ELECTRIFICATION OF THE MANCHESTER-SHEFFIELD-WATH RAILWAY.

(*Concluded from page* 166.)

MOTIVE power for the first stage of the Manchester-Sheffield-Wath electrification is being provided by 30 $B_0 + B_0$ locomotives, the mechanical parts of which were built in the Gorton works of the Railway Executive and the electrical equipment by the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17. These locomotives are illustrated in Figs. 14 and 15, below, and longitudinal-section and end-view drawings are reproduced in Figs. 17, 18 and 19, Plate XV. They are 50 ft. 4 in. long over the buffers; the wheelbase is 35 ft., and the distance between the centres of the bogies 23 ft. 6 in. The overall width is 9 ft. and the maximum height with the pantographs raised is 21 ft. The weight in running order is 86 tons 14 cwt.

The bogies are fabricated from 1-in. steel plates and carry a prefabricated assembly at their outer ends on which the buffers, drawgear and brake equipment are mounted. There is another prefabricated unit at the inner end which carries an articulation joint. The buffing and tractive forces are transmitted entirely through the bogies and articulation joint. At the centre of the bogie is a steel casting, which is riveted to the main frame and carries the brackets from which the traction motors are nose-suspended. These motors are hung from the axles, which they drive through single-reduction spur gearing with a ratio of 70 to 17. The rim and the centre of the gearwheels are separate parts which, on some of the locomotives, are connected by a system of helical springs. On others the drive is transmitted by rubber resilient pads. The body and understructure are spring-borne at four points on each bogie so that the body deflects a minimum for a given lift of the wheels. Compensation for longitudinal and side play is provided and all the working parts of the equipment are continuously lubricated from oil-boxes in the body. The under-structure of the locomotive is built up of side frame plates $\frac{3}{4}$ in. thick and the cast-steel bogie centre is carried by a structure of flanged plates and channel sections riveted to the main frames. A double cross-member is also riveted to the frames at the centre of the locomotive.

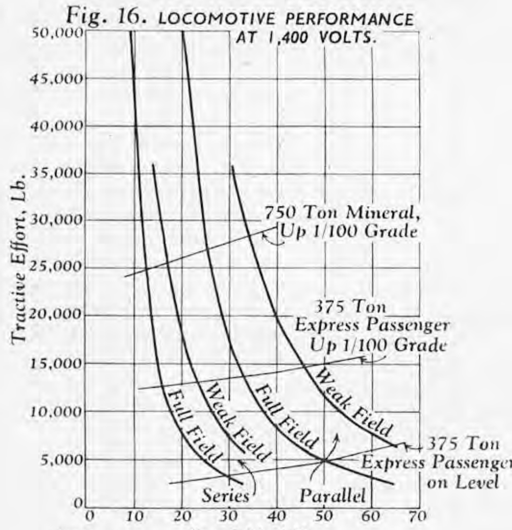
There are driving cabs at each end of the locomotive, communicating with machinery compartments. These compartments are connected by a side corridor from which access can be obtained to the resistance, high-tension and boiler cubicles. The resistance and high-tension cubicles are fitted with sliding doors, which are mechanically and electrically interlocked by the reversing key on the master controller so that access to them can only be obtained when the pantographs are lowered. The starting resistances are generously rated so that slow acceleration is possible as well as slow running under foggy conditions. They are cooled by natural ventilation. Both cabs contain, on the driver's left hand, valves for controlling the straight air brake and for operating the vacuum brakes on the train and varying the speed of the exhauster. The latter valve also controls the locomotive air brakes through a proportional valve. In addition, there is a control key switch and switches for resetting the overload, over-voltage and no-volt relays and for raising and lowering the pantographs. In front of the driver is an instrument and gauge panel and on his right the master controller and auxiliary switches, as well as the hand-brake wheel. One of the cabs is shown in Fig. 21, Plate XV. At the driver's feet are the deadman's pedal, which is duplicated on the other side of the cab and a sanding switch. In designing the layout of the cab, good use has been made of the experience obtained with the prototype locomotive, which was sent to Holland in 1947 and is still in service there, having run some 325,000 miles hauling express passenger and freight trains. For instance, electric heaters have been fitted to the front windows of the driving cab to maintain clear vision.

One machinery compartment contains a 5-kW motor generator from which a supply is taken at 50 volts to the control, lighting and other auxiliary circuits. A 33-cell alkaline battery floats across the generator of this set so that in the event of failure of the latter the circuits can still be supplied. The other motor-generator set, which is rated at

FIG. 14. $B_0 + B_0$ ELECTRIC LOCOMOTIVE.

FIG. 15. DOUBLE-HEADED TRAIN NEAR BARNSLEY JUNCTION.

Fig. 16. LOCOMOTIVE PERFORMANCE AT 1,400 VOLTS.



35 kW, supplies current for exciting the traction motors at any voltage up to 45 volts during regeneration. The compartments also contain an electrically-driven two-cylinder reciprocating compressor, from which air is obtained for operating the locomotive brakes, the electro-pneumatic control apparatus, the pantographs, horns, sanders and window wipers; and a four-cylinder exhauster for operating the brakes of vacuum-fitted trains. This exhauster is arranged for two-speed operation, the higher speed being used for releasing the brakes.

Current is collected from the overhead line by two pantographs, only one of which is normally used at a time. The lowerside members of the structures are light beams, while the top-side members are tubular. There is only one top diagonal bearer at each end. The main pantograph is fitted with an auxiliary pantograph, which follows small variations in the wire height closely. A manually-operated air pump is provided to raise the pantographs in case of insufficient air pressure.

Tractive effort is provided by four 750-volt motors, two of which are mounted on each bogie and are permanently connected in series. Each motor has an output of 435 h.p. at the one-hour rating with full field, or 1,740 h.p. per locomotive, under which conditions it exerts a tractive effort of 25,100 lb. at a speed of 26 m.p.h. The continuous rating of the locomotive at full field is 1,240 h.p., the tractive effort then being 14,600 lb. at 32 m.p.h. The one-hour rating with a weak field is 1,868 h.p., giving a tractive effort of 15,400 lb. at 45 m.p.h., and the continuous weak-field rating is 1,360 h.p., giving a tractive effort of 8,800 lb. at 50 m.p.h. The tractive effort with full field at starting is about 45,000 lb. As stated above, the motor fields are separately excited.

The control gear is of the electro-pneumatic type and is operated through contactors from the master controllers, one of which is shown in Fig. 20, on Plate XV. The 36 main contactors, as well as those for operating the auxiliaries, are housed in the high-tension compartment and are arranged crosswise so that there is ample space between and at the rear of the banks. Each bank can easily be disconnected and lifted out. Both master controllers are provided with four controls: a removable "forward" and "reverse" key, a lever enabling the motors to be connected in series or parallel, an accelerating lever, and a regeneration lever for varying the amount of regeneration by altering the excitation of the traction-motor field. The rate of notching is entirely in the hands of the driver.

An unusually wide range of field weakening is provided in order that one type of locomotive can deal with such a variety of traffic as single-headed 750-ton mineral trains; all classes of goods trains, with either unbraked, partially braked or fully braked stock; and both stopping and express passenger trains. The maximum locomotive availability is thus achieved, a feature which is of great importance on a comparatively short mileage, such as that involved in this scheme. The wide range of economical tractive effort and speed thus obtained is illustrated by the curves given in Fig. 16, on page 321.

If full adhesion efficiency is to be obtained from a double-bogie $B_0 + B_0$ locomotive with nose-suspended motors, the alteration in axle load caused by the reactions of the motor torque and the drawbar pull must be counteracted. For this purpose the field of the leading motor on each bogie can be weakened by closing a weight transfer switch near the master controller. This has the effect of reducing the tractive effort of these two motors to accord with the reduced weights on the corresponding axles, which have been caused by the tilting action of the bogies during acceleration. By thus notching up on the accelerating lever, the maximum tractive effort available can be obtained. The fact that this switch has been closed is indicated by a red lamp, which reminds the driver to open it, and thus restore conditions to normal, as soon as the tractive effort can be reduced.

The brakes can be operated either separately or in synchronism and come into action automatically should the deadman's pedal be released or the train part. The locomotives, for the first time on British Railways, are also fitted with equipment to enable energy to be fed back into the line when trains are being worked down heavy gradients. This regeneration is available down to a speed of 16 m.p.h., below which the air brake is used. If regeneration should fail at any speed the air brake is automatically applied. Other auxiliary equipment includes an electric boiler for heating the train and electric heaters in the cabs.

BRISTOL AEROPLANE COMPANY IN AUSTRALIA.—To handle the general development of their interests in Australia, a wholly-owned subsidiary company has been formed in that country by the Bristol Aeroplane Co., Ltd., Filton House, Bristol; it is known as the Bristol Aeroplane Co. (Australia) Proprietary Ltd., Melbourne.

THE FUEL LUNCHEON CLUB.—The next monthly meeting of the Fuel Luncheon Club will take place on Tuesday, March 18, at the Connaught Rooms, Great Queen-street, London, W.C.2, at 12.40 for 1.10 p.m The luncheon will be followed by an address on "The Problems of the Furnace Manufacturer," to be delivered by Mr. J. Fallon, chairman and managing director of the Incandescent Heat Company, Limited. The honorary secretary of the club is Mr. R. T. Rees, 18, Devonshire-street, London, W.1.

LITERATURE.

Annuaire pour l'an 1952, publié par le Bureau des Longitudes.

Gauthier-Villars, 55, Quai des Grands-Augustins, Paris, 6e. [Price 750 fr. in paper covers; 1,100 fr. in cloth.]

As is customary, the first part of this handy and useful work of reference consists of three chapters, the first of which gives the times of the rising and setting of the sun, moon and planets throughout the year at Paris, together with a list of eclipses and other astronomical predictions, tidal data and a comparison of different calendars. After the section on tides and bores, there is a new article on the periodic variation in gravity, which is followed by tables predicting the maxima and minima of the luni-solar action and the hours of their occurrence. In the second chapter, on the Earth, a portion of the section on geodesy and one of the meteorological tables have been held over for inclusion in the next issue. On the other hand, revisions have been made in the articles on atmospheric electricity and terrestrial magnetism, as well as in the table of magnetic declinations. Chapter III is devoted to astronomy. It contains a new article dealing with distances in astronomy, fresh information concerning the sun, a section on the minor planets and an important account of the motion of the sun, the radial velocities of the stars and galactic rotation, by J. Delhaye. The data on international time signals have been brought up to date by N. Stoyko, and revisions of the articles on stellar spectra, and on galactic novae and supernovae, have been undertaken by P. Couderc and Ch. Bertaud, respectively. It is interesting to note that results from the Palomar observatory are becoming available.

The second part opens with a chapter on numbers and units of measurement, which is prefaced by a new article on numeration and includes the latest details of the M.K.S. system of units. The concluding chapter contains a comprehensive selection of chemical and physical constants. The table of the specific heats of water is new, with values given in joules per degree; and additions and corrections have been provided by R. Grégoire to the tables of the densities, melting points and boiling points of the elements and to the section on radioactivity. This part ends with an article on ocean currents, revised by A. Gougenheim. In the alternative definition of surface tension on page 459 it should be stated that the work is done under isothermal conditions. The international standard pitch, assigning to tuning A a frequency of 440 cycles per second, now replaces the 435 value given on page 472; and the information concerning mesons on page 549 might be expanded.

The supplement for 1953 includes particulars on the passage of Mercury across the sun's disc on November 14, 1952. The first notice takes the form of a summary by A. Danjon of the matters considered and the recommendations made at a conference on the Fundamental Constants of Astronomy, held at Paris in 1950; and the second is a mathematical investigation on the estimation of magnitudes from their measurements, by G. Darmois. The extensive numerical data have been carefully selected and conveniently arranged, the accompanying articles are admirably concise and informative, and the folding plates and charts should prove most useful.

Flow Measurement with Orifice Meters.

By REID F. STEARNS, RUSSELL R. JOHNSON, ROBERT M. JACKSON and CHARLES A. LARSON. D. van Nostrand Company, Incorporated, 250, Fourth-avenue, New York 3, U.S.A. [Price 7.50 dols.]; and MacMillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 56s. net.]

AT first sight, the size and style of this book are likely to lead the reader to expect the latest and comprehensive data on orifice meters, but, in fact, the book is somewhat disappointing in this respect, as the only orifice meters dealt with in any detail are the mercury manometer types with relatively high differential pressure, and these are considered principally in connection with the metering of fluids in chemical and oil plants. Very little is said on the subject of gas, air or steam flow, and the absence of reference to the common industrial combustion gases suggests that fuel metering has not been in the authors' minds.

The book starts with derivations of the various flow equations and their application to metering problems. A large number of worked-out examples assists the reader in following the somewhat elaborate procedure, and numerous charts give the requisite data. It seem rather surprising that, in the first few chapters, there is practically no reference to Reynold's Number, though its evaluation is dealt with a little later. The chapter on the principle of operation of commercial meters would be much better if it were considerably enlarged. At present, it only touches on a very few types, and gives by no means a true picture of the field that it purports to cover. The chapter on the installation of orifice meters contains numerous sketches and graphs to indicate the required length of straight pipe before and after the meters, but what is perhaps, the most commonly used type of tapping, namely, the "radius" tap which is placed at one pipe diameter upstream and one pipe radius downstream, is not mentioned at all. This method of tapping is used a great deal in this country and is gradually superseding others—for example, the *vena contracta* type—in America. Piezometer ring tappings also are not mentioned, though they are widely used.

It is surprising that no mention is made of the Giese semi-circular profile orifice plate, recently developed in this country by the British Iron and Steel Research Association. The readings obtained with this plate are practically independent of Reynold's Number down to values as low as 300, and, in consequence, it is ideal for measuring oil and other fluids of varying viscosity. In fact, the book has little to say about measurement at Reynold's Numbers below 10,000. The chapters which follow deal with the testing and checking of meters, and special metering problems and considerations of accuracy.

The last third of the book consists of appendices, giving tables of discharge coefficients, charts of various factors, physical data, etc. This is, of course, a collection of data available from other sources, though it is useful to have it brought together in this way. It should be remembered that this is an American book and that the piping data on page 219 therefore apply only to American pipe. A somewhat irritating point is that the whole book is printed in blue type, with blue line and half-tone illustrations, the consequent lack of contrast making the book unnecessarily tiring to the eyes. It is difficult to see what useful purpose the book serves, since, in the author's country, the field has already been better covered by other American publications, and, so far as British use is concerned, the British Standard Code B.S. 1042 on *Flow Measurement,* gives all the data necessary for British users in a convenient compact form, and, indeed, covers a wider field.

Dimensional Analysis and Theory of Models.

By PROFESSOR H. L. LANGHAAR. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 4 dols.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 32s. net.]

DIMENSIONAL analysis is of increasing importance in engineering and physics because it furnishes a method by which a partial knowledge of a given problem can be utilised in the process of arriving at a solution. The kind of information necessary at the outset is a knowledge of the general nature of the fundamental equations which govern the system, and the nature of the boundary conditions which, together with the equations, determine the solution in any particular case. It is not necessary to express these equations in full; indeed, the value of the method is greatest in applications so complicated that the fundamental equations cannot be written down completely, as, for example, in the great majority of practical questions arising from the motion of fluids. In his book, Professor Langhaar therefore discusses a subject of general interest to those engaged in drawing office and laboratory. The subject-matter falls into two main parts,

MIXED-TRAFFIC ELECTRIC LOCOMOTIVE FOR

(*For Descript*

Fig. 17.

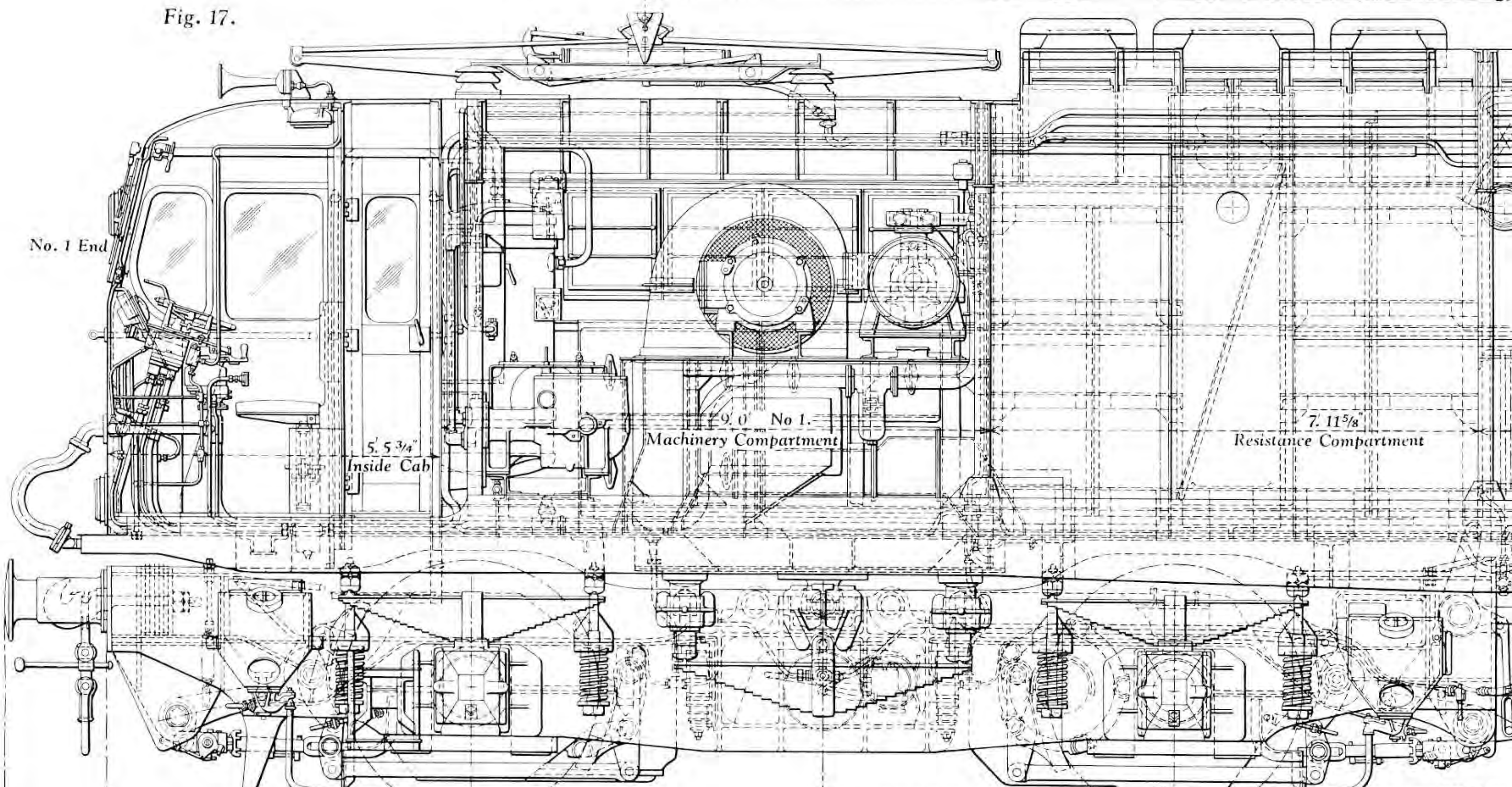


Fig.

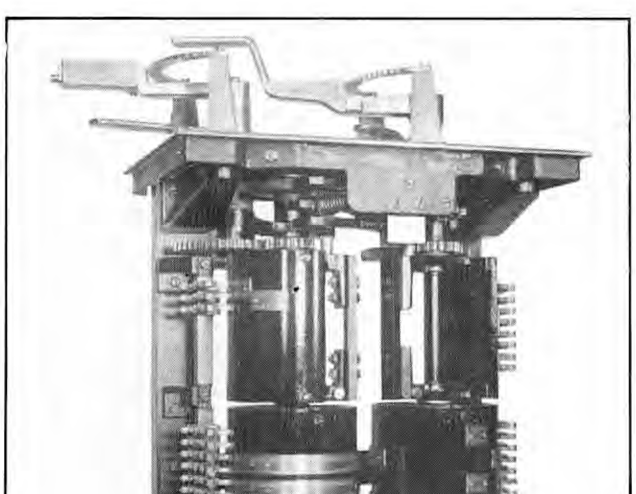
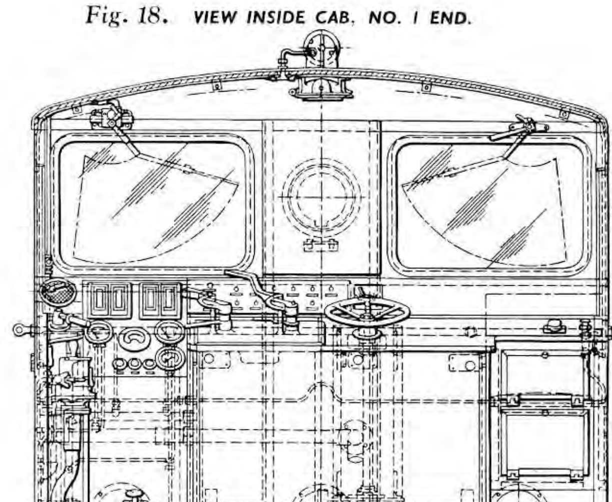
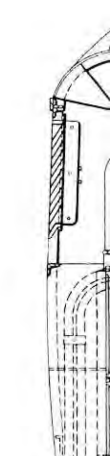


Fig. 20. Master Controller.

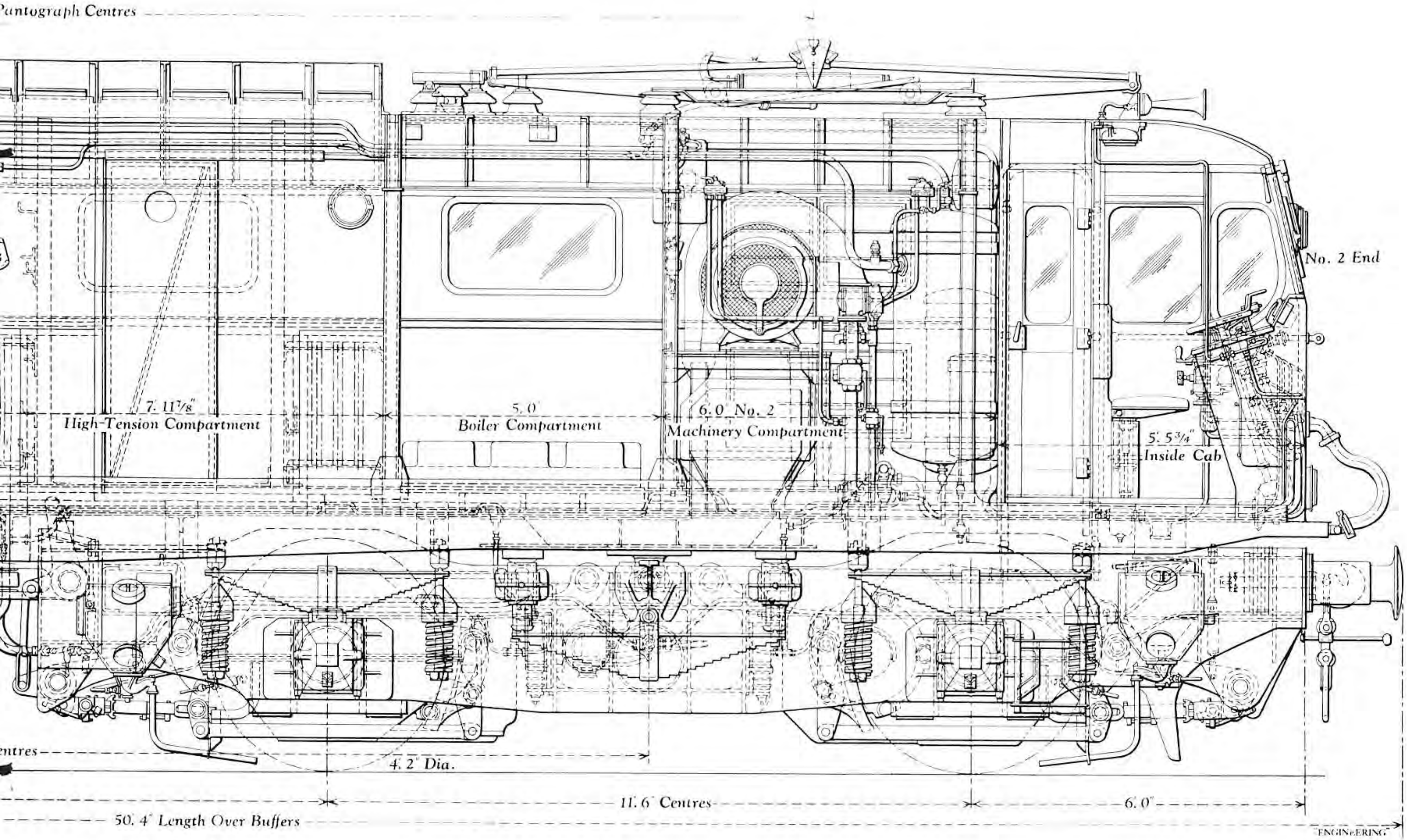
Fig. 18. VIEW INSIDE CAB. NO. 1 END.





THE MANCHESTER-SHEFFIELD-WATH RAILWAY.

see Page 321.)



VIEW OF RESISTANCE CHAMBER PARTITION FROM NO. 1 MACHINE COMPARTMENT.

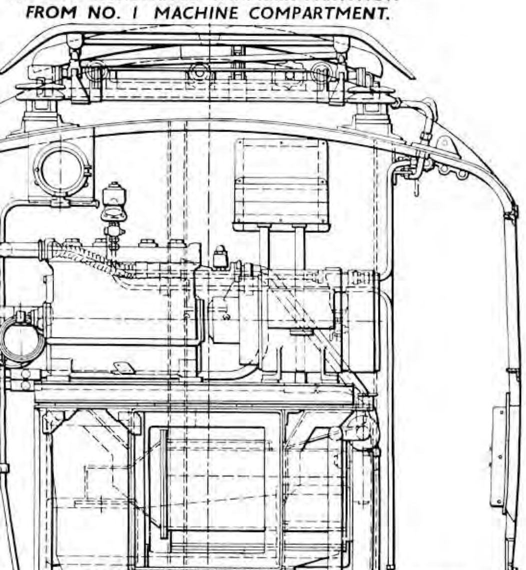


Fig. 21. Interior of Driver's Cab.

CONTINUOUS SOLVENT EXTRACTION PLANT FOR "ARDIL" FIBRE MEAL.

ROSE, DOWNS AND THOMPSON, LIMITED, HULL.

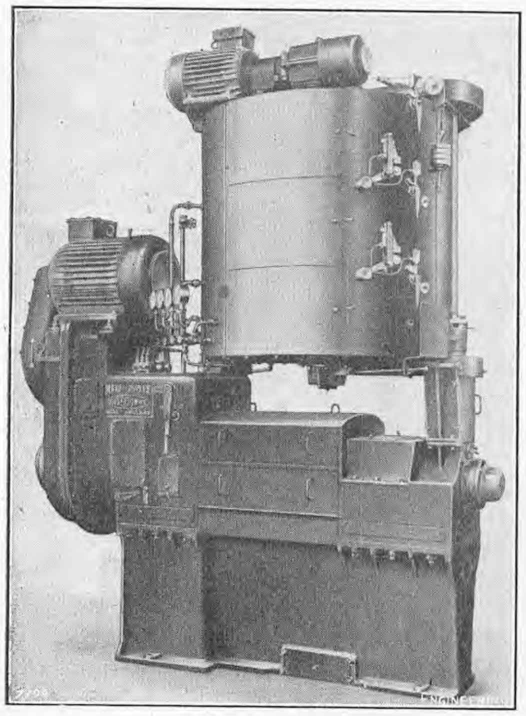


FIG. 1. "MAXOIL-DUPLEX" EXPELLER.

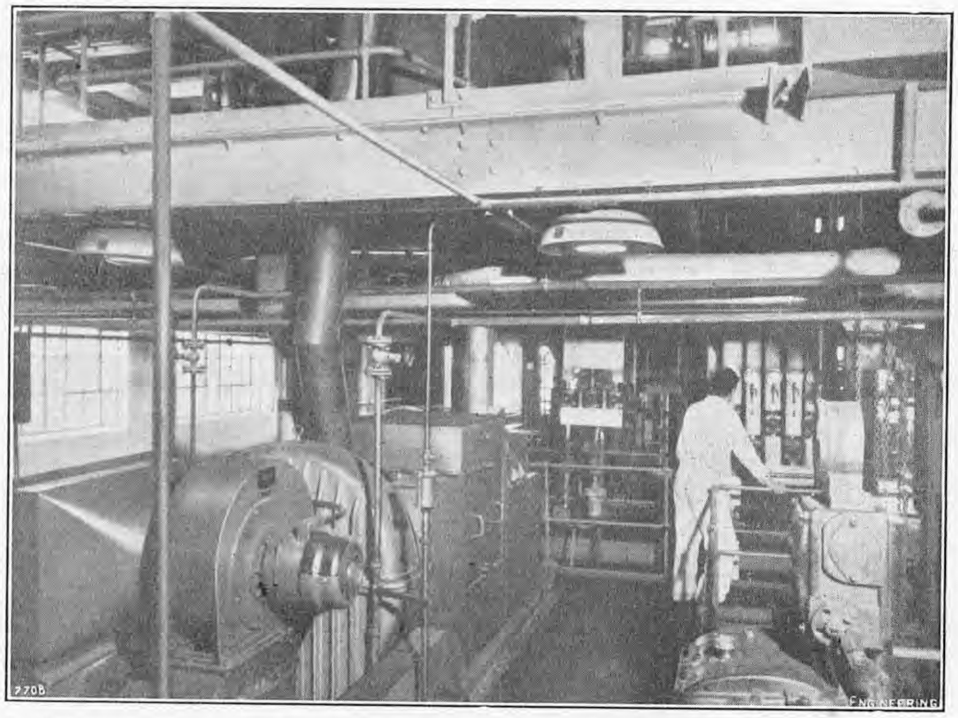


FIG. 2. LOW-PRESSURE EXPELLER INSTALLATION.

FIG. 3. FLAKING ROLLS.

the first of which is expounded in Chapters 1 to 4. Following an introductory discussion on the nature and use of physical dimensions, the idea of which is due to Fourier, the author proceeds to the study of the principles of dimensional analysis, where attention is drawn to Buckingham's theorem. He wisely states this important theorem without employing the customary π-notation, which is apt to render its meaning obscure to the beginner; and he very largely succeeds in his attempt to bring the applications within the grasp of those having little mathematical knowledge, other than basic algebra and an acquaintance with the concept of a function. This characteristic of the treatment is perhaps most noticeable in Chapter 3, on the systematic calculation of dimensionless products, with its concisely arranged sections on such topics as the singular dimensional matrix, the arrangement of variables, and the transformation of dimensionless products. The rigorous development of the algebraic theory in the next chapter has no doubt been included to meet the requirements of the specialist.

Professor Langhaar thus presents the whole theory of models, in which it is feasible to see the effect of changes in all the physical variables by making a change in a comparatively small number of them. Progress in this direction implies a working acquaintance with the connection between similarity and model testing, in Chapter 5, and, in the case of most engineering students, with the next chapter, where the analysis is applied to problems of elasticity. Here and in other parts of the book due attention is paid to the practical aspect of the work, as in the empirical method of model engineering, which affords the only known way of dealing with many difficult problems that lie at present beyond the scope of rational analysis. Success then depends most of all on the skill and experience of the investigator, and on the engineer's ability to recognise the factors that influence the phenomenon under consideration. The progress of scouring of the banks of a river over a period of years is an example from civil engineering; others are suggested by Chapter 7. Those approaching the subject for the first time will find the illustrative examples and exercises of real value, in a subject which, as the subsequent chapters show, has important applications also in the theory of heat and in that of electro-magnetism. It is well, too, to have in the final 20 pages a chapter on differential equations and similarity, since such equations occasionally provide a deeper insight into the laws of similarity than can be gained from a knowledge of the appropriate set of variables alone.

CONTINUOUS SOLVENT EXTRACTION PLANT.

THE production and processing of natural wool, to the point where it is ready to be woven into a fabric, is subject to so many economic influences and intermediate handlings that the product has become increasingly expensive; and, though no obvious obstacles appear to restrict the quantity that could be grown, the attractions of a synthetic product, near enough to natural wool in quality and appearance to be woven into the same fabric with it, would have induced chemists to pursue that line of research even without the encouragement of making something appreciably cheaper than the natural material. In ENGINEERING of December 17, 1937 (vol. 144, page 673), we described an Italian process for making artificial wool from casein, extracted from milk. Another method, developed in this country by Imperial Chemical Industries, Limited, uses protein, extracted from groundnuts, as the basis of a process of which the end-product is Ardil fibre.

In appearance and general characteristics, Ardil fibre approximates closely to natural wool, and for some purposes its qualities are superior to those of natural wool. It can be woven with all types of natural wool, and can be mixed with cotton and rayon; and cloth made from it can be produced on the normal textile machinery and made up by the ordinary methods, so that its introduction into textile manufacture can be effected with negligible capital outlay. At present, the amount available is small, but is is expected that, in due course, substantial quantities will be available at a price less than that of wool.

Protein exists in various forms and many previous attempts have been made to dissolve it from natural substances and to re-form it. A new continuous solvent extraction plant has been brought into use recently at the oil mills of the British Extracting Company, Limited—a component of the Unilever group—at Bromborough, Cheshire. This plant is designed to extract the oil from groundnut kernels by a process which will allow the protein in the residual meal to be used for the production of Ardil fibre. About 80 per cent. of the oil contained in the seed is first removed by crushing in expellers and the extractor removes nearly all of the remaining oil, leaving only about 0·5 per cent. in the finished fibre meal. The solvent used in the extraction process is reclaimed and can be re-used indefinitely,

CONTINUOUS SOLVENT EXTRACTION PLANT FOR "ARDIL" FIBRE MEAL.

ROSE, DOWNS AND THOMPSON, LIMITED, HULL.

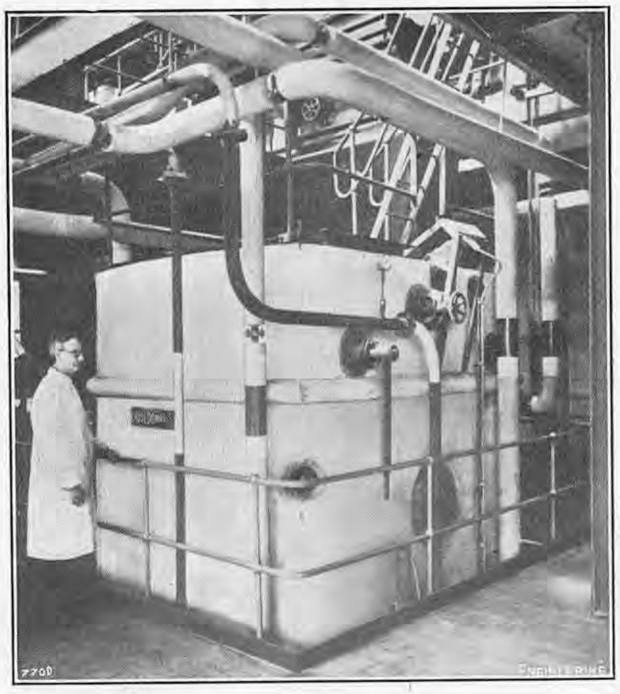


FIG. 4. TOP OF CONTINUOUS EXTRACTOR.

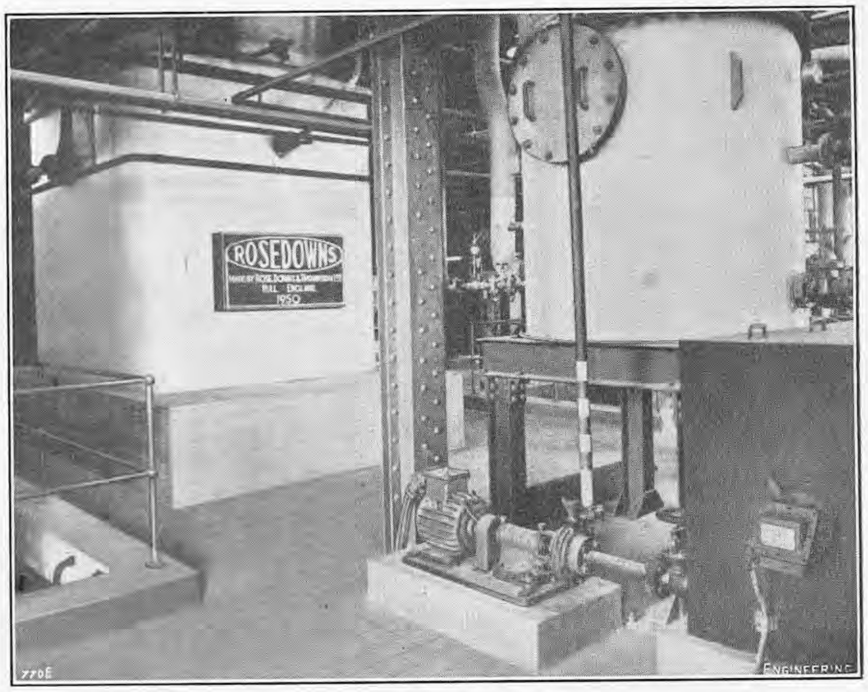


FIG. 5. EXTRACTOR AND CONTINUOUS STILL.

as the losses due to evaporation amount to less than a gallon per ton of seed processed. A Hansa-Muhle type of extraction plant has been supplied to the mills by Messrs. Rose, Downs and Thompson, Limited, of Hull, who have also supplied most of the pre-treatment machinery. The extractable protein that is suitable for Ardil fibre constitutes about 40 per cent. of the finished oil-free meal, and, when this protein has been removed, the residue is used in the production of balanced feeding-stuffs for livestock. The extracted protein is made into Ardil fibre in a factory at Dumfries, belonging to Imperial Chemical Industries, Limited.

Groundnuts, commonly known as peanuts or monkey-nuts, were chosen as the starting material for technical and economic reasons. They are a tropical and sub-tropical plant (*Arachis hypogaea L.*), mainly grown in India, China, West Africa, Borneo and the southern States of America, some 8 million tons being harvested annually. The groundnuts received in this country are usually shelled in the country of origin. The kernels contain about 50 per cent. of oil, which is a principal ingredient of margarine and other edible products. The proteins in groundnuts are a group of very complex compounds which are found in the kernels. They are not oil-soluble, and form about 50 per cent. of the residue from any oil-extraction process. The application of heat beyond specific limits, which occurs in most oil-extraction processes, causes a complicated series of irreversible reactions, which are generally referred to as "de-naturing." Normally, this de-naturing of the protein facilitates the extraction of the oil from the oil-bearing cells, but, in the preparation of the raw material for Ardil fibre, these reactions must not occur, and this new plant at Bromborough has been designed to extract the oil at comparatively low temperatures.

Ardil fibre meal is a finely divided material like flour, which would cause difficulties in any oil-extraction process, and particularly in a normal continuous solvent extraction plant. Although this plant is not new in principle, it has many novel and important features which are essential for Ardil fibre production. At the same time, it can be used to extract the oil from a wide variety of oil-bearing seeds by normal methods, the residue being used for compound feeding meals; and, whatever meal is produced, the oil extracted can be used for the production of edible fats. The capacity of the plant, nominally 100 tons per day of 24 hours, varies with the oil content of the seed under treatment. As in all processing industries, and particularly in the oil-milling industry, the preliminary treatment of the raw material has a definite bearing on the quantity and quality of oil which can be extracted, and on the value of the residual meal.

The pre-treatment and pre-pressing section is capable of dealing with an annual intake of 70,000 tons of groundnuts. The new plant being situated close to Bromborough Dock, the shelled seed can be brought by sea and delivered directly to the British Extracting Company. Before it is treated in the extraction plant, it is purged of foreign material, dried and graded, and the oil contained is reduced by mechanical pressing. In grading, the red-brown inner skins and the "culls" (broken portions of skinned kernels and adhering fines) are separated from the kernels and are treated separately, to recover the oil that they contain, by passing them through high-pressure oil expellers of the type shown in Fig. 1, on page 323, followed by extraction. The residual meal is used in the compound feeding-stuffs industry and the extracted oil is further processed and refined for edible products; none of the raw material is wasted.

The main stream of cleaned and graded kernels goes forward for Ardil fibre meal, and, after cracking in horizontal rolls, is fed to steam-heated kettles, where it is cooked before pressing in low-pressure oil expellers. A view of the low-pressure expeller installation is shown in Fig. 2, on page 323. With skilful cooking, the protein remains unharmed, but the oil-cell walls, which are not ruptured in rolling, are rendered more permeable to the flow of oil, and the droplets of oil tend to coalesce into larger drops. In each expeller, the cooked meal is continuously and automatically compressed by pressure worms in three successive cages, and the oil is expressed through perforations in the cage walls. In each cage, the meal is considerably decreased in volume, with a corresponding increase in pressure. The type of expeller used is extremely versatile, and, since it does not generate high temperatures in the meal, it is particularly suitable for low-temperature oil expression.

The residual meal from the expeller will contain from 13 to 15 per cent. of oil, and, after reduction in breaker rolls, it is passed through flaking rolls before reaching the extractor house. Flaking rolls are used because the material, including fine particles, must be blended as far as possible to a thin membrane which can be easily penetrated by the solvent; the efficiency of the process depends not only on the design and operation of the extraction plant, but on the condition of the meal. The flaking rolls comprise two smooth rollers which subject the material to a long heavy pressure. The flaking-rolls room is shown in Fig. 3, on page 323. The machines are oil-lubricated and water-cooled from a central system.

The solvent oil extraction process consists of washing the prepared material with a suitable volatile solvent, which is usually introduced in counterflow to the movement of the flakes. A diffusion of solvent and oil occurs through the cell walls until a state of equilibrium is reached. Theoretically, washing with fresh solvent can continue indefinitely, but the period of washing or, in a batch plant, the number of washes, and therefore the amount of oil left in the residue, is governed by economic factors. It is not usual to continue oil extraction much below a figure of 1 per cent. of oil left in the residue, though a figure of less than 0·5 per cent. is being achieved in this plant. As stated above, the solvent is reclaimed from the oil and meal for re-use.

In practice, various methods are adopted to fulfil the theoretical requirements economically and to overcome the physical difficulties which are encountered in handling highly volatile solvents. The extractor at Bromborough, the top and bottom sections of which are shown in Figs. 4 and 5, herewith, resembles a large bucket elevator in which the flaked meal is carried in buckets supported on endless chains within a gas-tight housing. The meal is received through an automatic feeder, and passes over a magnet to a variable-capacity measuring chamber at the top of the extractor casing, from which it is admitted to the buckets through a sealing chamber. The feeding gates open automatically when each bucket is in a position to receive a measured charge, and the sealing effect of the meal assists in preventing the escape of vapour to the atmosphere. The buckets move slowly down one side of the extractor and up the other side. When each bucket has completed a full circuit, it is automatically inverted and discharges the meal to a small hopper from which it is conveyed out of the vapour-tight casing to the desolventisers.

The solvent is sprayed into each bucket at the top of the casing and on each side, so that, in its progress through the extractor, the meal is subjected to an initial washing with solvent in parallel flow. The bulk of the oil is thus removed, and a final washing with solvent in counterflow removes the remaining traces of oil. Additional hand-controlled sprays are provided for use, when required, with different seeds. Clean solvent from a thermo-

CONTINUOUS SOLVENT EXTRACTION PLANT.

ROSE, DOWNS AND THOMPSON, LIMITED, HULL.

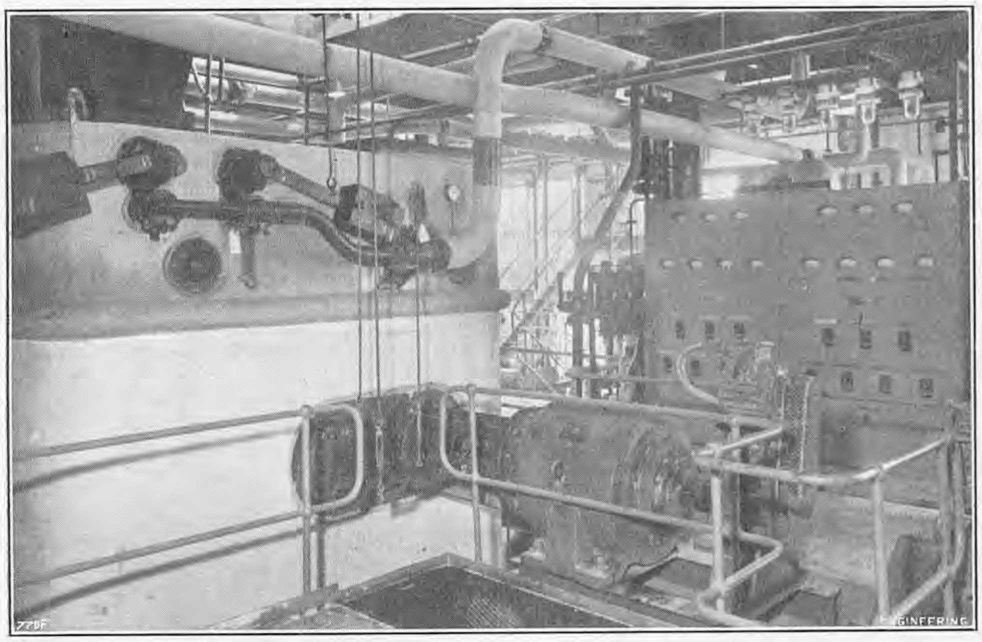


FIG. 6. EXTRACTOR DRIVE AND CONTROL PANEL.

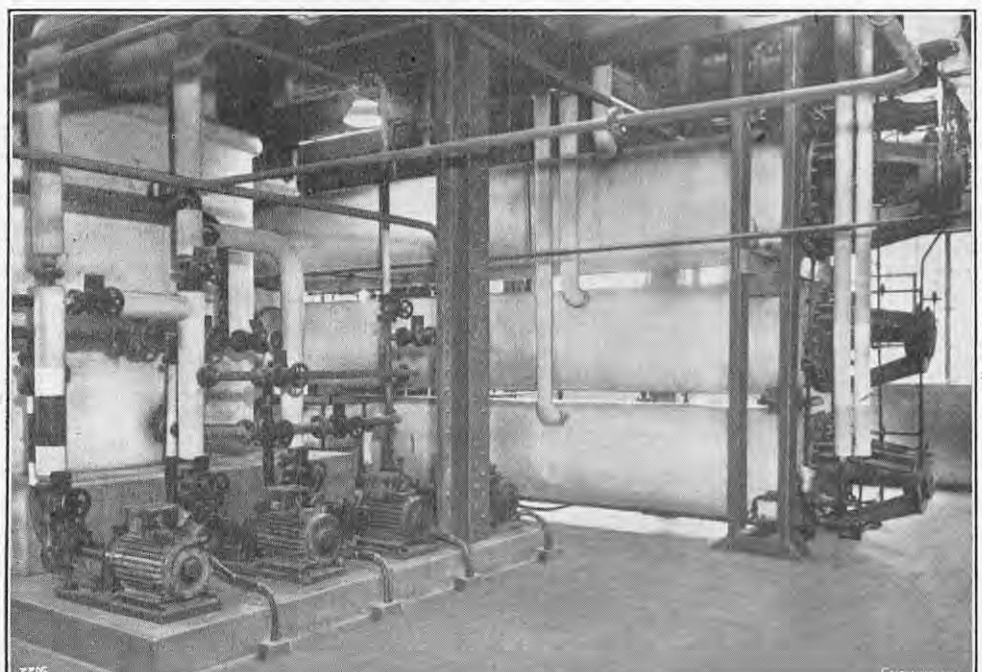


FIG 7. SOLVENT PUMPS AND DESOLVENTISER.

statically-controlled gravity tank is used for the final wash on the counterflow side of the extractor, and is flooded over the meal in each ascending bucket in turn. Each bucket is fitted with a gauze filter, and the drainage of solvent passing through the meal into the following bucket can be adjusted from a point outside the extractor housing. Fines are removed from the filters by an automatic rapping device. The weak mixture of oil and solvent known as "half miscella," which is obtained from this part of the process, is collected in a compartment at the foot of the extractor. This half miscella, being capable of extracting further oil, is pumped through a filter, to be used again for the initial washing of the fresh meal in the descending buckets. As already described, it is sprayed into the buckets as they are filled, and floods over and through the meal in each bucket in turn. The resulting oil-saturated solvent, known as "full miscella," is collected in a separate compartment at the foot of the extractor, from which it is drawn off for distillation.

The operation of the extractor is continuous and automatic, the supply of solvent and the timing of the sprays being controlled so as to ensure a full charge of solvent to each charge of meal. Only a small power is required to drive the extractor, a 1-horse-power motor being used, with a "Heliocentric" reduction gear having a speed ratio of 2,800 to 1. The speed of the extractor can be adjusted to regulate the movement of the buckets, according to the condition of the seed. Under normal conditions, when treating groundnuts, the full cycle is completed in a little over two hours. The driving gear and the extraction-house master control panel are illustrated in Fig. 6, herewith, and the solvent and miscella pumps in Fig. 7.

In the normal continuous solvent extraction plant, the solvent can be reclaimed from the meal by vaporisation. In the production of Ardil fibre meal, however, the rise in temperature must be restricted, and the reclamation of the solvent requires particular care. The process is further complicated by the very fine composition of the dried material, and its tendency to cake and form a solid cement-like substance when in contact with moisture.

Desolventising is carried out at Bromborough in a partial vacuum. The unit consists of six horizontal tubes arranged one above the other. Each tube is steam-jacketed, and provision is made for the injection of open steam, which may be required for certain seeds. The extracted meal enters the top tube, through a rotary sealing valve, from a small buffer bin. A similar rotary valve is fitted at the outlet from the bottom tube. Stirrers move the meal along the tubes and provide sufficient agitation to free the vapours. To ensure a proper seal, lantern glands are provided at each shaft end. The vapours are drawn through filter combs, and across hot-water washing columns into the condensers, by steam ejectors. The spent ejector steam, plus any entrained vapour, is condensed and eventually passes with the condensate from the main condensers into a water/solvent separator. The temperature of the water passing through the washing columns is regulated to minimise solvent condensation and to avoid water evaporation.

The solid particles which are washed out in the columns, and any solvent which may be entrained, are precipitated and the solvent reclaimed. The dried meal is conveyed out of the extractor house to another building, where it is cooled, screened, and the larger fragments ground to a size suitable for the production of Ardil. It is then automatically weighed and bagged for despatch.

The full miscella is pumped from the extractor through filters to a gravity tank. It passes through a heat-exchanger to a pre-still, where some of the solvent is evaporated, and is then delivered to a continuous still in which the solvent is evaporated in two stages, open steam being used to remove the final traces. The dry solvent vapours from the first stage of the still pass through the heat-exchanger before they are condensed and returned to the process tank for re-circulation. Vapours from the wet section are condensed and pass into the water/solvent separator. The solvent-free oil, collected at the foot of the continuous still, drains to a small tank from which it is automatically pumped to the finished-oil tanks. The lecithin in the oil is freed in swelling tanks and separated from the oil in centrifugal separators. The oil is then weighed and despatched for further treatment and refining, the nature of which depends on the purpose for which the oil is intended.

The solvent and water mixtures from the wet condensers in the plant are collected in the water/solvent separator, where the low specific gravity of the solvent is used to effect an immediate separation. The solvent returns to the process tank for recirculation, and the excess water goes to another still, where any solvent that remains is evaporated and reclaimed. These solvent recovery systems reduce solvent losses to a minimum, but there remains a potential source of loss in the vapours arising in various pipelines and vessels. The solvent from these vapours is reclaimed by a separate system. All pipelines and vessels carrying solvent are vented to an air balancing main and the vapours are collected in a receiver, to be passed through an air cooler to a dephlegmator in which refrigerated brine lowers the temperature of the air, the solvent is precipitated, and the air is exhausted to atmosphere. The brine and the entrained solvent fall to a gravity separation tank and the reclaimed solvent is returned to the process, while the brine recirculates through the dephlegmator.

The British Extracting Company have installed an effective warning system which indicates bin, tank and motor overloads. Stringent precautions have been taken to minimise fire hazards; every possible source of static electricity is earthed, and an automatic system is installed to flood the entire extractor house with methyl bromide gas, should an outbreak of fire occur.

The equipment in the new factory is designed to operate continuously. The Ardil fibre meal produced at Bromborough will make a highly important contribution to the production of the new Dumfries factory, which is expected to produce some 20,000,000 lb. annually of Ardil fibre—a welcome addition to the supply of textiles in the United Kingdom, where stocks have fallen considerably, and consumption has risen appreciably, since the war. In 1950, 640,000,000 lb. of raw wool were consumed, 120,000,000 lb. being exported or re-exported. Stocks fell from 475,000,000 lb. at July, 1946, to 200,000,000 lb. at the end of 1950.

THE ENGINEERING OUTLOOK.

XI.—TEXTILE MACHINERY.

By all accounts, 1951 was a fairly successful year for the textile-machinery industry. As may be seen from Table I, herewith, the total output of the industry, valued at 74·4*l.* millions in the twelve months to September, 1951, was 9 per cent. higher than in the previous twelve months. Even more important, the year ended with order books generally fuller than at the beginning, so that the slow but worrying downward trend of orders which affected some branches of the industry, notably those manufacturing the traditional types of cotton spinning and weaving machinery, has been arrested. Some difficulties have been encountered, of course, but these have been fewer and generally have proved less serious than was originally feared. Manufacturers have not always found it easy to obtain all the steel and components they require, but so far the shortages have not affected output. Table II, opposite shows, that the deliveries of textile machinery in 1951 were at a much more level rate than in 1950, when there was a steady decline during the first three quarters. There is a prospect of more steel by the third quarter, and deliveries are likely to be maintained in 1952.

Some companies have been worried about the supply of skilled labour, particularly those in areas where priority defence industries are located. Textile Machinery Makers, Limited, for example, are situated in the same district as A. V. Roe and Company, who are building the Canberra bomber in Oldham, and Ferranti, Limited, who have important contracts for radar equipment. The defence industries, however, have not yet made very large claims on the labour market and the total number employed in the textile machinery industry, as will be seen from Table III, opposite, was only 900 fewer in September, 1951, than in September, 1950. The number engaged in the manufacture of bleaching, dyeing, printing and finishing machinery increased by 720 and the overall decline was due almost entirely to a drop of 16 per cent. in the number employed on the production of accessories. Since, however, the output of that section increased in value by 13 per cent., the fall in the labour strength suggests higher productivity rather than any difficulty in obtaining labour.

Re-armament work is potentially very important for manufacturers of textile machinery, who made ammunition and machine tools on a large scale during the recent war. Some have been given pilot orders, in accordance with the Government's policy of giving suitable manufacturers small contracts for the manufacture of a product (e.g., ammunition) which they might be expected to make on a large scale in war. Re-armament work, however, accounts for only a small proportion of the industry's turnover.

In the field of cotton textile machinery there is a satisfactory volume of home orders on hand, which is all the more welcome in view of the high proportion of old and obsolescent machinery in Lancashire. The need for increasing productivity in the cotton industry was brought out very clearly in 1950 in the reports of the Productivity Teams on Cotton Spinning and Cotton Weaving. A Team from the United States, who visited the United Kingdom in 1951, found much to commend in the way that modernisation is being carried out. In almost every mill visited, they found new machinery installed or in process of installation, and many improvements made to existing machinery. Conventional draft spinning machines, for example, had been converted to long draft, and two-process scutching to single-process. While, however, the Team expressed their admiration of the extent and methods of re-equipment and modernisation in individual instances, they left on record their general impression that these measures had been taken by too few companies, and that efforts to improve productivity should be augmented and accelerated in every possible way.

The Cotton Spinning Re-equipment (Subsidy) Act of 1948 was not, perhaps, an unqualified success, but nevertheless, it has stimulated modernisation and reorganisation. Twenty-nine groups, controlling 60 per cent. of the total number of spindles in place, eventually registered with the Board of Trade to take advantage of the Government's subsidy of 25 per cent. of the outlay required under their modernisation and re-organisation programmes. The visits of the Productivity Teams to the United States also seem to have achieved practical results in stimulating orders for new plant. The high rate of ordering in 1951, however, was no doubt indirectly affected by re-armament. Many of the orders placed were for blow-room machinery, and the decision to replace old machinery was probably influenced in many instances by the fear of serious plant failures which might arise if new equipment should be unobtainable for a long time as a result of intensified re-armament. The productivity reports have certainly resulted in action so far as the machinery manufacturers are concerned. It was noted in the report on Cotton Spinning that travelling overhead blowers were fitted in most of the ring rooms visited, which greatly reduced manual cleaning and prevented the accumulation of "fly." Mr. K. H. Preston, of Platt Brothers and Company (Holdings), Limited, at the annual general meeting of his company in July, said that one of their subsidiaries had entered into an agreement with the Parks-Cramer Company of Fitchburg, Massachussetts, the leading makers of travelling cleaners in the United States. Under this agreement, an exclusive manufacturing and selling licence for the world outside the Americas was obtained. The first major installation was then in course of erection at Victoria Mill, Leigh, Lancashire.

The need for modern machinery in Lancashire has been greatly accentuated by the expansion of the Japanese cotton industry. After the limitation of four million spindles was abolished in the autumn of 1950, the number of spindles installed increased from 3·89 million to 6·37 million at the end of 1951, a figure which, according to Mr. Kippei Hara, president of the Dai Nippon Spinning Company, "must have caused a stir in Lancashire." Japanese cotton exports, though only half the pre-war volume, now account for 20 per cent. of the world trade in cotton goods. Samples of Japanese textiles offered for sale in Dominion and Colonial markets, moreover, now appear to be of much higher quality than before the war, and, in some cases, have been offered at prices 25 to 30 per cent. below those of the equivalent British goods. Even the Japanese, however, now appear to be afraid of surplus capacity. Mr. K. Abe, chairman of the All-Japan Cotton Spinners' Association, has drawn attention to the risks inherent in over-expansion and has suggested that the productive capacity for cotton yarn may shortly exceed the possible demand for cotton goods and the likely prospect of raw cotton supplies. The expansion of capacity is at present at the discretion of the individual companies (principally the ten big spinning combines) and, if present plans are carried through, the total number of spindles must continue to increase throughout 1952. There is, however, at least some indication that the cotton industry may be well disposed to some scheme for the voluntary control of capacity such as existed before the war, when only eight million out of 12 million spindles were in operation.

TABLE I.—DELIVERIES OF TEXTILE MACHINERY (VALUE 1,000*l.*).

Type of Machinery.	12 Months ended September, 1948.		12 Months ended September, 1949.		12 Months ended September, 1950.		12 Months ended September, 1951.	
	Total.	For Export.	Total.	For Export.	Total.	For Export.	Total.	For Export.
Spinning, twisting and preparatory processes	14,769	11,439	19,618	14,946	26,118	16,368	28,198	16,119
Processes subsequent to spinning, but preparatory to weaving ..	5,268	2,289	8,196	3,489				
Weaving	5,034	2,112	6,735	2,517	8,012	2,914	8,486	3,141
Bleaching, dyeing, printing and finishing	4,050	1,827	5,394	2,337	6,034	2,756	6,344	2,691
Jute, flax and hemp spinning and weaving	6,069	4,365	5,913	4,305	6,957	4,935	7,266	5,710
Hosiery and lace	4,367	2,212	5,420	3,435	5,753	2,892	6,770	3,572
Accessories	12,111	5,115	13,944	5,427	15,261	5,983	17,296	5,803
Total	51,668	29,359	65,220	36,456	68,135	35,848	74,360	37,036

In many respects, British makers of machinery are ahead of their rivals. The visitors from the United States were most impressed with the automatic doffer developed by the British Cotton Industry Research Association (Shirley Institute). This small mobile machine, which is now in routine operation at one mill, can doff 12 full bobbins of yarn at a time, replace them with 12 empty bobbins, and automatically move on to the next batch. There is no organisation in the United States corresponding to the B.C.I.R.A., which was paid high tributes by the Team. Though the quality and range of the research being conducted at present leaves little to be desired, the industry has as yet made too little use of it. As Mr. G. N. McCulloch, chairman of the Council of the B.C.I.R.A., pointed out in January, the remarkable growth in textile research has not been matched by an equal development in the rate and extent of the industrial application of the results. Machinery and methods have been discovered which could raise productivity considerably if they were more widely adopted. In an effort to translate research work more quickly into effective action on the mill floor, Shirley Developments, Limited, have been formed to undertake the commercial development and exploitation of the research work. The Institute is, meanwhile, expanding its activities and its premises are being rapidly enlarged. By the end of March, 1951, 507,000*l.* had been obtained, of which more than half was contributed by the industry and the remainder by the Government. Shortage of materials has delayed the progress of the building programme, which includes a building for the use of the engineering department and for chemical processing machinery, but a new physics block is to be opened shortly.

The home demand for other types of textile machinery has generally been better maintained in the past few years than the demand for cotton-spinning machinery. Detailed output figures for the various types of machinery are not available. Those relating to "spinning, twisting and other processes preparatory to weaving," given in Table I, refer to wool and rayon as well as to cotton machinery; but it may be assumed that all the types of machinery included shared in the increase in home deliveries from 9·75*l.* millions in the year to September, 1950, to 12·08*l.* millions in the year to September, 1951. Winding machinery for cotton, wool and rayon is also included in the total figure. The demand for this type of machinery has been very strong over the past few years and is unlikely to have decreased. Deliveries of winding machinery probably account for about 25 per cent. of the total value figure shown in Table II, namely, about 1·75*l.* million in the third quarter of 1951. The expansion of British output of this type of machinery has been spectacular since the war. Muschamp Taylor, Limited, one of the largest manufacturers in this field, was formed in 1935 with cash assets of 400*l.*; the annual turnover of the Muschamp group of companies is now 1*l.* million. Whereas, before the war, 95 per cent. of the British requirements of pirn-winding machinery had to be imported, there is now an important export market for automatic pirn-winders, and Muschamp Taylor, Limited, are exporting 40 per cent. of their output.

The output figures for weaving machinery disguise the extent of the increase in output of automatic looms, as they include older types of looms, the output of which has been falling. Automatic looms are being widely installed in Lancashire, though the rate at which redeployment is being carried out is not, perhaps, as rapid as might be thought desirable; nevertheless, the home market is taking as many automatic looms as manufacturers can assign to it and some are being imported, mainly from the United States. Exports of all types of looms were valued at 5·4*l*. millions in 1951. Makers of automatic looms have been asked to give priority to British weavers, which means allotting about 65 per cent. of their output to the home market, though they are not rigidly tied to this quota. This policy, however justified, carries the danger that British manufacturers may find it difficult to recapture export markets in which United States, German, Japanese and Swiss manufacturers have perforce been allowed to establish themselves.

Deliveries of jute, flax and hemp spinning machinery are shown separately in Table I. Home deliveries, which account for a relatively small proportion of the total (21 per cent. in 1951), have been falling, but large orders were booked in 1951. Little serious criticism can be directed at the jute industry on the score of modernisation. Spurred on by the fear of intense competition from Indian mills and the rapidly developing industry in Pakistan, manufacturers in Dundee have undertaken extensive re-organisation and re-equipment.

TABLE II.—UNITED KINGDOM: QUARTERLY DELIVERIES OF TEXTILE MACHINERY: VALUE (1,000*l*.).

Type of Machinery.	1950, 1st Quarter.		1950, 2nd Quarter.		1950, 3rd Quarter.		1950, 4th Quarter.		1951, 1st Quarter.		1951, 2nd Quarter.		1951, 3rd Quarter.	
	Total.	For Export.	Total.	For Export.	Total.	For Export.	Total.	For Export.	Total.	For Export.	Total.	For Export.	Total.	For Export.
Spinning, twisting and preparatory processes ..	6,429	4,083	6,474	3,951	5,988	3,672	7,883	4,942	6,340	3,321	6,905	3,680	7,070	4,176
Processes subsequent to spinning, but preparatory to weaving														
Weaving	2,371	852	1,920	675	1,806	663	2,080	777	2,101	788	2,106	687	2,199	889
Bleaching, dyeing, printing, finishing	1,518	741	1,599	708	1,422	606	1,494	594	1,550	655	1,748	787	1,552	655
Jute, flax and hemp ..	1,722	1,212	1,947	1,320	1,644	1,242	1,908	1,448	1,938	1,503	1,687	1,273	1,733	1,486
Hosiery and lace	1,474	722	1,356	690	1,393	656	1,706	878	1,702	860	1,750	965	1,612	869
Accessories	4,362	1,842	3,684	1,479	3,345	1,113	4,096	1,434	4,213	1,423	4,620	1,590	4,367	1,356
Total	17,776	9,452	16,980	8,823	15,598	7,952	19,167	10,073	17,844	8,550	18,816	8,982	18,533	9,431

TABLE III.—TEXTILE MACHINERY INDUSTRY: ESTIMATED NUMBERS EMPLOYED.

Type of Machinery.	1938.		August, 1948.		October, 1949.		September, 1950.		September, 1951.	
	Number.	Index.	Number.	Index.	Number.	Index.	Number.	Index.	Number.	Index.
Spinning and preparatory processes	12,780	100	19,130	195	18,397	203	23,833	187	23,764	186
Processes subsequent to spinning, but preparatory to weaving ..			5,720		7,543					
Weaving	4,450	100	6,380	143	7,318	164	7,395	166	7,323	166
Dyeing and finishing	2,340	100	3,520	150	3,658	156	3,271	140	3,993	171
Jute, flax and hemp spinning and weaving	4,500	100	7,950	176	7,465	165	7,184	160	7,436	165
Hosiery and lace	3,950	100	6,100	154	6,892	175	6,800	172	6,658	167
Accessories	12,000	100	11,260	94	12,012	100	10,071	89	8,471	76
Total	40,020	100	60,060	152	63,285	158	58,554	145	57,645	143

At the same time, it has been the policy of the Government to reduce Dundee's dependence on jute by encouraging other industries to settle in the district. This policy, which should have been a boon to the jute industry, is now, temporarily at least, an embarrassment, since, despite efforts to improve conditions, the jute mills are finding it difficult to obtain all the labour they require. Much has been done, however, to reduce labour requirements. Many mills have installed new high-speed spinning frames and a start has been made on the installation of new looms. Some of these are of a circular type which can achieve a rate of output three and a half times that of the old flat looms, and the tubular fabric produced greatly speeds up the subsequent process of bag-making. The new loom, which is being built in Dundee under licence, is of French design. The older flat looms still in use in the industry are being improved by the attachment of an automatic shuttle-loading device which makes it possible for a weaver to attend four or five times as many looms as formerly. The design of the new shuttle loaders owes much to an automatic weft-replenishing device which investigators, working under the auspices of the British Intelligence Objectives Sub-committee, found in German jute mills. This apparatus has been greatly improved after several years' work by British machinery makers.

A certain amount of re-equipment has also taken place in the linen industry; but Mr. S. A. G. Caldwell, F.T.I., states* that this has not gone far enough and thinks it "regrettable that the industry at home has not availed itself of the advantages resulting from installing modern equipment, as have its overseas competitors." This was partly due to the fact that, before the war, large labour reserves were available, that wages were low, and capital scarce. The industry is now faced, however, with the problems of increasing production costs, greatly aggravated by the upward trend of raw material prices, and of rapidly growing consumer resistance. A solution could be found if the industry made full use of developments in the design of flax-preparing and spinning machinery. Some of these, such as the automatic spreadboard, though not new, have not been widely adopted, as few mills have learned to use them efficiently. In many cases, they have been acquired, but discarded after short trial periods. Double-thread screw frames and can tramping mechanisms, which can greatly increase output capacity, are also insufficiently used, while modern ring frames for wet spinning, such as the Fairbairn Lawson Combe Barbour ring-frame, which can achieve speeds upwards of 25 per cent. greater than the standard flyer frame, and on which doffing stoppages are reduced to about one quarter, have found all too small a market.

The upward trend of deliveries of hosiery and lace machinery was continued in 1951. Deliveries to the home market rose from 2·9*l*. millions in the twelve months to September, 1950, to 3·2*l*. millions in the twelve months to September, 1951, and sales are still limited only by manufacturers' ability to produce. Capacity has been increasing; Mellor Bromley and Company, for example, have started quantity production of their "four division machines" for the manufacture of fully-fashioned stockings. Mr. H. R. Backhouse, chairman of the company, said in July that, though initial manufacturing difficulties had been encountered, the output of these machines had been rising; having regard to their intricacy and the consequent heavy demands on highly skilled labour, progress had been satisfactory. The output of the company's circular knitting machinery has also been expanding. Manufacturers of fully-fashioned stockings, who contributed 7·2*l*. millions to the United Kingdom's earnings of foreign exchange in 1951—1·4*l*. millions more than in 1950—have established for themselves a good case for priority treatment where supplies of machinery are concerned. Hitherto, authority to import machinery from the United States has been granted fairly freely, since until recently only a few machines could be obtained from the home market. The quantity imported has been declining, however, over the past two years. The total imports of hosiery and lace machinery into the United Kingdom in 1951 were valued at 1·7*l*. millions, compared with 1·8*l*. millions in 1950 and 3·5*l*. millions in 1949. Though some licences are still outstanding, imports are likely to fall farther in 1952. Apart from the fact that more machines will be available from the home market, the sales of stockings abroad have been falling lately, and the immediate prospect of improvement seems small.

* *Textile Industries and Fibres*, January, 1932.

Another organisation which has been increasing capacity is the Bentley Engineering Company. The chairman, Mr. P. A. Bentley, said in July that production was rising steadily and that the opening of their new Parker Drive factory had given them an extra 80,000 square feet of floor space, which had enabled them to re-organise assembly lines. The company have an extensive market in the United States for their Komet knitting machine, which, until recently, was made in the United States under licence. The agreement has now expired and the Bentley Engineering Company set up their own subsidiary, the Bentley Knitting Machinery Organisation, Incorporated, with headquarters in Providence.

A shortage of needles was, for a long time, a serious handicap to the production of hosiery and lace machinery. The productive capacity for hosiery needles in the United Kingdom has increased considerably in the past two years, but has only kept pace with demand. Hosiery needles from abroad are still required in large quantities, and imports in 1951, valued at 773,000*l*., were as high as in 1950.

The increase in exports of hosiery and knitting machinery was particularly striking in 1951, and, as will be seen from Table IV, on page 328, taken from the *Trade and Navigation Accounts*, was proportionately greater than that achieved by any other section of the textile-machinery industry; exports, at 3·9*l*. millions, were 30 per cent. higher than in 1950. Exports of looms and of bleaching, dyeing and printing machinery also increased substantially, being 20 per cent. and 15 per cent., respectively, higher in 1951 than in 1950. The increase in exports of machinery for spinning, twisting and preparatory processes, which account for 47 per cent. of the total value of exports of textile machinery, was relatively small, and consequently the latter increased by only 8 per cent. in 1951.

As may be seen from Table V, on page 328, also taken from the *Trade and Navigation Accounts*, India is still by far the largest market for textile machinery, though it accounted in 1951 for only 14 per cent. of the total exports, compared with 25 per cent. in 1949. The downward trend has been due to internal financial difficulties, which made it necessary to curtail imports drastically to conserve foreign exchange. A complete ban on imports of ring spindles, imposed in September, 1949, was later relaxed, though licences were not easily granted. The Indian Government are now granting them more readily and the flow of orders to the United Kingdom has recovered a little, so that exports to India should be somewhat higher in 1952; nevertheless, the future of the Indian market remains uncertain. Much of the machinery in use is old and due for replacement, but many mill-owners are encumbered by high taxation and are reluctant to place orders under the present unsettled conditions. There is also a danger of surplus capacity arising from either a shortage of raw cotton or from a fall in the present very high exports of piece goods. During the first quarter of 1951, the exports of cotton piece-goods from India to Malaya, the United Kingdom, Aden, Ceylon, Burma and Australia, averaged 154·7 million square yards a month, compared with 114·1 for Japan, 82·2 for the United Kingdom, 48·8 for the United States, and 36·4 for China, who were by far the largest exporters. Fears of a fall in exports have been intensified by the rapid expansion of the Japanese cotton industry. The Indian cotton industry, which is the second largest in the world, is now equipped with 10·5 million spindles and 191,500 looms, with an output of cloth totalling just over four million square yards (1951 estimate). It consumes most of the Indian cotton crop, but also has to rely on imported supplies. For 1951-52, permits have been issued for the import of 900,000 bales of cotton from the United States. Most of the machinery requirements still have to be imported, but spinning and carding machinery is now made in India by four firms and looms by six.

The flow of orders from Pakistan has been more satisfactory than from India. A large jute-manufacturing industry, which will enable Pakistan to take advantage of indigenous raw-material supplies, is rapidly coming into being. Exports of textile machinery, which increased nearly fourfold in 1951 as a result of large orders for jute machinery received in 1950, will again reach a high level in 1952, since further important orders were received in 1951. Mr. G. Faruque, chairman of the Pakistan Jute Board, who visited the United Kingdom at the head of a trade delegation, said in December that orders valued at 4*l.* million had been placed. Six or seven companies benefited, including James Mackie and Sons, Fairbairn Lawson Combe Barbour, and Urquhart Lindsay and Robertson Orchar. Large orders have also been placed in the United Kingdom for cotton-spinning machinery. Substantial orders have been received, too, by Japanese manufacturers, who were able to offer delivery at an early date. At present, there are only three cotton mills in Pakistan, but it is the Government's intention to build a spinning and weaving industry which will be capable of handling the bulk of the country's cotton crop and of meeting the home demand for cotton cloth.

The second largest market for British textile machinery is Brazil. In 1951, exports, at 3·2*l.* millions, were 26 per cent. higher than in 1950. Large orders placed by Brazil will ensure a high level of orders in 1952. These orders appear to have been prompted to some extent by the fear that textile machinery would be difficult to obtain because of re-armament, but a steep rise in wages in Brazil, which has induced many manufacturers to discard obsolete equipment in favour of automatic machinery, is also partly responsible. United States manufacturers are exporting as much textile machinery to Brazil as the United Kingdom, and recently German machinery makers have been active in the market. The demand for textile machinery from the other South American countries has been falling of late and British exports to Argentina and Chile were considerably lower in 1951 than 1950. Despite the currency difficulties encountered, however, textile-machinery manufacturers have succeeded in obtaining orders which may be regarded as satisfactory in the circumstances.

Exports to the United States and Canada, valued at 2·8*l.* millions, were 47 per cent. higher in 1951 than in 1950, and large orders were received in 1951. Until recently, it did not seem likely, in view of the large American output, that there was much scope for exports of cotton machinery to these markets. In 1950, however, Textile Machinery Makers, Limited, exhibited some of their machinery at the Atlantic City Exhibition, and, in the annual report of Platt Brothers, in 1951, Mr. K. H. Preston was able to state that the resultant volume of business being obtained from both Canada and the United States was "most gratifying." Exports of textile machinery to the Western Europe countries were, in most cases, rather lower in 1951 than in 1950, though there were important exceptions in the case of France and Italy. There is undoubtedly a large amount of obsolescent machinery in use in European countries. The old machinery can, if properly maintained, continue in use for a long time, and much will depend upon the level of wages prevailing in the textile industries in relation to the cost of installing new machinery. European capacity for the production of highly specialised and automatic types of machinery which can greatly reduce labour costs has increased so rapidly since the war that there is now a real danger of over-production unless textile manufacturers can be induced to renew their equipment more frequently than in the past. The textile-machinery industry in the United States has also expanded rapidly since the war, but in that country machinery is replaced every ten or 15 years. Even in the United States, however, there is a real threat of surplus capacity, as experience in 1949 showed when orders for textile machinery dropped sharply and output fell.

The work of the Organisation for European Economic Co-operation may do much to help the European textile-machinery industry to reach a healthy footing. Considerable progress has been made already in freeing the intra-European trade in textile machinery, though progress is retarded by currency difficulties in member countries, and France has found it necessary to restrict imports of machinery, including British textile machinery. The movement towards integration of the various textile-machinery industries in O.E.E.C. countries, which goes hand in hand with attempts to remove restrictions of trade, is likely to be fraught with even greater difficulties.

So far as foreign competition is concerned, the greatest danger to British manufacturers is presented by the rapidly expanding output of textile machinery in Japan. Output in Germany has also been expanding, and in 1950 the output of the Western zone had reached about half the pre-war level of output for Germany as a whole. This increase in output can be accounted for by the need to replace that of Eastern Germany, and much of it is absorbed by the German textile manufacturers, but Germany has again become an important factor in the export markets. The output of the Eastern German manufacturers as well as of the Czechs, is still almost entirely absorbed behind the Iron Curtain.

In Japan, large-scale production of cotton-spinning and weaving machinery did not begin until 1927, but by 1937 Japan had become virtually independent of imports and was exporting substantial quantities to China. Production was on a very small scale during the war, but has increased rapidly since 1946. In 1947, the output was 119,000 spindles and rose steadily to 984,000 in 1950. In the period April, 1948, to March, 1949, machinery to the value of 9·7 million U.S. dollars was exported, of which two-thirds went to India and the remainder to Hong Kong. Exports, however, subsequently fell off as a result of Indian restrictions on the import of textile machinery. Since the removal of the restrictions on the capacity of the Japanese cotton industry, the industry has been heavily engaged upon home-market requirements. The total capacity of the five large companies, which employ about 10,000 hands, is about 700,000 to 800,000 spindles per annum, but has been insufficient to cope with the flood of orders. At the beginning of 1951, the domestic orders alone on hand were

TABLE IV.—TEXTILE MACHINERY: EXPORTS BY MAIN MACHINERY GROUPS.

Type of Machinery.	1949.		1950.		1951.	
	Cwt. (1,000).	Value (1,000*l.*).	Cwt. (1,000).	Value (1,000*l.*).	Cwt. (1,000).	Value (1,000*l.*).
For spinning and twisting and all preparatory processes	1,239	21,581	1,129	20,555	1,117	20,727
For processes preparatory to weaving but subsequent to spinning and twisting	75	1,603	76	1,724	69	1,667
Looms and other weaving machinery	328	4,152	335	4,495	361	5,416
Bleaching, dyeing, printing and other finishing	138	2,471	147	2,636	151	3,003
Hosiery and other knitting	36	2,882	38	3,060	48	3,925
Bobbins separately consigned	33	813	15	540	14	538
All other sorts	229	6,402	221	6,362	226	7,395
Secondhand	159	1,191	137	1,063	116	970
Total	2,237	41,095	2,098	40,435	2,102	43,641

TABLE V.—UNITED KINGDOM: EXPORTS OF TEXTILE MACHINERY, BY COUNTRIES.

—	Quantity (1,000 Cwt.)			Value (1,000*l.*).		
	1949.	1950.	1951.	1949.	1950.	1951.
Union of South Africa	45	40	59	727	760	1,183
India	615	445	305	10,074	7,731	6,265
Pakistan	43	46	170	545	553	2,153
Hong Kong	26	22	37	476	406	741
Australia	99	80	75	1,967	1,605	1,709
New Zealand	12	14	14	271	329	352
Canada	40	36	60	797	820	1,273
Other Commonwealth Countries	32	23	13	361	379	273
Irish Republic	22	25	43	403	469	750
Finland	9	18	40	183	406	870
Sweden	36	76	53	936	1,591	1,439
Norway	31	27	22	626	578	506
Denmark	23	23	14	589	538	359
Poland	17	39	25	369	656	480
Germany	14	51	46	320	1,083	1,230
Netherlands	80	91	70	1,638	1,919	1,553
Belgium	101	76	60	1,994	1,521	1,398
France	102	107	129	2,355	2,444	3,180
Switzerland	10	10	9	326	340	366
Portugal	47	74	47	765	1,200	806
Spain	26	9	5	677	224	160
Italy	53	70	99	1,036	1,549	1,913
Czechoslovakia	39	37	3	716	598	66
Greece	31	58	25	529	1,012	508
Turkey	17	55	68	339	988	1,192
Syria	8	8	8	117	122	106
Egypt	134	57	44	2,039	1,082	934
Iraq	9	13	12	144	193	168
Iran	46	43	23	662	646	425
China	21	25	15	354	450	360
United States of America	41	40	52	1,024	1,065	1,506
Mexico	15	25	27	387	530	612
Peru	22	11	8	418	227	202
Chile	27	22	10	551	478	311
Brazil	186	139	165	3,312	2,860	3,514
Uruguay	14	10	7	274	236	258
Argentine Republic	71	56	41	1,408	1,070	910
Other foreign countries	73	98	199	1,386	1,777	3,610
Total	2,237	2,098	2,102	41,095	40,435	43,641

THE FUTURE OF THE FLYING BOAT.

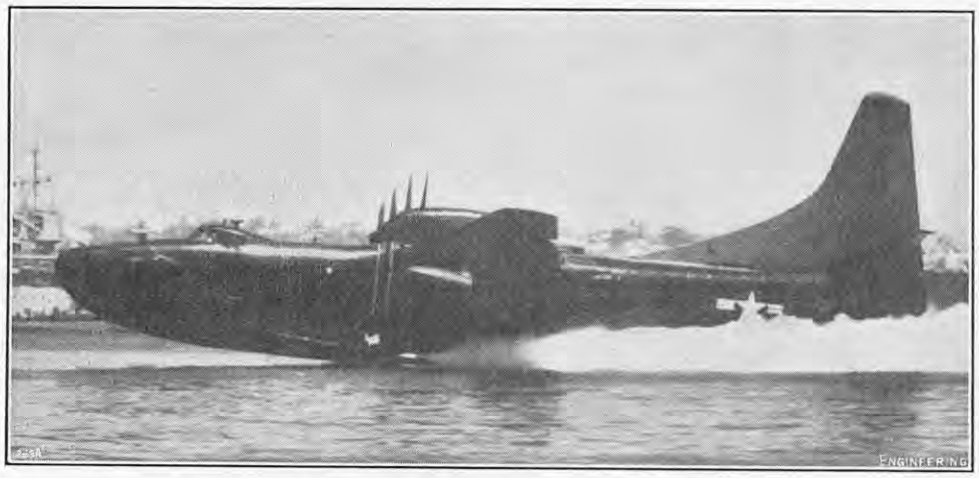
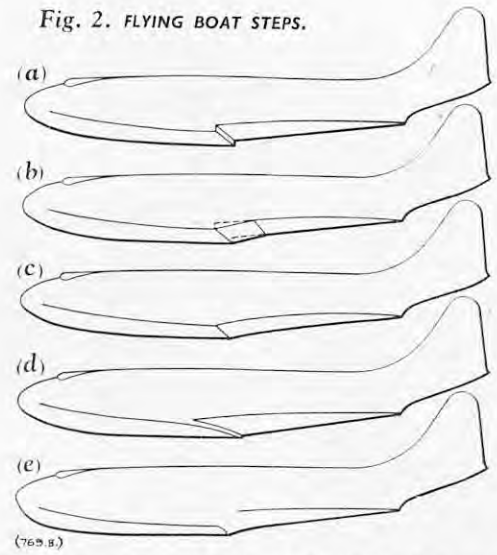


FIG. 1. "CONVAIR XP5Y-1" OCEAN-PATROL FLYING BOAT.

Fig. 2. FLYING BOAT STEPS.



equivalent to 18 months' production. Japanese manufacturers claimed that export orders were lost through inability to give delivery soon enough. Later in the year, however, as mentioned above, the Japanese were able to promise better delivery than British manufacturers. As the re-equipment of the Japanese cotton industry nears completion, greater attention is being devoted to exports. The high prices of steel and materials at present counteract the low labour costs, but Japanese competition is likely to prove increasingly formidable, particularly in India and Pakistan. The future of the Chinese market, which before the war absorbed 80 per cent. of Japanese exports of textile machinery, is problematical, and Japanese manufacturers are likely to be thrown more and more upon the traditional British markets. Per contra, of course, there is always the possibility that, in the event of a satisfactory outcome of the Korean conflict and an easing of political tension, British manufacturers may obtain large orders in the Chinese market.

On the whole, the outlook for British textile machinery manufacturers in 1952 is very satisfactory. The volume of orders on hand, both on home and export account, is large enough to dispel for the present any fears of falling demand. No doubt, there will be some difficulties on the production side as a result of scarce materials and labour, but these will probably be less pronounced than was originally feared.

ROYAL AGRICULTURAL SHOW.—The Council of the Royal Agricultural Society of England have made arrangements for the 1953 Royal Agricultural Show to take place at Blackpool. In 1954, it will be held in Windsor Great Park, where it has been three times before. The Society hope to hold the 1955 Show in the Midlands. This year's Show will take place at Newton Abbot.

AIRCRAFT NAVIGATION EQUIPMENT.—British European Airways are to fit Decca Navigator equipment in their whole fleet of aircraft. Decca "chains" which serve both for marine and air navigation, are now working in this country, in Scandinavia, and in Germany, and are being built in France and other parts of Europe. For land areas where there are no ships and where there is insufficient air traffic to justify setting up a full chain, the Decca Navigation Company, Limited, have designed a cheaper and simpler system of ground stations, known as the Integrated Track Range.

WORLD PETROLEUM CONGRESS.—The Permanent Council of the World Petroleum Congress has decided that the Fourth World Petroleum Congress shall be held in 1955 in Italy, probably at Rome. The Council hope to arrange for the Congress to open in the last week of May, 1955, and to close during the first week of June. In general, the procedure adopted at the 1951 Congress at The Hague will be followed. Programme committees will be set up for each section and they will welcome the submission of papers. The committees will also invite experts in various fields of the oil industry to present reviews of recent developments in their spheres between the years 1951 and 1955. Additional information may be obtained from the secretary, the Institute of Petroleum, 26, Portland-place, London, W.1.

THE FUTURE OF THE FLYING BOAT.*

By HENRY KNOWLER, A.M.I.C.E., F.R.Ae.S.

DURING the three decades before the Second World War, the hull form of flying boats remained substantially the same, with a transverse main step a little aft of the centre of gravity and a second step situated well aft. In the course of time, the second step was gradually reduced in width until finally the aft planing bottom terminated in a point. Until recently, it has been necessary to make the depth of the main step about 8 per cent. of the maximum beam to avoid instability. This was a major cause of drag. In early developments a change of angle between the fore and aft planing bottoms had been found to be necessary, and this has persisted up to the present time. An angle of about 8 deg. is usual, but 5 deg. to 11 deg. have been used. Other hull features which have persisted are the heavy turn-down of the bow chine in order to deflect spray, and the retention of a sharp chine throughout the length of the planing bottom.

Throughout the period which ended shortly before the Second World War, flying boats were in advance of landplanes in size and in their attainment of range. However, as a consequence of the large size of hull required, firstly, for buoyancy, and, secondly, in order to raise the wing and propellers above waves and heavy spray—and of the high drag associated with the contemporary boat form—the speeds attained fell behind those of landplanes. The Schneider Trophy racing aeroplanes, however, demonstrated the possibility of building high-speed water-based fighters.

Turning to contemporary flying boats, ocean-patrol boats are required for operation from areas which are not suitable for landplanes. Their primary duty is submarine search, but they are also used for locating and destroying enemy transports, convoy escort, shadowing enemy ships, air-sea rescue, etc. Long endurance, coupled with a large radius of action, is required. For search or convoy escort a slow speed at a relatively low altitude is necessary, although high cruising speed out to the scene of action is also desirable. The various duties of piloting, navigation, search and protection, call for a relatively large crew. A high standard of seaworthiness is required, so that the aircraft can alight on the open sea. Modern examples of this type of flying boat are the Glenn Martin Marlin P5M-1 and the Convair XP5Y-1.

The latter, shown in Fig. 1, is the first example of hull design in which increased fineness ratio has been used. The aircraft weighs 138,000 lb. but can carry a considerable overload. It is fitted with four Allison T.40 coupled turbines, driving contra-rotating propellers, with a total equivalent horse-power of 22,000. On account of its low power loading it has a high top speed of 390 m.p.h.

It is hardly necessary to recall the honoured place, in passenger transport development, in which the Short Empire boat stands. Although the original design dates back to 1935, the Solent IV, a derivative of the original Short C-class boat, is still in operation. The first Saunders-Roe Princess, designed as a civil flying boat, is nearing completion by the builders. It has a take-off weight of 330,000 lb., and is fitted with ten propeller-turbine engines of a total equivalent horse-power of 35,000, estimated to give it a high cruising speed of 380 m.p.h. at 40,000 ft. The cross-section of the hull, for pressurising reasons, is a figure eight; consequently, the cabin space is arranged on two decks. This is the first flying-boat hull to be pressurised. The designed range is 5,000 miles when carrying 105 passengers. The hull design embodies a number of new features. The main step, in plan, is semi-elliptical, and the aft bottom is faired away directly from the step without a break in depth. This has resulted in a useful reduction in air drag, while providing one of the most stable hull models so far tank-tested.

With the advent of the jet engine, which has removed the necessity for mounting the propeller and engine high above the water, a new type of fighter has become possible. The first and only example so far built is the Saunders-Roe S.R./A1, first flown in 1947. It does not include some recent developments in flying-boat form which have made possible a further considerable reduction in drag. The S.R./A1 weighs 15,000 lb., and is fitted with a pair of early axial-flow jet engines, manufactured by Metropolitan-Vickers. The armament consists of four 20-mm. cannons.

There is a steady demand for amphibians for inter-island traffic, forestry patrol and river communications, naval communications and air-sea rescue. Probably the best example of the naval communication and air-sea rescue amphibian, although not the most recent, is the Vickers Supermarine Walrus, and its later version, the Sea Otter. Being exceptionally seaworthy, they were found to be very suitable during the Second World War for air-sea rescue. A recent civil amphibian is the Short Sealand, a passenger-carrying machine, suitable for inter-island traffic and river communication. It weighs 9,100 lb. and is fitted with two de Havilland Gypsy Queen engines. It carries seven passengers and has a range of 220 miles.

Up to and during the Second World War, flying-boat hulls were poor aerodynamically. From an analysis of the factors contributing to the increased drag of a hull over that of a streamline form, comprising a body of revolution based on the shape of the airship R.101, it was found that contemporary hulls had a relative drag factor of 1·43 to 1·51 times that of the streamline form. From wind-tunnel tests at high Reynolds numbers on representative hull bodies carried out by the National Advisory Committee for Aeronautics in America and the National Physical Laboratory in this country, together with certain additional information available, an analysis of drag increments for a typical hull of the form used during the Second World War, stated as a percentage increase in drag relative to a body of revolution, is as follows:—cambering the basic streamline, 3 to 5 per cent.; adding fin and cabin, 2 to 3 per cent.; adding fore and aft planing bottoms, 8 to 9 per cent.; squaring the mid-body chines, 1 per cent.; turning down of bow chine, 1 to 8 per cent.; addition of main step, 20 to 38 per cent.

The most serious cause of drag is the main step, the purpose of which is to break the water flow over the bottom of the hull at a point approximately where the normal pressure from the water diminishes and further aft changes to suction. Fig. 2 (*a*) shows a traditional form of step. A hull without a main step cannot leave the water because of this suction and it is necessary, therefore, to supply adequate air ventilation, in order to prevent the spray which leaves the step from rising and clinging to the aft planing bottom. A step which retracts in flight, as in Fig. 2 (*b*), has been tried, but the weight and difficulty of maintenance have ruled it out as a practical proposition.

* The Fifth Louis Blériot lecture, read before a meeting of the Association Française des Ingénieurs et Techniciens de l'Aéronautique in Paris on Wednesday, March 12. Abridged.

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Fig. 3. WATER RESISTANCE DIAGRAM.

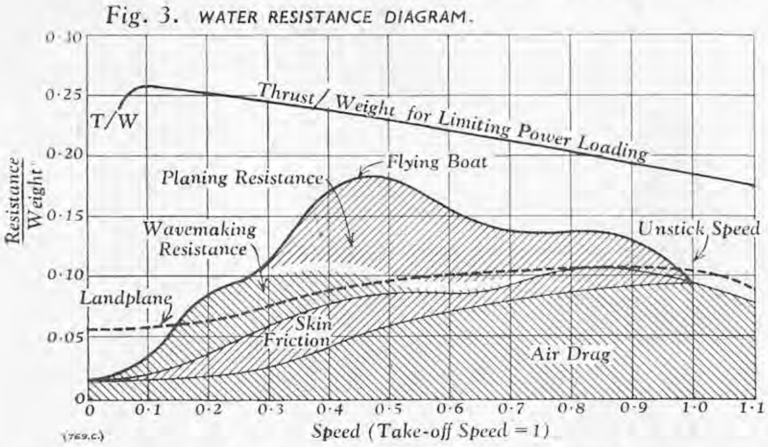
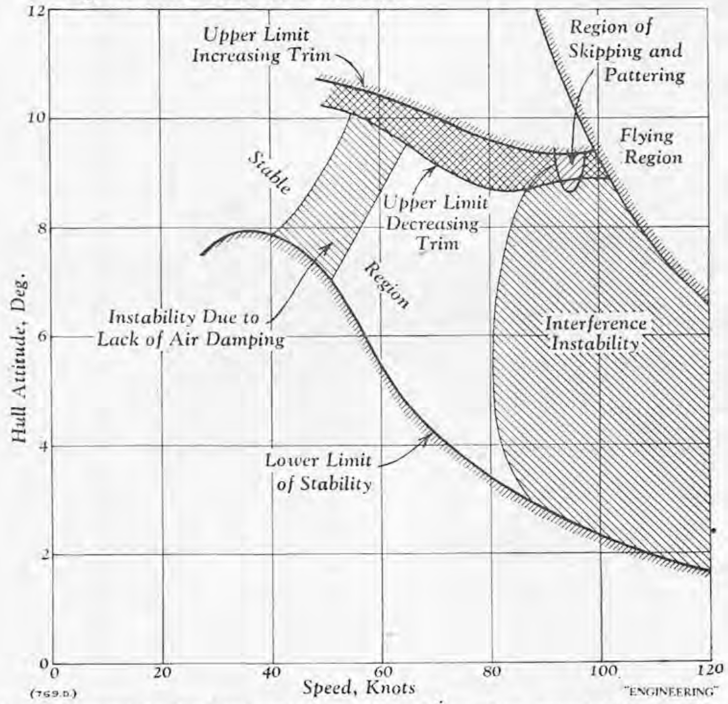


Fig. 4. WATER STABILITY DIAGRAM.



Another solution used with considerable success has been to add a fairing behind the main step (Fig. 2 (c)), in elevation alone or by combining the fairing in elevation and plan. The drag of transverse steps, having straight fairings in elevation, decreases appreciably with fairing ratios above 3, the optimum fairing ratio being 9. At this value the total hull drag is approximately 20 per cent. above that of the basic body of revolution under conditions of minimum drag. With long straight fairings the natural ventilation of air along the break of the step must be supplied by other means. One method is to ventilate through air ducts to slots in the region of the step, with additional air ventilation slots some way down the aft planing bottom. Concave fairings are inferior to straight fairings and, although convex fairings are an improvement aerodynamically, they are unsuitable for hydrodynamic reasons.

Applying the fairings with taper in plan, as well as elevation (Fig. 2 (*d*)) further improves the drag and, as the included angle of V is reduced, the drag due to the step decreases and virtually disappears when the angle is 10 deg. Unfortunately, satisfactory hydrodynamic properties have not so far been associated with small angles of V. A compromise in hull step fairing has been applied to the Saunders-Roe Princess (Fig. 2 (*e*)). This has a 6 to 1 fairing, springing from a semi-circular break in the bottom lines. The drag of this hull is approximately 15 per cent. greater than that of the basic body of revolution.

Fairings of greater length have been tested up to ratios of 20 or more, and forced ventilation has been used in order to overcome instability troubles. The improvement in air drag was, however, small. A certain amount of preliminary work has been done in the testing tank on the elimination of the step altogether by the use of forced ventilation. A deflection of $7\frac{1}{2}$ per cent. of the jet-engine compressor delivery to a suitable pattern of air jets below a streamline body caused the body to run stably at satisfactory attitude and resistance.

It has hitherto been customary to make the forward planing bottom length 3 to $3\frac{1}{2}$ times the maximum beam, corresponding to an overall length/beam ratio of 6 to 7. Recent tank tests on a series of hulls of differing fineness ratio have led to an empirical relationship connecting length l and beam b where, for equivalent hydrodynamic behaviour, $l^2 \times b =$ constant. Therefore the length-to-beam ratio can be varied and much higher beam loadings can be accepted. This has encouraged the projected use of hulls of greater fineness ratio, with corresponding low beam. In this way the drag increment due to the step can be reduced. For example, an increase in the forebody length-to-beam ratio from 3·5 to 6·5 results in a reduction in hull drag of 5 per cent.

The basic streamline form can be chosen to suit the function of the aircraft, a high length-to-beam ratio being preferable. The depth of body will be decided either by the internal disposal of payload or by the necessity for providing adequate clearance of the power plant from spray. The planing bottoms, together with the keel and chines, are responsible for about 9 per cent. increase in drag over the basic body. This figure can be reduced a little by carrying the aft bottom to the sternpost, and, at the same time, the cambering of the basic streamline can be reduced. By careful design in the bow, so that the chines follow the air-flow pattern, the large increment of drag observed in one set of tests can be avoided. Alternatively, the drag cost for heavy bow turn-down can be eliminated completely by the use of spray plates which are retracted after take-off. It is also possible to make the mid-body chines follow the natural streamline flow for the mean cruising attitude. To summarise, the basic drag of the ideal streamline body need not be increased by more than 10 to 12 per cent. in converting it to a suitable hull form, compared with a 4- to 5-per cent. increase in converting the streamline form to a typical landplane fuselage.

The resistance during the take-off of a flying boat is the sum of quantities due to air drag, wave-making resistance, planing resistance and skin friction. Fig. 3 shows how the resistance varies with speed during the take-off run. The wave-making resistance is greatest during the early part of the take-off but, being proportional to displacement, it reduces as the wing lift increases, and is of low value beyond the "hump." Planing resistance varies with (speed)^2 and is directly proportional to area and attitude. At present, a refined form of flying boat has a resistance to weight ratio of 0·18. It is not expected that further important reductions can be made with a conventional type of hull. The skin friction component may be increased considerably by the impact of spray. If negative pressure is allowed to build up on the aft planing bottom the hull may ride at inefficient attitudes and additional lift is required to balance the downward suction. The take-off drag of a landplane is shown in Fig. 3 for comparison.

It is a well-known fact that high efficiencies, of the order of a 30-to-1 lift-to-drag ratio, can be obtained with hydrofoils operating in optimum conditions. By the use of such lifting surfaces it should be possible to provide additional water lift at low speeds for low cost in resistance, thus improving the overall efficiency. Investigations show that a resistance-to-weight ratio of the order of 0·12 should be possible. There are, however, many difficulties to be overcome before the application of hydrofoils can be successful. An excessive rise in suction over the back of the foil, due to speed, attitude or loading, results in cavitation. Furthermore, breakdown of efficient lift may be precipitated if the foil is too close to the water surface. It is difficult, therefore, to ensure stable running conditions. The most successful experiments have had two sets of foils, one at the bow and the other—the main lifting foils—just aft of the centre of gravity. "Ladder" systems which may include pronounced dihedral have also been used. A possible solution is to use hydrofoil lift up to medium speeds, and, after cavitation to use the planing lift from the lower surfaces. Subsequently, the foils would retract completely into the streamline body.

Hydro-skis obtain their lift from the water pressure on their lower surface in a similar manner to the planing lift of the boat planing bottom, but a considerably higher loading can be used, and consequently a higher attitude of the planing surfaces is necessary. Researches in England and America on the application of hydro-skis to high-speed designs have shown that it is possible to have a highly stable hydro-ski system which is capable of lifting an aircraft body off the water at relatively low speed. The hydrodynamic efficiency of a hydro-ski is low and it is unlikely that a resistance-to-weight ratio lower than 0·35 can be obtained. However, because of their capability of total retraction, hydro-skis are very suitable for water-based fighters where the power available is more than adequate to ensure a short take-off run.

Perhaps the most successful method of estimating spray height is that based on the results of tests, made in America, on a series of hulls having varying length-to-beam ratios and deadrise angles. From these and other results curves have been produced, from which the propeller tip heights can be determined.

Local curvature at the chine, which terminates horizontally, or nearly so, has practically no effect on spray height. Reflex curvature at the chine is found to increase the spray height. Transverse bottom sections which are hollowed from keel to chine are an improvement over straight bottom sections. Spray strips, or plates, which project horizontally from the chine have no effect on spray height and setting the plates at small negative angles to the horizontal shows no benefit, but plates at about 90 deg. have proved successful. Spray strips, parallel to the keel but at varying distances from the chine, are less effective, the reduction in efficiency being proportional to their distance from the chine.

Most flying boats in the past have shown some degree of fore-and-aft instability on the water. With the advent of high loadings and increases in take-off speeds, any form of instability can become uncontrollable. Porpoising, a cyclic oscillation in pitch and heave, is the most dangerous type of instability, especially when it occurs at low trim angles. Analysis of records made in various tanks indicates that trim and heave are out of phase, with trim usually leading.

Two types of porpoising occur, as shown in Fig. 4, which is a plot of hull datum attitude against speed. "Low angle" porpoising, which occurs at trim angles below the lower limit of stability, is due to the hull forebody design, except in the hump region. Tests of a forebody alone show that the lower stability limit occurs at very high trims at low speeds, the trim decreasing as speed increases. The effect of the afterbody is to damp the motions in the hump region and cause the limit to occur at lower trims. It has also been found that if the afterbody is removed the upper limit is raised by 3 deg. or 4 deg. Increasing the forebody deadrise also raises the limit.

High angle instability, above the upper limit, occurs at trims and speeds which nearly mark the configurations at which the afterbody enters the water; thus, it is dependent on the geometry of the afterbody, in particular the afterbody keel angle. If the upper limit is crossed at mid-planing speeds the attitude is so high that the aircraft is usually thrown clear of the water and stalls on again, perhaps in a regular pattern. When the aircraft is thrown entirely clear of the water intermittently, the motion is called "skipping." This may occur on both take-off and landing, but more often on landing. The skipping characteristics of an aircraft depend largely on the geometry of the step and step fairing. A second type of upper-limit instability was observed in American tank tests. The model is trimmed up until porpoising occurs and the angle is noted. The trim is then decreased until porpoising ceases; the angle is lower than before, because water clings to the afterbody after contact and does not break away until the latter has been pulled appreciably clear of the undisturbed trough. The two limits are called upper limit increasing and decreasing trim, respectively (Fig. 4).

If a craft meets a disturbance in the hump region between the upper and lower limits, instability may occur, due to inadequate tail damping at these speeds. "Interference instability" is experienced with some aircraft at high speeds, where the afterbody design does not allow free entry of air between the bottom and the trough. High suctions then occur, because the limited air supply is entrained and drawn away in the water faster than it can be replaced, so that the water intermittently sticks to the hull bottom.

Other types of instability that can occur include a small amplitude "skip" just before take-off, due to spray from the forebody striking the afterbody. In the same period is encountered "pattering," in which the afterbody appears to remain just touching the water while the main step comes clear intermittently. The aircraft normally accelerates through these regions before the motions have time to develop.

With hulls of conventional length-to-beam ratio of about 6, it was found that increases in load raised the lower limit, and it was necessary to restrict the forward range of centre-of-gravity position in order to take off. With the large increases in loading made available by using high length-to-beam ratios this trend has been accentuated. In subsequent investigations, it was found that for good planing stability the forebody bottom must have no longitudinal curvature over the area wetted at planing speeds, this region being from the main step to about one and a half beams forward of the step. A constant deadrise angle over this region caused the forebody to become much more powerful than the afterbody, resulting in higher static trims. To counteract this, the deadrise was increased in a uniform manner, while still maintaining straight buttock lines. It was also found that increasing the forebody warp—i.e., the increase in deadrise angle per beam—improved the lower limit. Increasing the afterbody angle up to about 9 deg. raised the upper limit of stability.

Flying-boat hulls are laterally unstable because their metacentre is below the centre of gravity. Many successful flying boats have been stabilised with stub wings, or sponsons, but the view in the United Kingdom is that their extra drag and weight are too great. Floats can be of two types—those which are retracted into the wing tip and those positioned inboard. The latter are attached to a stronger part of the wing structure, but retraction is difficult, particularly as they are necessarily larger, because of their small moment arm. Retracting systems have been devised which permit the complete retraction of the float and chassis into the wing, but the total increase in structural weight may be greater than the weight of fuel saved. Wing-tip floats are smaller and the wing structure is not so seriously weakened by recesses to take the chassis. With floats retracted to the wing tip, the effective aspect ratio of the wing is increased. The improvement in induced drag in cruising flight goes some way to compensate for the increase in profile drag.

The upsetting lateral moments are as follows:—a static moment due to negative metacentric height; a lateral wind moment; propeller-torque reaction; static moment increase, due to inclination of the aircraft when riding on waves; inertia moment due to rolling motion; inertia moment, due to turning during taxi-ing. A combination of these moments may produce forces tending to bury the floats during low-speed taxi runs, and careful design is necessary to ensure that the lift of the float is progressive with increasing speed. This can only be obtained by float development in the towing tank. It is possible to use a step form which is favourable to low drag increase, since its fore-and-aft stability is unimportant. The float-supporting structure must withstand landing impact in circumstances of dropping wing and adverse cross wind, in addition to the usual taxi-ing conditions. This calls for a high degree of sturdiness. Some flexibility is an advantage, and a cantilever structure is suitable.

Recently, due to changed configurations and heavy loadings, the problem of directional instability on the water has become important. This is usually worst at, or just before, the hump speed during take-off, but it can also occur during the landing run; it is caused by water flowing up around the afterbody sides and tail cone. It is aggravated by the sides overhanging the chines of the last third of the afterbody. By employing high length-to-beam ratios, the tail extension behind the second step can be eliminated and thus overhanging afterbody is avoided, but a greater controlling moment is necessary with long hulls.

There are three methods of preventing or overcoming directional instability: (i) By an additional keel plate below the afterbody extending forward of the second step. Its success is limited to the range of trims at which it will run in solid water. (ii) By water rudder, essential with jet-engined flying boats, where the possible offset thrust moment is small. With large aircraft it may be necessary to provide power assistance for its control. (iii) By water flaps, equivalent to a split water rudder. The flaps are mechanically operated and combine the functions of water brakes and water rudder, supplying powerful controlling forces. It is claimed that, even in the most severe conditions, yawing can be counteracted and a directionally-stable take off can be made.

(*To be continued.*)

HEATING UNIT FOR SPRAYING HOT LACQUER.

A HEATING unit for paint and lacquer, incorporating a circulating pump and thermostatic control, for use in conjunction with any standard spray gun, is shown in the accompanying illustration. It is manufactured in this country by Spray Finishing Systems, 5, St. James's-place, London, S.W.1, under licence from Bede Products Incorporated, Ohio, U.S.A., but has been adapted to conform with B.S. 229-1946. The use of lacquers and synthetic enamels at high temperatures calls for appreciably lower quantities of solvent to give the same viscosity at the nozzle. The manufacturers also claim that a smaller number of coats are required with hot-spraying or, alternatively, that by using higher-viscosity materials the quality of the finish can be improved.

The Bede hot lacquer unit contains a cast-aluminium heater and paint-coil block with a 2,000-watt flameproof heating element, operating from a 115-volt or 230-volt supply; the paint is circulated through the coil by a

pump. Fibreglass heat insulation is provided. In addition to the thermostat, which can be set to operate at the desired temperature by a control at the top of the unit, a fusible link is provided in the heater circuit, within the flameproof enclosure, to protect the unit from excessive temperature rise in the event of thermostat failure. The self-priming pump, which is constructed integrally with an air motor, gives a maximum delivery of 12 gallons per hour at a pump speed of 150 r.p.m., and has a speed range from 20 to 150 r.p.m. The pump runs in an oil bath and is driven through a 6-to-1 epicyclic gearbox by the motor, which consumes up to $3\frac{1}{2}$ cub. ft. per minute of air at 80 lb. per square inch. A thermometer and fluid-pressure gauge are provided at the top of the unit; a control for the fluid-pressure regulating valve can be seen in the illustration on the right. A priming valve is also fitted to bleed air from the system when starting up. The working temperature normally selected is between 140 deg. and 180 deg. F. The unit is capable of raising the temperature of the lacquer, from an ambient temperature of 50 deg. F., to 100 deg. F. in about 5 minutes and to 180 deg. F. in about 9 minutes.

TRAINING AIRCRAFT FOR ROYAL NEW ZEALAND AIR FORCE.—On February 29, the High Commissioner for New Zealand, H.E. the Right Hon. F. W. Doidge, C.H., M.P., formally accepted from the de Havilland Aircraft Company, Limited, Hatfield, Hertfordshire, two Devon aircraft which are the first of a fleet of radio and navigational trainers ordered by the Royal New Zealand Air Force. The Devon, the military form of the Dove light-transport aeroplane, is fitted with two de Havilland Gipsy Queen 70 engines.

THE EX-BRITISH WESTINGHOUSE ASSOCIATION.—The 30th annual reunion of the Ex-British Westinghouse Association will be held on Friday next, March 21, at the Connaught Rooms, Great Queen-street, London, W.C.2, commencing at 6 p.m. The chair will be taken by Mr. D. MacArthur. Further particulars regarding the reunion and the Association may be obtained from the honorary treasurer, Mr. W. D. Taylor, Metropolitan-Vickers Electrical Co., Ltd., St. Paul's Corner, 1-3, St. Paul's Churchyard, London, E.C.4.

TEMPORARY RADIO TRANSMITTING STATION AT BARNSTAPLE.

IN accordance with the previously-announced plan to improve reception of the Home Service programmes in certain areas, the British Broadcasting Corporation are building a new low-power transmitting station at Fremington, between Barnstaple and Bideford, Devon. As, however, the building and installation will take a considerable time to complete, a temporary transmitter installed in a caravan will be used on the site in order that listeners in this area may have an improved service much earlier than would otherwise have been possible. The caravan transmitter was brought into service on Sunday, March 9, with a wavelength of 285 m. (1,052 kc. per second), and radiates the West of England Home Service. The aerial system already erected for the permanent station is used for the temporary transmitter.

The station is intended to serve Barnstaple, Bideford and the immediate surroundings, but maximum coverage of the outlying areas will not be achieved until the permanent station is in operation. The temporary transmitting equipment consists of two 250-watt medium-wave transmitters, one normally being a reserve for use in the event of a breakdown, but provision is being made for paralleling the two outputs to give a total aerial power of 500 watts. The programme will be fed to the transmitter over Post Office circuits. Four G.P.O. lines terminate in the vehicle: a programme line and a spare programme line, a control line to the nearest B.B.C. centre and a G.P.O. telephone circuit. Power for the transmitter is obtained from the British Electricity Authority, who have terminated their supply cable on the site in a small kiosk which houses the main fuses, metering equipment and main switch, and is provided with an outlet socket to take a special heavy-duty watertight plug to which is connected the main cable feeding the caravan. The forward end of the caravan forms the "transmitter hall." In this part are lockers which house the monitoring equipment, re-broadcast receiver, spares and test equipment. A collapsible writing table and a work bench with two cupboards underneath are also provided. The transmitters, which face forward, form the rear boundary of this section, and are mounted one on each side of the caravan. The space between them gives access to a "corridor," the sides of which are formed by the crystal drive, which maintains the transmitter exactly on its allotted wavelength, and the programme amplifiers and test equipment. At the rear end are an electric cooker, a sink unit and an electric water heater. Provision is made for connection to the mains water supply, but should this not be available water is drawn from a storage tank. Space has been left for the future installation of remote-control gear which would enable the transmitter to work unattended. It would then be controlled over a Post Office telephone circuit from the nearest permanent B.B.C. establishment.

A standard four-berth caravan, measuring approximately 7 ft. wide and 20 ft. long, mounted on a specially-strengthened chassis and with its interior arrangement modified, has been used. The vehicle is electrically heated, the distribution fan of the system being capable of independent operation for cold-air circulation if required in the summer. Additional extraction fans are provided to discharge waste heat from the transmitters through louvres in the side of the vehicle in hot weather.

CRUDE OIL FROM ENGLISH OILFIELDS.—According to a statement issued by the Anglo-Iranian Oil Company, Limited, just over 700,000 tons of crude oil will have been produced from the Company's English oilfields by the end of last month. Production from these fields, which are situated round Eakring, Nottinghamshire, and Formby, Lancashire, began in 1938, during which 100 tons were produced. Peak production was reached in 1943 with an output of 112,760 tons, but the average output has been approximately 50,000 tons annually. The company are continuing their search for new English oilfields and recently drilling began on a new well near Ainsdale-on-Sea, Southport, Lancashire.

ALMANACS AND CALENDARS.—We have received monthly tear-off wall calendars from the International Construction Co., Ltd., 56, Kingsway, London, W.C.2, and A. V. Roe & Co., Ltd., Greengate, Middleton, Manchester. That from Roe & Co. shows the current month in heavy type, and the preceding and following months in smaller type, on each sheet. A tear-off wall calendar having two months on each sheet has reached us from the Parolle Electrical Plant Co., Ltd., Newcastle-upon-Tyne. This calendar contains illustrations and brief accounts of six Northumbrian tales and legends. All three are current until the end of February next year. A tear-off desk diary has been received from Russell and Chapple, Ltd., 23, Monmouth-street, Shaftesbury-avenue, London, W.C.2.

COOLING-WATER INTAKE FOR CORYTON OIL REFINERY.

Steady progress is being made with the construction of the Vacuum Oil Company's new refinery at Coryton and, unless something unforeseen occurs, it is expected to be completed early next year. Coryton is situated on the north bank of the Thames estuary and the refinery occupies a site affording deep water approaches for large ocean-going tankers. Cooling water for the power station and process plant generally will, of course, be taken from the Thames, and to accelerate completion of the plant a novel method of constructing the pump decks and associated intake has been employed. The basic structure, which is made from reinforced concrete, was built upstream and, on completion, floated to the site and sunk in position—a method similar to that employed for the construction of Mulberry harbour during the second World War.

The unit has been designed and constructed by Messrs. John Laing and Son, Limited, Bunns-lane, London, N.W.7, on behalf of the Lummus Company, Limited, of London and New York. It was built in two separate stages, the bottom part being constructed in a disused dry dock at Gravesend and the top part subsequently added while it was afloat in the Tilbury docks. The dry-dock used for the first part of the construction is situated at Red Lion Wharf, Gravesend, though "dry-dock" is, possibly, a misnomer as there were no gates and the sides were overgrown with weeds, etc. To render the dock dry, the entrance was closed with a ballast-filled sheet-pile dam designed to withstand the water pressure imposed by the highest tides expected. Fortunately, the dock had a moderately level base and on this a concrete screed was built. This was covered by hollow tiles and then by a layer of building paper on which the floor of the intake was laid. Concreting of the floor and side walls proceeded in the dock to a height of 12 ft. 6 in., the concrete mixer being located at the sides of the dock. Eighteen 6-in. valves were built into the lower part of the walls to control flooding, and when the unit had been finished to the 12 ft. 6 in. level the temporary dam was removed. Before it was transferred to Tilbury, however, the unit was tested for watertightness; this was accomplished by filling with water and checking for leaks at low tide.

The first part of the construction programme occupied four months, which included a month's delay due to shortage of steel. The unit was removed to Tilbury on November 30, 1951, and the photograph reproduced in Fig. 1, on this page, shows it leaving the dry dock. Three tugs were used to tow the partially completed unit across the river, one at each side and one in front, the structure having been provided with the necessary towing connections. It is shown under tow in Fig. 2, on this page. On arrival at Tilbury the unit was moored at a berth normally occupied by liners, and, to give protection from passing craft, was encircled by a floating boom; the boom was also used as a working platform by the joiners and steel fixers during the next stage of construction. The concrete was added in increments, or "lifts," of 2 ft. and it was possible to use the boom as a working platform for the first five lifts, water ballast being introduced from time to time to keep the shuttering within reach of the workmen. When construction reached a total height of 30 ft., however, all water ballast was removed and scaffolding supported by brackets fixed to the walls was erected round the outside. The scaffolding can be seen in position in Fig. 4, on page 336, which shows the unit nearing completion; the floating boom can also be seen in this illustration. Concreting was continued in this way until the 22nd lift was reached, when 600 tons of 15 : 1 lean concrete were placed in the base to ensure that it had a draught of 29 ft. when towed to Coryton.

Shuttering for the concrete walls was formed from light timber units prefabricated in the central joinery works of the contractors at Mill Hill, each unit being 2 ft. deep and varying in length from 2 ft. to 6 ft. according to its position. The water-cement ratio in the concrete mix was carefully maintained and an average cube compressive strength of 6,000 lb. per square inch at 28 days was achieved, the concrete being vibrated by immersion equipment. As construction proceeded, care was taken to prevent listing by suitable adjustment of the ballast. An opening was left at one side for later installation of the steel grids which protect the pump inlets from the heavier trash, the opening being closed temporarily by steel-sheet piling suitably sealed to prevent the ingress of water. Part of this opening can be seen in Fig. 4. When completed, the intake was towed to Coryton, a distance of approximately 8 miles, by four tugs; it is shown leaving the lock at Tilbury in Fig. 5, on page 336, and in progress down the river in Fig. 3, on this page. Towing was accomplished without incident and the unit was manœuvred into position partly by the tugs and partly by winches installed on the river bank, being held at the correct distance off-shore by a barge fitted with temporary fenders and provided with the necessary guide marks. The unit was manœuvred into position in a surprisingly short time and was then lowered on to a prepared site in the bed of the river by opening the flood valves. It is shown approaching the barge in Fig. 6, on page 336.

The structure has an overall length of 100 ft. and a width of 53 ft. and is divided into six main compartments. The external walls are 1 ft. 6 in. thick and there are three longitudinal walls 9 in. thick with nine transverse walls of the same thickness disposed below a bottom floor arranged 20 ft. above the base. There are a number of longitudinal and cross braces; these are 13 in. wide with depths varying from 30 in. at the base to 18 in. at the top of the structure. Some of the braces can be seen in Fig. 7, on page 336, which shows the interior of the unit prior to being towed down the river. The total height of the unit when it left Tilbury was 50 ft. 6 in., but this will be increased to 59 ft. 6 in. by the addition of two further lifts of concrete and the decking; the reinforcement for the additional lifts of concrete can be seen in position in Fig. 7. The original portion constructed in the dry dock weighed 1,300 tons and the complete unit, as sunk in position, 4,200 tons, the draught in the latter instance being 29 ft. When completed, the top of the structure will be 18 ft. above the Newlyn Datum, and as the maximum recorded high-water is only 14 ft. 4 in. above Newlyn Datum, adequate allowance has been made for tidal fluctuations.

When in commission, the unit will be equipped with three pumps capable of delivering 15,000 gallons per minute each, two of which will be operated by 650-h.p. vertical electric motors and the third by a 650-h.p. horizontal condensing geared steam turbine. There will also be three pumps, each with a capacity of 6,360 gallons per minute, two of which will be driven by 200-h.p. electric motors and the third by a 200-h.p. horizontal steam turbine. Provision will be made for the water to be chlorinated so as to prevent marine growths, and future construction envisages the installation of two further pumps, one driven by a 650-h.p. steam turbine and having a capacity of 15,000 gallons per minute and the other a capacity of 6,360 gallons per minute, a steam turbine of 200 h.p. being employed in the latter case. The delivery pipes, which will include three of 42 in. diameter and three of 39 in. diameter, will be supported by a steel structure arranged on box piles, and access to the platform will be by a reinforced-concrete roadway, also supported by a steel structure on box piles, the road being arranged so that the supporting piles protect the unit from damage by drifting craft.

COOLING-WATER INTAKE FOR OIL REFINERY.

JOHN LAING AND SON, LIMITED, LONDON.

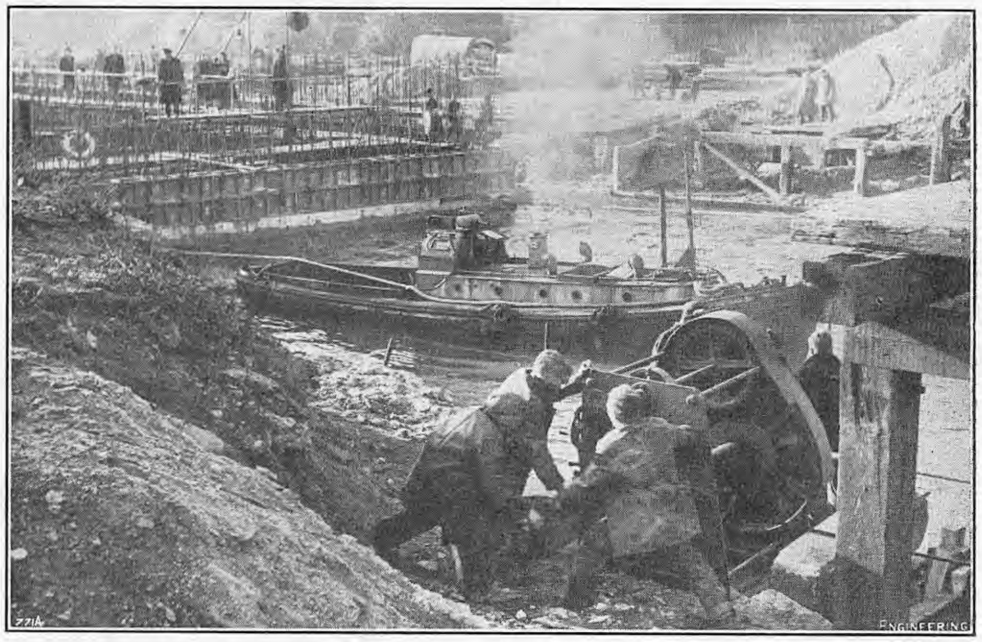


Fig. 1. Partly-Constructed Intake Leaving Dry Dock.

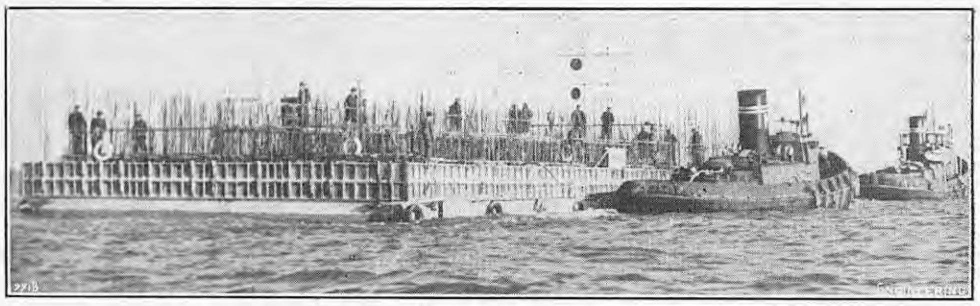


Fig. 2. Intake Being Towed to Tilbury.

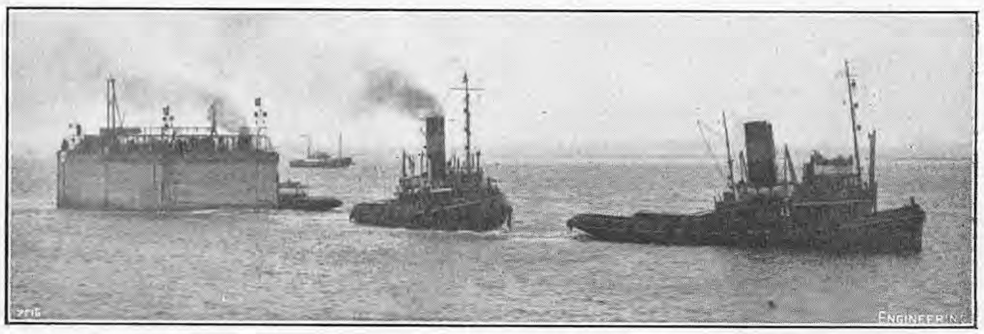


Fig. 3. Towing Completed Intake from Tilbury to Coryton.

AUTOMATIC BAR-SAWING MACHINE.

NOBLE AND LUND, LIMITED, GATESHEAD.

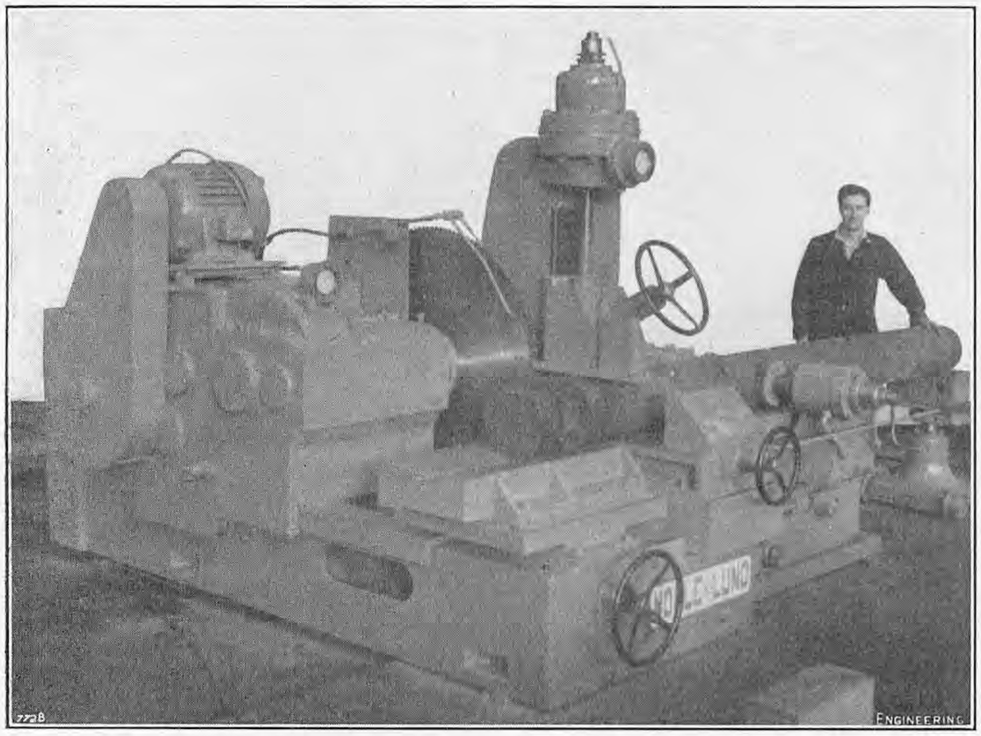


FIG. 1.

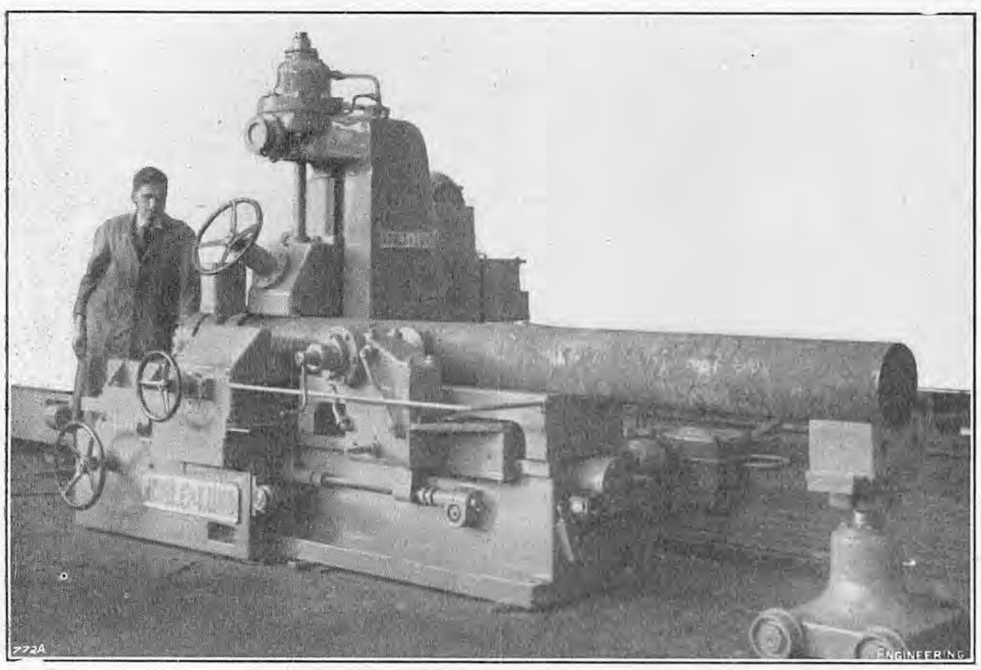


FIG. 2.

AUTOMATIC BAR-SAWING MACHINE.

THE "Fluifeed" machine shown in the above illustrations has been designed by Messrs. Noble and Lund, Limited, Gateshead, 10, for automatically cutting up steel-bar stock into short lengths, thus reducing the need for attention to a minimum. Once the machine has been set up, the whole of the operations are automatic up to the sawing of the last piece, when the machine stops. The machine can cut up 13-in. round bars or $11\frac{1}{2}$-in. square bars, using a circular saw 40 in. in diameter, and 17-in. round bars or $15\frac{1}{2}$-in. square bars using a 48-in. saw. The maximum length of bar that can be cut off automatically is 18 in., and there are four peripheral cutting speeds, from 30 ft. to 68 ft. per minute.

The saw is of the latest design, with segments of high-speed steel rigidly fixed to the blade. An improved shape of saw tooth greatly reduces the sawing time and power consumption. The saw spindle is of nickel-chromium steel, with an integral flange for the saw and a double-helical gear forged solid with the spindle. The saw carriage, shown on the left in Fig. 1, is a box-section casting mounted on slides on the bed of the machine. It has a long narrow guide with a tapered adjusting slip. Change-speed gears fitted inside the saw carriage give the four rates of cutting mentioned, to enable mild steel or high-tensile steel to be cut. Reduction gears in the saw carriage are of the spur and double-helical types; the customary worm and wormwheel have been eliminated. The main drive is by a 15-h.p. constant-speed motor, running at about 950 r.p.m., which is mounted on the saw carriage and drives through V-ropes.

Feed and return of the saw carriage are provided by an oil cylinder fitted in the carriage, the piston being fixed to the bed. The feed can be varied from zero to the maximum by adjusting a knob on the machine. The bar being cut is clamped by means of an oil cylinder which operates a vertical jaw (Figs. 1 and 2). For feeding the bar between successive cuts, an oil-operated grip takes hold of the bar and an oil-operated slide, to which the grip is fixed, moves the bar along to give the length for which the machine has been set. As the pieces are cut off they are pushed along a V-shaped trough by the stock-feeding device until they fall into a suitable receptacle. A counting mechanism at the front of the machine can be pre-set for any required number of cuts, and when these have been made an electric switch stops the machine. The counter is actuated by the quick-return motion of the saw carriage at every return stroke. Oil pressure for the various cylinders is derived from a motor-driven pump.

The machine is set up as follows: set stops on saw carriage to suit size of bar being cut; set stock-feed stops to suit required length of pieces; set counting device to number of pieces required; engage appropriate speed of saw; place bar on the machine in line with the saw, ready for moving up by the stock-feed device; adjust bar grip on stock-feed device and set vice to suit size of bar; finally, start the machine by a push-button. The cycle of operations is then as follows: stock moved up to cutting position; bar clamped and stock-feed grip released; saw feed completed and stock-feed slide returned; bar unclamped and gripped by stock-feed grip; and, finally, saw returned to back position, clear of work. The timing of each motion is controlled by tappets on the previous motion, these tappets operating the control valves. This method prevents an operation being initiated at the wrong time. Other equipment supplied with the machine includes an outer bogie to support the ends of long bars, as shown in Fig. 2, a suds pump, a chip remover, and an oil tank, which is placed at the highest point of the machine to eliminate air. The machine weighs approximately 10 tons 12 cwt.

TRANSPARENT CONDUCTING FILMS ON GLASS.

THE National Physical Laboratory, Teddington, has recently been investigating methods of preventing the accumulation of static charges of electricity on the glass windows of instruments when the latter are cleaned in dry weather. These charges are of some importance, as they occasionally affect the readings of delicate instruments. In the present instance, however, the research has resulted in a development which may have wider and more important applications than those initially envisaged.

An obvious way of preventing the accumulation of static electricity is to make the window material a conductor and ensure that it is earthed. A glass surface may be made conducting by depositing a thin film of metal upon it, using industrial techniques which are well known; but in the ordinary event either the film is opaque or a considerable loss of transparency results. There are certain metals, however, which can be deposited very evenly on glass in extremely thin films and then rendered almost perfectly transparent by oxidation. Tin is an example of such a metal. To convert the layer of metal to its oxide, the glass is heated almost to its softening point and cooled again. The film is then washed in water and dried—a process which improves its conductivity—and, in its final state, is hard, inseparable from the glass, resistant to chemical attack, and almost completely transparent.

The coating, however, has appreciable electrical resistance. In the case of the films deposited in the N.P.L. experiments, the resistance between two opposite edges of any square area of the film is approximately 1,000 ohms. As a result, if a current is passed through the film, heat is generated. This leads to the second and possibly more important application of the new development because it has been found possible to generate sufficient heat in this way to prevent the formation of ice or mist on the glass in a cold atmosphere or the possibility of snow adhering to it. The treated glass could be used, therefore, with advantage for the windscreens of aircraft and automobiles or for shop windows. In practice, the film would be sandwiched between two layers of plain glass. Ceramic materials, also, may be coated in this way, and the process can be employed to manufacture fixed and variable resistances for use in the electrical industry.

ROYAL AERONAUTICAL SOCIETY GARDEN PARTY.—The annual garden party of the Royal Aeronautical Society is to be held at White Waltham aerodrome on Sunday, June 15. Further details will be announced later.

INCREASED PRICES OF NUTS AND BOLTS.—The Minister of Supply has made an Order which increases the controlled maximum prices of bolts, nuts, etc., from February 27. The increased prices reflect the increase in the price of steel, under the Iron and Steel Prices Order, 1952, which also came into effect on February 27, together with increases in the costs of the bolt and nut industry, including increases in wages, transport and fuel costs. The Order—the Bolts, Nuts, etc., Prices Order, 1952, S.I. 1952 No. 362—is obtainable from H.M. Stationery Office, Kingsway, London, W.C.2. [Price 4*d*.]

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

IMPORT OF JAPANESE STEEL.—The first direct shipment of Japanese steel to Scotland for many years arrived at the Clyde on March 6 in the Automedon. The consignment of 2,087 tons included a good proportion of wire rods for distribution to local wire-rope makers, whose order books are well filled, but whose completions are being retarded by inadequate supplies of raw material.

REPLACEMENT OF OBSOLESCENT ROLLING MILL.—The No. 1 guide rolling mill—the last remaining mill of its type at Dalzell Steel Works, Motherwell—closed down on March 8. Essentially a jobbing mill, it was installed some 70 to 80 years ago, and it is now coming out of commission under plans for the replacement of obsolescent plant. Its functions will be taken over by a new merchant mill in course of erection. This is not expected to come into operation for some months.

PROPANE FOR LIGHTING BUOYS.—Experiments with propane as an illuminating gas for buoys were being continued, reported Mr. George A. Workman, the chairman, at a meeting of the Clyde Lighthouses Trust in Glasgow, on March 5. A visit of the engineer and master of works to Holland, a pioneer country in the use of this gas, had been highly successful, and, as a result, the trustees had authorised an initial expenditure to make preliminary tests in gas-proof buoys.

ELECTRIC-CABLE MANUFACTURE AT CARFIN.—The British Standard Electric Cable Company have taken over a factory, extending to 90,000 sq. ft., at Carfin Industrial Estate. The factory was wholly occupied by Smith's Clocks before they moved to Wishaw. A small unit of the clock-making industry is still in operation at Carfin, but this will also be transferred to Wishaw in the near future. One half of the factory has been completely vacated, and the cable company will take over this portion in the spring.

CLYDE'S MILL POWER STATION.—The British Electricity Authority have received the consent of the Ministry of Fuel and Power to the extension of the Clyde's Mill power station, Glasgow, by two 30,000-kW turbo-alternator sets and four boilers, each of an evaporative capacity of 180,000 lb. of steam an hour.

CLEVELAND AND THE NORTHERN COUNTIES.

TEES-SIDE PORTS TRADING STATISTICS.—Trade statistics presented at a meeting of the Tees Conservancy Commission, held at Middlesbrough on March 3, revealed that, during January, shipments from Middlesbrough and other Tees ports to coastwise and overseas destinations were 28,521 tons below those for the corresponding month a year ago. The decrease was mainly due to the shrinkage of 9,556 tons in the loadings of sulphate of ammonia and of 12,039 tons in those of iron and steel. On the other hand, imports in the first month of this year, from overseas and coastwise ports, exceeded those for the corresponding month of 1951 by 59,366 tons, this being principally due to an increase of 64,976 tons in the unloadings of iron ore. This increase, however, was offset by decreases of 18,862 tons in imports of iron and steel scrap and of 7,320 tons in incoming cargoes of chemical manure. The total tonnage exported, in January of this year, from the Tees to coastwise and overseas ports amounted to 110,425 tons, while the aggregate imports, in that month, reached 283,407 tons.

REDUCTION IN SHIFTS AT ROLLING-MILL SHOPS.—The number of shifts worked in all the rolling-mill shops of Dorman, Long & Co., Ltd., Middlesbrough, has been reduced to 15 a week instead of the normal 17. This means that, in place of an average of 5⅔ shifts, rolling-mill employees will now work an average of five shifts a week, but none will be discharged. Four works, namely, the Redcar plant, the Acklam and Britannia works at Middlesbrough, and the Cleveland works at Grangetown, are involved. Some 2,500 employees are affected by the change.

LANCASHIRE AND SOUTH YORKSHIRE.

THE MARK "MADE IN SHEFFIELD."—A complaint was made at the recent annual meeting of the Sheffield Advisory Committee that some Sheffield cutlery manufacturers are marking inferior products "Made in Sheffield." The financial secretary of the Sheffield Cutlery Union, Mr. E. Wood, produced specimens of scissors which, he said, had been cold-pressed from wire. These were stamped "Made in Sheffield," but did not bear the name of the manufacturer. The Master Cutler, Mr. G.M. Flather, suggested that the application of a British Standard specification to such cutlery products might be possible. The Law Clerk pointed out that as long as a product was made in Sheffield, there was no legal method of stopping a manufacturer from saying so.

COLLIERY STEEL RECLAMATION CENTRE.—It is proposed to establish a steel reclamation centre at Bullcroft Colliery, near Doncaster, to serve the thirteen pits in the Doncaster area of the National Coal Board. Steel, which otherwise would be scrapped, would be used to make pit props by a welding process. Scrap which cannot be reclaimed locally will be sent to the centre.

EMPLOYEES' SENSE OF SECURITY.—The chairman of the Thorncliffe Joint Production Advisory Council, Sir Harold West, states he is convinced that the important factor in incentives, both to production and to harmony in industry, is a sense of security. He is considering therefore, the possibility of offering to increase the agreed period of notice of a number of employees who have established themselves by ten years' adult service, or more, from a week's notice to a month's notice on either side. Sir Harold is managing director of Newton Chambers & Co., Ltd.

RECONSTRUCTION OF ROLLING-MILL PLANT IN TURKEY.—As briefly stated in our "Contracts" column, on page 349, Davy and United Engineering Co. Ltd., Park Iron Works, Sheffield, 4, have received an order for the large-scale extension and modification of a 28-in. blooming and section rolling-mill plant at Karabuk Iron and Steel Works in Northern Turkey. The rolling-mill plant was built by Messrs. Davy and United just before the outbreak of the recent war. The new contract will involve the supply of more than 1,000 tons of new mill machinery and hydraulic equipment. This will include a new ingoing main table, an electrically-operated universal side-guard manipulator, a new pinion housing, new finials, a main coupling, coupling spindles and boxes, a modified shear approach table and an automatic pressure grease-lubrication system. Apart from an annual output of 190,000 tons of rails, sleepers, billets, sheet bar, pit arches and other sections, the converted plant will also be expected to produce 20,000 tons of plate a year. The modifications to the section-mill stands will include the provision of new spindles and balance gear, electric screw-down and index gear, four Williams manipulator-extensions to the skid gear and additions to the roller tables.

THE MIDLANDS.

CLAERWEN DAM.—The new dam being constructed for the City of Birmingham Water Department on the river Claerwen, near to the existing Elan Valley undertaking, is nearing completion. Concrete arches are now being built across the top of the dam to carry a roadway and footpaths. Meanwhile the reservoir is filling and already contains more than half the estimated total capacity of 10,625 million gallons of water. It is expected that the dam will be finished, and the construction plant and equipment dismantled and removed, by September of this year. The work will then have been in progress for just over six years.

MINING UNDER THE TOWN OF CANNOCK.—The National Coal Board have notified the urban district council of Cannock, Staffordshire, that plans for the development of Mid-Cannock Colliery include working the coal under the town centre. The colliery is only about half a mile from the area in question, but the coal there has not been worked previously. The Board own the coal, but the question of working it is somewhat complicated because the right to do so is vested in several copyholders, and their consent, together with that of the Lord of the Manor, is necessary before the seams can be worked. The Board say that the various copyholders are too numerous for individual negotiations to be undertaken, and therefore, they are to apply to the Chancery Court for an order giving them the right to work the coal. Some alarm has been expressed in Cannock because of the possibility of subsidence in the town's commercial centre. The Board have invited the Council to a meeting at which full details of the proposed workings will be given.

INVESTIGATION OF "MUD" BUILDING.—Officers of the Building Research Station of the Department of Scientific and Industrial Research at Garston, Hertfordshire, have conducted an investigation into a method of building formerly practised at Lye, Worcestershire. Lye, known in the Midlands in the Eighteenth and Nineteenth Centuries as "mud city," had a considerable number of houses built of the local earth. The last of these buildings was demolished only two years ago. The soil of the neighbourhood, which is clay-bearing, is particularly suitable for the purpose. The old method was to make walls of lumps of earth, surface them with mud, and whitewash them all over. The report issued by the Building Research Station says of the last surviving house that it "withstood some centuries of exposure, and, if maintained without alteration, might have survived several more." It only became unserviceable because of "ill-conceived alterations."

OPENCAST MINING PROJECT ABANDONED.—The Ministry of Fuel and Power have abandoned a proposed opencast coal-mining site at Spon-lane, Grendon, Warwickshire. The site was restricted by housing, and boring did not show a workable quantity of coal.

SMOKE ABATEMENT.—Members of the Midlands Joint Advisory Council for the Abatement of Smoke and Atmospheric Pollution visited the Bilston Steelworks of Stewarts and Lloyds Ltd. on March 6, to see some of the work done by the company to reduce pollution by smoke and dust. Pointing out that the problem was one of particular magnitude in an iron and steel works, Mr. W. M. Larke, the general works manager, said that as much as 20 per cent. of the capital investment in the plant was devoted to equipment for dust-catching. The Bilston works have in operation some experimental apparatus designed by the British Iron and Steel Research Association for cleaning blast-furnace and other gases.

SHORT-TIME WORKING IN THE NON-FERROUS TRADES.—A shorter working week has been introduced by the Metals Division of Imperial Chemical Industries, Ltd., at Birmingham, as a result of copper shortage. About 1,000 men are affected, and they will work nine shifts a fortnight instead of ten.

SOUTH-WEST ENGLAND AND SOUTH WALES.

FUTURE DEVELOPMENT OF STEEL COMPANY OF WALES.—Speaking at a Swansea dinner last week, Mr. E. Julian Pode, managing director of the Steel Company of Wales, Ltd., declined to be drawn into commenting upon future possible developments. The Mayor of Swansea, Alderman D. Jones, had referred to the Llangyfelach site which it had earlier been reported was to be developed by the company. Responding to the toast, Mr. Pode said he was not going to include any reference to questions put by the Mayor. These would be answered in due course. South Wales during the past year had become, without doubt, the premier steel-making area of Great Britain, measured in ingot output. They were now ahead of the North-East Coast and he felt that the stability of the steel trade in the area was, at all events for the present, assured.

CLOSURE OF PORT TALBOT BAR MILL.—Port Talbot and Margam representatives of the Iron and Steel Trades Confederation have met again to consider their protest against the decision of the Steel Company of Wales, Ltd., to close the old Port Talbot bar mill on June 30. No statement was issued after the meeting. The Bar Mill is the only rail-making works of its type in Wales and its closure will affect 580 men.

MEETING OF WELSH BOARD FOR INDUSTRY.—It was revealed at a meeting of the East-Wales district Committee of the Welsh Board for Industry, at Merthyr, that shortage of steel is holding up the Lady Hill service reservoir, the main feed for the Uskmouth Power Station, and also the Talybont second pipeline which supplies water to the new town at Cwmbran. It was agreed that every endeavour be made to bring the seriousness of the shortages to the notice of the proper authorities. The meeting was also informed that there had been a rise of 3,184 in the number of people unemployed from December 10. On January 14 there were 17,144 workless in the area but, since that date, there had been a slight improvement.

LLANDARCY REFINERY.—Believed to be the first refinery in the world to be electronically controlled, a new plant commissioned by the Anglo-Iranian Oil Co., Ltd., at the National Oil Refineries, Llandarcy, Swansea, is now producing 500 tons of premium grade kerosene daily. Electronic measuring and control instruments are used exclusively for flow, pressure and level control at the plant.

SOUTH WALES PORTS TRAFFIC.—So far this year the trade of the South Wales ports has improved over that of a year ago. From January 1 to February 24 last the total traffic was 3,467,911 tons, a gain of 812,334 tons compared with the corresponding period of 1951 when it was 2,655,577 tons. Imports rose from 1,203,843 tons to 1,390,937 tons and exports from 1,451,734 tons to 2,076,974 tons.

NOTICES OF MEETINGS.

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

ILLUMINATING ENGINEERING SOCIETY.—*Sheffield Centre:* Monday, March 17, 6.30 p.m., The University, Western Bank, Sheffield, 10. "Colour," by Mr. W. J. W. Ferguson. *Bradford Group:* Thursday, March 20, 7.30 p.m., Yorkshire Electricity Board's Offices, 45-53, Sunbridge-road, Bradford. "Black Light," by Mr. H. L. Privett.

INSTITUTE OF PACKAGING.—*Midland Area:* Monday, March 17, 6.30 p.m., Imperial Hotel, Birmingham. Annual Meeting and Film Display.

INSTITUTION OF ELECTRICAL ENGINEERS.—*Mersey and North Wales Centre:* Monday, March 17, 6.45 p.m., Philharmonic Hall, Liverpool. Faraday Lecture on "Sound Recording: Home, Professional, Industrial, and Scientific Applications," by Dr. G. F. Dutton. *Measurements and Supply Sections:* Tuesday, March 18, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. "Application of Transductors as Relays to Protective Gear," by Mr. R. K. Edgley and Mr. F. L. Hamilton. *East Midland Centre:* Tuesday, March 18, 6.30 p.m., Gas Showrooms, Nottingham. "A Logical Approach to the Problems of Electric Space-Warming," by Mr. D. H. Parry. *Southern Centre:* Wednesday, March 19, 6.30 p.m., Grand Hotel, Bournemouth. "The Dimming of Low-Pressure Discharge Lamps," by Mr. C. E. Williams. *London Students' Section:* Wednesday, March 19, 7 p.m., Savoy-place, Victoria-embankment, W.C.2. "Industrial Electronics," by Mr. R. A. Jones. *Utilization Section:* Thursday, March 20, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. (i) "The Individual-Generator System as Applied to the Tandem Cold-Strip Mill," by Mr. D. Bolton. (ii) "The Magnetic-Fluid Clutch," by Mr. E. J. R. Hardy. (iii) "The Measurement of Electrical Activity in the Human Body," by Mr. J. C. Shaw.

INSTITUTION OF PRODUCTION ENGINEERS.—*Manchester Section:* Monday, March 17, 6.30 p.m., College of Technology, Manchester. Annual Meeting. "Noise and Vibration in Machinery," by Dr. A. J. King. *Derby Section:* Monday, March 17, 7 p.m., Midland Hotel, Derby. Annual Meeting. *North Eastern Section:* Monday, March 17, 7 p.m., Neville Hall, Newcastle-upon-Tyne. Informal Address, by Major-General K. C. Appleyard. *Birmingham Section:* Wednesday, March 19, 7 p.m., James Watt Memorial Institute, Birmingham. "Productivity and Its Measurement," by Mr. F. G. S. English. *London Section:* Thursday, March 20, 7 p.m., Old Ship Hotel, Brighton. "Costing as an Aid to Management," by Mr. H. H. Norcross. *Leicester Section:* Thursday, March 20, 7 p.m., College of Art and Technology, The Newarke, Leicester. Annual Meeting and Film on "Lubrication." *Glasgow Section:* Thursday, March 20, 7.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. "Electronic Control of Machine Tools and Self-Regulating Systems," by Mr. S. A. Ghalib.

INSTITUTION OF WORKS MANAGERS.—*Glasgow Branch:* Monday, March 17, 7.15 p.m., 39, Elmbank-crescent, Glasgow, C.2. "British and American Industrial Relations," by Mr. Taylor G. Belcher. *Leicester Branch:* Tuesday, March 18, 7 p.m., Works of British Thomson-Houston Co., Ltd., Rugby. "Lamps and Lighting: A Record of Industrial Research," by Mr. R. V. Mills.

SHEFFIELD SOCIETY OF ENGINEERS AND METALLURGISTS.—Monday, March 17, 7.30 p.m., University Building, St. George's-square, Sheffield. Joint Meeting with INSTITUTE OF METALS (*Sheffield Local Section*). "Bearings and Bearing Alloys," by Mr. R. T. Rolfe.

INSTITUTION OF CIVIL ENGINEERS.—Tuesday, March 18, 5.30 p.m., Great George-street, S.W.1. "The Most Recent Dams by the Società Adriatica di Elettricità (S.A.D.E.) in the Eastern Alps," by Mr. Carlo Semenza. *Midlands Association:* Wednesday, March 19, 7 p.m., Loughborough College, Loughborough. "The Construction of Loch Sloy Dam," by Mr. James Stevenson.

INSTITUTE OF FUEL.—Tuesday, March 18, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "Fuel, Heat and Power Auditing," by Mr. L. Clegg and Mr. J. Price Walters. *North-Western Section:* Wednesday, March 19, 6.30 p.m., Engineers' Club, Manchester. Discussion on "Steam and Heat Utilisation in Industry," opened by Dr. E. G. Ritchie. *Yorkshire Section:* Wednesday, March 19, 6.30 p.m., The University, Leeds. "Atomic-Energy Developments in Relation to the Fuel Industries," by Mr. J. M. Hutcheon. *East Midland Section:* Thursday, March 20, 7.15 p.m., Electricity Theatre, Irongate, Derby. "The Chemical Aspect of Low-Temperature Carbonisation," by Mr. G. S. Pound. *Scottish Section:* Friday, March 21, 7 p.m., Royal Technical College, Glasgow. "Some Aspects of the Complete Gasification of Coal," by Dr. F. J. Dent.

ROYAL STATISTICAL SOCIETY.—*Bristol Study Section:* Tuesday, March 18, 5.45 p.m., Library Room, The University, Bristol. "Assumption of Randomness in Applied Statistics," by Mr. G. F. Todd. *North-Eastern Industrial Applications Section:* Wednesday, March 19, 7 p.m., 18, Louvain-place, Newcastle-upon-Tyne. "The Arithmetic of Statistics," by Mr. D. Gold.

INSTITUTE OF METALS.—*South Wales Section:* Tuesday, March 18, 6.30 p.m., University College, Singleton Park, Swansea. Annual Meeting and Film Display.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—Tuesday, March 18, 6.30 p.m., 2, Savoy-hill, W.C.2. "Statistical Methods as Aids to Efficiency," by Dr. B. P. Dudding.

INSTITUTE OF BRITISH FOUNDRYMEN.—*East Anglian Section:* Tuesday, March 18, 7 p.m., Public Library, Ipswich. Discussion on "Feeding Techniques." *North-East Scottish Section:* Wednesday, March 19, 7.30 p.m., Imperial Hotel, Keptie-street, Arbroath. "Patternmaking for the Repetition Foundry," by Mr. R. R. Shaw.

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—*Midlands Centre:* Tuesday, March 18, 7.30 p.m., White Horse Hotel, Birmingham. "Aspects of Motor Racing and Engine Design," by Mr. Bob. Gerard and Mr. Reg. Parnell. *North-Western Centre:* Wednesday, March 19, 7.30 p.m., Victoria Hotel, Wigan. "Chassis Frame Construction and Repair," by Mr. C. F. Cunningham. *North-Eastern Centre:* Thursday, March 20, 7.30 p.m., Hotel Metropole, Leeds. "All-Metal Bodies," by Mr. H. A. Cooke. *Institute:* Thursday, March 20, 6.30 p.m., Royal Society of Arts, John Adam-street, W.C.2. "Pistons, Rings and Cylinder Liners," by Mr. G. W. Yarwood.

ROYAL SOCIETY OF ARTS.—Wednesday, March 19, 2.30 p.m., John Adam-street, W.C.2. "Supplementary Sources of Power: Wind, Volcanic Heat, Sun and Tide," by Mr. C. W. Marshall.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—Wednesday, March 19, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. Annual Meeting. "Application of Welding to Locomotive-Boiler Copper Fireboxes," by Mr. J. F. Harrison.

INSTITUTION OF STRUCTURAL ENGINEERS.—*Lancashire and Cheshire Branch:* Wednesday, March 19, 6.30 p.m., College of Technology, Manchester. "Soil Mechanics and Foundations," by Dr. G. G. Meyerhof. *Yorkshire Branch:* Wednesday, March 19, 6.30 p.m., Great Northern Hotel, Leeds. "Problems in Foundation Engineering," by Mr. H. B. Sutherland.

INSTITUTION OF MECHANICAL ENGINEERS.—*Western Branch:* Wednesday, March 19, 7 p.m., College of Technology, Bristol. "The Manufacture of Friction Linings and Its Engineering Problems," by Mr. J. G. Remington. *Midland Branch:* Thursday, March 20, 6 p.m., James Watt Memorial Institute, Birmingham. "Gas-Turbine Development," by Mr. B. E. G. Forsling. *Institution:* Friday, March 21, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Centrifugal Pumps in Steam Power Stations," by Mr. R. Pennington. AUTOMOBILE DIVISION.—*Derby Centre:* Monday, March 17, 7 p.m., Midland Hotel, Derby. Annual Meeting. *Scottish Centre:* Monday, March 17, 7.30 p.m., 39, Elmbank-crescent, Glasgow. "Incidence of Cavitation in Journal Bearings," by Dr. H. L. McBroom. *Luton Centre:* Tuesday, March 18, 7.30 p.m., Town Hall, Luton. "Design and Development of Very Large Road-Haulage Vehicles," by Mr. C. E. Burton.

INSTITUTE OF INDUSTRIAL ADMINISTRATION.—*London Centre:* Wednesday, March 19, 7 p.m., 8, Hill-street, W.1. "Management in Practice. No. 7. How to Achieve Increased Productivity," by Lieut.-Col. Ian A. Marriott.

INCORPORATED PLANT ENGINEERS.—*Western Branch:* Wednesday, March 19, 7.15 p.m., Grand Hotel, Bristol. Annual Meeting. "Applications of Hydraulics," by Mr. F. H. Towler. *Liverpool Branch:* Thursday, March 20, 7.15 p.m., Radiant House, Bold-street, Liverpool. Annual Meeting.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—*Yorkshire Branch:* Wednesday, March 19, 7.30 p.m., Hotel Metropole, Leeds. "Corrosion in Boilers," by Mr. J. C. Stainton. *Birmingham Branch:* Thursday, March 20, 6.30 p.m., Imperial Hotel, Birmingham. "Panel Warming Installations," by Mr. H. H. Bruce.

DIESEL ENGINE USERS ASSOCIATION.—Thursday, March 20, 2.30 p.m., Caxton Hall, Westminster, S.W.1. "The Internal-Combustion Engine from the Users' Point of View," by Mr. A. K. Bruce.

ROYAL AERONAUTICAL SOCIETY.—Thursday, March 20, 6 p.m., Institution of Civil Engineers, Great George-street, S.W.1. "Terminal Air Traffic Control," by Group Captain E. A. Whiteley.

JUNIOR INSTITUTION OF ENGINEERS.—Friday, March 21, 6.30 p.m., 39, Victoria-street, S.W.1. "Industrialists in the New Towns," by Mr. A. S. Ladley.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, March 21, 6.45 p.m., Mining Institute, Newcastle-upon-Tyne. "Modern Foundry Practice," by Mr. T. W. Bushell.

PERSONAL.

SIR GEORGE PAGET THOMSON, F.R.S., son of the late Sir J. J. Thomson, O.M., F.R.S., has been elected, by the Fellows of Corpus Christi College, Cambridge, to succeed SIR WILL SPENS, C.B.E., as Master of the College, when Sir Will retires on August 1. Sir George is an Honorary Fellow of the College.

MR. CHARLES CONNELL, M.A., M.I.N.A., chairman of Charles Connell & Co. Ltd., Glasgow, has been elected President of the Shipbuilding Conference, in succession to MR. J. RAMSAY GEBBIE, C.B.E., B.Sc., M.I.N.A., who has completed two years in office. MR. J. W. ELLIOTT, C.B.E., chairman of Swan, Hunter, and Wigham Richardson Ltd., Wallsend-on-Tyne, has been elected vice-president.

British Railways announce the appointment of MR. A. F. WIGRAM, A.M.I.E.E., M.I.R.S.E., hitherto assistant signal and telecommunications engineer, Reading, Western Region, to be signal and telecommunications engineer, York, North-Eastern Region. MR. E. R. DEWDNEY, assistant to the superintendent marine engineer, Southampton, has been made executive officer (marine), Railway Executive Headquarters, London. MR. P. PROTOPAPADAKIS, A.M.I.C.E., formerly in charge of the soil-mechanics section, Western Region, has been made development assistant to the civil engineer, Western Region. MR. G. D. S. ALLEY, hitherto permanent-way assistant to the civil engineer, London Midland Region, has been made assistant civil engineer (permanent way), Western Region.

CAPTAIN W. H. COOMBS, C.B.E., President of the Officers (Merchant Navy) Federation, has been granted an honorary commission as a Captain in the Royal Naval Reserve in recognition of "exceptional service in promoting the interests of the Royal Naval Reserve." There are only 12 other honorary captains, R.N.R., a distinction only rarely bestowed.

MR. G. DARNLEY SMITH has been elected chairman of the Radio Industry Council, in succession to MR. J. W. RIDGEWAY, O.B.E., who has been chairman since 1948. MR. G. A. MARRIOTT, B.A., has been elected vice-chairman of the Council. MR. P. H. SPAGNOLETTI, B.A., M.I.E.E., and MR. E. K. BALCOMBE have been re-elected chairman and vice-chairman, respectively, of the British Radio Equipment Manufacturers' Association, a constituent association of the Radio Industry Council.

MR. E. H. HARMAN, B.Sc., who has been general manager of the Sheffield and Rotherham Division of the East Midlands Gas Board since 1949, has succeeded MR. SYDNEY SMITH as deputy chairman of the Board. Mr. Smith is now the chairman.

MR. D. M. GLENDINNING, B.Sc., A.M.I.C.E., F.Inst.P., has been appointed manager of the new refinery of the Vacuum Oil Co., Ltd., at Coryton, Essex. Mr. Glendinning has had a wide experience in the oil industry, dating from 1927 when he joined the Shell Group in their Suez refinery.

MR. J. FEARN has relinquished the chairmanship of Normalair Ltd., West Hendford, Yeovil, Somerset, but retains his seat on the board, MR. E. MENSFORTH, C.B.E., has been appointed chairman and MR. D. C. COLLINS has been elected a director.

MR. H. L. COLLINS has been made manager of the controls and soot-blower division of Hopkinsons Ltd., Huddersfield, following the retirement of MR. W. B. DALE. MR. S. BROOK has been appointed manager of the soot-blower department.

MR. F. W. BRUCE has been appointed managing director of the Northern Aluminium Co. Ltd., Bush House, Aldwych, London, W.C.2, in succession to MR. KENNETH HALL, who has been given an appointment in the head office of the Aluminium Ltd. Group of Companies, Montreal.

MR. R. H. SNOWBALL, who has been Borough Engineer of Hartlepool since 1947, has been appointed Borough Engineer and Surveyor of Rawtenstall, Lancashire.

Owing to the increasing demand for Franber transmission equipment, FRANCIS W. BIRKETT AND SONS, LTD., Cleckheaton, Yorkshire, are building a new factory adjoining their present premises. They have also appointed two further representatives: MR. J. S. BERRIMAN, 18, Carmel-gardens, Darlington, who will cover the North-East Coast, and MR. W. J. WHETTON, Daimler House, 33, Paradise-street, Birmingham, who will deal with the Birmingham area.

MESSRS. D. E. MORRISON, B.A., A.R.I.B.A., and L. M. ROSE, chartered architects and surveyors, have moved into more extensive premises at 8, Park-street, Mayfair, London, W.1. (Telephone: GROsvenor 7522.)

RICHARD W. CARR AND CO. LTD., Pluto Works, Wadsley Bridge, Sheffield, 6, have now terminated their agency agreement with BROOKS AND WALKER LTD., 41, Dockhead, London, S.E.1, for the sale of their tool steels and engineers' small tools in London and the Home Counties. This area is now covered by the firm's branch office at 38, Coram-street, W.C.1 (Telephone: TERminus 8410), under the supervision of MR. J. L. BUXTON, assisted by MR. E. F. WREN and MR. G. W. HOBBS.

COOLING-WATER INTAKE FOR CORYTON OIL REFINERY.

JOHN LAING AND SON, LIMITED, LONDON.

(*For Description, see Page* 332.)

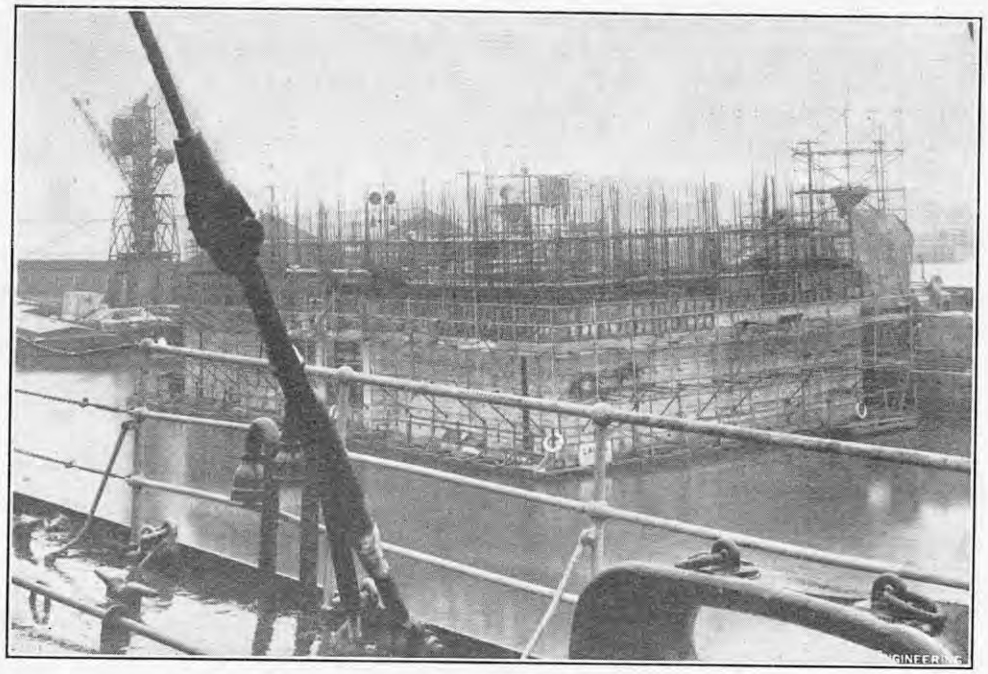


Fig. 4. Final Stage of Construction in Tilbury Docks.

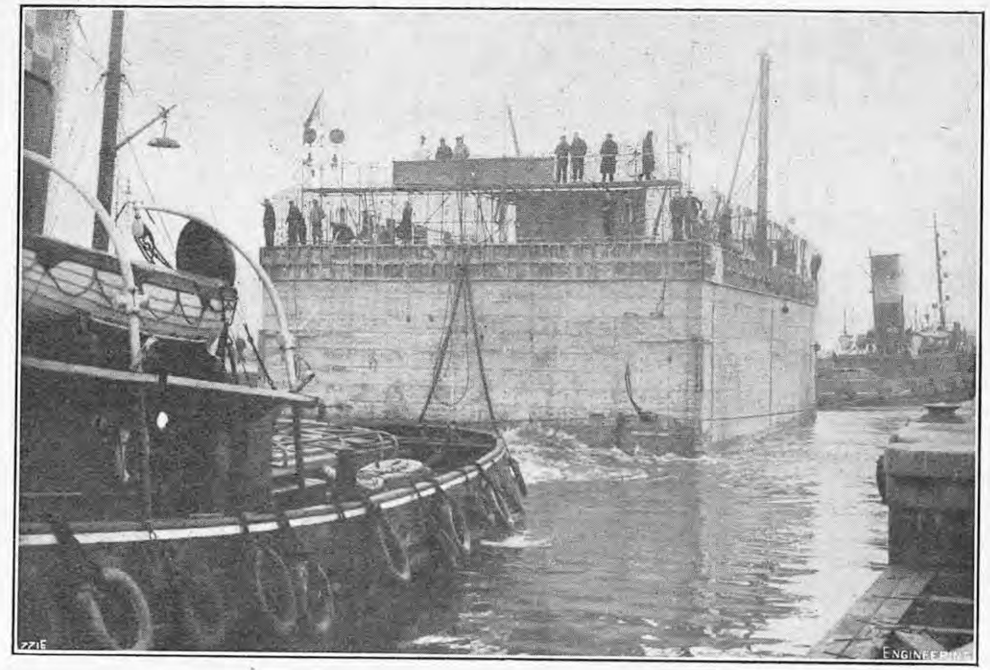


Fig. 5. Completed Intake Leaving Lock at Tilbury Docks.

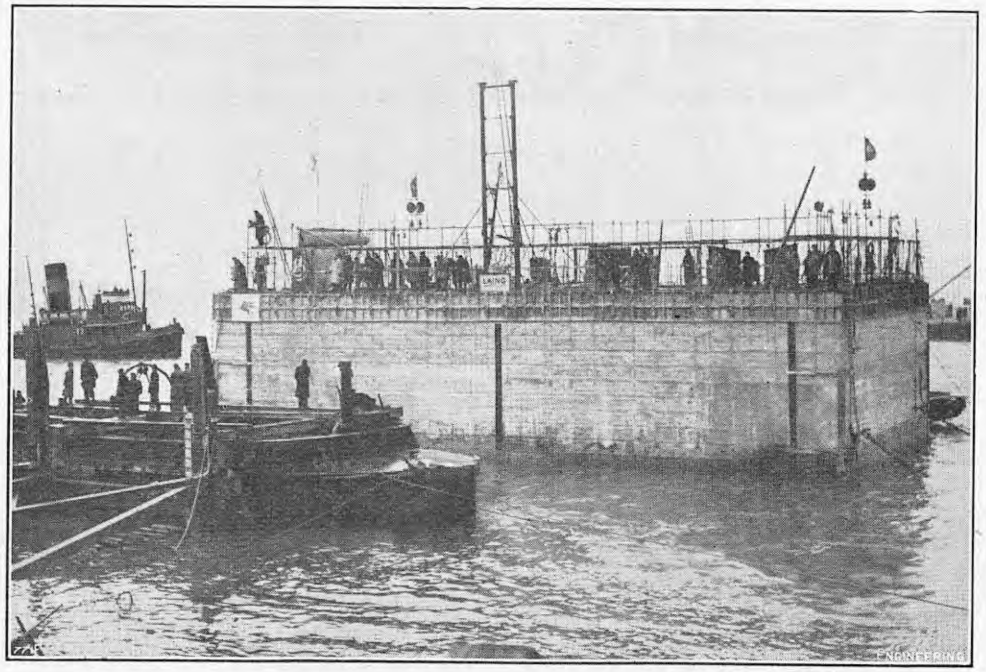


Fig. 6. Manœuvring Intake into Position at Coryton.

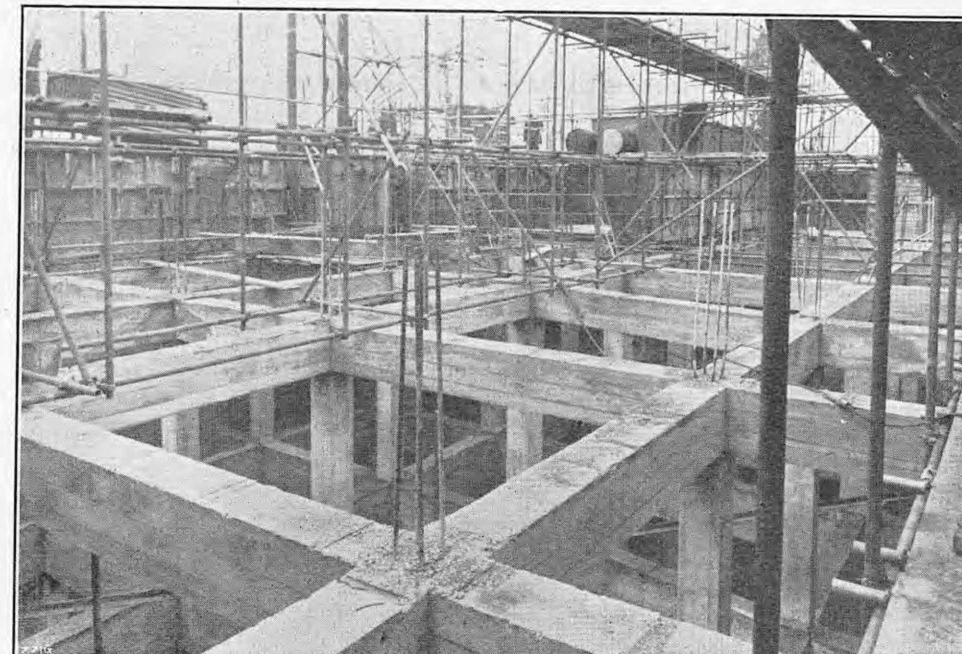


Fig. 7. Interior of Intake before Adding Top Platform.

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ENGINEERING

FRIDAY, MARCH 14, 1952.

VOL. 173. No. 4494.

FUEL ECONOMY.

ACCORDING to the latest statistics published by the Ministry of Fuel and Power,* 216·9 million tons of coal were made available for consumption in the year 1950, the figure including opencast coal. The total was not only available but was consumed, and so far from any surplus being left, stocks were drawn on to the extent of 2·3 million tons. A table in the Digest giving the various consumers shows electricity works at the top of the list at 33 million tons; they are followed by "other industries" at 32·5 million tons, domestic users at 32·5 million tons, gasworks at 26·2 million tons, and railways 14·5 million tons. "Other industries" comprises most industries except engineering and iron and steel; examples are the chemical trades, brickmaking, textiles, etc.

As the demands of almost every type of coal user are continually increasing and as any considerable rise in output seems unlikely, the importance of increasing the efficiency with which coal is burned is continually becoming more urgent. The electricity-supply industry, the heaviest consumer of all, is steadily improving its operating efficiency as modern power stations are brought into service, but demands for electricity supply are increasing at a rate which will mask any improvement in power-station efficiency, so that a rise rather than a fall in coal consumption may be expected. Railways occupying the lowest position in the list given above, could certainly reduce their coal consumption by extensive electrification, but the capital cost would be large and is not likely to be faced in the early future.

Of the other main consumers, domestic users and "other industries" offer the most promising fields for coal saving by improving the efficiency of the appliances in which it is burned. In connection with the former, Professor F. E. Simon, in his book entitled *The Neglect of Science*,* stated that "the wholesale replacement of open fires by closed stoves of some simple type—even of as low efficiency as 40-50 per cent.—would . . . save about 10 million tons of coal per year." This is equal to the annual consumption by collieries. The "wholesale replacement" is a large order, but nevertheless is a matter in which some progress is being made. The latest report of the Fuel Research Board† records that the Ministry of Health requires local authorities to install only "improved" grates and stoves as the principal heating appliances in the smaller houses that are now being built with public funds. The "improved" grates and stoves have been developed as a result of work by the British Coal Utilisation Research Association, the Fuel Research Station, and other bodies. The Scottish Branch of the Fuel Research Station, which has been established at Thorntonhall, near Glasgow, is largely concerned with the testing and development of such domestic appliances; about half of the grates and stoves used in Great Britain to burn solid fuel are made in Scotland. In connection with this matter, Professor Simon boldly suggests that "an enterprising Government would offer free provision and installation of simple stoves suitable for fitting in existing fireplaces." This does not seem a likely development, although "enterprising" Governments have not hesitated, in effect, to pay part of the house rent of selected individuals.

Although there is clearly no impediment, except possibly at times an administrative one, in arranging for the installation of improved types of solid-fuel burning appliances in houses built with public money, the extension of the process to privately-owned existing property is likely to proceed but slowly and, in spite of the publicity given to the subject of house building, most people still live in pre-war houses. Some house owners may certainly install more efficient stoves or grates, with the idea of making the most of their restricted quota of coal and coke, but neither tenants nor landlords, the rents of whose property are fixed at an uneconomic level, are likely to spend money on the matter. In the industrial field, however, more rapid progress may possibly be expected. The cost of fuel may be an important item in the overall accounts of a factory, and industrial firms, in general, may be less loth to incur capital expenditure than a private householder. An example of progress in this way is recorded in the Fuel Research Board report. During the war, the Fuel Research Station developed a smoke eliminator for hand-fired boilers, the primary purpose of which was to increase the safety of ships sailing in convoy. The smoke eliminator has the second advantage that its use results in an increase in boiler efficiency which may amount to 10 per cent. The appliance is now being applied to factory boilers; it is being manufactured by a number of firms and several hundred installations are now at work. As it is estimated that 20 million tons of coal are burnt annually in Great Britain in small hand-fired boilers, if the smoke eliminator were extensively employed an

* *Ministry of Fuel and Power Statistical Digest*, 1950. H.M. Stationery Office. [Price 15*s*. net.]

* See ENGINEERING, vol. 172, page 241 (1951).

† *Report of the Fuel Research Board, with the Report of the Director of Fuel Research for the Period 1st April, 1949 to 31st December,* 1950. H.M. Stationery Office. [Price 2*s*. 6*d*. net.]

important coal saving would result even if an average gain in efficiency of only 5 per cent. were obtained.

The report gives some particulars of recent experimental work with smoke eliminators on both natural- and forced-draught boilers. The term "smoke eliminator," although an appropriate one when it was coined during the war, is not altogether satisfactory for an appliance the essential purpose of which is to improve boiler efficiency. Basically, the method used is to supply secondary air over the fire and to set up a swirling motion in the combustion space. Tests on a natural-draught, hand-fired Lancashire boiler showed that maximum efficiency was obtained with about 35 per cent. of excess air, but it was realised that a further gain might be obtained if the percentage of excess air could be reduced without increasing the loss due to incomplete combustion. This end was achieved by inducing the swirling motion obtained by supplying the secondary air by means of a steam-jet injector situated over the firing door. As already mentioned, apparatus of the smoke-eliminator type is now being manufactured and supplied commercially, but it is evidently considered in official circles that progress might well be accelerated, and it is now announced that the Government is prepared to grant loans for the installation of fuel-saving devices.

As coal is the basic raw material of this country, on which its whole industrial future depends, it is necessary that the Fuel Research Station should concern itself not only with the immediate problem of efficiency in use, but also with problems which may affect the commercial practice of the future. It is usual to draw a distinction between fundamental and applied research, but it is frequently difficult to determine where the frontier between them lies. Some of the subjects dealt with in the report may be described as fundamental research such, for example, as that concerned with coal analysis, but the greater part of the matters dealt with bear directly on practical problems. The work which has been carried on over a number of years on the synthesis of oils from coal by the Fischer-Tropsch process, with cobalt and iron catalysts, was, no doubt, fundamental but the ultimate purpose is decidedly practical. As a result of the initial work, a pilot-scale plant is now being built for the recovery of gaseous and liquid products equivalent to 30 to 50 gallons of oil a day. An investigation which may ultimately prove of importance was concerned with the underground gasification of coal. It is clearly difficult, or impossible, to simulate the conditions of a coal seam in the laboratory, but some work was done on a 17-cwt. block of coal encased in concrete; the results were not very convincing and the report does not suggest that they were.

On pages 229 and 261, *ante*, an article entitled "The Collection of a Representative Flue-Dust Sample" appeared. This gave detailed information about an investigation forming part of an extensive series concerned with steam-raising problems, being carried out at the Station. Two other investigations of the series may be mentioned here. The subject of one is the nature of boiler deposits and samples have been collected from various types of boiler and from different generating stations. Mention is made in the report of a case in which the availability of boilers fired by retort stokers, that had been reduced by phosphatic deposits, was improved by the auxiliary firing of part of the coal in pulverised form, and that additional improvement had been achieved by recirculating some of the flue gas through the fuel bed. Examination of deposits from a number of boilers tends to support the conclusion that firing with pulverised fuel is less likely to lead to the formation of bonded deposits than is stoker firing; corrosion is also reduced. Recently, however, bonded deposits have been found in pulverised-fuel fired boilers and it is stated that it cannot be assumed that very salty coals can always be burnt in pulverised form without giving trouble.

The second investigation which may be mentioned is concerned with the removal of sulphur compounds from flue gas. Before the war, Messrs. Simon-Carves and the Metropolitan Borough of Fulham suggested that sulphur compounds could be removed from flue gas by scrubbing with ammoniacal liquor, with the production of ammonium sulphate. A pilot plant which was built was not entirely satisfactory as it was found impossible to maintain conditions in which neither ammonia nor sulphur escaped in the gas leaving the scrubber. An electrical method was subsequently developed for measuring and recording the vapour pressures of sulphur dioxide and ammonia in equilibrium with the scrubber liquor and it was hoped that by this means the composition of the liquor could be so controlled that neither sulphur dioxide nor ammonia passed off in the scrubbed gas. A test plant, which is described in detail in the report, was set up at the Fuel Research Station and has given such good results that an installation capable of dealing with 25,000 cub. ft. of flue gas per hour has been designed and is being erected at the Station.

THE EUROPEAN TRACTOR INDUSTRY.

IN the fourth of this year's "Engineering Outlook" articles, in our issue of January 25, we dealt with the agricultural machinery industry. A considerable part of that article was devoted to the British manufacture of tractors and to its importance as a factor in the export trade of this country; an importance which has developed remarkably in the past few years, as is evidenced by the fact that the numbers exported had increased from 58,974 in 1949 to 104,175 in 1951, and the corresponding values from 17,717,000*l*. to rather more than 38*l*. millions. The totals related to eleven months only in each year because, when our article was prepared, the figures for 1951 were only available to the end of November, but they afford a fairly adequate comparison of one year with another.

Since that article was published, however, the Economic Commission for Europe have issued a much more detailed study* than that in the *General Survey of the European Engineering Industry*, from which we had quoted. It has been prepared by Industry and Materials Division of the Economic Commission and is directly concerned only with European tractor production and trade; but, for purposes of comparison, a chapter is devoted to the corresponding trends in the United States. The data cited refer, in general, to the production of agricultural tractors only, though there are a few instances among the 66 tables and appendices, where it has not been possible to separate the figures for the agricultural types and the "garden" types. The principal conclusions are that, in spite of the considerable scale of European tractor production—more than half of which comes from the United Kingdom—"there is ample scope for further mechanisation of European agriculture"; that "there is a tremendous potential scope for the absorption of tractors by the less-developed countries"; but that "the principal difficulty will be to convert potential requirements into actual effective demand."

The survey is divided into two parts, the first relating to the tractor industry itself and the second comprising an evaluation of future requirements. A striking contrast appears in the first of the 66 tables, which shows that North America, though containing only 18 per cent. of the world's arable land, nevertheless possesses more than two-thirds of the world's tractor fleet, whereas Latin America, Asia and Africa, which together have nearly half of the world's arable land, own less than 5 per cent. of the total number of tractors. Europe (including Russia) has some 32 per cent. of the world's arable land and about 25 per cent. of the tractors; but a broad consideration of Europe as a whole may be misleading as a guide to future possibilities, because the concentration of tractors is as varied, between one country and another, as it is in the world as a whole. The United Kingdom and Switzerland have, respectively, one tractor to 23 and 25 hectares of arable land (1 hectare = 2·47 acres). The United States has one tractor to 48 hectares; the Netherlands, one to 58; Sweden, one to 62; and Western Germany, one to 68 hectares. Austria, Belgium, Czechoslovakia, Denmark, Finland, France and Italy, however, lie between the proportions of one tractor on 100 to 230 hectares, and these ratios are stated to be more representative of average European conditions; and Russia, in spite of the much-publicised tractor-construction programme in that country, has only one to 400 hectares. Some of the smaller European countries—Portugal, Spain and Turkey, for example—are much less mechanised, their respective ratios ranging from 1,160 to 1,980 hectares per tractor.

Tractor production has increased with great rapidity in the post-war years. In 1938, North America produced 175,000, but the figure rose to 584,000 by 1948 and 615,000 in 1949. There was a slight recession in 1950, to 558,000. In Europe, however, the increase continued without intermission; excluding Russia, the annual European totals rose from 40,000 in 1937 to 164,000 in 1948, 172,000 in 1949 and 243,000 in 1950. The corresponding figures for Russia in 1948, 1949 and 1950 were 51,000, 79,000 and 97,000, respectively. The development of tractor production has been particularly marked in the United Kingdom, which constructed only 18,000 in 1937, but 120,000 in 1950. There is a definite increase in the proportion of all-purpose types produced, and in the percentage of the total output to be fitted with Diesel engines. Figures quoted for the United Kingdom show that the percentage of Diesel-engined types, compared with the total production, has risen, for wheeled tractors, from 3 per cent. in 1948 to 12 per cent. in 1950; and, for tracklaying machines, from 35 per cent. in 1948 to 57 per cent. in 1950.

Further developments are, at the moment, in some doubt by reason of economic considerations, some of which are rather complex in origin. In 1949, it is stated, sales of tractors fell short of production in both Western Europe and the United States; and it was estimated that, in Western Europe alone, over 140,000 more tractors could have been produced in 1950 if the market had been able to absorb them. In 1951, there have been the further complications of raw-material shortages and the competing demands of defence programmes for labour and capital investment. The incidence of these factors differed in different countries; in the United Kingdom and in Western Germany, production is being limited by lack of materials, but in Austria, France, Italy and Switzerland by "lack of demand," which probably means lack of available capital, to a large extent. If the mechanisation of agriculture progresses in the future at the same rate as in the past few years, it is estimated that a world total of some 10,843 million tractors will be needed by January, 1956; but if the potential demand could be translated into effective demand, 14,368 millions would be required. The former "target" would represent a yearly increase of about 12 per cent.; the latter, an increase of 18 per cent. annually. The world production in 1951 is estimated to be slightly under a million tractors, and the increases in capacity actually in hand are reckoned to raise the potential output to over 1,400,000 a year.

* *The European Tractor Industry in the Setting of the World Market.*

NOTES.

BRITISH RAILWAYS.

SPEAKING to the Rotary Club of London on March 12, Mr. John Elliot, chairman of the Railway Executive, said that, owing to the reduced allocation of steel, it was probable that British Railways would be able to complete only 65 per cent. of the planned construction of freight vehicles in 1952. The locomotive programme was likely to be cut by half, and it was unlikely that a single new passenger coach of the 1952 programme could be built. It was hoped, however, to complete the "carry-overs" of the past two years with the steel they had in hand. As regards the track, they would have enough steel to carry out most, but not all, of the full renewal programme of 1,750 miles. The limiting factor here was not so much shortage of material as of labour; they were 7,000 permanent-way workers short, in spite of recruitment of Italian labour and the progressive introduction of mechanical appliances. If the situation was no better in 1953, they would have to impose more speed restrictions. One example of economies in organisation and working, which had been made possible by the unification of British Railways, was that the locomotive workshops were now concentrating on particular parts; for example, the cylinders for locomotives being built at Swindon, Derby and Brighton were being cast in one railway foundry, and water and pressure gauges for all standard locomotives were made in one works. Many major development schemes were being seriously held up because of the capital investment position, or were going on far too slowly. In 1951, the American railroads had expended the record sum of 1,413 million dollars on capital investment, or 505*l.* millions; in the same year on British Railways only 72*l.* million were authorised. Referring to the operation of the railways, Mr. Elliot said that with 100,000 fewer wagons and with fewer locomotives than in 1948, and with a staff reduced by about 50,000, British Railways had nevertheless carried more traffic this winter than in any winter since unification, and the distance each ton of freight had been hauled (76 miles in 1951) was the highest on record. This had been accomplished by the better use of railway resources; for example, by reducing the numbers of vehicles out of service for repair. Apart from a period last October, when there were 20 successive nights of fog, freight traffic this winter had been conveyed without any real restriction. The number of wagons held in marshalling yards and at exchange points had been at or below normal. Nevertheless, the railways could not be complacent, because they had not catered for passenger traffic as they would like, nor were they building for the future as any progressive industry should be able to do under normal conditions.

CONFERENCE ON COLONIAL CIVIL ENGINEERING PROBLEMS.

The Council of the Institution of Civil Engineers are now completing the arrangements for the third Conference on Civil Engineering Problems in the Colonies, which is to be held at the Institution in London from June 16 to 20. These conferences are held every second year and are intended to cater for the particular needs of members of the colonial engineering service and of others engaged in civil-engineering work in the Colonies. It is emphasised that attendance at the Conference is not confined to members of the Institution of Civil Engineers; non-members may attend by making application to the Institution. The Conference will comprise three morning and one afternoon technical sessions, at which papers dealing with road research, railways, water power and water supply, will be presented and discussed, while two of the afternoons and the whole of Thursday, June 19, will be devoted to visits to research laboratories, works and other places of engineering interest. The authors of papers include Mr. H. W. W. Pollitt, Mr. P. H. Haviland, Mr. C. R. Westlake, Mr. H. Gatford, and Mr. L. L. R. Buckland. The annual conversazione of the Institution, this year, has been arranged for Thursday, June 19, and those attending the Conference will be welcome at this function. For members and students of the Institution, a capitation fee of 3*l.* 3*s.* (4*l.* 4*s.*, if accompanied by a lady) will be charged, and this will cover all the visits and also a copy of the proceedings of the Conference which will be published at a later date. The capitation fee for persons who are not members of the Institution is 5*l.* 5*s.*, or 6*l.* 6*s.* if accompanied by a lady. Copies of the proceedings, at 15*s.* each post free to members and students of the Institution and 1*l.* 2*s.* 6*d.* to others, will be available for those who are unable to attend the Conference. Orders for these may now be registered, and application forms and programmes are also available from the secretary of the Institution, Great George-street, London, S.W.1. Completed application forms should be returned to the secretary as soon as possible, or by May 19 at the latest.

THE PROFESSIONAL ENGINEERS APPOINTMENTS BUREAU.

The annual report of the Board of the Professional Engineers Appointments Bureau, for 1951, gives details of a year of increased activity and usefulness. The number of placings increased, and the total of appointment fees was the highest on record. Offers of employment far exceeded the number of appointments made, owing to the abnormal demands for engineers with specialised experience. Over 10 per cent. of those placed were more than 50 years of age. The nominations to vacancies were higher than in previous years, and the number of inquiries from employers was well maintained, but the demand was effective only if vacancies were available in the right proportion, at the right place and time. The total vacancies were 1,070, of which 314 were for civil engineers, 503 for mechanical engineers and 253 for electrical engineers. The figures only relate to notifications where it was possible to make a selection from the available register, otherwise the indications of supply and demand from the resultant total would tend to give a false impression. Overseas vacancies were approximately 30 per cent. of the total notified, the majority of which were for the Middle East, West and East Africa, India and Pakistan. The total number of nominations made was 7,276; of these 2,050 were civil engineers, 3,444 mechanical engineers and 1,782 electrical engineers. Enrolments at the end of the year totalled 1,679 compared with 1,947 in 1950 and 1,981 in 1949. Civil engineers accounted for 385, mechanical engineers 766 and electrical engineers 528. The general shortage of qualified engineers, the report suggests, may be a contributory cause of the decrease in registrations. Suitable living accommodation and the education of children are often the major reasons why many men, who might otherwise consider making a change, decide it is in their own interest to remain in their present jobs. As in previous years, a large number of engineers and employers visited the Bureau. A personal review of the register by the employer affords the opportunity of a more detailed discussion on the type of candidate best suited to the particular requirements of the vacancy. The Board acknowledge their indebtedness to industry, which has continued to support the activities of the Bureau in various ways throughout the year, and especially to those employers who have generously contributed to its finances. Donations totalled 2,563*l.*, compared with 1,041*l.* in 1950. With the increase in placings, the revenue from appointment fees has risen, but as the expenses incurred were much greater than the income received from fees, it was the larger sum received in donations which allowed the Bureau to meet its liabilities. The Registrar, Mr. J. Muil, A.M.I.E.E., is prepared to receive applications for registration for employment from members of the Institution of Civil Engineers, the Institution of Mechanical Engineers or the Institution of Electrical Engineers, and from persons whose qualifications for election or admission to one of these bodies have been approved by the respective Councils. Employers of professional engineers are invited to notify vacancies, and to assist the Bureau by furnishing the following particulars: title of post, with description of duties involved; age range; salary; essential technical qualifications; location of the appointment; and any other significant information. The address of the Bureau is 9, Victoria-street, London, S.W.1.

THE INSTITUTION OF HEATING AND VENTILATING ENGINEERS.

Proposing the toast of "The Building Industry" at the annual dinner of the Institution of Heating and Ventilating Engineers this week, Dr. Oscar Faber, C.B.E., said that low productivity, where it existed, was probably due partly to the feeling, prevalent in the shops and on the site, that materials were not forthcoming at the right times. If that uncertainty could be banished, productivity would rise. Dr. Faber said he was glad the Institution counted consultants as well as contractors among its members; the number of heating and ventilating consultants was small but it was increasing. Referring to the building industry, he said that it was virile; the treatment it had had in the past ten years would have killed any other industry. The toast was acknowledged by Sir Harry R. Selley, J.P., President of the Federation of Master Builders, who said he represented not the large contractors but the so-called "jerry" builders who, if they were given their head, could solve the housing problem and provide homes for all who needed them. At the end of a vigorous speech, in which he recalled incidents of his 66 years in the building industry, Sir Harry was warmly applauded. Sir Graham Cunningham, K.B.E., chairman of the Shipbuilding Advisory Committee and a member of the Economic Planning Board, proposed the toast of "The Institution." He congratulated the Institution on its membership of 2,000 and its expansion since the war. Central and local Government looked to the Institution for authoritative advice on heating and ventilating, though a recommendation made by the Institution in 1918 that fuel economy committees should be set up had only recently been adopted. The country's economic problems could be solved if 20 or 30 million tons more of coal could be mined annually for export; but it was difficult to persuade the miners to produce the extra coal or to accept foreign labour. It was a psychological problem. Responding to the toast, Mr. J. R. Kell, President of the Institution and a partner of Dr. Faber, suggested that when an engineer thought of government he was reminded of a governor, which was a device for regulating the supply of steam, but the engine did the work. Governments to-day, however, tried to do all the work and left industry without the power to do its share. The toast of "The Guests" was proposed by Mr. F. R. L. White, senior vice-president of the Institution, and Mr. A. C. Hartley, C.B.E., President of the Institution of Mechanical Engineers, responded. The dinner was held at the Savoy Hotel, London, on Tuesday, March 11.

PUBLICITY FOR ENGINEERS AND ENGINEERING.

The Council of the Institution of Civil Engineers are of the opinion that the public should be made better acquainted with the work of engineers, and feel that much could be done by engineers themselves to bring this about. This is the import of a note in the March issue of the *Chartered Civil Engineer.* The construction and opening of important engineering works (the note continues) are matters of public interest, but past experience has frequently shown that when, say, an important bridge, power station, hydro-electric scheme, or dock is opened, the name of the engineer is often omitted, or possibly mentioned incidentally, whereas prominence is given to the names of others less concerned with the work. It is felt that engineers responsible could take steps to ensure that due recognition is given to the part played by the engineer when reports are being prepared for the Press. The Council state that there is no objection to such action when it is directed to providing the public with proper information on which to form an opinion as to the value of the work of the engineering profession. The note proceeds to suggest that engineers should advise the secretary of the Institution when any specially interesting piece of work is to be taken in hand so that contact can be made with the British Broadcasting Corporation to find out if they would be interested in filming or recording it. The Television, Home, Light, Third and Foreign programmes are mentioned as possible media of publicity. Engineers are also recommended to take steps to influence the making of films of works for which they are responsible, and to see that advertisements issued by public authorities and contractors, and photographs of works appearing in the Press, show the name of the engineer responsible for designing the work.

EUROPEAN CO-OPERATION ON NUCLEAR PHYSICS.

An international laboratory for nuclear research is likely to be set up in Europe as a result of a recent conference in Geneva, organised by Unesco and attended by delegates and observers from many countries. Agreement was reached on the formation of a council, composed of representatives of states subscribing to the idea, which will make plans for the laboratory and arrange for other forms of international co-operation in the field of nuclear physics. Nine European countries, namely, Denmark, France, Germany, Greece, Holland, Italy, Sweden, Switzerland and Yugoslavia, have already indicated their willingness to support the new venture, and two others, Belgium and Norway, are likely to do so. The Council will co-operate with Unesco but will have an independent legal status and will be wholly financed by the member states. One of its first tasks will be to organise study groups, and one of these, which will review the present state of knowledge of atomic physics and decide on the problems which can best be tackled by the European countries working in collaboration and with existing equipment, will be centred at the Copenhagen Institute for Theoretical Physics. Although Britain is not subscribing to the Council, the latter is to consider an offer made by Liverpool University of facilities to enable a small number of European physicists to work there.

RESEARCH AT THE ROYAL TECHNICAL COLLEGE, GLASGOW.

The progress of research in civil, mechanical, electrical and mining engineering, mathematics, natural philosophy, chemistry, technical chemistry, metallurgy and industrial administration—to mention those departments of engineering significance—is recorded in *Report on Research*, for the session 1950-51, of the Royal Technical College, Glasgow. This publication has replaced the former *Journal* of the College. In civil engineering hydraulics, spillway, estuary, and river-bed model investigations were carried out for the North of Scotland Hydro-Electric Board, the laws of discharge of side weirs were investigated theoretically and experimentally, and some work was done on the action of stream-bed material. Soil mechanics research embraced the stress conditions for failure of soils, the storage of granular materials in deep bins, and protective filters; and work on cement and concrete included the distribution of internal stresses in concrete and investigations of mortar strengths obtained with ground blast-furnace slag employed as a pozzuolanic material. Various researches on water-tube boilers were sponsored by the British Shipbuilding Research Association. Thermodynamic studies were made of the losses in turbine-blade passag s, of thermo-compressors, heat transmission with periodic gas flow, fuel knock rating, cyclical heat interchange between the charge and cylinder in a refrigerating compressor operating on Freon 12, and absorption refrigeration. On fluids, the work included studies of air entrainment by fluid jets, the performance of natural-circulation cooling towers, hydrodynamic losses in valves of various forms, the improvement of impulse water turbines, and pressure dewatering of peat. The British Shipbuilding Research Association also sponsored research on lubrication, and, in the materials and structures section, on built-up marine crankshafts, surface finish of marine engine components, and corrosion fatigue. Other sponsored work in the latter section was concerned with the strength of angles in tension, the load-carrying capacity of thin-walled structures, and stresses in crane structures; some academic researches in this section were also conducted. Other engineering work was undertaken on the characteristics of control mechanisms and, in production engineering, on tool wear and metal-cutting. In other departments of the College the report mentions work on a stereoscopic technique for use with an electron microscope, and the continuation, in the Department of Metallurgy, of the basic research of slag/metal relationships.

LETTERS TO THE EDITOR.

BUCKLING OF STRUTS: TWO CASES GIVING ABNORMALLY LOW LOADS.

TO THE EDITOR OF ENGINEERING.

SIR,—The Euler load for a uniform strut having both its ends simply supported is, of course, $\frac{\pi^2 \mathrm{E\,I}}{l^2}$ where E I is the modulus of section and l is the length of the strut. For other end conditions the Euler load is $k\left(\frac{\pi^2 \mathrm{E\,I}}{l^2}\right)$, where the factor k may range from 4, for both ends clamped, to $\frac{1}{4}$ for one end clamped and the other completely free. The latter value is not, however, the lower limit; abnormal cases may occur for which the factor assumes an even lower value. The two cases which are cited below were both encountered as practical design problems.

In Case 1, illustrated in Fig. 1, a strut clamped at one end is loaded through a prop of length a, the far end of the prop being held in the original line of the strut. The equation o fequilibrium is

$$\mathrm{P}\left(\frac{a + l - x}{a}\,\delta - y\right) = \mathrm{E\,I}\,\frac{d^2y}{dx^2},$$

where y is the deflection at distance x from the clamped end and δ is the deflection at the free end $(x = l)$.

Fig. 1.

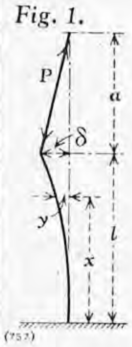
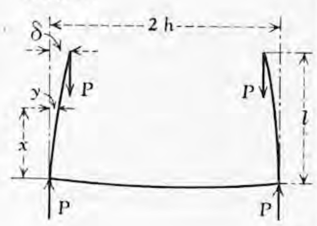


Fig. 2.



The solution adjusted to the end conditions is:

$$y = \frac{a + l}{a}\,\delta\,(1 - \cos\alpha\,x) - \frac{\delta}{a}\left(x - \frac{\sin\alpha\,x}{\alpha}\right),$$

where

$$(\alpha\,l)^2 = \frac{\mathrm{P}\,l^2}{\mathrm{E\,I}} = k\,\pi^2.$$

By substituting $y = \delta$ at $x = l$, the condition for instability is found in the form

$$\frac{\tan\alpha\,l}{\alpha} = 1 + \frac{a}{l}, \quad \text{and} \quad k = \left(\frac{\alpha\,l}{\pi}\right)^2.$$

The value of k varies uniformly from $\frac{1}{4}$ when a is infinite down to zero when a is zero; when $a = l$ the value of k is about 0·14.

In Case 2, illustrated in Fig. 2, two struts, each of length l, are interconnected at one end by a bar of the same section and of length $2h$, and are loaded equally at their free ends, the reactions being taken at the joints with the connecting bar. The equation of equilibrium is

$$\mathrm{P}\,(\delta - y) = \mathrm{E\,I}\,\frac{d^2y}{dx^2},$$

and the solution is:

$$y = \delta + \mathrm{A}\cos\alpha\,x + \mathrm{B}\sin\alpha\,x,$$

where

$$\alpha^2 = \frac{\mathrm{P}}{\mathrm{E\,I}},$$

The end conditions give $\mathrm{A}\cos\alpha\,l + \mathrm{B}\sin\alpha\,l = 0$, $\delta + \mathrm{A} = 0$ and $\mathrm{B} = \alpha\,h\,\delta$. Hence the condition for instability is $\alpha\,h\tan\alpha\,l = 1$; when $\mathrm{h} = l$, the value of k is about 0·075.

Yours faithfully,
H. L. COX,
D. L. R. BAILEY.

National Physical Laboratory,
Ph(E) Section,
Engineering Building,
Teddington,
Middlesex.
February 22, 1952.

"DANGEROUS" MACHINERY.

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of December 28, 1951 (vol. 172, page 816), you discussed in a leading article various aspects of the law concerning machinery which might be held, in the terms of the Factories Acts, to be "dangerous," and, more especially, the liability which might result to the factory owner to pay damages in compensation for injuries which workmen or others might suffer in consequence of the "dangerous" state of such machinery. There are, however, certain other considerations, not covered by that article, to which it may be well to direct attention.

The Industrial Injuries Act, under which a workman can claim compensation for injury sustained in the course of his employment, has now been in operation for some years. When it came into force, the Workmen's Compensation Acts were repealed, and it seemed likely that claims at law against employers would virtually come to an end, inasmuch as the new measure was, in some respects, more favourable to the worker. Nevertheless, actions for damages for personal injuries are still brought, notably against employers in whose works there is said to have been a breach of the Factories Acts or the regulations made thereunder. To bring an action against an employer for damages for negligence at common law is a risky business, for all sorts of defences can be raised; but if it can be shown that an accident has occurred owing to a breach of the Factories Acts or the regulations made under those Acts, the employer becomes liable almost as a matter of course. In a recent case, however, an employer successfully defended himself against a claim founded on a breach of the Factories Act, because of a regulation made (pursuant to the Act) dealing with the same subject!

The case in question (*Benn* v. *Kamm and Company, Limited* (1951) A All. E.R. 56) was heard in the King's Bench last December. The plaintiff, who was in the employment of the defendants, was adjusting a stop on the side of a horizontal milling machine. His index finger was caught in the machine and injured. He contended, *inter alia*, that the defendants were in breach of their duty under S.14 (1) of the Factories Act, 1937, and had failed to provide proper fencing of a dangerous machine. To this the defendants replied that their statutory obligation to fence was not under the Act, but was under Reg. 3 of the Horizontal Milling Machines Regulations, 1928, with which they had complied. That Regulation provided that the cutter of every such machine shall be "fenced by a strong guard, properly adjusted to the work, which shall enclose the whole cutting surface except such part as is necessarily exposed for the milling operation." To this contention the judge acceded, pointing out that the case was covered by a previous decision; he was referring to *Nicholls* v. *Austin* (1944) 2 All E.R. 485. Mr. Justice MacKinnon, when giving judgment in that case, said: "It seems to be clear, so far as the statement of claim in this case alleges breaches of the statutory obligation imposed by the Act of 1937, that the defendants fully complied with the requirements of the Regulations of 1922; any attempt to say that there was any surviving or additional duty upon them by S.14 is erroneous, and is not justified, having regard to the decision of this court." In the case of *Miller* v. *Borthman and Sons, Limited* (1-46) 1 A.E.R. 333, the plaintiff, a joiner in the employment of the defendants, suffered personal injuries while working a circular saw. It was not disputed that the saw complied with the regulations laid down by the Woodworking Machinery Regulations, 1922, Reg. 10, but it was contended on behalf of the plaintiff that the Factories Act, 1937, S.14, imposed an absolute obligation to fence securely, even though a machine may, as a result, be rendered unusable. Following the example of his learned predecessors, Mr. Justice Parker, dismissed the action.

Why, it may be asked, are such actions ever brought? Two reasons may be given. In the first place, the fact that an injured workman makes a successful claim under the Industrial Insurance Act does not prevent him from also suing his employers. When damages are being assessed in such an action, the amount received from the insurance funds is only partially taken into account. In the second place, a man who succeeds in an action can only be awarded a lump sum, while the only relief afforded under the Insurance Act is a weekly payment for a certain period. It may be that, in the hope of getting a substantial sum, the employee is still prepared to embark upon litigation.

Yours faithfully,
W. VALENTINE BALL.

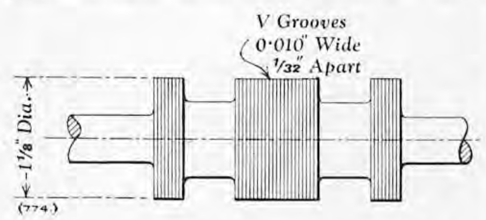
The Athenæum,
Pall Mall, London, S.W.1.
February 16, 1952.

PRELIMINARY INVESTIGATION OF HYDRAULIC LOCK.

TO THE EDITOR OF ENGINEERING.

SIR,—I have followed with a great deal of interest the article on hydraulic lock by Dr. D. C. Sweeney, in your issues of October 26 and November 9, 1951, and the letters of comment on this problem. In this connection, I refer you to a communication from me in the 1949 *Proceedings* of the Institution of Mechanical Engineers (vol. 160, page 554), in which I stated what I thought to be the cause of hydraulic lock and which substantially agrees with Professor Sweeney's conclusions.

My purpose in writing now is to describe a solution of the problem of eliminating hydraulic lock, one which I found to be most effective. This consists in machining on a very small pitch a series of circumferential grooves in the lands of the valve spool, in accordance with the dimensions shown on the accompanying sketch. Circumferential grooving is, of course, an old procedure, but its effectiveness is limited because of the usual practice of using a



relatively large pitch between grooves, which produces a series of lands upon which the pressure can still act with considerable force, with resultant hydraulic lock. With increase in the number of grooves, the possible unbalancing surface and the tendency to lock are reduced.

In experiments which I conducted on hardened steel valve spools, ranging from ⅝ in. to 1⅛ in. in diameter, in cast-iron bodies, using hydraulic oil (viscosity of 250 S.S.U. at 100 deg. F.) at pressures up to 3,000 lb. per square inch, I found it possible to maintain this pressure for periods up to an hour without lock when the small-pitch grooves were used; whereas, with spools incorporating grooves spaced ⅛ in. or more apart, such pressures produced a lock within a minute. A feature attendant to the use of the small-pitch grooves was a reduction in leakage due to the centring influence of such grooves upon the spool. Cycling the spool under pressure several hundred thousand times produced no measurable wear of the spool or valve body.

Very truly yours,
GEORGE I. CHINN.

43, Harriet-avenue,
West Englewood, N.J.,
U.S.A.
February 18, 1952.

FIFTH HYDRAULICS CONFERENCE.—The transportation of sediment has been chosen as the theme for discussion at the Fifth Hydraulics Conference in the United States, which will be held at Iowa City, Iowa, on Monday, Tuesday and Wednesday, June 9, 10 and 11. These conferences are held triennially, under the sponsorship of the Iowa Institute of Hydraulic Research of the State University of Iowa, Iowa City, U.S.A. Problems relating to laboratory and field measurement, and to sedimentation in canals, rivers, estuaries and harbours are among the aspects of the subject to be considered at this year's conference. There will also be a tour of the Institute's laboratories.

OBITUARY.

MR. W. H. PILMOUR.

WE have learned with regret of the sudden death, on March 7, of Mr. William Henry Pilmour, managing director and secretary of Messrs. Parsons Marine Steam Turbine Company, Limited, Wallsend-on-Tyne. We understand that Mr. Pilmour, who was 75 years of age, collapsed in his office at the Turbine Works of the company, with whom almost the whole of his working life had been spent. He entered the employ of Sir Charles Parsons at the Heaton works of Messrs. C. A. Parsons and Company when only 21 and was appointed secretary of the then newly-formed Parsons Marine Steam Turbine Company as long ago as July, 1900. He was made a director in 1930—one of the last appointments to the board made by Sir Charles, who died in February, 1931—and deputy managing director in 1933. Three years later, following the death of Mr. R. J. Walker, C.B.E., who had succeeded Sir Charles Parsons as chairman and had combined with that office the position of managing director, Mr. Pilmour became managing director and secretary. He was an associate of long standing in the North East Coast Institution of Engineers and Shipbuilders and had served as honorary treasurer of the Institution for many years; and he was also an associate of the Institution of Naval Architects.

MR. G. C. PILLINGER.

WE have also to record the death on March 8, at his home in Cheam, Surrey, of Mr. Gilbert Cecil Pillinger, who, until failing health obliged him to retire from active business a few years ago, was well known as a general engineer, and as an inventor, more especially in connection with the automatic control of emergency lighting and pumping machinery. Mr. Pillinger, who was 77 years of age, was a native of Merton, Surrey, and obtained his initial engineering experience with the Brush Electrical Engineering Company when they occupied their Victoria Works in Belvedere-road, Lambeth. He attended technical classes at Finsbury College, and at King's College, London. His natural inventiveness was shown when he was only 23, when he took out a patent for an electricity meter. Electric control circuits were of considerable interest to him and, although primarily a mechanical engineer, he took out a succession of patents, some in his own right and others in association with his partner for a number of years, Leo Sunderland. While still a young man, he undertook the representation of Messrs. R. A. Lister and Company, of Dursley, and, with them, developed the automatic control of emergency engine-driven lighting sets, of which the Lister-Bruston lighting plant, in particular, became very well known.

About 30 years ago, Mr. Pillinger decided to set up in business for himself, which he was enabled to do by the success of several of his inventions, and eventually established a works in Cheam. There, while maintaining his interest in small electric remote-control gear and automatic controls, he also branched out into the construction of small pumping plants and, more recently, oil-burning apparatus, on which, too, he held various patents. Some years ago, Mr. Pillinger decided to vacate his office in Victoria-street, since when his interests had been mainly outside of London; but he will be remembered as one of the pioneers of the small self-contained electric-lighting set and a link with a time when the internal-combustion engine itself had still to emerge from the stage of batch production.

MR. J. H. HARLEY-MASON.

As we go to press, we have learned of the death, on March 11, of Mr. J. H. Harley-Mason, M.I.C.E., formerly New Works Engineer to the London Passenger Transport Board, in which capacity he was responsible for many improvement works on the London Underground system. We hope to publish a memoir of Mr. Harley-Mason in our next issue.

THE BRITISH STANDARD CODE OF PRACTICE FOR REINFORCED CONCRETE.

By D. A. STEWART, A.M.I.C.E.

BRITISH Standard Code of Practice CP114 (1948) sets out to represent "good present-day practice" in "The Structural Use of Normal Reinforced Concrete in Buildings," on the assumption that the design of such buildings will be in the hands of chartered structural or civil engineers; though it should be noted that the Code is only intended for guidance and does not possess the authority of a Building Act. In the following criticisms of the Code and its effect upon normal reinforced concrete practice, the writer has borne in mind that the interpretation put upon the recommendations contained in it may differ considerably from those intended by the committee who drafted the Code. For instance, quite obviously it was never intended that the Code should become "the ignorant and lazy man's recipe for good concrete." There is, however, considerable evidence to suggest that, in many cases, this is what it has become.

Consider, for example, the mix proportions and strength given in Table 1 on page 12 of CP114. Was it really the intention of the committee who drafted the Code that a nominal 1 : 2 : 4 mix was never to be used if the minimum 28-day strength required was 3,750 lb. per square inch—in spite of the fact that, in normal contracting work, mixes of these nominal proportions can and do produce concretes having minimum 28-day strengths exceeding 4,000 lb. per square inch? The attitude of some official bodies is that a 1 : 2 : 4 mix is a 1 : 2 : 4 mix and can only have the official strength granted to it; therefore it must not be specified if the minimum strength demanded for structural purposes happens to be that related to some other proportions. The official ruling appears to say that it is the proportions which make a mix suitable for a particular use, and not the qualities of the concrete.

The general effect of this slavish adherence to the dictates of the Code has been to produce a large volume of concrete of doubtful characteristics, at an unnecessarily high cost in cement, at a time when the utmost economy is being called for in this material. This liberal use of cement has undoubtedly been recommended with the best of intentions, the object being to provide for the high workability, favoured by the contractor of 20 years ago, while still maintaining a water-cement ratio commensurate with the minimum strength requirements. Unfortunately, as so often happens, these good intentions have led in the wrong direction. When the Code is strictly applied, in respect of normal hand-punned concrete, the strengths developed in a nominal 1 : 2 : 4 mix at 28 days vary between 4,500 lb. and 5,500 lb. per square inch, giving a large margin of safety above the minimum requirement; a state of affairs well known to the contractor and his operatives. It is quite understandable, therefore, with some 2,000 lb. per square inch in hand, the standard of workmanship and the degree of supervision are reduced. A contractor is fully justified in taking this step when he knows he has a safety margin of 50 to 80 per cent., particularly as he will win no reward for providing better value than is specified. Thus the use of rich mixes for relatively low minimum strengths tends to set a premium upon poor practice. At the same time, it favours the placing of too wet a concrete, which will become porous as the mixing water dries out, leaving the steel exposed to corrosion and the resultant breakdown of the covering concrete.

Under Section 202, the Code deals with aggregates. Sub-section (*a*) states that they shall comply with B.S. 882–1944 for "Concrete aggregates and building sands," and sub-section (*b*) gives a number of other alternatives. For the purposes of this article, (*a*) will be considered. B.S. 882 specifies, among other things, the range of gradings within which the various aggregates must fall. Section 202, however, continues by stating that the concrete shall be "of the specified proportions which will work readily into position without segregation and without the use of an excessive water content." Also, the "grading should be carefully controlled throughout the work so as to conform closely to that used in the preliminary tests." This seems good sense, but the requirement fails on two counts. Firstly, since the aggregates are to conform to B.S. 882, they are permitted to vary over a wide range, particularly in regard to the continuous gradings. To the concrete contractor, this means that the mean size of aggregate in the $\frac{3}{4}$ in. to $\frac{3}{16}$ in. range can vary from 0·2 in. to 0·36 in., a change of size equal to an increase of 80 per cent. on the finer grading; thus the variation for the mean grading may be as much as 28·5 per cent. Secondly, the method commonly adopted by the suppliers in proportioning the quantities of the constituent sizes of a continuous grading makes for considerable variation from batch to batch, and usually produces a marked initial segregation. In the process of loading, the trucks are run in under the various hoppers and the quantities of each size are added, one after the other. Even where aggregates are purchased in single sizes and weigh-batched into the mixer, the grading variations that can arise are very considerable, as can be seen from an examination of Table 2 in B.S. 882.

It is clear from the foregoing that, under existing conditions, no real attempt at a close grading control is possible. It follows from this that, if the grading used in the preliminary tests is within the range specified by B.S. 882, the control which can be obtained is that covered by the percentage variations permitted in that specification. If a closer control is demanded, the purchaser will have to pay a higher price for his materials.

In its attempts to deal with aggregates, the Code makes no attempt to advise on such important characteristics as shape, bulk density and specific gravity of aggregates and their inter-related effects upon the concrete. Section 203, which deals with the maximum size of coarse aggregate, has the effect of reducing the maximum size of the coarse material unnecessarily because it makes two assumptions that are rarely true. In stating that the maximum size of the coarse aggregate shall, in the case of heavily reinforced sections, be $\frac{1}{4}$ in. less than the minimum lateral distance between main bars, it is assumed that all the aggregates will be required to pass between the bars and that the aggregates are all spherical in form, i.e., all have dimensions of equal magnitude.

As regards the first of these assumptions, it is evident that the whole of the aggregates will never have to pass through the reinforced zone, except in a few cases which are dealt with below. Generally, 90 per cent. of the concrete is placed in positions free from the restricting influence of reinforcement. In any case, it should be remembered that, in most continuous gradings, at least 90 per cent. of the aggregates have passed through square or circular apertures of a given size, that is to say, they have been selected on a basis of one degree of freedom only, whereas, when they are placed as concrete, the selective action of the bars is such as to provide two degrees of freedom. The effect of binders and stirrups is negligible as a rule, except at beam ends, where a little extra working will generally suffice to ensure compaction and sound bond.

An examination of any graded aggregate will disclose the fact that, in the range covered by the coarse material alone, by far the greater number of particles lie below the size group represented by the largest passing and retaining sieves; hence, even where bars are spaced laterally by, say, $\frac{3}{4}$ in., the chances of a serious blockage taking place when a concrete is used which has a maximum aggregate size of $\frac{3}{4}$ in. is theoretically impossible and practically very remote. In any event, the bulk of such a concrete would have a coarse particle size not greater than $\frac{3}{8}$ in. on a basis of statistical calculation. As to the spacing of the bars: this is in the hands of the designer, whose job should be to ensure that the member can be made with economy and, when constructed, will carry the load for which it was intended. Unfortunately, many designers consider their work done when the compression, tension and shear loads have been accommodated at the permitted stress in the respective materials of which the member is built; the actual construction of the member seems to be seldom considered.

One of the aspects of reinforced-concrete design which the Code might well have brought to the notice of designers is the importance of the choice of bar sizes and their distribution, not forgetting overlaps, hooks, bends and intersection. Very often, mixes have to be over-watered and are poorly compacted because the designer has no experience of placing conditions. This inexperience results in insufficient space being available for either feeding the concrete into the member or compacting it thereafter.

The bar spacing is of very great importance in its effect upon the placing and compaction of the embedding concrete. The fact that the lateral distance between bars is greater than the maximum size of the coarse aggregate is no guarantee that the concrete can be adequately compacted, within or below the reinforced zone, if that zone contains two or more layers of bars, particularly when these extend the full width of the member, excluding cover. Where Code of Practice bar spacing is adopted in a doubly-reinforced beam having multi-layer reinforcement, it will be found that both placing and compacting are difficult to the extent of being uneconomic, because of the amount of labour and supervision involved and the great fluidity required of the concrete. The use of these over-wet mixes, which, with little effort, can be made to assume the general appearance of full compaction, in many instances leads ultimately to partial breakdown of the structure through oxidation of the reinforcement, the cover being unable to resist the ingress of air and water because of its porosity.

The use of vibrators in placing concrete in heavily reinforced beams is often inefficient and unsatisfactory because of the difficulty of applying the vibration at the points where it is most needed, that is, within the reinforced zones. The mass and spread of the bars in the upper layers often make the use of internal vibrators impossible. The employment of shutter vibrators is often undesirable because of the construction of the formwork; or, if they are used, they are often largely ineffective in their action, which is damped out by the mass of steel present.

If the recommendations of the Code as to the spacing of reinforcement are neglected, it is usually a simple matter to arrange the bars in groups so that both the concrete and internal vibrators are easily introduced into the formwork as a whole and into the reinforcement zones in particular. Such an arrangement of bars greatly assists in the development of a high value of bond strength between steel and concrete because it permits the effective compaction of the concrete, which may be worked into place when possessing an appreciably lower water content than would otherwise be possible.

It has been pointed out that, if the spacing of bars is no greater than the nominal maximum size of aggregate, their restrictive effect, taken in conjunction with that of the stirrups, is appreciably less than that offered by the maximum normal screen size for that range of coarse aggregate. This being so, it is reasonable to reduce the bar spacings in their groups to as little as $\frac{1}{2}$ in. where aggregates of $\frac{3}{4}$ in. maximum size are to be employed. The effect of this tighter regrouping is to reduce the overall width of the beam cross-section, and hence the dead load on the structure. This, in turn, reduces the steel cross-section for the same stress and live load.

Tests on placing which were carried out recently, using internal vibrators to compact the concrete, have shown that the spacing and rearrangement of the reinforcement discussed above give very satisfactory results, even when harsh mixes of low water content are used. It is suggested that, in view of the urgent need of steel economy at the present time, the bar spacing recommended by the Code of Practice should be reconsidered by the committee and revised in the light of modern practice. These remarks also apply to various Building Acts and by-laws which, at present, tend to reduce certain aspects of structural efficiency.

The last paragraph of Section 203 states that, for general purposes, a $\frac{3}{4}$-in. maximum size is usually satisfactory. This last paragraph has done a great deal of harm to the establishing of good concreting practice, because aggregate of $\frac{3}{4}$-in. maximum size is called for in the bulk of specifications where reinforcement is to be used, without reference to whether the percentage of reinforcement is large or small.

Sections 206 and 207 represent the heart of the matter, for in them the proportions, strengths and even the water-cement ratio are discussed. The most striking aspect of these Sections is that they fail to make any reference to the scientific approach to mix design developed by the Road Research Laboratory during the past 15 years. This neglect has resulted in the Code putting forward recommendations which entirely controvert well-authenticated research on the subject. As an example, the Code specifies the ratio of coarse to fine aggregate as lying between 2 : 1 and $1\frac{1}{2}$: 1, suggesting that, if the 2 : 1 ratio fails to give sufficient workability to the concrete, the sand content may be increased. An examination of the curves which may be derived from *Road Research Laboratory Road Note* 4 and *Technical Paper No.* 5 clearly indicates that, for a given set of aggregate-cement and water-cement ratios, the workability decreases as the sand content is increased. It is also surprising to note the absence of any warning regarding the deterioration of both strength and durability due to the presence of voids, whether these are filled with air or water; yet the same *Technical Paper No.* 5, which deals with mix design, also contains a curve showing the very rapid decrease in strength due to the presence of voids. This curve shows that a 5 per cent. void content represents a loss of strength equal to 30 per cent. of the value obtainable with a fully compacted concrete.

Apart from the fact that the percentage value of the sand content recommended is technically unsound, it has the effect of causing a scarcity of fine aggregate in certain parts of the country, particularly in the Thames Valley, where the sand content of the natural aggregates is low, causing the price of sand to be high. This unnecessary use of sand is, however, not the end of a somewhat gloomy tale, for the use of continuously graded coarse aggregate combined with a Class A sand, and the usually high water contents commonly employed, produces a concrete which cannot be compacted to a sufficient density to resist atmospheric attack. Consequently, repairs to descale and re-cover corroding reinforcement have often to be undertaken within five to 20 years of construction.

It is surprising that the Code, which goes so far in its recommendation in many directions, should have neglected entirely the importance of considering the effect of heat generation in large volumes of concrete due to the use of rich mixes. Often these very rich mixes can be placed at quite low water-cement ratios and, in conditions favouring the development of heat, the hydration of the cement may be adversely affected, while very appreciable internal stresses may develop. In these circumstances, 6-in. test cubes are unlikely to reflect the quality of the concrete in the mass. Incidentally, the Code has made no serious attempt to advise on placing conditions, though these are bound to have a considerable influence upon the type of concrete required for any particular undertaking.

Under the heading of tests for concrete quality, the Code puts forward the beam test, from which the modulus of rupture may be determined. These tests are good in themselves, but associated, as they are in Clause 208, with mix proportions, and without reference to the effect of aggregate shape or surface texture, they leave much to be desired. It is also evident that, because of the dimensions of the beam, aggregate sizes greater than $\frac{3}{4}$ in. are not contemplated. It would appear, therefore, that the economies and other advantages which could well be derived from the use of, say, $1\frac{1}{2}$-in. aggregates are to be discouraged by those adhering to the requirements of the Code. If the modulus of rupture is to be used in future—as, no doubt, it should be, particularly in connection with road and aircraft runways—then a beam of larger proportions will have to be incorporated in any specification for work of this nature. The relationship between beam and cube crushing tests on these larger specimens will have to be the subject of research; and when the new beams, which will have to have a cross-sectional area of not less than 6 in. by 6 in., are put into standard use, the frequency of tests will have to be considered, because the volume of material to be disposed of as debris will have increased by at least 125 per cent.

EXPERIMENTAL "MOCK-UP" OF AIR-LINER.

BRISTOL AEROPLANE COMPANY, LIMITED, BRISTOL.

On the subject of vibration the Code says very little, except that the stresses in the concrete may be increased by 10 per cent. where vibration is used. It is also suggested that the water content should be reduced when vibration is employed.

This Code of Practice generally makes very depressing reading for anyone with a knowledge of concrete technology or with a desire to see a valuable and responsible lead given by the structural and civil engineers in this country to their fellows both here and abroad. To the present writer, the whole of the first part of the Code appears to be out of date, and it is earnestly proposed that it should be withdrawn immediately and rewritten in the light of modern research and development, and of present-day requirements.

WIND-POWER GENERATOR IN NORTH WALES.

THE British Electricity Authority have received the formal consent of the Minister of Fuel and Power to the erection of a wind-driven power generator at Mynydd Anelog, Aberdaron, Caernarvonshire. Soon after the Authority were established in 1948, they decided to associate themselves directly with the research work on wind generation already being carried out by the British Electrical and Allied Industries Research Association (E.R.A.). In March, 1949, tenders were invited for the design and construction of an experimental 100-kW wind generator, and investigations began, in collaboration with the E.R.A., into wind conditions on the North Wales coast. In June, 1950, a contract was placed with Enfield Cables, Limited, for a machine operating on a principle evolved by Monsieur J. Andreau. De Havilland Propellers, Limited, are responsible for the aerodynamic performance and the English Electric Company, Limited, for the alternator and control apparatus.

The wind-driven propeller of the Enfield-Andreau generator is not connected by gearing to the turbine; the two aluminium-alloy blades, sweeping a circle of 80 ft. diameter, are of hollow construction with air exit ports at the tips. When the propeller rotates, air is discharged from the blade tips by centrifugal force and suction is thereby created in the 100-ft. high hollow tower on which the propeller is mounted. Air is drawn through apertures in the base of this tower and, in its passage up the vertical shaft of the tower, drives a turbine. The controls of the generator are operated automatically by wind pressure on a speed-sensitive device. Electrical controls operate a valve for the in-drawn air to by-pass the turbine in the support tower, and thus, when this valve is open, the turbine cannot operate although the propeller is rotating. Hydraulic controls, similar to those developed for de Havilland aircraft, change the pitch of the blades to suit various wind speeds, ensuring that the propeller turns at a constant speed of 100 r.p.m. An 8-kW model of the "Anemo" machine, as the Enfield-Andreau generator is called, has been tested in France. The 100-kW machine now being constructed for the Authority will be erected temporarily on a site near St. Albans within the next few months, and, after undergoing operational tests extending throughout the winter, will probably be transferred to the permanent site on Mynydd Anelog next spring.

BRISTOL "BRITANNIA" AIR-LINER.

A PROGRESS report on the Britannia air-liner, which is expected to make its first flight later this year, has been issued by the Bristol Aeroplane Company, Limited, Filton House, Bristol. It may be recalled that 25 Britannia air-liners have been ordered by the British Overseas Airways Corporation for service on trunk routes to Australia and South Africa. Two prototype aircraft have also been ordered by the Ministry of Supply. The Britannia, which has a maximum take-off weight of 140,000 lb., is fitted with four Bristol Proteus propeller-turbine engines, each developing 3,200 equivalent h.p. plus 800 lb. thrust for take-off at sea level. The fuel capacity is 7,000 Imperial gallons. It is designed to cruise at a speed of about 360 m.p.h. at an altitude of 30,000 ft. and is estimated to have a maximum still-air range, with no reserves, of 5,600 statute miles, carrying a payload of 12,000 lb. (equivalent to 50 passengers, seated four abreast, and their baggage). The cabin capacity allows for the carriage of up to 104 passengers, seated six abreast; with the maximum payload, 25,000 lb., the still-air range, with full fuel tanks and no reserves, is 4,000 statute miles. The seating attachments are designed to allow for a wide variety of seating arrangements.

It is believed that the Britannia is the first civil aircraft in which a "functional mock-up" has been adopted for laying-out and testing the various aircraft services, and checking their accessibility for maintenance work. The functional mock-up, shown in the accompanying illustration, was built, from sub-standard material, to the prototype drawings, so that it is fully representative in dimensions and detail. It consists of the fuselage, as far back as the wing trailing edge; the port wing, out to the aileron, complete with nacelles, and the starboard wing out to, and including, the inner nacelle. It is equipped with the nose-wheel and main-bogie undercarriage units, the complete port flaps, and the starboard inner flaps. Partial control runs are installed, which can be connected to load-simulating mechanisms, and flying controls are fitted in the cockpit. The functional mock-up serves as a test rig for the engine and flying controls, the hydraulic system which operates the undercarriage and control-surface locks, the air-conditioning equipment, the fire-extinguishing system, the emergency equipment, the radio, the electrical system and the fuel system. In testing the latter, an Exactor fuel-system testing rig was mounted on the fireproof bulkhead of each engine nacelle, and flow tests were carried out with the mock-up jacked into various attitudes which might be experienced in flight. The flows to collector boxes from each tank were measured both under gravity feed and with the booster pumps switched on; the tests were then repeated with the balance cocks open, to check the cross feeds. The pressure-fuelling system was also checked on the mock-up to ensure that the fuel galleries would withstand the fuelling pressure of 50 lb. per square inch.

In addition to the functional mock-up, a full-scale wing specimen, with nacelles and a representative portion of fuselage, has been constructed for structural tests, as has also a half-scale fuselage. A 30-ft. long specimen of the front fuselage has been built for pressure tests, and scale-model tab-operated control surfaces have been fitted and flight-tested on a Bristol Freighter aeroplane for comparison with wind-tunnel model-test results.

"SHELL" X-100 MOTOR OIL.

TO-DAY, Friday, March 14, Messrs. Shell-Mex and B.P., Limited, introduce a new motor oil, Shell X-100, which is a highly-refined mineral oil blended with a petroleum-based additive which makes it detergent, stable and protective. Other grades of Shell motor engine oils, previously retailed to the motoring public, are being withdrawn. Shell X-100 motor oil has been developed to provide the motorist with an oil which will assure an all-round improvement in engine performance. One of the qualities which has been stressed in the development of this oil is its ability to protect the engine from corrosive wear, which is the result of operating with low cylinder-jacket temperatures such as are experienced during the period immediately after starting and on short journeys. At the same time, the oil has been designed to give results better than for conventional oils under the rigorous conditions of mountain driving and similar high-temperature and high-load operation; during operation such as this, the oil markedly reduces the formation of lacquer and deposits and prevents corrosive attack of the bearings.

From the experience gained at the firm's Thornton Research Centre and the other "Shell" Group laboratories in Holland and the United States, a great deal is known of the theory underlying formulation of improved lubricants. With this background as a guide, compounds having a desirable molecular structure are synthesised. Such compounds are used to improve the already good properties of a mineral oil which has been developed as the result of extensive research and development of refining techniques. Combinations of these additives and oils are then screened and evaluated in laboratory bench tests. Their performance is carefully noted and, in the light of these tests, alterations are made to achieve further improvements. Selected additive-oil combinations are then investigated in single-cylinder engines operating under conditions which will emphasise particular attributes of the oil. For example, to determine the protection given by an oil against low-temperature wear, an engine is operated for long periods with an artificially-cooled cylinder jacket and sump. Under such extreme conditions of test, Shell X-100 motor oil, it is claimed, shows a two-fold or three-fold reduction in wear compared with that given by a straight mineral oil.

Recently, a valuable technique has been added to the equipment available for fundamental additive research, namely, the evaluation of wear in a radio-active tracer unit, which employs a piston ring activated at the Atomic Energy Research Establishment at Harwell. By determination, in the oil, of the quantity of radioactive metal worn from the ring it is possible, without dismantling or stopping the engine, to assess rapidly the ability of the oil to prevent wear. Moreover, information is obtained on the life of the anti-wear additive present in the oil. If an oil is to show a true anti-wear effect in service, then the additives must have a life sufficient to ensure adequate protection of the engine throughout a normal oil-drain period. In addition to the radioactive tracer unit, other engines are used to provide information on additive life and effectiveness. In another screening test, oil is subjected to severe conditions of high-temperature operation. If an ordinary oil is used, the piston becomes heavily lacquered, piston rings are stuck and scraper rings plugged. Shell X-100 motor oil, it is claimed, will produce a piston with a clean skirt and free, unplugged rings.

Oils which appear excellent in tests such as these are then subjected to critical examination in engines typical of those used in automotive service. In one such test the engine speed and load are varied at low cylinder-jacket and oil temperatures to simulate the type of service met with in doctors' cars, tradesmen's vans and general town driving. These conditions provide a severe test of the oil and give rise to excessive corrosive wear when normal straight oils are used. Shell X-100 oil frequently showed more than a two-fold reduction in wear under such conditions. Satisfactory cleanliness of scraper rings was also achieved. Oxidation stability, a property of motor oils which determines their ability to withstand continuous high-temperature operation, is examined in the Chevrolet L-4 test. Corrosive acids formed by deterioration of the oil attack alloy bearings used in the engine. Compared with a high-quality straight oil, the new oil reduces by a factor of four the corrosion encountered in this test.

For examining protection against cold corrosion, a popular British car engine is operated under varying speeds and loads at low jacket temperatures. Whereas a straight mineral oil will normally allow rusting of the bores to occur, in this test the new oil considerably reduces or prevents such rusting, so preserving the bores and reducing wear on re-starting. To assess valve life a well-known commercial vehicle engine is run under continuous high load conditions and the time taken for valves to fail is measured. Shell X-100 is reported to have tripled the valve life in comparison with a straight oil. The beneficial influence of the oil on valve life has been confirmed in the field by one of the foremost American manufacturers of gasoline engines.

In addition to bench tests such as these, the performance of the lubricant has been verified by a further programme of work carried out at Thornton, using a range of car engines representative of current British and Continental manufacture. Those exceptional oils which emerge from the preceding development programme are then tested under controlled road conditions. Some road tests emphasise low-temperature operation and the ability of the oil to combat acid action. The facilities of the Motor Industry Research Association Proving Ground at Nuneaton have been used in such tests. Where it is necessary to carry out road testing under special conditions aerodrome tracks are used. Other road trials carried out in mountainous and hilly circuits in North Wales and other parts of the country, in summer and winter conditions, have emphasised continuous high-load operation and its influence on piston and ring condition and valve life. As well as providing data on the performance of an oil, such tests provide proof of the ability of the original laboratory tests to give results in line with service.

Before placing it on the market the oil was subjected to still more testing in cars that were run on normal schedules. Careful inspection of the engines after thousands of miles of operation showed that the new oil was superior in all its characteristics, keeping wear and deposits to a low level throughout the operating life of the engine. The tests show that Shell X-100 motor oil increases engine life by reducing low-temperature wear, maintaining adequate cleanliness under high and low-temperature conditions, protecting the cylinder bores from rust and corrosion, increasing valve life and preventing deterioration of the oil due to oxidation, and thereby protecting the alloy bearings from corrosive attack.

CIVIL AIRCRAFT INSPECTION PROCEDURES.—The Air Registration Board have issued the following leaflets of the publication *Civil Aircraft Inspection Procedures:* No. BL/7-1, Issue 1, *Anodising;* No. BL/9-1, Issue 1, *Heat-Treatment of Aluminium Alloys;* No. AL/3-1, Issue 2, *Manually-Operated Flying Controls*, cancelling Issue 1; No. AL/3-4, Issue 1, *Duplicate Inspection of Flying Controls:* No. AL/3-5, Issue 1, *Power-Assisted and Power-Operated Flying Controls:* No. AL/7-5, Issue 1, *Rivets and Riveting*. Copies of the leaflets may be obtained, price 4*d*. each, from the Board's Publications Department, 37, Gratton-road, Cheltenham.

HASTINGS TRANSPORT AIRCRAFT FOR NEW ZEALAND.—The first of four Hastings C3 military transport aircraft, which are being constructed by Handley Page Ltd., Cricklewood, London, N.W.2, for the Royal New Zealand Air Force, was recently handed over to the Prime Minister of New Zealand, the Right Hon. S. G. Holland, at Radlett Aerodrome, Hertfordshire. The Hastings C3, which is fitted with four Bristol Hercules engines of a later mark than those fitted to the Hastings aircraft in service with the Royal Air Force Transport Command, will serve as a 50-seat trooper, as a long-range freighter, or as an ambulance for 32 stretcher cases and 28 sitting cases. The all-up weight is 80,000 lb. It will carry a pay load of 20,311 lb. over a still-air range of 1,535 miles at a cruising speed of 247 m.p.h. The maximum still-air range is 3,820 miles, with a corresponding payload of 7,100 lb.

LABOUR NOTES.

APPEALS to members of the trade-union movement to support their recognised leaders were made by Mr. Arthur Deakin, C.B.E., chairman of the Trades Union Congress and general secretary of the Transport and General Workers' Union, in a statement issued after the quarterly meeting, on March 7, of the union's general executive council. Mr. Deakin stated that the union viewed with "very great concern any attempt to cause a split in the labour movement on fictitious issues." The council was in complete opposition to agitation inspired by extreme left-wing elements for industrial action on political issues. It contended that such agitation was not leadership, but rather an attempt to mislead, and thereby involve the trade-union movement in policies which contain in themselves the seeds of its own destruction. He was confident, however, that members of the union would not respond to "adventures" of this description.

Referring to the re-armament programme, Mr. Deakin said that the council realised, in general, the difficulties which were likely to confront the trade-union and labour movements at the present time, and the council desired to emphasise how necessary it was for the union's members to remain loyal and steadfast to the policies devised by their own union and the wider trade-union movement. The union's executive would face the economic situation with determination and consider on their merits any proposals put forward to meet the country's difficulties. Also, it would continue to play its part in discussions with Government Ministries and agencies on day-to-day economic and labour problems. In spite of the foregoing, however, it seems improbable that the Trades Union Congress General Council will take part, in the future, in personal consultations with Ministers on proposed legislative action, as was done in the case of the previous Government. Only after the terms of such action have been disclosed, are joint consultations with Ministers likely to take place.

An unofficial strike of apprentices at shipbuilding and engineering establishments on Clydeside commenced on Monday last, when the apprentices walked out from their factories and workshops, in support of demands for an all-round wage increase of 20*s*. a week. Although some 2,500 youths are stated to have taken part in the stoppage, many firms in the area were able to report a full attendance of their apprentices. Other establishments affected by the dispute stated that only a small number of their apprentices went out. A mass meeting of the strikers took place at Glasgow later in the day, at which they declared their intention of picketing factories and arranging daily demonstrations outside their employers' offices. The district committee for the Clyde area of the Confederation of Shipbuilding and Engineering Unions issued a warning on Monday that any continuance of strike action would delay a settlement of the claim, and perhaps seriously damage the apprentices' case.

At Sheffield, a mass meeting of apprentices was held on March 9, at which resolutions affirming their support to the 20*s*.-a-week claim were approved. This demonstration was attended by youths from some fourteen of the larger engineering establishments in the area. On the following morning, about 25 engineering apprentices employed by Messrs. Ambrose Shardlow and Company, Limited, at their Meadow Hall, Sheffield, works commenced a sudden strike, which their union has not recognised. Claims for the 20*s*.-a-week increase were presented to the Engineering and Allied Employers' National Federation some time ago by the apprentices' unions, through the Confederation, and the employers' reply is expected shortly.

A strike commenced on Monday last at the Preston, Lancashire, works of the English Electric Company, Limited, due to a dispute over working hours, in which some 130 engineering draughtsmen were concerned. It was stated, on behalf of the men, that the stoppage had resulted owing to a request by the firm's management that the draughtsmen should work a week of 40 hours, whereas the national agreement applicable to engineering draughtsmen stipulated a working week of 38½ hours only. It was claimed that about half of the men involved were engaged on work connected with Canberra jet-fighter aircraft and that the strike was recognised by their union.

Methods for ensuring the wider employment of older persons in industry are to receive special attention by the Ministry of Labour and National Service in the future. It was announced on Monday that the Minister, Sir Walter Monckton, Q.C., had set up a committee for this purpose, which would be known as the National Advisory Committee on the Employment of Older Men and Women. Its terms of reference: "To advise and assist the Minister in promoting the employment of older men and women" have been made as wide as possible. Included among the 26 men and women appointed to the committee are three members of the Trades Union Congress General Council: Sir William Lawther, Mr. Alfred Roberts and Mr. Tom Williamson. The chairman is Sir Peter Bennett, O.B.E., the Parliamentary Secretary to the Ministry of Labour and National Service.

The Engineers' Guild and five other professional associations, including the British Medical Association and the National Union of Teachers, sent representatives to a meeting at B.M.A. House, London, on March 4, which had been called to consider what action should be taken respecting the intention of the Durham County Council to require applicants for posts on its staff to be members of trade unions or professional associations. It was decided to recommend to the organisations concerned that a joint emergency committee should be set up to review the position.

The proposals of the National Coal Board to construct additional houses in colliery areas, for the exclusive use of mine employees, were due to be discussed at length at yesterday's meeting of the executive council of the National Union of Mineworkers. The executive council is understood to regard some aspects of the Board's housing plans with something approaching concern. Although the N.U.M. can hardly do otherwise than give general support to a scheme which has for its object the benefit of the union's members, the executive council is particularly desirous that its officials shall not be involved in any disputes which may arise regarding the rights of different families to occupy houses erected under such schemes. The agitation in some districts against the creation of a new kind of "tied cottage" is also recognised.

As in the case of so many other schemes designed to effect improvements in social or working conditions, the difficulties confronting the National Coal Board in connection with its housing plans are quite considerable. Among the safeguards sought by those concerned are that miners who retire for ill-health or old age, or who have to leave the industry for some other sufficient reason, should not be prejudiced in their occupancy of a house. Other groups with claims for special consideration are the families of men who die while continuing in their employment as miners. No doubt these and other aspects of this scheme for providing good housing for men engaged in a basic industry will receive careful consideration during the forthcoming negotiations between the N.C.B. and the union's executive council. Requests from miners for more houses in colliery areas have been continuous.

Statistics relating to many aspects of national income and expenditure during the four years 1948 to 1951 are given in a White Paper issued on behalf of the Treasury on Monday last (Cmd. 8486, H.M. Stationery Office, price 6*d*. net). The figures are of a preliminary nature only, owing to the advance in the date of the Budget, and a further White Paper will be published later. It is estimated that, in Great Britain, the gross national product amounted to 12,414 million pounds during 1951, compared with 11,907 million pounds during 1950, representing an increase of 507 million pounds, or about 4 per cent. The corresponding increase in the year 1950 above that of 1949 was approximately 600 million pounds, or about 5 per cent. The gross national product comprises, for this purpose, the estimated money value of the country's internal production added to its net income from abroad. It is emphasised that these figures are money figures only and that they reflect the rise in prices due to the increase in costs in Britain, but not the increases in the cost of goods and services purchased from overseas. It is also pointed out that the change in the balance of payments during the years 1950 and 1951, from a surplus to a deficit, added some 740 million pounds to the internal supply of goods and services, compared with 507 million pounds added by advances in home production.

The money value of goods and services consumed in Britain during 1951 was 1,451 million pounds, or about 10 per cent., above that for 1950. Personal consumption in the former year was increased by 710 million pounds, or 8 per cent.; consumption by public authorities rose by 387 million pounds, or 19 per cent.; while the value of inland investments was increased by 354 million pounds, or about 19 per cent. also. With the re-armament drive already beginning, an increased proportion of Government expenditure was spent on goods and services for defence, namely, 25 per cent. in 1951, against an average of 22 per cent. for the four years 1948 to 1951. Personal incomes in Britain increased by 8 per cent. during 1951, which was twice as much as the increase during the preceding year. The great bulk of this increase was due to the advances in wages and salaries. It is recorded that the general design of personal spending in 1951 showed but little change, compared with 1950.

STRUCTURE OF MOLYBDENUM-STEEL STEAM PIPE.

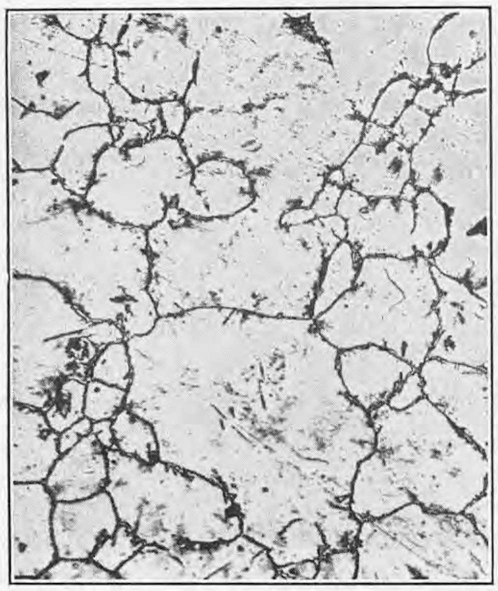


FIG. 1. HOT-DRAWN CR-MO STEEL: MCQUAID-EHN TEST. × 150.

FIG. 2. HOT-DRAWN CR-MO STEEL. × 150.

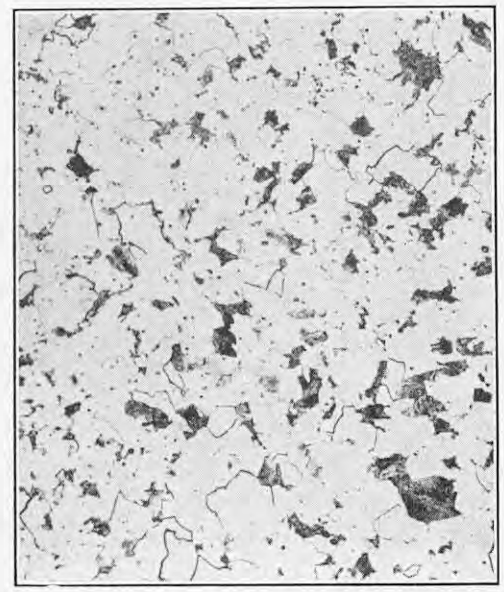


FIG. 3. HOT-DRAWN CR-MO STEEL, NORMALISED. × 150.

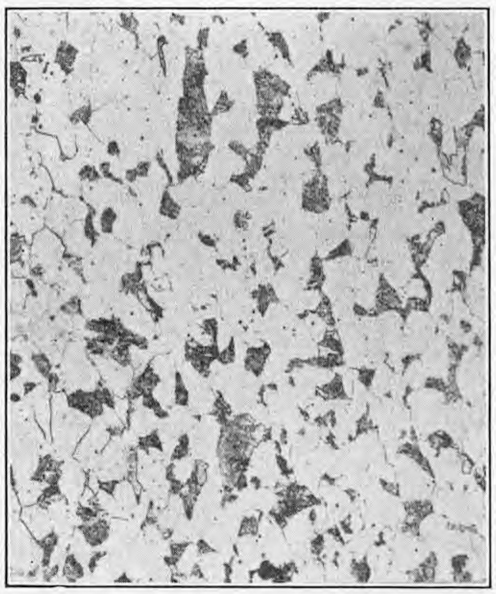


FIG. 4. COLD-DRAWN CR-MO STEEL. × 150.

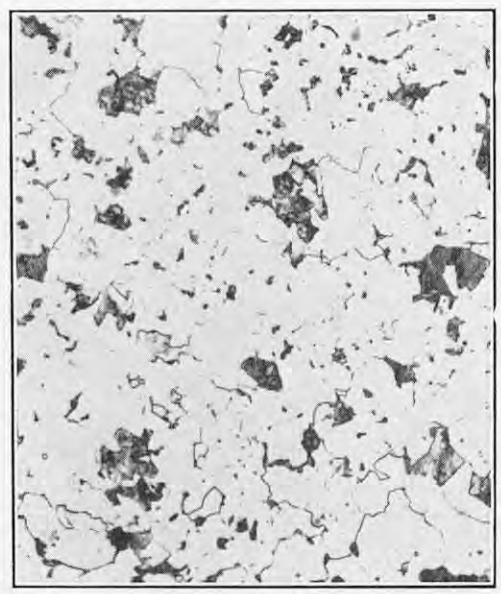


FIG. 5. COLD-DRAWN CR-MO STEEL, NORMALISED. × 150.

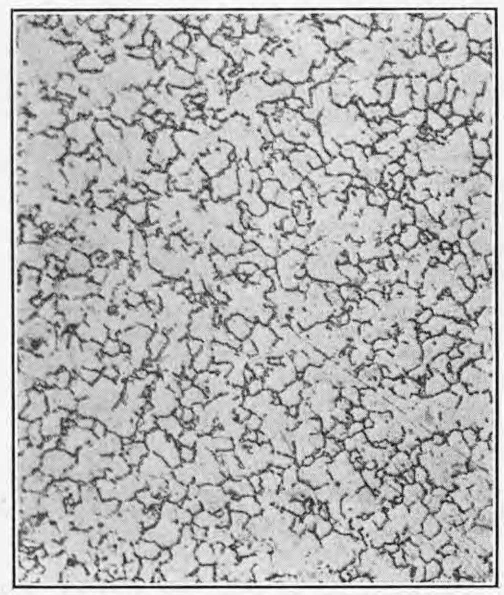


FIG. 6. HOT-DRAWN MO-V STEEL: MCQUAID-EHN TEST. × 150.

EFFECT OF COLD DRAWING ON CREEP-RESISTING MOLYBDENUM-STEEL STEAM PIPE.*

By E. A. JENKINSON, M.Sc., A.I.M., and D. C. HERBERT, B.Sc.(Eng.), G.I.Mech.E.

IN 1946† it was reported that certain molybdenum-steel steam pipes had cracked in service and that it was important that pipes should have smooth and undamaged surfaces. Although there were other factors in the failures, it was considered that the use of cold-drawn pipes, having smooth surfaces, would be one of the means of eliminating further failures. Cold drawing, during the intermediate stages of manufacture, has been used to improve the surface of carbon-steel pipes, and these pipes have been put into service after normalising without apparent detriment to their high-temperature creep resistance. It was not known however, how cold drawing would affect the creep resistance of molybdenum-steel steam pipes, and tests have accordingly been made. Since it has been reported from America that carbon-molybdenum steels may be weakened by graphitisation in the neighbourhood of welds, some tests were also made of the effect of cold working on the graphitisation of the steels after welding. Two steels were chosen for the work, one a chromium-molybdenum steel containing 0·9 per cent. of chromium and 0·4 per cent. of molybdenum, the other a molybdenum-vanadium steel containing 0·5 per cent. of molybdenum and 0·2 per cent. of vanadium. The chromium-molybdenum steel was made in an acid open-hearth furnace and the molybdenum-vanadium steel in a basic electric furnace. The chemical compositions of the steels are shown in Table I.

TABLE I.—*Chemical Composition.*

Element.	Cr-Mo Steel.	Mo-V Steel.
	Per cent.	Per cent.
Carbon	0·20	0·10
Silicon	0·19	0·11
Manganese	0·40	0·54
Sulphur	0·038	0·012
Phosphorus	0·026	0·020
Nickel	0·096	0·14
Chromium	0·91	0·09
Molybdenum	0·42	0·54
Vanadium	Nil	0·21
Copper	0·13	0·16
Aluminium-soluble	0·001	0·004
,, -insoluble ..	0·002	<0·001
Oxygen*	0·008	0·005
Nitrogen*	0·006	0·008
Hydrogen*	Trace	0·000004

* By vacuum-fusion carbon-reduction method.

Tubes of 8 in. bore and ¾ in. thick were produced in the hot-rolled and cold-drawn condition from billets of the two steels. Details of the reduction and the intermediate heat-treatments between the passes during the cold-drawing operations are given in Table II. The outside surface of the molybdenum-vanadium steam pipe was machined before the cold-drawing passes. Whereas the chromium-molybdenum steel was given a sub-critical anneal between each stage of cold drawing, the molybdenum-vanadium steel was normalised. The surfaces of the cold-drawn tubes

TABLE II.—*Details of Cold Drawing Given to the Tubes.*

Treatment.	Cr-Mo Steel.	Mo-V Steel.
Machining before 1st pass	None	Machined on outside surface $10\frac{1}{2}$ in. o.d. by $8\frac{1}{8}$ in. i.d. to $10\frac{1}{8}$ in. o.d. by $8\frac{1}{8}$ in. i.d.
Normalised before cold drawing	At 920 deg. C. ..	At 950-975 deg. C.
Scaling pass ..	1·88 per cent. reduction of area	None
Inter-pass heat treatment	Tempered 660-670 deg. C. $1\frac{1}{2}$ hours	None
Straightening pass	12·05 per cent. reduction of area	None
Inter-pass heat treatment	Tempered 660-670 deg. C. $1\frac{1}{2}$ hours	None
1st pass	14·9 per cent. reduction of area	8·95 per cent. reduction of area
Inter-pass heat treatment	Tempered 660-670 deg. C. $1\frac{1}{2}$ hours	Normalised 950-975 deg. C.
2nd pass ..	8·0 per cent. reduction of area	10·98 per cent. reduction of area
Inter-pass heat treatment	Tempered 660-670 deg. C. $1\frac{1}{2}$ hours	Normalised 950-975 deg. C.
3rd pass	6·6 per cent. reduction of area	8·07 per cent. reduction of area

* Communication from the National Physical Laboratory, entitled "The Effects of Cold Drawing on the Creep Resistance and Structure of 0·5 per cent. Molybdenum-Steel Steam Piping," being a report of work carried out in the National Physical Laboratory on behalf of the J/E Committee of the British Electrical and Allied Industries Research Association. (Ref. Report J/T. 154). Abridged.

† See ENGINEERING, vol. 162, page 209 (1946).

STRUCTURE OF MOLYBDENUM-STEEL STEAM PIPE.

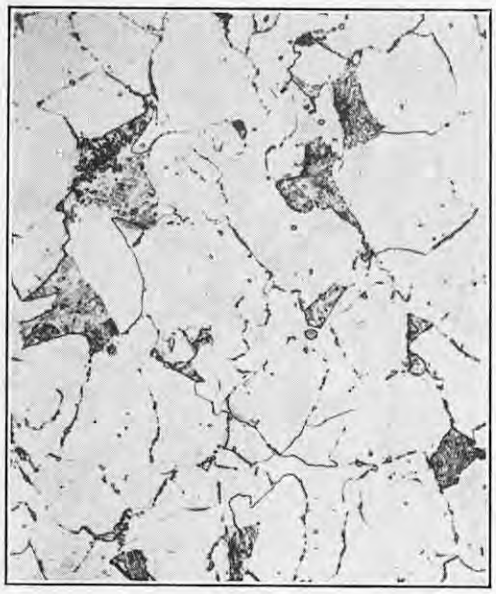


FIG. 7. HOT-DRAWN MO-V STEEL. × 500.

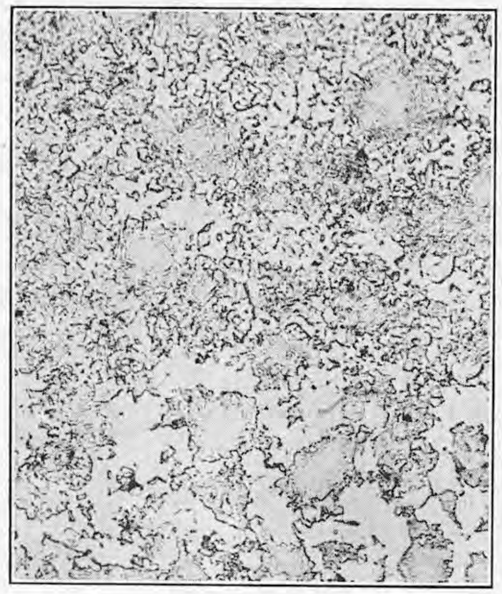


FIG. 8. HEAT-AFFECTED ZONE OF WELD, CR-MO STEEL. × 150.

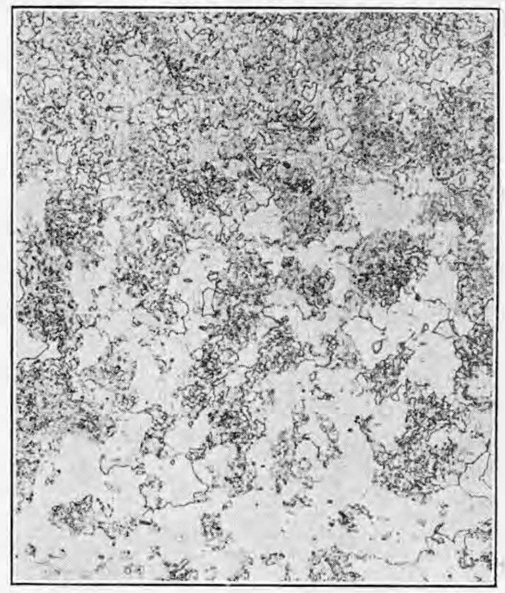


FIG. 9. AS FIG. 8, AFTER 350 HOURS AT 625 DEG. C. × 150.

were smooth; the surface imperfections to be found on the hot-drawn tubes were not present. Little decarburisation was found at the surface of any of the tubes whether hot- or cold-drawn or after the various heat-treatments to which the tubes were subjected. The treatments were carried out in the works of the manufacturers. Details of the heat-treated conditions in which the steels were tested are as follows.

Cr-Mo Steel Steam Pipe.

Hot Drawn.
Hot Drawn, Normalised at 930 deg. C.
Hot Drawn Normalised at 930 deg. C., Tempered for 2 hours at 620 deg. C.
Hot Drawn, Tempered for 2 hours at 620 deg. C.
Cold Drawn.
Cold Drawn, Normalised at 930 deg. C.
Cold Drawn, Normalised at 930 deg. C., Tempered for 2 hours at 620 deg. C.
Cold Drawn, Tempered for 2 hours at 620 deg. C.

Mo-V Steel Steam Pipe.

Hot Drawn.
Hot Drawn, Normalised at 950-980 deg. C.
Hot Drawn, Normalised at 950-980 deg. C., Tempered for 4 hours at 670-690 deg. C.
Cold Drawn.
Cold Drawn, Normalised at 950-980 deg. C.
Cold Drawn, Normalised at 950-980 deg. C., Tempered for 4 hours at 670-690 deg. C.

Micro-examination of the chromium-molybdenum steel in the hot-drawn condition showed the structure to consist of large Widmanstätten type grains of pearlite with small proportions of free ferrite (Fig. 2, page 345). Normalising the hot-rolled pipe at 930 deg. C. changed the large pearlite areas shown in Fig. 2 into small compact pearlite areas (Fig. 3). The structure of the cold-drawn pipe consisted of small compact pearlite areas in a ferrite field with some directionality due to the drawing of the pipe (Fig. 4). Normalising this cold-drawn pipe at 930 deg. C. gave a more uniform shape to the pearlite and ferrite grains (Fig. 5). The McQuaid-Ehn grain size of this chromium-molybdenum steel was 4 to 5 on the American Society for Testing Materials scale (Fig. 1).

FIG. 10. HEAT-AFFECTED ZONE OF WELD. MO-V STEEL AFTER 350 HOURS AT 625 DEG. C. × 150.

FIG. 11. COLD-DRAWN MO-V STEEL AFTER 350 HOURS AT 625 DEG. C. × 5.

TABLE III.—RESULTS OF CREEP TESTS ON CR-MO STEEL AT 4 TONS PER SQUARE INCH AND 575 DEG. C. (COMPARISON OF HOT-DRAWN AND COLD-DRAWN MATERIAL IN VARIOUS CONDITIONS).

Condition.*	Creep Rate per hour × 10^6 at Following Times in Hours.				Time in Hours to Reach 0·1 per cent. Creep Strain.
	50	200	500	1,000	
HD	2·5	1·4	1·1	—	576
HD + 50 hours at 650 deg. C.	4·0	1·75	—	—	166
CD	3·8	2·3	2·1 M	2·4 BM	280
CD + 50 hours at 650 deg. C.	6·7	—	—	—	78
HDN	1·4	0·68	0·46	0·41	1,800†
HDN + 50 hours at 650 deg. C.	1·5	1·1	0·69	0·80 BM	1,070 BM
CDN	1·8	0·71	0·54	0·44	1,260†
CDN + 50 hours at 650 deg. C.	1·9	1·0	0·68	1·2 BM	925 BM
HDNT	2·0	1·2	0·75	0·71 M	900
HDNT + 50 hours at 650 deg. C.	2·5	1·4	0·80	—	710 BM
CDNT	1·7	0·98	0·73	0·66	1,000
CDNT + 50 hours at 650 deg. C.	2·5	1·5	1·6	—	516 BM
HDT	2·0	1·2	1·0	0·98	726
HDT + 50 hours at 650 deg. C.	3·4	2·3	—	—	238
CDT	4·0	2·0 M	2·0 M	2·2 BM	325
CDT + 50 hours at 650 deg. C.	3·8	2·6	—	—	217

* HD = Hot drawn; CD = Cold drawn; N = Normalised; T = Tempered 2 hours at 620 deg. C.; BM = Beyond occurrence of minimum creep rate; M = Minimum creep rate. † = Extrapolated.

Creep tests were carried out at a temperature of 575 deg. C. under a load of 4 tons per square inch for periods up to 1,000 hours. This temperature is about 50 deg. C. higher than that to which the steel would normally be exposed in a steam pipe, and the stress is also somewhat higher. The creep rates at 50, 200, 500 and 1,000 hours and the times to reach 0·1 per cent. creep strain are shown in Table III. The results of these tests showed the creep rates on cold-drawn samples to be almost double those on hot-drawn samples but after normalising at 930 deg. C., the creep rates were similar for the two conditions. Normalising lowered the creep rate. Tempering for 2 hours at 620 deg. C. after normalising increased the creep rates, but there were still no marked differences between cold-drawn and hot-drawn samples.

Further creep tests were carried out on samples of cold-drawn and hot-drawn pipe in the various heat-treated conditions after heating to 650 deg. C. for 50 hours. This heat-treatment simulates the condition of the material after service of at least 50,000 hours at 500 deg. C.* The heating to 650 deg. C. produced

* The rates of spheroidisation of carbides in carbon steels at temperatures from 500 deg. to 700 deg. C. have been discussed by Bailey and Roberts, who suggest the following equation for the variation of the rate of spheroidisation with temperature:

$$t = A\,(e)^{\frac{33,000}{T}}$$

where t is the time in hours required to bring about a given degree of spheroidisation, T is the abolute temperature, and A is a constant influenced by the thermal history and mechanical condition of the material. Thus, assuming a similar relation exists for low-alloy steels, 50 hours at 650 deg. C. is equivalent to 55,000 hours at 500 deg. C. or 4,000 hours at 550 deg. C. See R. W. Bailey and A. M. Roberts, *Proc. I.Mech.E.*, vol. 122, page 209 (1932).

a definite increase in creep rate in all the conditions and showed in general the cold-drawn material to be slightly weaker than the hot-drawn material. The results are included in Table III. The increase in creep rate is associated with spheroidisation of the carbide, and it has been shown that the rate of spheroidisation increases if the material undergoes plastic deformation during the spheroidisation treatment. The effect, however, is small if the total strains are small, and it is considered that, provided the steels undergo little deformation in service, their behaviour after long service can be estimated from the results of creep tests after preliminary spheroidisation.

Microscopic examination showed little difference between the structures of the various samples of molybdenum-vanadium steel. A little more precipitation of carbide was visible in the ferrite grains of the cold-drawn material which had been normalised and tempered than in the other samples. The similarity in structural condition is not unexpected because the cold-drawn pipe was given a normalising treatment between each of the cold-drawing passes (Table II). The microstructure of the steel in the hot-drawn condition is shown in Fig. 7, opposite. The McQuaid-Ehn grain size of the steel was 6 to 7 on the A.S.T.M. scale (Fig. 6, page 345).

Preliminary creep tests to rupture showed that, as received, this steel had a greater elongation before fracture and rather lower creep resistance than other samples of molybdenum-vanadium steels that have been examined. This suggests that the sample may not be entirely typical. Creep tests were made under 4 tons per square inch at 575 deg. C., using the same conditions as were used for the chromium-molybdenum steel, and in view of the higher creep resistance of the molybdenum-vanadium steel, which justifies its use at a higher temperature than can be employed with chromium-molybdenum steel, two tests were made under 4 tons per square inch at 600 deg. C., and a series of stress to rupture tests under 10 tons per square inch at 625 deg. C. The results are given in Table IV.

In the creep tests at 575 deg. C. and 4 tons per square inch the creep rates at times up to 1,000 to 2,000 hours did not show much variation between the samples in the various conditions. Comparison of the steel in the various conditions on the basis of time to reach 0·1 per cent. creep strain indicated that normalising caused these times to be roughly doubled. The results of the tests at 600 deg. and 625 deg. C. on the steel in the various conditions are very similar. In the rupture tests at 625 deg. C. the ductility, as given by elongation and reduction of area at fracture, was high in almost all the conditions. The cold-worked sample, however, showed relatively low ductility.

Graphitisation tests on welded samples of the two steam pipes were then carried out. To simulate a welded joint, round grooves approximately ⅛ in. deep were machined on the convex surfaces of the samples, and a single or two-run deposit of mild-steel weld metal was laid in these grooves. Sections of these welded samples were heated for 350 hours at 625 deg. C., which is considered to be roughly equal in its effect to heating for over 100,000 hours at 500 deg. C. Both steels were tested in all the conditions supplied, and the microstructures of all the samples were examined after welding and after heating at 625 deg. C. Little change was found, and no trace of graphite was observed in any case. Typical examples of the structure of the two steels in the heat-affected zone of the weld before and after exposure at 625 deg. C. are shown in Figs. 8 to 10, opposite. Fig. 8 shows the heat-affected zone of the weld of the chromium-molybdenum steel, cold drawn and normalised at 930 deg. C. Fig. 9 shows the zone after 350 hours at 625 deg. C. Similarly, Fig. 10 shows the heat-affected zone of the molybdenum-vanadium steel, cold-drawn and normalised at 950 deg. C., and after 350 hours at 625 deg. C. A typical section of a two-run weld of the molybdenum-vanadium steel, cold drawn and after 350 hours at 625 deg. C., is shown in Fig. 11, opposite. The area adjacent to the dark band represents the heat-affected zone.

From the results of the experiments it was concluded that the cold-drawing of the two steels improved the surface finish, and did not result in any deterioration of the creep resistance of the steels, provided that the pipes were normalised after cold-drawing. When the pipes were left as drawn, or annealed below the critical temperature, the creep resistance of the cold-drawn pipes was somewhat inferior to that of the pipes that had not been cold-drawn. These conclusions are based on tests lasting 1,000 to 3,000 hours. Tests made on samples given heat-treatments intended to simulate the metallographic effects of very long periods of exposure to high temperatures, however, showed no striking difference between the normalised specimens that had been cold worked and those which had not, and it is very improbable that the cold-drawn and normalised pipes would show any abnormal behaviour in longer tests. Both steels showed no tendency to graphitise on prolonged heating after welding, either in the cold-drawn or in the hot-drawn condition. Normalising slightly improved the creep resistance of both steels, both in the cold-drawn condition and in the hot-drawn condition. It may be concluded that there is no objection to cold-drawing the pipes to improve their surface provided they are suitably normalised after the operation.

TABLE IV.—RESULTS OF CREEP TESTS ON THE MO-V STEEL AT 575 DEG. C. AND 625 DEG. C. (COMPARISON OF HOT-DRAWN AND COLD-DRAWN MATERIAL IN VARIOUS CONDITIONS).

Condition.*	Results of Creep Tests at 4 tons per square inch and 575 deg. C.					Results of Creep—Rupture Tests at 10 tons per square inch and 625 deg. C.		
	Creep Rate per hour × 10^6 at Following Times in Hours.				Time in Hours to Reach 0·1 per cent. Creep.	Time to Fracture, Hours.	Elongation Per Cent. on $4\sqrt{\text{Area}}$.	Reduction of Area, Per cent.
	100	500	1,000	2,000				
HD .. .. (T)	1·4	0·70	0·40	—	1,170	77½	36	64
HD .. .. (L)	—	—	—	—	—	—	—	—
CD .. .. (T)	2·6	0·70	0·49	—	750	187	3	9
						205	6	5
CD .. .. (L)	—	—	—	—	—	292	9½	12½
HDN 950 deg. .. (T)	1·0	0·59	0·29	0·19	2,010	115½	33	55
HDN 950 deg. .. (L)	1·3	0·64	0·33	0·44 BM	1,615	—	—	—
CDN 950 deg. .. (T)	1·0	0·57	0·32	0·16	1,630	188	32	53
CDN 950 deg. .. (L)	0·98	0·46	0·32	0·11	3,390	—	—	—
HDN 950 deg.—								
T 670 deg. for 4 hours (T)	1·3	0·55	0·35†	0·26	2,080†	77½	41	62
T 670 deg. for 4 hours (L)	—	—	—	—	—	99	57	75
CDN 950 deg.—								
T 670 deg. for 4 hours (T)	0·98	0·47	0·29†	0·18	3,195†	109	50	61
T 670 deg. for 4 hours (L)	—	—	—	—	—	98½	51½	68

* HD = Hot drawn; CD = Cold drawn; N = Normalised; T = Tempered, 4 hours at 670 to 690 deg. C.; BM = Beyond occurrence of minimum creep rate. Temperatures of treatment are indicated. (T) = Transverse; (L) = Longitudinal.

† Tests at 600 deg. C. and 4 tons per square inch gave the following results: HDN 950 deg., T 670 deg. for 4 hours, 0·84 creep rate at 1,000 hours; 483 hours to reach 0·1 per cent. creep. CDN 950 deg. T 670 deg. for 4 hours, 0·57 creep rate at 1,000 hours; 756 hours to reach 0·1 per cent. creep.

ASLIB FUEL AND POWER GROUP.—A group of information officers and technical librarians concerned with the fuel and power industries is to be formed under the auspices of Aslib. Any member of Aslib interested in the project is invited to attend the inaugural meeting, which will be held in the council room of the British Electrical and Allied Manufacturers' Association, 36-38, Kingsway, London, W.C.2, at 5.30 p.m. on Wednesday, March 19.

PRODUCTION OF "COMET" AIR LINERS AT BELFAST.—An agreement has been made between the de Havilland Aircraft Co., Ltd., Hatfield, Hertfordshire, and Messrs. Short Brothers and Harland, Ltd., Queen's Island, Belfast, whereby the latter company will manufacture Comet air liners. It is expected that the output of Comet aircraft will thus be doubled. The first Comet from the new production line is expected to be completed in 1954. The de Havilland Company will continue to market the Comet.

SCOTTISH SHALE OIL.—A brief description of the operations of the Scottish shale-oil industry is given in a booklet issued recently by Scottish Oils Limited, part of Anglo-Iranian Oil Company group. The booklet gives a short history of the industry and includes an account of the activities at such typical units as the Burngrange shale pit, the Westwood crude-oil works and Pumpherston refinery. The manufacture of the main products is described and reference is made to the production of building bricks from spent shale.

AERODYNAMIC INVESTIGATION OF THE PROPOSED SEVERN SUSPENSION BRIDGE.

(*Concluded from page 300.*)

Aerodynamic Oscillations of Suspension Bridges.—The normal action of wind on a suspension bridge is to displace the structure to a new equilibrium position. Gusts and their occasional impulses will cause disturbances which are followed by small free oscillations of the bridge, but, with a stable design, any movements of this type die away, and the equilibrium position is continuously resumed without significant departures. The action of the load is therefore effectively static. With an unstable design, however, free oscillations increase for some wind conditions and may become serious. When a bridge is in still air its free oscillations die away, owing to the positive damping due to the structure and the air. These damping forces are small in relation to the enormous inertia, and their main effect is to cause the natural constituent oscillations to become damped to various different extents without sensible changes of the natural modes and natural frequencies.

The experimental evidence is that when a bridge is exposed to a wind the effects are very similar, except in one very important respect. With certain bridge designs it is possible for the net damping (aerodynamic plus structural) of a constituent oscillation to become negative for certain wind directions and for certain ranges of the wind speed. At the end points of any such speed range the net damping is zero, so the oscillations occurring are simple harmonic. Any wind speed producing this condition is termed a critical speed. When the net damping is negative, the oscillations are unstable and therefore increase initially Ultimately, the movements will either become maintained steadily at a constant finite amplitude, and so cause inconvenience to traffic; or they will continue to grow until a structural failure occurs. The issue here will depend on the severity of the negative damping and on the departures from linear relationships between loads and displacements. It is possible for two or more constituent oscillations to become unstable simultaneously for a given wind condition. In this case one of the constituents so affected may overpower all the others. Alternatively, an irregular-looking motion will develop due to the interferences between the different modes and different frequencies.

The critical wind speeds for which simple-harmonic oscillations occur will be influenced by the external shape of the bridge structure, the frictional damping, and the wind direction. The experimental evidence is that, with a given bridge and a given wind direction, all the different vertical bending oscillations will be critically affected for roughly the same sets of values of the ratio $V_r = \frac{V}{N B}$, where V denotes the wind speed, N the actual oscillation frequency at that speed, and B the bridge width. This non-dimensional parameter is termed the "reduced velocity." It is also found that, with winds encountered in practice, the influence of the speed on the frequency is small, so that, as an approximation, N may be replaced by the appropriate natural frequency in the evaluation of the reduced velocity. Torsional oscillations have similar properties. The liability of a bridge to unstable oscillations in wind can therefore be predicted, once the critical value of the reduced velocities and the natural frequencies are known. The primary purpose of tests of model bridges in wind tunnels is the determination of the values of the reduced velocity. With some bridge designs aerodynamic oscillations of a more complex type, involving coupling between torsional and vertical bending movements in pairs, are also possible. Experiments carried out in this connection indicate that such oscillations are avoided if the corresponding pairs of natural frequencies are not close to equality.

A simple physical picture of the way in which wind action excites unstable oscillations of suspension bridges cannot be offered. The study of this intricate problem involves fundamental researches which were not considered to be within the scope of the Severn Bridge investigation. However, a few explanatory remarks on the aerodynamic forces concerned may be helpful. The bridge components which have most influence on the damping due to wind are the deck and the stiffening girders. If small steady oscillations having a given natural mode and the corresponding natural frequency were imposed on the system, vortex sheets, and perhaps large-scale eddies, would be generated periodically and carried downstream. The aerodynamic restoring force induced at any instant by the travelling vortex distribution would clearly not, in general, be in the same phase as the displacement of the system. It would, in fact, have a positive or a negative damping tendency, according as it acted in advance of or lagged behind the displacement. These considerations are sufficient to account for unstable oscillations, although they do not help to explain why some systems are immune from instability while others are not. The difficulty is not peculiar to bridge sections. Torsional oscillations of aeroplane wings are stable when the mean angle of incidence is small, but can be unstable when the wings are stalled. The reasons for this behaviour have not yet been clarified theoretically. Bridge sections, and particularly truss-stiffened sections, are much more complex than wing surfaces, and no reliance could be placed on a purely theoretical determination of their stability characteristics. For this reason the investigation of the oscillations of suspension bridges must, at the present state of knowledge, depend very largely on experimental or semi-empirical methods. In the past decade the subject has been studied particularly from this point of view in the United States. The aim in some of the investigations has been to throw further light on the ways in which unstable oscillations are excited: in others it has been to provide simple notes to aid design against aerodynamic instability. In all this work much use has been made of wind tunnels to provide the necessary basic information.

Theoretical Determination of Elastic Stiffnesses and Natural Oscillations.—Although the structural form of a suspension bridge is the most potent factor influencing the aerodynamic oscillations, the stiffnesses and natural frequencies play an important part in the design. The stiffnesses control the displacements when the bridge is loaded statically by traffic or wind. The natural frequencies influence the critical wind speeds at which unstable oscillations are introduced. From the remarks in connection with the reduced velocity it will be seen that the onset of such oscillations occurs approximately at wind speeds which are directly proportional to the natural frequencies. Reliable determinations of the stiffnesses and frequencies are therefore important both for normal static structural design and for the prediction of aerodynamic instability. They are also a necessary aid in the design of model bridge structures.

In connection with the Severn Bridge investigation a special method was developed for the calculation of the stiffnesses and natural oscillations. The method is, in certain respects, analagous to one developed in the United States, which has yielded natural frequencies and oscillation modes correlating well with those observed for models and full-scale bridges. However, the alternative treatment now proposed is rather more complete in that it takes into account the discrete panelling of the bridge and the framing of the structure. Normally, in deflection theory, the span is assumed to be long, the suspended structure is regarded as a uniform beam, and the suspender loading is taken to be continuous over the span. A discrete treatment offers the advantages that it is applicable for any length of span and that it provides a clearer insight into the torsional properties of the bridge. In common with all other existing forms of deflection theory, the method suffers from certain limitations. Perhaps the most serious limitation is the neglect of the inclination of the suspenders. Hence no information is provided on the effects of coupling between torsion and lateral flexure.

Natural Winds and Artificial Wind-Streams.—In the study of wind action on a suspension bridge, information of a statistical nature on the winds to be expected on the site is very desirable. An effort to obtain such information is being made by the Joint Engineers for the Severn Bridge with the use of anemometers which have been developed by the Meteorological Office. The instruments are designed to record automatically the wind speeds and the horizontal and vertical inclinations at several positions simultaeously. For the purpose of wind-tunnel tests on bridge models it is usual to suppose that the wind is steady and distributed evenly along the span, and to place reasonable limitations on the wind speeds and wind directions. In the case of the Severn Bridge investigation, it was assumed that winds of up to 100 miles an hour could be incident from any quarter and with a vertical inclination ranging between $\pm$ 15 deg. Only in a few special tests was any attempt made to simulate gusty winds. It is, of course, extremely unlikely that a natural wind would ever be maintained evenly and steadily across the entire span of a long bridge, except perhaps for short periods. However, since the stability of a bridge section is influenced by both wind speed and wind direction, the most unstable condition for the complete bridge may be assumed to be when it is exposed to the most unfavourable combination of wind speed and wind direction at all positions along the span. In this respect then, tests of model bridges in wind tunnels should give results erring on the safe side.

General Basis of Experimental Investigation.—For the Severn Bridge investigation, sectional models and full models were used. A sectional model is a rigid model copy of a sample length of the suspended structure. A model of this type can be used either to determine the stability properties of the section concerned for "rigid-body" modes of oscillation, or for measurements of the static forces on the bridge structure due to wind. In the first case, the model is mounted across the wind tunnel with its span horizontal and normal to the wind stream, and allowed freedom to oscillate in simple ways against spring constraints. In most of the tests relating to the Severn Bridge the freedoms permitted were pitching and vertical translation, which are the two-dimensional equivalents of twisting and vertical bending on the actual bridge. These movements were allowed to occur simultaneously in the study of coupled oscillations, or could be included for tests with a single freedom. A few experiments were also made with lateral translation included, corresponding to the lateral bending of the bridge. Experiments with section models for oscillatory conditions are barely practicable in winds not directed normally to the span. However, with some complication of the model, measurements of static forces on such models are possible for any direction of the wind. Tests of sectional models can be carried out in normal wind tunnels and without unduly elaborate equipment. As the models are rigid, minor modifications to them can be made, and the effects of systematic changes can be studied rapidly. In the Severn Bridge research the stability tests usually involved no more than the observation and measurement of the critical wind speeds and frequencies bounding the ranges over which oscillations were maintained in the wind. In some cases the damping rates of oscillations in the wind were also measured.

A "full model" is a replica of a complete bridge constructed so that it oscillates similarly to its parent bridge. The full model used in the course of the Severn Bridge investigation was over 50 ft. long, and it required the construction of a large wind tunnel. This was installed in a disused aircraft hangar at Thurleigh airfield, in Bedfordshire, by the Ministry of Transport. The direction of the wind stream in the tunnel could not be varied, but horizontally and vertically inclined winds were effectively simulated by appropriate inclinations of the model itself. Critical wind speeds, frequencies, and oscillation modes were recorded.

In the early stages of the investigation it was uncertain whether the stability of a complete bridge could be predicted satisfactorily from experiments on a sectional model alone, since with this method of test the influence of several factors cannot be represented directly. Such factors include, for example, the tower stiffnesses and inertias, the longitudinal camber, the mode of oscillation, and the horizontal inclination of the wind. However, it was also clear that full models were unsuitable for routine comparisons between different forms of suspended platform, owing to the length of time required for construction and the high cost. To provide a practical programme it was therefore decided to depend on tests of sectional models to a linear scale of 1 : 100 for an indication of the most promising structural forms. While the preceding tests were in progress, the design and construction of a full model were also put in hand, with a view to tests of the correlation between the two different experimental methods. This full model was necessarily based on a very early design for the bridge, and it became available for wind-tunnel tests in 1948.

The results obtained with the two types of models led to the conclusion that tests of sectional models were sufficient for reliable full-scale prediction, and accordingly the construction of a further full model, based on the design finally preferred for the bridge, was considered to be unnecessary. To prove a final verification of the stability of this design, special tests were carried out on a sectional model of linear scale 1 : 32. The increase of linear scale was considered to be advisable, because previous tests had shown that the stability was sensitively influenced by details of the structural form which could not be reproduced with sufficient accuracy to the scale of 1 : 100.

Summary of Main Conclusions.—So far as concerns the Severn Bridge project, the principal conclusion to be drawn from the investigation is that a bridge built to the proposed design will be free from unstable aerodynamic oscillations. Conclusions relating to the aerodynamic stability of suspension bridges generally, based on the evidence obtained, are listed below.

(*a*) Bridges stiffened by plate girders are liable to both vertical bending oscillations and torsional oscillations. The continuous blocked area which they present bluff to the wind appears to render them more prone to instability than truss-stiffened bridges.

(*b*) Bridges with truss stiffening are immune from vertical bending oscillations, and their tendency to instability in torsional oscillations can be corrected by suitable design of the suspended structure. Design features which have a corrective influence are:—stiffening-truss chords of high width to depth ratio; separation of roads by open slots or gratings; deck stringers of truss type in preference to plate type; castellated parapets, or other types of parapet, designed to break up the continuity of the flow pattern; side-tracks (e.g., footpath, cycle tracks, etc.) mounted outboard of the stiffening trusses; and lateral bracing of the lattice type fitted near deck level.

(*c*) A suspension bridge shows greatest instability in transverse winds (i.e., in winds blowing at right angles to the span). The stability characteristics improve progressively as the horizontal inclination of the wind to the transverse direction is increased.

(*d*) Unstable oscillations are unlikely to occur in steady longitudinal winds with any type of suspended structure. It is possible that irregular movements may be caused in longitudinal or nearly longitudinal winds by the buffeting action of the eddying wakes shed from the towers. For this reason the incorporation in the towers of portal members of great depth would be undesirable.

(*e*) It is possible for certain types of gusts to excite erratic vertical bending and lateral swaying movements. No evidence was obtained that torsional oscillations are promoted by gusts, or that any regular oscillations of large amplitude can be excited by periodic gusts synchronising with a natural frequency.

(*f*) The information listed under heading (*b*) can be used to help the initial choice of a design for a truss-stiffened bridge. However, if any important new features are to be incorporated, confirmatory tests of the stability are advisable. For this purpose tests with sectional models are considered to be adequate.

(*g*) A sectional model should be sufficiently large to allow accurate reproduction of structural details, but aerodynamic interference effects from the roof and the floor of the wind tunnel must at the same time be avoided. Also the model must be sufficiently long to avoid significant effects due to the changed pattern of the airflow near the ends.

(*h*) Oscillations involving coupling between corresponding modes of oscillation in vertical bending and in torsion are avoided unless the values of the natural frequencies concerned are close to equality.

(*i*) Further information on the structural damping properties of long-span bridges and on winds at bridge sites would be valuable.

(*j*) Further theoretical research on the natural oscillations of suspension bridges is desirable in order to clarify the effects of coupling between lateral flexure and torsion.

PHYSICAL SOCIETY'S EXHIBITION.

THE 36th annual exhibition of scientific instruments and apparatus to be arranged by the Physical Society will be held from Thursday, April 3, to Tuesday, April 8, at the Imperial College, South Kensington, London, S.W.7. As was the case last year, both the Royal College of Science main building, Imperial Institute-road, and the Huxley Building, Exhibition-road, will be used, and all tickets will be valid for entry to both buildings. On the opening day, only Fellows of the Society and the Press will be admitted between the hours of 10 a.m. and 6 p.m., but the exhibition will be open to the public on that day from 6 p.m. to 9 p.m. The exhibition will be closed on the Sunday. On the remaining days, it will be open generally from 10 a.m. to 1 p.m. and from 2 p.m. to 9 p.m., with the exception of Saturday, April 5, and Tuesday, April 8, when the afternoon sessions will end at 5 p.m. Two discourses, each of approximately 45 minutes duration, will be delivered: the first on Friday, April 4, commencing at 6.45 p.m., when Mr. B. N. Wallis, of Vickers-Armstrongs Ltd., will speak on "Engineering Supersonic Aerodynamics," and the second on Monday, April 7, also commencing at 6.45 p.m., when Mr. E. R. Davies, of Kodak Ltd., will speak on "The Physical Basis of Colour Photography." The prizes for the Society's craftsmanship and draughtsmanship competition will be awarded in the large chemistry theatre on Saturday, April 5, commencing at 3 p.m. A handbook containing descriptions of the items to be displayed is now available and copies may be obtained from the secretary of the Society, 1, Lowther-gardens, Prince Consort-road, South Kensington, London, S.W.7, at the price of 6*s*., plus 1*s*. 3*d*. postage.

ALUMINIUM-ALLOY CANTEEN BUILDING.—A light-alloy framed canteen building for the Fulmer Research Institute, Stoke Poges, has recently been constructed by Structural and Mechanical Engineers, Ltd. (S.M.D.), 2, Buckingham-avenue, Slough, Buckinghamshire. It has aluminium-alloy portal frames, consisting of extruded hollow 6-in. by 3-in. box-section members, at 9-ft. centres. The rafters are exposed below the low-pitch roof. The cavity walls comprise a brick outer shell with a 3-in. inner shell of light-weight insulation blocks The roof is made up of 2-in. Stramit boards supported on aluminium T-section purlins; it is surfaced with bituminous built-up roofing. A roof light of curved Perspex sheets is provided. Metal-framed windows are set in pre-cast concrete surrounds. The new canteen comprises the first bay of a series of standardised single-storey buildings, each to house a specialised laboratory, and each connected to a two-storey general laboratory and administrative block.

LAUNCHES AND TRIAL TRIPS.

M.S. "BAYSDALE H."—Single-screw tank barge, built by Cook, Welton and Gemmell, Ltd., Beverley, Yorkshire, for John Harker, Ltd., Knottingley, Yorkshire, for service on canals and inland waterways between the Humber, West Yorkshire and Nottinghamshire. Second vessel of an order for two. Main dimensions: 138 ft. between perpendiculars by 17 ft. 6 in. by 7 ft. 7½ in.; six cargo tanks having a total capacity of 300 tons. Oil engine, working through reduction gearing and developing 152 b.h.p. at 900 r.p.m., constructed by L. Gardner and Sons, Ltd., Manchester. Launch, February 16.

M.S. "CORNWALL."—Single-screw refrigerated-cargo vessel, built and engined by Alexander Stephen & Sons, Ltd., Linthouse, Glasgow, for the Federal Steam Navigation Co., Ltd., London, E.C.3. Twentieth vessel built for the New Zealand Shipping Co., Ltd., and their associates, the Federal Steam Navigation Co. Main dimensions: 489 ft. overall by 62 ft. 6 in. by 40 ft. 3 in.; deadweight capacity, 9,500 tons on a draught of 26 ft. 7½ in.; gross tonnage, 7,580; general-cargo space, 515,000 cub. ft.; refrigerated-cargo space, 67,700 cub. ft. Two Stephen-Sulzer eight-cylinder Diesel engines, each developing 4,000 s.h.p. at 225 r.p.m., coupled through two hydraulic clutches and single-reduction gearing to the propeller shaft, which has a speed of 100 r.p.m. The clutches were supplied by Barclay, Curle & Co., Ltd., Glasgow, and the gearing by the Power Plant Co., Ltd., West Drayton, Middlesex. Service speed, 16 knots. Trial trip, February 22.

M.S. "SCOTTISH EAGLE."—Single-screw oil tanker, built and engined by Swan, Hunter, and Wigham Richardson, Ltd., Newcastle-upon-Tyne, for the Scottish Tanker Co., Ltd. (Managers: Cayzer, Irvine & Co., Ltd.), London, E.C.3. Main dimensions: 515 ft. between perpendiculars by 69 ft. 6 in. by 38 ft. 4½ in.; deadweight capacity, about 15,850 tons on a summer draught of 30 ft. Swan Hunter-Doxford six-cylinder opposed-piston oil engine, developing 6,400 b.h.p. at 115 r.p.m. and an estimated speed of 14 knots in service. Launch, February 25.

M.S. "LONDON MAJESTY."—Single-screw oil tanker, built by the Furness Shipbuilding Co., Ltd., Haverton Hill, County Durham, for London and Overseas Freighters, Ltd., London, W.1. Second of a new series for these owners. Main dimensions: 525 ft. between perpendiculars by 71 ft. by 39 ft. 3 in.; deadweight capacity, about 18,100 tons on a summer draught of 30 ft. 5¾ 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, February 26.

M.S. "NORDVARD."—Single-screw cargo vessel, built by Short Brothers, Ltd., Sunderland, for Klosters Rederi A/S, Bygdoy, near Oslo, Norway. Main dimensions: 425 ft. between perpendiculars by 58 ft. 9 in. by 37 ft. 9¼ in. to shelter deck; deadweight capacity, 9,350 tons on a summer draught of 26 ft. 1 in. N.E.M.-Doxford four-cylinder opposed-piston airless-injection balanced oil engine, developing 4,400 b.h.p. at 115 r.p.m. in service, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Service speed, 13¼ knots. Trial trip, February 26.

CONTRACTS.

DAVY AND UNITED ENGINEERING CO., LTD., Park Iron Works, Sheffield, 4, have received an order for the large-scale extension and modification of an existing 28-in. blooming and section rolling-mill plant at the Karabuk Iron and Steel Works, Northern Turkey. The present reconstruction calls for the conversion of a previous three-high blooming mill stand to a two-high stand. The blooming-mill stand will be followed by a three-stand two-high section-mill train for which existing stands will be considerably modified. The work involved is described in our "Notes from the Industrial Centres," on page 334.

THE GRANGEMOUTH DOCKYARD CO., LTD., Grangemouth, Stirlingshire, have received orders to build four ships. The first is a steam tanker of 1,500 tons deadweight capacity for the Vacuum Oil Co. Ltd., London; the engine is to be supplied by the NORTH EASTERN MARINE ENGINEERING CO. (1938), LTD. The second is a cargo motorship of 2,000 tons deadweight capacity for owners in Leith, and it is to be fitted with an engine supplied by BRITISH POLAR ENGINES, LTD. The third is a passenger and cargo motorship of 2,300 tons deadweight for Burns, Philp & Co. Ltd., Australia; it is to be fitted with a Kincaid-B. and W. engine manufactured by JOHN G. KINCAID & CO., LTD. The fourth vessel is a 3,500-ton deadweight cargo motorship for H. P. Lenaghan and Sons, Ltd., Irish Bay Line, Belfast. The engine will be supplied by BURMEISTER AND WAIN LTD., Copenhagen.

HIGH-TORQUE SERVO-MOTOR.

THE air-operated servo-motor shown in Figs. 1 and 2, below, can operate against a torque of 47,000 lb.-in. and can exert a torque of 70,000 lb.-in. when moving from rest, using air at 100 lb. per square inch. The Gordon-Hagan A640 servo-motor, made by Messrs. James Gordon and Company, Limited, Dalston-gardens, Stanmore, Middlesex, consists of a piston-type air motor driving a lever through spur gearing. It has been designed to operate in conjunction with their Hagan relays and automatic regulators.

The "output" lever, which is shown on the right of Fig. 1, is 10 in. between centres. It is coupled by a rod to the damper, gate, or valve it actuates, and it can be fixed at any angle to suit the layout. The motor turns the lever 6 deg. per second, so that the total travel of 60 deg. is completed in ten seconds. At the high-speed end of the gear train a double clutch assembly is fitted which enables the machine to be released from automatic or remote control and operated by means of the handwheel shown in both illustrations. A brake can be applied to lock the operating lever in any desired position. The air inlet to the motors, fitted with a filter, is shown in Fig. 1. The filter can also be seen on the right of Fig. 2. The compensating gear, which is similar to that used in other Hagan servo-motors, gives a specific relationship between the control pressure received by the motor from a regulator or relay and the position of the lever. Normally, a straight-line relationship is required, but by cutting the cam (shown in Fig. 2) to a suitable shape, any other relationship can be obtained. High torque at starting is particularly useful for lifting single-seated high-pressure steam valves off their seats.

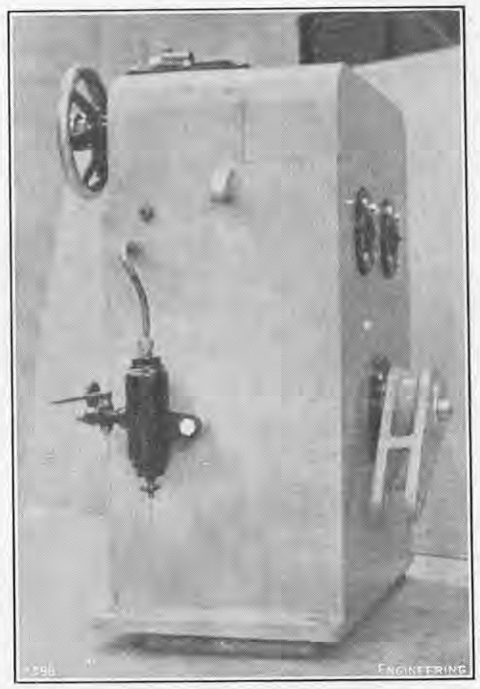


FIG. 1. MOTOR, SHOWING "OUTPUT" LEVER.

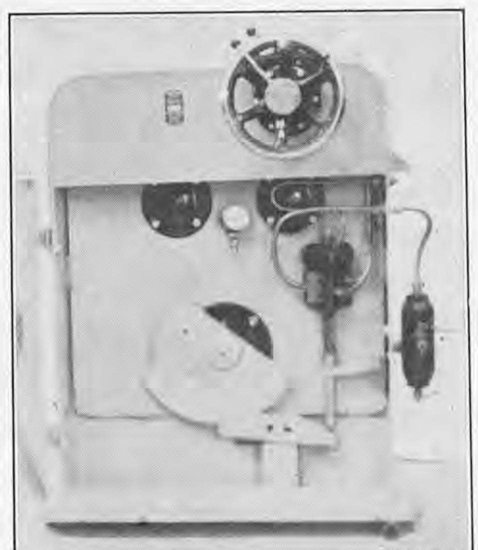


FIG. 2. DOOR OPEN TO SHOW CONTROL AND COMPENSATING GEAR.

THE CROSS-CHANNEL STEAMER "NORMANNIA": BRITISH RAILWAYS.

RATHER more than 40 years ago, the then London and South Western Railway Company made shipping history by putting into service the first geared-turbine channel steamers, the Normannia and Hantonia. Designed by Professor J. H. Biles (afterwards Sir John Biles) and built by the Fairfield Shipbuilding and Engineering Company, they measured 299 ft. in length overall and were propelled by twin screws, driven by turbines of about 5,000 collective shaft horse-power, which gave them a speed of 19½ to 19¾ knots. The Normannia was lost at Dunkirk in May, 1940, but the Hantonia is still in service on the Southampton-Havre route, though she is soon to be withdrawn.

We illustrate on the next two pages the second Normannia, built and engined for the Southern Region of British Railways by Messrs. William Denny and Brothers, Limited, Dumbarton; she made her maiden voyage from Southampton to Havre on the night of March 3-4. Like her predecessor of the same name, she is driven by twin screws and geared turbines, at the same speed of 19½ knots; but the great increase in passenger accommodation, etc., that is achieved by modern design work with only a small increase in length (309 ft. as against 299 ft.) is indicated by the fact that the new Normannia requires machinery of 8,000 shaft horse-power. The new vessel, however, has a moulded breadth of 48 ft., whereas the old Normannia had only 36 ft. The other main dimensions of the new ship are: length between perpendiculars, 291 ft.; depth moulded to the upper deck, 25 ft. 6 in.; gross registered tonnage, 3,543. Accommodation is provided for 1,400 passengers, which is about three times the number for which the previous vessel was designed. The crew number 71.

As will be seen from Fig. 1, on page 350, the ship has a raked stem and cruiser stern, one large stream-lined funnel and two tripod masts. There are two continuous decks, namely, the main deck and upper deck; with a superstructure comprising the promenade deck, boat deck, and bridge deck above the forward end of the boat deck. There is a lower deck forward and aft of the machinery spaces. The hull is divided into eleven compartments by ten watertight bulkheads. Electrically-operated horizontal sliding watertight doors, supplied by J. Stone and Company, Limited, Deptford, are fitted to the bulkheads in the machinery spaces, and can be controlled from the wheelhouse. Welding has been employed extensively in the construction of the bulkheads and for the vertical butts of the shell plating. There are five fuel tanks, constructed independently of the hull structure; they are situated forward of the boiler room, and are fitted with Malone depth gauges. The centre tank of the five contains Diesel oil for the generating sets and the other four contain boiler fuel. Forward of the fuel tanks are two tanks containing distilled water for boiler feed; and fresh-water and feed-water tanks, with a capacity of 70 tons, are arranged below the lower deck at the sides of the recess at the after end of the engine room. A forward trimming tank is arranged immediately abaft the compartment containing the bow rudder, and upper and lower after trimming tanks forward of the after steering-gear compartment. The main rudder is of the balanced type, and like the bow rudder (which is provided for use in manœuvring stern-first into and out of ports) is actuated by a twin-motor electro-hydraulic steering gear, with telemotor control, supplied by Brown Brothers, Limited, Rosebank Ironworks, Edinburgh. The holds, forward and aft, are arranged for the carriage of motor cars and baggage, and are provided with hinged steel hatch-covers, operated by electric winches supplied by Thomas Reid and Company, of Paisley.

PASSENGER ACCOMMODATION.

The passenger accommodation comprises, on the promenade deck, a smoke-room and bar at the forward end, extending for the full breadth of the ship; a first-class lounge; and a lounge and a smoke-room for third-class passengers. (It may be noted that the designation of the accommodation follows railway practice—first-class and third-class, with no second class.) The first-class smoke-room (Fig. 3) has windows at the sides and the forward end, and is equipped with settees, easy chairs, etc., upholstered in red and beige hide. The first-class lounge, illustrated in Fig. 2, on page 350, also has easy chairs; but in the third-class lounge and smoke-room the seating is differently arranged, the lounge having seats in units of three, and the smoke-room fixed seats at the sides and the forward end, with loose chairs at the small tables. A buffet serves both the lounges. The deck covering is Korkoid. The only other public room is the restaurant (apparently, the term "dining saloon" has been superseded, and railway practice adopted there also) which is illustrated in Fig. 4, on page 351; it is on the upper deck and has accommodation for 104 passengers,

CROSS-CHANNEL STEAMER "NORMANNIA": BRITISH RAILWAYS.

WILLIAM DENNY AND BROTHERS LIMITED, DUMBARTON.

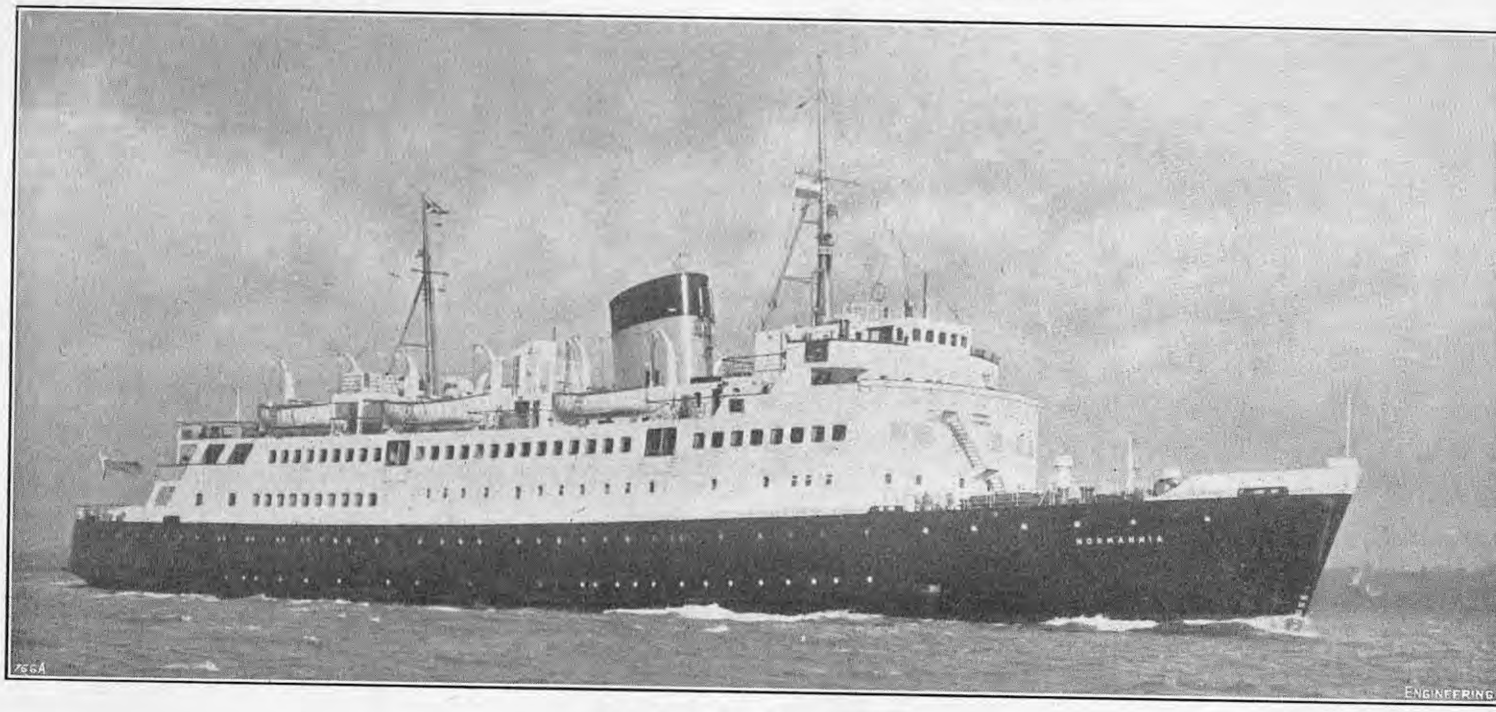


Fig. 1. S.S. "Normannia."

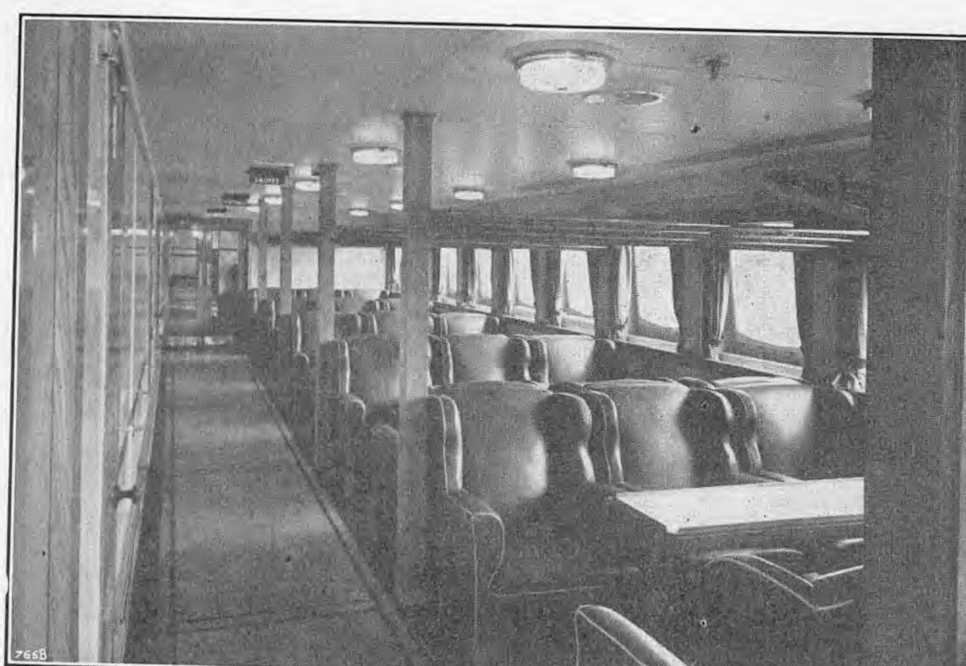


Fig. 2. First Class Lounge.

either first-class or third-class. It extends for the full width of the deck and is lighted by large side windows. The rest of the upper deck is devoted to cabins—three-berth forward and at the ship's sides, with two *cabines de luxe* amidships, to port and starboard. Each *cabine de luxe* has two cot beds, and a private toilet and shower-bath. In the centre casing, amidships on this deck, there is a ladies' rest room.

Amidships on the main deck are two-berth private cabins, and aft of these are two "sleeping lounges," with berths arranged in two tiers, for third-class passengers. The lower deck, forward and aft of the machinery spaces, is also devoted to private cabins, most of which have two berths. There are, however, five single-berth cabins on this deck, in the forward section. In all, there are 325 sleeping berths in the ship, namely, on the upper deck, four in the cabins-de-luxe, 66 in three-berth cabins, four in two-berth cabins and ten in the ladies' rest room; on the main deck, 72 in two-berths cabins, 32 in the ladies' sleeping lounge, and 32 in the gentlemen's sleeping lounge; and, on the lower deck, 100 in two-berth cabins and five in the single-berth cabins.

The accommodation for the captain and the navigating officers is on the bridge deck, the captain having a suite comprising a day cabin, sleeping cabin and bathroom. The engineer officers have their cabins on the boat deck, where also are their messroom, office and a bathroom. Direct access from their quarters to the engine room is provided via the engine-room casing. The messrooms and washplaces for the petty officers, seamen, engine-room ratings and catering staff adjoin their quarters on the main deck. The main galley, pantry, still room, etc., and also the crew's galley, are immediately abaft the restaurant.

Propelling Machinery.

The main engines consist of two sets of double-reduction geared turbines, taking steam from two oil-fired Foster Wheeler water-tube boilers and driving twin screws of 9 ft. 4 in. diameter and 8 ft. 9 in. pitch at 270 revolutions per minute. The turbines, gearing and boilers were constructed by the builders of the ship, Messrs. William Denny and Brothers, but the propellers, which are three-bladed and of the solid type, were supplied by Messrs. J. Stone and Company. The boilers, which are of Messrs. Foster Wheeler's "D" type, have a total heating surface of 5,395 sq. ft. (including 300 sq. ft. of superheater surface), a furnace volume of 680 cub. ft., and a normal evaporation of 40,000 lb. per hour. The steam is supplied at 350 lb. per square inch and a temperature of 650 deg. F. The boilers burn oil, with a closed-stokehold system of forced draught, and each has four oil sprayers. The oil-burning equipment, supplied by Messrs. J. I. Thornycroft and Company, comprises two electrically-driven Weir "Horzoil" rotary gear-type pumps, two heaters, two Auto-Klean strainers on the pump discharges, and a duplex suction strainer. The pumps each have a capacity of 7,500 lb. of oil per hour. The oil sprayers and furnace fronts are of Messrs. Thornycroft's design. The electric lighting-up unit, supplied by Messrs. White's Marine Engineering Company, Limited, Hebburn-on-Tyne, comprises an electrically-driven Hamworthy pump, a three-section 12-element cylindrical heater, and suction and delivery strainers. It can deliver 500 lb. of fuel oil per hour at 200 deg. F. As a stand-by, there is a rotary hand-pump and a coil heater unit, with a paraffin burner. The boiler mountings include full-bore safety valves with silencers, and self-closing main stop valves, supplied by Messrs. Cockburns, Limited, Cardonald, Glasgow; Weir "Robot" feed regulators; Klinger double-plate water-level gauges and "Igema" distant-reading gauges; and, on each boiler, two retractable soot-blowers, supplied by Messrs. Clyde Blowers, Limited, Clydebank. A Crockett multi-point group-type electric salinometer is provided to detect any leakage of salt water from the condensers into the boilers.

The main turbines are of Pametrada design. Each set comprises a single impulse turbine for ahead working, driving the propeller shafting through a locked-train articulated double-reduction gear. The astern turbines, also of the all-impulse type, are contained in the same casings as the ahead turbines, and give an astern power equal to 85 per cent. of the ahead power. The propellers turn outboard when going ahead. In both the ahead and the astern turbines, the nozzles and diaphragms are carried in a single pressure casing of cast steel, contained in an outer fabricated shell and so supported as to allow for differential expansion. The space between the outer shell and the pressure casing is connected to the steam space of the condenser, so that uniform temperature conditions are maintained all round the pressure casing and there is no need to insulate the outer shell. The after end of the shell is rigidly bolted to the gearcase and the forward end is carried on a seating. The condenser is bolted to the lower half of the outer shell.

The turbine rotors, each of which is machined from a single forging, are designed to be stiff enough to ensure that the first critical speed is at least 30 per cent. above the normal running speed. The blading and shrouding are of stainless iron. Each nozzle passage is machined from a separate nozzle segment of stainless iron, the segments being secured by rivets and an interlocked joint to a steel centre. Each turbine drives its primary pinion through a fine-tooth flexible coupling; and the pinion engages with two primary

CROSS-CHANNEL STEAMER "NORMANNIA": BRITISH RAILWAYS.

WILLIAM DENNY AND BROTHERS, LIMITED, DUMBARTON.

FIG. 3. FIRST CLASS SMOKE ROOM.

FIG. 4. RESTAURANT.

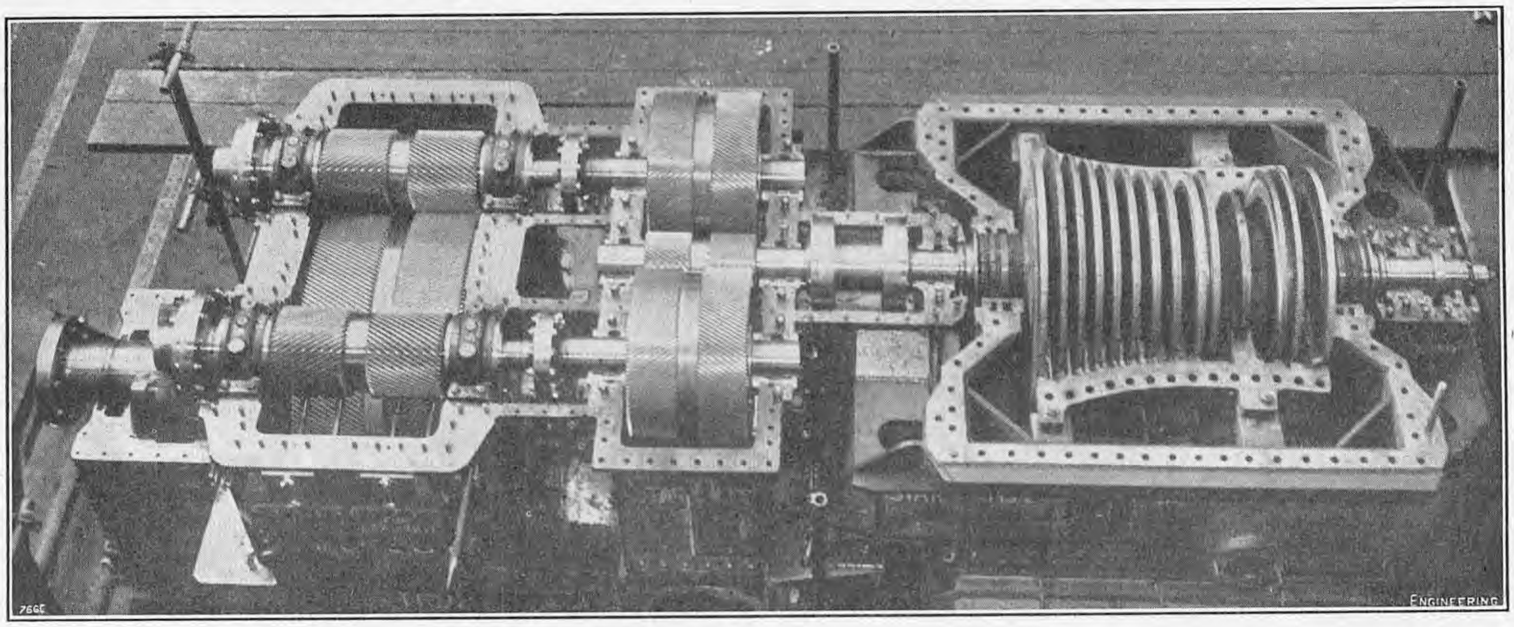


FIG. 5. STARBOARD TURBINE AND GEARING.

gearwheels which are connected to the secondary pinions through quill shafts having flexible couplings at their after ends. The secondary pinions engage with the main gearwheel, as can be seen in Fig. 5, herewith, which shows the starboard set in the makers' works. The primary and secondary pinions are of nickel steel, and the primary and main wheels have forged-steel rims shrunk on to cast-iron centres and are secured to taper shafts. The teeth of the primary gears are of the all-addendum form and those of the secondary gears are of the deep-tooth form. The primary gearcase is of cast iron and the secondary gearcase is fabricated from steel plate. Incorporated in the gearcases are thrust blocks of the Michell type, with line-contact bearing pads. The shafting is supported in Cooper split roller bearings. The tail shafts, which have no liners, run in oil-filled stern tubes which are fitted with packed glands of the usual type at their inboard ends and, at the outboard ends, oil glands of the "Newark" type, supplied by Messrs. Ferguson Brothers (Port Glasgow), Limited. The stern-tube bushes are of brass, whitemetal-lined.

The manœuvring valves are of Messrs. Cockburn's "super-balanced" type, with cast-steel bodies and stainless-steel spindles; the valves and seats are of nickel alloy. Separate handwheels control the ahead and astern valves. Each astern valve is provided with a leak-off and drain valve. Between the boilers and the manœuvring valves there are Cockburn emergency shut-off valves, designed to close automatically in the event of loss of vacuum; these valves can be operated also by hand levers from the starting platform. Cockburn self-closing stop valves are also inserted between the ahead manœuvring valves and the turbines, and are arranged to close automatically in the event of over-speeding, loss of lubricating-oil pressure, or the development of undue axial clearance between the blade rows in the turbine. These valves work in conjunction with the Aspinall patent governors at the turbines; thus astern steam can be applied if necessary to bring the turbines rapidly to rest if the lubricating-oil pressure should fail. The turning gear for the main engines is electrically driven. The main condensers are of the Weir regenerative two-flow type and each contains 1,712 tubes of aluminium brass, $\frac{3}{4}$ in. external diameter and 9 ft. $2\frac{1}{2}$ in. long, giving a cooling surface of 3,000 sq. ft. in each condenser. The tubes are packed in the tubeplates with Crane's metallic packing. A Negretti and Zambra multi-point pyrometer is fitted in the engine room to indicate the temperatures of the steam, funnel gases and feed water.

AUXILIARY MACHINERY.

The main condensers are connected to, and form part of, a Weir closed-feed system consisting of two closed-feed controllers; two Weir "Lo-Hed" two-stage vertical-spindle extraction pumps with a capacity of 80,000 lb. each per hour against a pressure of 30 lb. per square inch from a vacuum of $28\frac{1}{2}$ in. and driven by electric motors of $13\frac{1}{2}$ brake horse-power; two Weir three-stage "Maxivac" steam-operated air ejectors; two Weir horizontal-spindle centrifugal three-stage turbine-driven feed pumps, each with a capacity of 80,000 to 104,000 lb. per hour; two Weir three-flow gland-steam condensers with ejectors, each with a total of 30 sq. ft. of cooling surface; a Weir eight-flow U-tube surface feed-heater with a heating surface of 340 sq. ft.; and a Weir horizontal four-flow surface-type drain cooler with a surface of 120 sq. ft. The 16-in. centrifugal main circulating pumps are of the Drysdale upright type, driven by turbines made by Messrs. Weir; each has a capacity of 4,750 gallons a minute. The Weir auxiliary feed pump is of the three-throw reciprocating type, electrically driven, and has a capacity of 14,300 lb. per hour.

The forced-draught fans, of which there are two, were supplied by Messrs. W. H. Allen, Sons and Company, Bedford, and are turbine-driven, through gearing, at 1,360 r.p.m. Each has a capacity of 23,000 cub. ft. of air per minute at $7\frac{1}{2}$ in. w.g. They discharge into a system of air trunks in the boiler room. An electrically-driven fan is provided for use when lighting-up and under stand-by conditions. The two lubricating-oil pumps for the main engines were made by Messrs. Stothert and Pitt, Limited, Bath, and each is capable of supplying both main engines. They are of the vertical-spindle screw displacement type and are driven by 12-h.p. electric motors; and they have each a capacity of 10,000 gallons per hour at 30 lb. per square inch, with a suction lift of 10 ft. Included in the lubricating-oil system are Serck oil coolers, Auto-Klean discharge strainers, perforated-plate suction strainers, Philips magnetic filters, and a Sharples lubricating-oil centrifuge, of 200 gallons per hour capacity. Worthington-Simpson, Limited, supplied the two vertical self-priming bilge, ballast and fire pumps, and also a general-service pump, all of which are of their "Numarine" type, with a capacity of 75 tons an hour each against a total head of 60 ft., including a suction lift of 18 ft. They are driven by electric motors of 13 brake horse-power. When used for fire purposes, these pumps can deliver 40 tons an hour against a total head of 110 ft. There is also an emergency bilge pump, in the boiler room, of the Drysdale "Centrex" vertical-spindle submersible type, electrically driven, and having 4-in. branches.

An evaporator and distiller, supplied by Messrs. G. and J. Weir, Limited, provided the boiler make-up feed. The capacity of the unit is 30 tons an hour when using fresh water. The evaporator has a heating surface of 55 sq. ft., and uses steam at 200 lb. per square inch pressure. The cooling surface of the distiller is 90 sq. ft. The evaporator feed pump is a Drysdale "Wee Mac," driven by an electric motor of $2\frac{1}{4}$ brake horse-power and capable of delivering 2 tons per hour against a head of 80 ft. Steam for the "hotel services" is provided by a Spanner "Swirlyflo" boiler, situated in the boiler room and working at a pressure of 60 lb. per square inch. It is oil-fired by a Laidlaw-Drew automatic oil-burning unit, electrically driven, and has an output of 2,350 lb. per hour. For fresh-water supply there is a Drysdale "Pneupress" installation, the pressure chamber of which is placed in the engine room. Its duplicate self-priming pumps are electrically driven and are equipped with automatic starting switchgear. A steam-heated calorifier maintains the hot-water supply. There is also a salt-water service, similar in arrangement to the fresh-water system; and a sewage-disposal plant, supplied by Messrs. Adams Hydraulics, Limited.

The electricity supply is provided by three Diesel-driven generators of 150 kW each, constructed by Messrs. W. H. Allen, Sons and Company, and delivering direct current for lighting and power at 225 volts. The engines have five cylinders, 240 mm. bore and 300 mm. stroke, and develop 222 brake horse-power at 600 r.p.m. Each engine is complete with its own lubricating-oil pumps, fresh-water pumps and coolers; and there are electrically-driven vertical-spindle centrifugal pumps, also supplied by Messrs. Allen, for circulating water to the fresh-water heat exchangers. The generating sets are started by compressed air, stored in three air receivers, each of 11·2 cub. ft. capacity. The two air compressors were supplied by the Hamworthy Engineering Company, Limited, of Poole. One is electrically driven by a motor which is arranged to take current from either the main or the auxiliary circuit, and the other by a single-cylinder Diesel engine. There is also an emergency direct-current generating set of 35 kW capacity at 225 volts, which is driven by a six-cylinder Ruston and Hornsby Diesel engine. To supply low-voltage current, there is a storage battery connected to a motor generator. The main switchboard, which measures 18 ft. 8 in. long and 6 ft. 6 in. high, was supplied by Messrs. Whipp and Bourne, Limited, Castleton, Manchester.

As the Normannia will be engaged on night services, special attention has been given to the comfort of passengers. A Denny-Brown ship stabiliser has been fitted, following its successful use in other ships to obviate rolling in bad weather; and particularly thorough systems of heat and sound insulation and of heating and ventilation have been embodied in the design. The ventilation system has been installed by the Thermotank Company, Glasgow, and the temperature control is such that, where several spaces are served by one heating unit, they can be maintained at different temperatures, if desired. The machinery spaces also are ventilated by Thermotank torpedo fans, and powerful exhaust fans are provided to extract from the galleys and pantries. The fans and Thermotank units are housed in compartments fitted with spray-excluding jalousies. The heat and sound insulation, by Messrs. Newall's Insulation Company, extends to the boiler uptakes as well as the casings.

NAVIGATING EQUIPMENT, ETC.

In the wheelhouse and chartroom, and on the bridge wings, there is a very complete equipment of navigating instruments, etc. This includes a Marconi Radiolocator marine radar set, a Fathometer echo sounder, a Chernikieff electric log, Willett-Bruce automatic whistle control, Siemens-Elliott engine revolution indicators and Siemens rudder indicator, Siemens electric main and emergency engine telegraphs, and docking and steering telegraphs, and a 10-in. searchlight projector for signalling. Kent clear-view screens are fitted in two of the wheelhouse windows. The steering telemotor for the after rudder is fitted in the wheelhouse, and telemotors for controlling the bow rudder are placed in the bridge wings. There is also a secondary steering position for the after rudder on the poop, and hand gear in the steering flat. The standard and steering compasses have been supplied by Messrs. F. S. Smith and Son, Southampton. The wireless installation, constructed by the Marconi Company, comprises main and emergency sets, radio-telephone equipment, an auto-alarm, and a radio direction-finder. For fire detection and extinction, a Grinnell automatic sprinkler and fire-alarm system has been supplied by Messrs. Mather and Platt, Limited, in addition to the usual fireproof doors, hydrants, manually-operated alarms, and portable extinguishers. A Lux-Rich CO_2 fire-extinguishing system has been installed in the boiler room, and the fuel-tank compartments and holds, by the Walter Kidde Company, Limited, who have also provided a Lux-Rich smoke-detecting system for the hold spaces, with an indicator cabinet in the wheelhouse. The vessel has six wooden lifeboats, one of which is motor-propelled, and these are carried in Welin-MacLachlan davits.

Other equipment includes an electric windlass and an independent electric capstan forward, and two electric mooring capstans aft on the upper deck. All of these were supplied by Messrs. Stothert and Pitt, Limited, and are fitted with Mawdsley motors. Most of the electric motors for the auxiliary machinery were constructed by Messrs. Lancashire Dynamo and Crypto, Limited. The electric controllers and motor starters were supplied by Messrs. Allen West and Company, Brighton. For communication between the bridge, engine room and mooring positions, there is an installation of loud-speaking telephones and amplifiers by Messrs. Clifford and Snell, Limited, of Sutton, Surrey, who were also the contractors for the system of running and alarm indicators for the electrically-driven engine-room and boiler-room auxiliaries and the steering-gear motors. An Ardente sound-reproduction installation affords communication from the bridge to the crew's quarters and the passenger accommodation.

NOTES ON NEW BOOKS.

Theory of Elasticity.

By PROFESSOR S. TIMOSHENKO and PROFESSOR J. N. GOODIER. Second edition. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 9.50 dols.]; and McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 51*s.*]

THE first edition of this book was published in 1934, and was reviewed on page 409 of our 139th volume (1935). It was noteworthy for the presentation of the theoretical side of the subject in a form that could be grasped without great difficulty by engineers who had not forgotten their mathematics. For the second edition, fresh material has been incorporated by expanding into separate chapters the previous treatment of the photo-elastic method of investigation, two-dimensional problems in curvilinear co-ordinates, and stresses from thermal causes. There is also an appendix, covering 30 pages, on the application of finite-difference equations in elasticity, the practical value of which is considerable, since it provides an introduction to approximate methods of solution in instances where rigorous analysis is impracticable. By easy steps the student thus acquires a working knowledge of the relaxation method developed by Professor Southwell, in which the theory is exemplified by consideration of triangular and hexagonal nets, the block and group processes of relaxation, and the problem of torsion of bars with multiply-connected cross-sections and of a circular shaft with variable diameter. The exposition of this numerical method, in which differential equations are replaced by the corresponding finite-difference equations, gains much from the use of appropriate illustrative diagrams. In the work of revision, the authors have also rewritten several sections of the previous text, so that additional emphasis is now given to St. Venant's principle, the reciprocal theorem, the components of rotation, the approximate treatment of slender sections subjected to combined bending and twisting, and other questions of special interest. The bibliographical references to further sources of information, and the inclusion of exercises, amounting to 85 in all, will be welcomed by readers of this most informative book.

Current Developments in Ocean Transportation.

Division of Statistics and Reports, European Co-operation Administration, 1, Grosvenor-square, London, W.1. [No price stated.]

THIS brochure, which is an extract from the 40th Report for the Public Advisory Board of the European Co-operation Administration, illustrates by means of a series of diagrams, the rise in demands for world shipping, coal shipments from the United States, the increased rates for tramp and tanker tonnage and the effect upon them of the re-commissioning of vessels from the mercantile reserve fleet of the United States, and, in general, the part taken by United States shipping in the transport of materials from that country, mainly to Europe, in connection with the economic aid given to other countries. The statistics embodied relate to the position down to mid-September, 1951. The effect of the war in Korea is plainly shown; for example, in the six months following the outbreak of hostilities there, ocean ship loadings in the ports of the free world increased by 27 per cent., and by an additional 10 per cent. in the next half-year.

BOOKS RECEIVED.

The British Electrical and Allied Industries Research Association. Technical Report No. B/T 111. *Review of Problems of H.V. D.C. Transmission and Future Possibilities.* [Price 7*s.* 6*d.*] No. G/T 255. *Gas-Blast Circuit-Breakers. Effect of Arcing on the Mass-Flow of Air Through the Nozzle and on the Nozzle Pressure. First Progress Report.* By A. A. HUDSON. [Price 10*s.*] No. L/T 253. *Bound Electronic States in Solids, Resulting from a "Potential Hill."* By J. J. O'DWYER. [Price 6*s.*] No. L/T 265. *Theory of Barium Titanate*—Part 2. By A. F. DEVONSHIRE. [Price 10*s.*] No. M/T 113. *A Pulse Generator Producing 0·01 microsec. Pulses.* By S. F. PEARCE and D. C. G. SMITH. [Price 7*s.* 6*d.*] No. V/T 109. *The Incidence and Avoidance of High Resistance Joints in Steel Conduit Runs in Service.* By L. GOSLAND and E. E. HUTCHINGS. [Price 12*s.*] Offices of the Association, Thorncroft Manor, Dorking-road, Leatherhead, Surrey.

Overseas Economic Surveys. Malaya. By K. E. MACKENZIE. [Price 6*s.* 6*d.* net.] *Ceylon.* By C. E. THOROGOOD. [Price 3*s.* 6*d.* net.] H.M. Stationery Office, Kingsway, London, W.C.2.

Equivalent Circuits of Electric Machinery. By GABRIEL KRON. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 10 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 80*s.* net.]

Tensor Analysis: Theory and Applications. By PROFESSOR I. S. SOKOLNIKOFF. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 6 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 48*s.* net.]

The Surface Area and Volume of Dished Ends. By D. E. W. ALDOUS. Mechanical World Monographs No. 59. Emmott and Company, Limited, 31, King-street West, Manchester, 3. [Price 2*s.* 6*d.* net.]

The London Chatham and Dover Railway. By R. W. KIDNER. The Oakwood Press, Tanglewood, South Godstone, Surrey. [Price 9*s.* 6*d.*]

Wire Ropes in Mines. Proceedings of a Conference held at Ashorne Hill, Leamington Spa, Warwickshire, in September, 1950. The Institution of Mining and Metallurgy, Salisbury House, Finsbury-circus, London, E.C.3. [Price, to members, 40*s.* post free; 50*s.* post free to non-members.]

TRADE PUBLICATIONS.

Water Purification.—The Pulsometer Ionomatic water-purification plant is described in a leaflet issued by the Pulsometer Engineering Co., Ltd., Nine Elms Iron Works, Reading. The process is intended for the treatment and clarification of highly-polluted and turbid waters.

Laboratory Refractory Ware.—The Morgan Crucible Co., Ltd., Battersea Church-road, London, S.W.11, have sent us a leaflet in which are set out particulars of their "Triangle" crucibles, trays, dishes, tubes and other pure alumina refractory ware for process-laboratory and research work.

Fixing Devices.—A revised illustrated brochure has been issued by the Rawlplug Co., Ltd., Cromwell-road, London, S.W.7, giving particulars of their full range of fixing devices for use in brick, stone, concrete, glass, etc., and tools, both manual and power-operated, for boring holes, hammering, etc.

Welding Electrodes.—The "Weldirectory" for 1952, which has just been published by Lincoln Electric Co. Ltd., Welwyn Garden City, Herts, contains full details of the properties of the welding electrodes manufactured by them and facilitates the correct choice being made of the type required for a particular application.

White-Metal Melting Furnaces.—A leaflet giving particulars of the dimensions and general characteristics of their electric furnaces for melting white bearing metals and alloys of various kinds has been published by Funditor Ltd., 3, Woodbridge-street, London, E.C.1. Hooded, tilting and round and rectangular bale-out furnaces are available.

Steel and Steel Products.—A publication issued recently by Hadfields Ltd., East Hecla Works, Sheffield, 9, contains a brief history of the firm and of its founders, succinct descriptions of the steel-melting department, pattern shops, steel foundry, forge, rolling-mill and machine shops of the firm, and a short summary of its products.

Basic Refractories.—A folder containing leaflets, each relating to one particular type of magnesite, dolomite, chrome-magnesite or other basic refractory, has been issued by General Refractories Ltd., Genefax House, Sheffield, 10. On one side of the leaflets are given chemical and physical test data and typical applications, and, on the other, curves of thermal conductivity, refractoriness under load and maintained refractoriness under load.