on the comparator reading. A third form of measuring head, for gauging thickness, is illustrated in Fig. 9. Two jets are connected in parallel so that the effective area of escapement M at the measuring head depends on the sum of the two escapement gaps formed between the jets and the material being measured. With this arrangement the reading of the comparator will, within certain limits, be independent of the location of the material between the jets since the sum of the two air gaps between jets and material will remain constant for a given thickness of material.

The theoretical analysis briefly outlined above depends on the assumption that the coefficient of contraction for the air escaping at the measuring head remains reasonably constant. This will be the case

unless the material is moved too close to one of the jets, when the coefficient of contraction for the air escaping from this jet may be reduced appreciably, making the effective total escapement for the air at the measuring head less than before; the pneumatic gauge will then indicate an apparent increase in the thickness of the material. To obviate this, a guard ring is fixed around each jet, as shown in Fig. 7, with the surface of the ring protruding slightly beyond that of the jet. If the material should touch the guard ring, air can still escape from the jet through holes drilled in the side of the measuring head as indicated in the diagram. The guard rings also provide mechanical protection for the jets.

As an example of the use of the comparator for fine measurement, mention may be made of a determination of the movement of the flapper of an industrial pneumatic amplifier of the type described in the authors' paper, already referred to. This determination was made in order to establish the mode of action of the flapper mechanism. The comparator was used in association with the simple jet measuring head, which was fixed rigidly to the amplifier case so that the nose of the jet was at a mean distance of 0.0008 in. from the flapper. By varying the input to the amplifier in steps, a series of corresponding values of comparator reading and amplifier output was obtained. The results are given in Fig. 8, which shows a plot of the distance of the flapper from the amplifier nozzle against amplifier output pressure. The total range of movement of the flapper corresponding to a change in output from the minimum value of 2 lb. per square inch to the maximum of 14 lb. per square inch is 0.0002 in.

The comparator which has been described has the advantages of a simple and robust design, so that it may be used in the workshop as well as in the inspection room. At its maximum sensitivity, it may be used to measure displacements of the order of a few millionths of an inch; by changing the size of the control orifice, which can be done quickly and simply, the sensitivity can be reduced so as to provide for direct measurements of up to a few thousandths of an inch. As an approximate working rule, when it is required to measure displacements of a surface in the range x in., the minimum gap between the measuring head and the surface will be $\frac{x}{2}$ in.

As the measuring head does not make actual contact with the surface under measurement, the comparator is particularly useful in certain applications. Thus it has been found that, with the calliper arrangement of jets as measuring head, accurate determinations can be made of variations in thickness of rubberised fabric during actual production and despite the stickiness of the surfaces. When necessary, the measuring head can be made very small in overall dimensions and since its connection to the comparator is by a thin flexible tube it can be inserted into confined spaces which would be inaccessible to the more common type of comparator with rigidly attached measuring head. The speed of response is quite high, so that even at maximum sensitivity readings may be taken almost immediately. There are no sources of hysteresis so that the comparator is completely free from this type of error.

It is clear from what has been said that the instrument is a comparator and is unable to provide absolute measures. Calibration may be carried out in the usual manner, using slip gauges, but at the highest sensitivity it becomes necessary to use special slip gauges (for example, differing in steps of 0.00002 in.) which have been accurately standardised. Since the reading of the comparator is dependent on the value of the working pressure P, the pressure of the air supplied to the precision regulator should be kept reasonably constant. To realise the precision quoted it was necessary to limit the range of variation of the supply pressure to 5 lb. per square inch.

BICYCLE FACTORY IN INDIA.—A new bicycle factory of T.I. Cycles of India, Ltd., who are associated with Tube Investments, Ltd., London, was opened at Ambattur, near Madras, on September 26.

TECHNICAL EDUCATION IN MIDDLESEX.—The Middlesex County Council Education Committee have issued an 80-page booklet entitled "Further Education in Middlesex," for the 1951-52 session, which is a guide to courses held at the technical colleges throughout the county, and to related matters.

LOCOMOTIVES FOR CEYLON.—Messrs. W. G. Bagnall, Limited, Castle Engine Works, Stafford, have recently completed the last of six 4-8-0 steam locomotives for the Ceylon Government Railways. Several improvements have been embodied in the design, which is otherwise similar to that of three engines of the A3D supplied in 1939. The new locomotives are for use on the Batticaloa-Trincomalee section of the 5 ft. 6 in. line and are required to haul the heavy traffic due to the Gal-Oya irrigation scheme.

to prevent transmission of excessive vibration to the dial-gauge mechanism a simple damping device consisting of a weight W, Fig. 3, is fixed to the dial-gauge spindle and a small compression spring T is fitted between this spindle and the top of the plunger.

The comparator has been calibrated in terms of light-waves by means of a displacement interferometer. For this purpose the instrument was fitted with a simple jet, Fig. 4, and was used to measure the displacement of the movable glass plate of the interferometer. The diameter of the jet was 0.040 in., that of the control orifice 0.010 in. and the pressure P was 10 lb. per square inch.

The results of the calibration are shown in Fig. 5, in which the readings of the dial gauge are plotted against the displacement of the surface in relation to the jet, as measured by the interferometer. It will be seen that the calibration is linear over the range 0.00015 in. and that one division of the dial gauge represents 1×10^{-6} in. approximately. The standard deviation of the results from the best straight line is 0.8 division.

An approximate calculation of the force which is exerted in normal conditions of use by the jet of air impinging on the surface under measurement indicated a value of the order of $\frac{1}{4}$ oz. weight. As the premises of this calculation were open to doubt, an experimental measurement of the force was made. It may be of interest to describe the method adopted since it employs a technique which might prove useful in other, and at first sight, somewhat unrelated applications. Fig. 6 shows the apparatus. The jet J_1 to be tested is rigidly fixed at the appropriate distance beneath an aluminium disc A supported with its surface horizontal by three light springs. It is connected to the compressed-air supply through a precision regulator so that the pressure at the jet, as indicated on the gauge, can be accurately set to the required value. The upward force exerted by the jet of air on A is determined by

TURNTABLE FOR COLLIERY TUBS.

For changing the direction of travel of empty or full coal tubs in pits where space is limited, a turntable (provisional patent No. 25675/49), invented by Mr. C. V. Peake, has been developed in the West Midlands division of the National Coal Board; it is described in Information Bulletin No. MP(51)13, issued by the production department of the Board. Figs. 1 and 2, herewith, show the arrangement of the turntable as originally designed, for handling standard mine cars of 1½-ton capacity. A circular table is mounted on a vertical driving shaft, the lower end of which is supported in a ball thrust bearing and a plain journal bearing. The table is supported around its periphery by equally-spaced rollers carried on brackets attached to the foundation. To form guide rings for the tubs, the turntable carries an inner annular flange, and is surrounded by a fixed flange except at the stations where the tubs enter and leave the table. The turntable is normally arranged to rotate at such a speed that only one tub is on the platform at any time; the tubs run on to the platform tangentially and are restrained by the guide rings as the turntable rotates, until they encounter a stationary deflector plate which directs the front wheels of the tub on to the receiving runway, down which they are guided by suitable check rails.

The driving motor and reduction gearbox are mounted on a girder framework above the turntable; with this arrangement, the motor and gearbox are in a dry position relatively free from dust, and only a small amount of excavation is required at floor level. It has the disadvantage, however, that considerable head room is required to accommodate the drive. Alternative arrangements, which leave the floor clear, have been designed with the motor and gearbox below the floor level; in one, the reduction gearbox output shaft is coupled directly to the turntable shaft, which necessitates appreciable excavation. In another, the excavation is reduced by installing the motor and gearbox on a higher level to one side of the turntable shaft, which is driven by an additional spur-wheel drive from the reduction gearbox. Neither of these layouts is suitable for wet conditions.

A turntable similar to the one illustrated is installed at Cannock Wood colliery, on the "empties" side of the pit bottom. It handles 1,500 tubs per shift, each of 12-cwt. capacity, turning them through an angle of 154 deg. The turntable rotates at a speed of 7.2 r.p.m., and each tub is turned in about 5 seconds. It is driven by a 650-volt 10-h.p. motor, rotating at 1,440 r.p.m., with a horizontal V-belt drive, through reduction gearing giving a speed ratio of 200 to 1. The motor and reduction gears are carried on an overhead platform 6 ft. 6 in. high, which also carries the top bearing of the turntable shaft. The installation of the machine at Cannock Wood has enabled two men to be released for other work.

The design of the turntable is easily adapted for use with heavier tubs, by increasing the number of supporting rollers and by stiffening the turntable circumferentially and radially.

BOOKS RECEIVED.

- Report on the Work of the British Council for the Year Ended 31st March, 1951.* Offices of the Council, 65, Davies-street, London, W.1. [Gratis.]
- Productivity Team Report. The Brassfoundry.* Report of a Visit to the U.S.A. in 1950 of a Productivity Team Representing the British Brassfoundry Industry. Anglo-American Council on Productivity, 21, Tothill-street, London, S.W.1. [Price 7s. 6d., post free.]
- Factories Acts, 1937 and 1948. Memorandum by the Senior Electrical Inspector of Factories on the Electricity Regulations.* Fourth edition. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 3s. net.]
- Ministry of Labour and National Service. Electrical Accidents and Their Causes.* 1949. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2s. 6d. net.]
- The British Electrical and Allied Industries Research Association. Technical Report No. G/T 252. Rates of Rise of Restriking Voltage at Circuit-Breaker Positions on 66-kV Systems (Systems D, E, F, G, H, and K).* By L. GOSLAND and J. S. VOSPER. [Price 10s.] No. G/T 254. *Maximum Arc Energy Liberated During the First Current Loop in a Series A.C. Circuit.* By H. GOLDENBERG. [Price 10s.] No. G/T 258. *Intrinsically Safe Electrical Apparatus: Relation of Igniting Current to Circuit Inductance for Inflammable Mixtures of Blue Water-Gas with Air.* By DR. E. M. GUENAU and E. ATHERTON. [Price 6s.] No. L/T 234. *Relaxation Spectrum for Rubber.* By B. GROSS. [Price 4s. 6d.] No. L/T 240. *Dielectric Relaxation in Dilute Solutions of Polar Molecules in a Non-Polar Liquid.* By S. ZIENAU. [Price 4s. 6d.] Offices of the Association, Thornecroft Manor, Dorking-road, Leatherhead, Surrey.
- Scientific Survey of South-Eastern Scotland.* British Association for the Advancement of Science, Local

TURNTABLE FOR COLLIERY TUBS.

Fig. 1. SECTION A-A

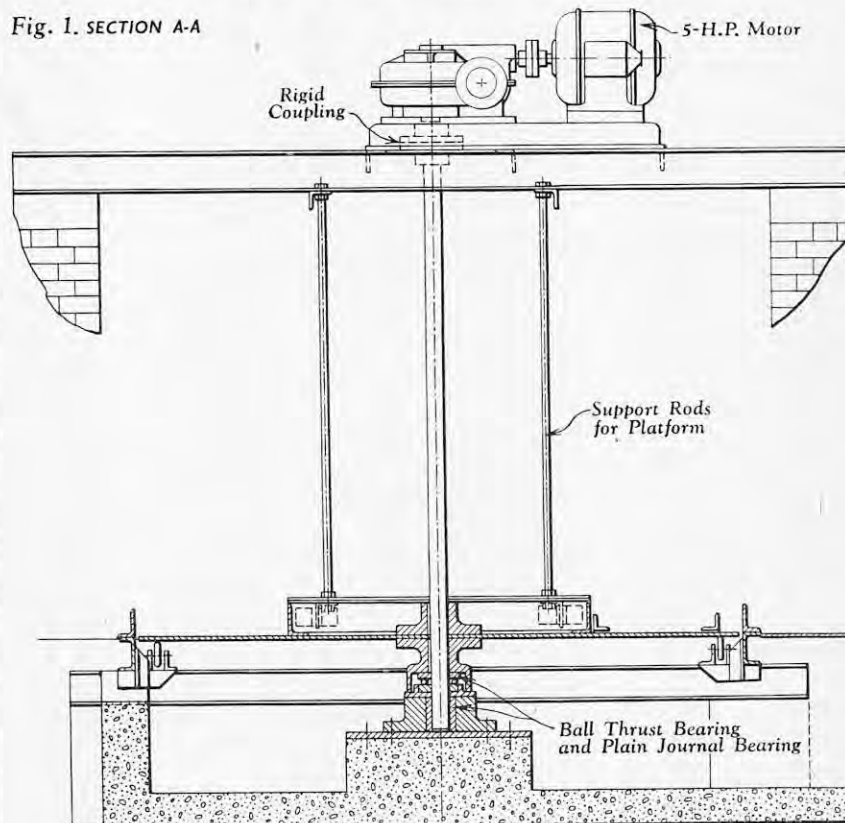
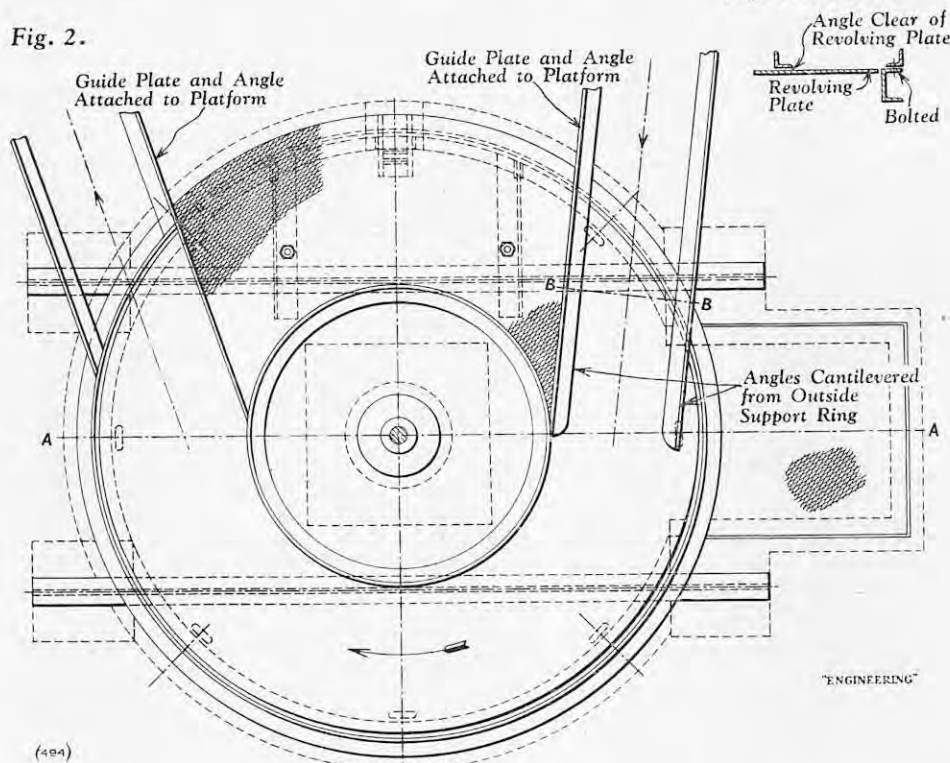


Fig. 3. SECTION B-B

Fig. 2.



- Executive Committee, University of Edinburgh, Scotland. [Price 15s.]
- Filing and Indexing.* By O. W. STANDINGFORD. Office Management Association, Management House, 8, Hill-street, London, W.1. [Price 5s.]
- The Institution of Structural Engineers. First Report on Prestressed Concrete.* Offices of the Institution, 11, Upper Belgrave-street, London, S.W.1.
- United States National Bureau of Standards. Applied Mathematics Series No. 11. Tables of Arctangents of Rational Numbers.* By JOHN TODD. [Price 1.50 dols.] No. 16. *Tables of $n!$ and $\Gamma(n + \frac{1}{2})$ for the First Thousand Values of n .* By HERBERT E. SALZER. [Price 15 cents.] The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A.
- United States National Bureau of Standards. Handbook No. 47. Recommendations of the International Commission on Radiological Protection and of the Interna-*

- tional Commission on Radiological Units, 1950.* The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 15 cents.]
- Fundamentals of Atomic Physics.* By DR. SAUL DUSHMAN. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 5.50 dols.]; and McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 47s.]
- Applied Atomic Energy.* By K. FEARNSIDE and E. W. JONES. Temple Press Limited, Bowling Green-lane, London, E.C.1. [Price 8s. 6d. net.]
- Production Forecasting, Planning, and Control.* By E. H. MACNIECE. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 5.50 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 44s. net.]