

100-MW TURBO-ALTERNATORS AT THE RICHARD L. HEARN STATION, TORONTO.

THE Hydro-Electric Power Commission of Ontario, Canada, for some time considered the erection of two steam power stations to supplement the water-power resources of the province. One of these, the J. Clark Keith station at Windsor, has an ultimate capacity of 240 MW and was opened on Friday, November 16, 1951, and the second and larger, with an ultimate capacity of 400 MW, was inaugurated a few weeks earlier. This second station, which is known as the Richard L. Hearn station, is situated on Toronto's eastern waterfront, and is of interest since the first two machines, which were ordered from Messrs. C. A. Parsons and Company, Limited, Newcastle-on-Tyne, and are now running, each have an output of 100 MW and

way than to install converters. The construction of the station has been supervised by the Stone and Webster Engineering Corporation, of New York.

As will be seen from Fig. 8, Plate XVI, the turbine consists of two cylinders in tandem; the connection between is made by a flexible coupling. In the high-pressure cylinder the steam is expanded from the stop-valve pressure of 850 lb. per square inch to about 30 lb. per square inch absolute. It is then led by a pair of overhead pipes to the centre of a double-flow, low-pressure cylinder and thence through the two exhausts to a single condenser.

The casing of the high-pressure cylinder is of cast steel with a cast-iron exhaust end. It is shown on the boring machine in Fig. 7, Plate XVI. It will be seen from Fig. 8 that the high-pressure rotor is of hollow construction, the body being integral with the extended portion which forms the high-pressure end of the shaft. The exhaust end is, however, a separate forging which is extended to form the other end of the shaft. This method of construction enables the metal forming the body of the rotor to

be balanced, and no dummy pistons are necessary. As will also be seen from Fig. 8, the rotor is of hollow construction and is built up from three forgings comprising the two ends and the centre drum. This method of construction employs forgings that can be readily produced and results in a rotor of relatively light weight and high critical speed. Fig. 3, on page 354, shows the assembled low-pressure rotor.

A gland of the spring-backed labyrinth type is fitted at each end of the high-pressure and low-pressure turbines. Each gland consists of a separate housing carrying four rings, which are held in contact with the turbine spindle by springs mounted in the recess behind them. The glands are packed with steam supplied from two distribution boxes.

Two chests are arranged, one on each side of the turbine, and interconnecting pipes with "U" and "S" expansion bends convey steam to the inlet branches on the top and bottom halves of the turbine cylinder. In each chest are a single-seated

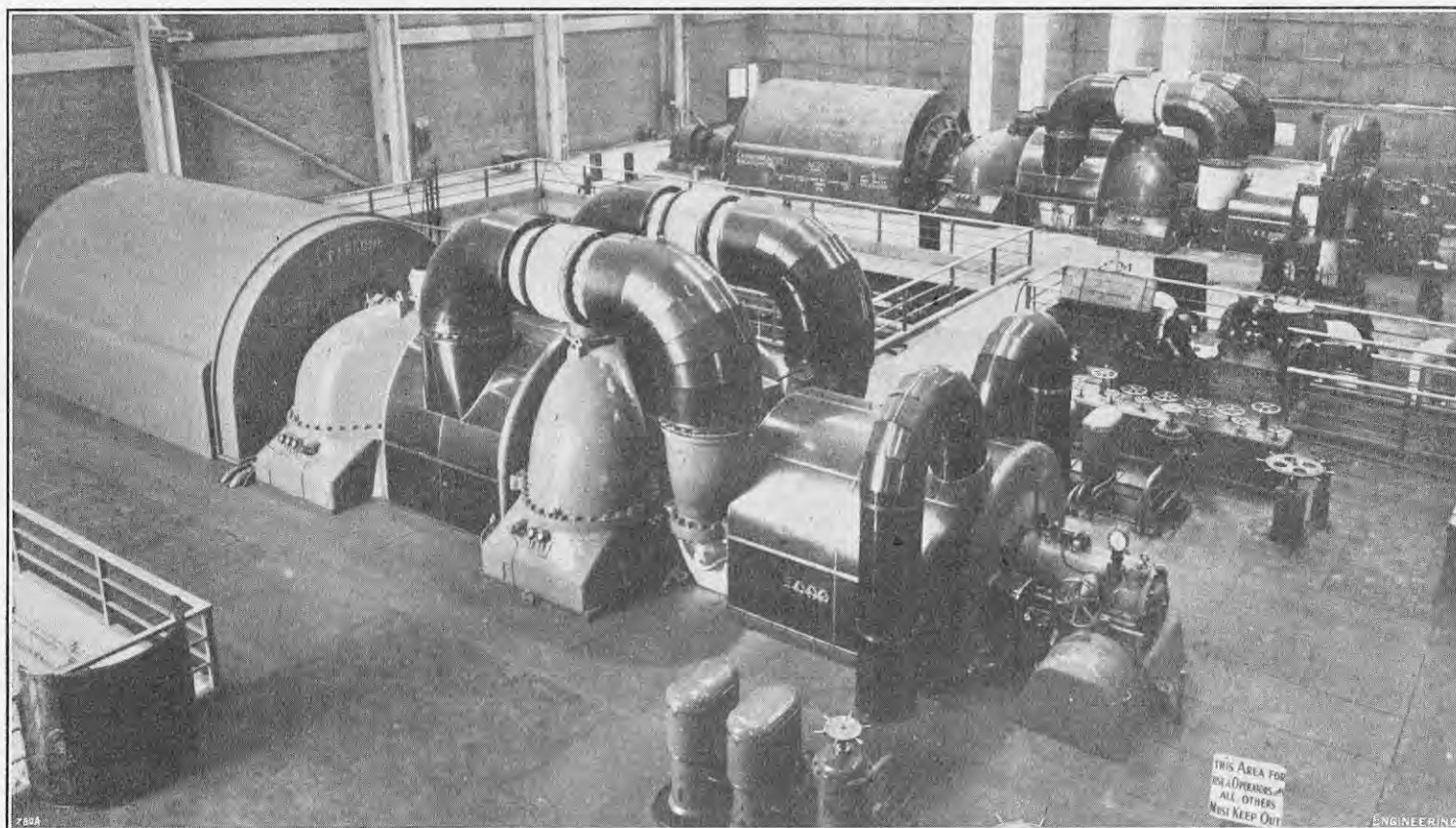


FIG. 1. TURBINE ROOM.

are probably the largest two-cylinder tandem sets yet made in this country.

Before describing this plant in detail, it may be mentioned that the Richard L. Hearn station is well placed for obtaining coal by rail and water transport, while ample supplies of cooling water are available from Lake Ontario. An area suitable for stocking 800,000 tons of coal has been provided and the coal-handling plant has been designed so as to give the maximum operating convenience. The unit system has been adopted, each set having its own steam generator, auxiliary plant and chimney. Pulverised fuel is used and electrostatic dust-removal plant has been installed to comply with the local anti-smoke legislation. Steam is supplied to the turbines at a pressure of 850 lb. per square inch and a total temperature of 900 deg. F. Work was started in September, 1949, and it is expected that the third set will be running by the end of this year; the four units, all of which will be of Parsons manufacture, should be completed by 1953. A further interesting point is that the first of the two machines, illustrated in Fig. 1, has been designed to generate at 25 cycles, but can be converted to 60-cycle supply by changing the rotor, an operation which will take only two or three weeks. This was considered desirable as frequency change-over is taking place in the area; and it was more economical to provide the 25-cycle power temporarily in this

be made of comparable thickness with that of the steel cylinder surrounding it, and thus obviates difficulties due to differential expansion of rotor and casing when temperature changes occur. Fig. 6, Plate XVI, shows the turbine in course of erection with the bladed shafts in position. The blading in the high-pressure turbine comprises a two-row impulse wheel followed by 29 stages of reaction blading. All the blading material, both impulse and reaction, is of stainless iron which contains 12 to 14 per cent. chromium and has a carbon content of about 0.1 per cent.

The impulse nozzles are arranged in four groups. Steam is admitted simultaneously to the first two groups, each of which comprises 17 nozzles, one group being carried in the bottom and the other in the top half of the cylinder so as to avoid unsymmetrical heating and consequent distortion. These two groups pass the amount of steam required to develop a 60 per cent. load. The secondary nozzle group, which is located in the bottom half of the cylinder, contains 13 passages and passes the additional steam required to develop an 80 per cent. load. A tertiary nozzle group is located in the top half of the cylinder and contains 18 passages, thus enabling full load to be developed.

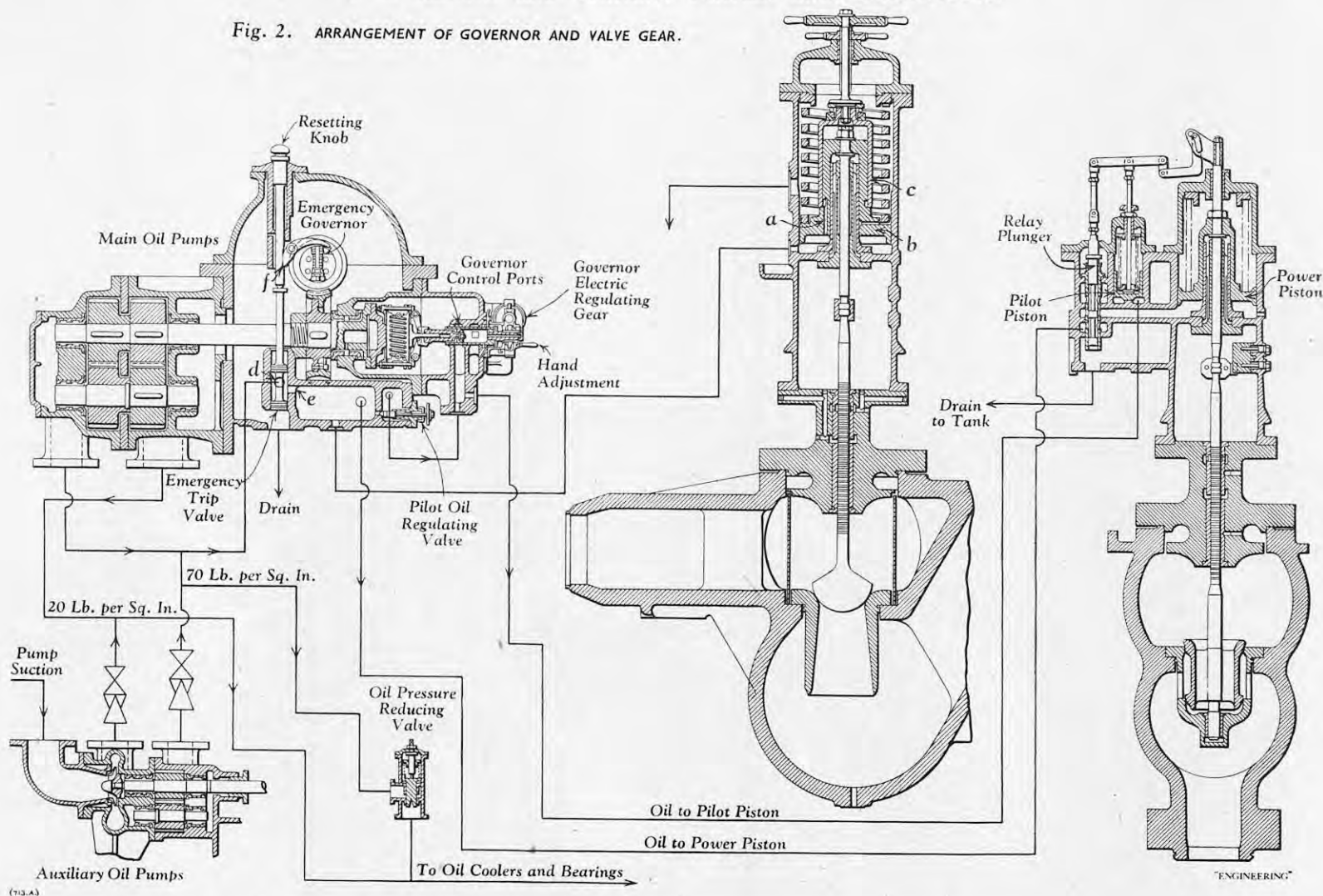
Steam enters the cast-iron low-pressure cylinder at the centre of its length and flows to an exhaust at each end. The thrust on the blading is thus

runaway stop-valve and two double-beat balanced-type governor valves which control the supply of steam to the turbine. The first governor valves in each chest operate in parallel and supply steam to the turbine for all loads up to and including 60 MW. When the second governor valve on the right-hand steam chest is fully open, sufficient steam is being supplied to the turbine to carry loads up to 80 MW; and when the second governor valve, mounted on the left-hand steam chest is fully open, a load of 100 MW is obtained. These valves are controlled by a speed governor through oil-operated pilot and power relays mounted above the valves and connected to the valve spindles. Fig. 2, on page 354, is a diagram of the governor and valve system, showing a governor-valve relay (on the right) in a closed position; the two governor valves, however, are not shown alongside the runaway valve in the centre of the diagram. The speed governor controls the pilot oil pressure, the pilot oil being connected to the under-side of the pilot piston of the relay. The lift of the pilot piston depends on the pilot oil pressure. An upward movement of the pilot piston lifts the relay plunger which, in turn, allows power oil to flow to the under-side of the power piston, causing it to rise by an amount sufficient to return the relay plunger to its neutral position through a bell-crank floating lever. A downward movement of the pilot piston

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C. A. PARSONS AND COMPANY, LIMITED, NEWCASTLE-ON-TYNE.

Fig. 2. ARRANGEMENT OF GOVERNOR AND VALVE GEAR.



lowers the relay plunger and allows oil from the under-side of the power piston to flow to drain. The spring above the power piston forces the piston downwards until the movement of the piston returns the relay plunger to its neutral position. The relay is sensitive to the slightest change in pilot-oil pressure.

Steam entering the steam chests passes through the runaway stop-valves, which shut automatically if the turbine overspeeds or the oil supply fails. They may also be tripped at any time by the attendant. Fig. 2 also shows a diagrammatic arrangement of the runaway-valve oil relay. The valve is opened by screwing down the handwheel so that the oil ports *a* in the piston *b* are closed, thus allowing oil pressure to build up under the piston so that the valve rises when the handwheel is turned in the opening direction. Should the oil pressure fail at any time due to the operation of the emergency trip gear, or to any other cause, the spring above the piston will begin to close the valve automatically. The first downward movement of the piston will separate it from the sleeve *c*, thereby allowing the oil beneath the piston to escape freely through the ports *a*, thus accelerating the closing of the valve.

The arrangement of the governor gear and oil system is also shown in Fig. 2. There are two sets of pumps, main and auxiliary, each consisting of a power oil pump of small capacity and a low-pressure pump of large capacity. The main gear-type pumps are driven from the high-pressure turbine shaft through a worm and wormwheel housed in the steam-end bearing pedestal, a photograph of which is reproduced in Fig. 4, opposite. The power oil pump supplies oil to the governor pilot system, and power oil to the governor-valve relays. It also normally provides oil at a suitable pressure to the alternator shaft seals. The pump discharge pressure is maintained substantially constant by a spring-loaded relief valve which is adjustable and is set to maintain a steady pressure of 70 lb. per square inch.

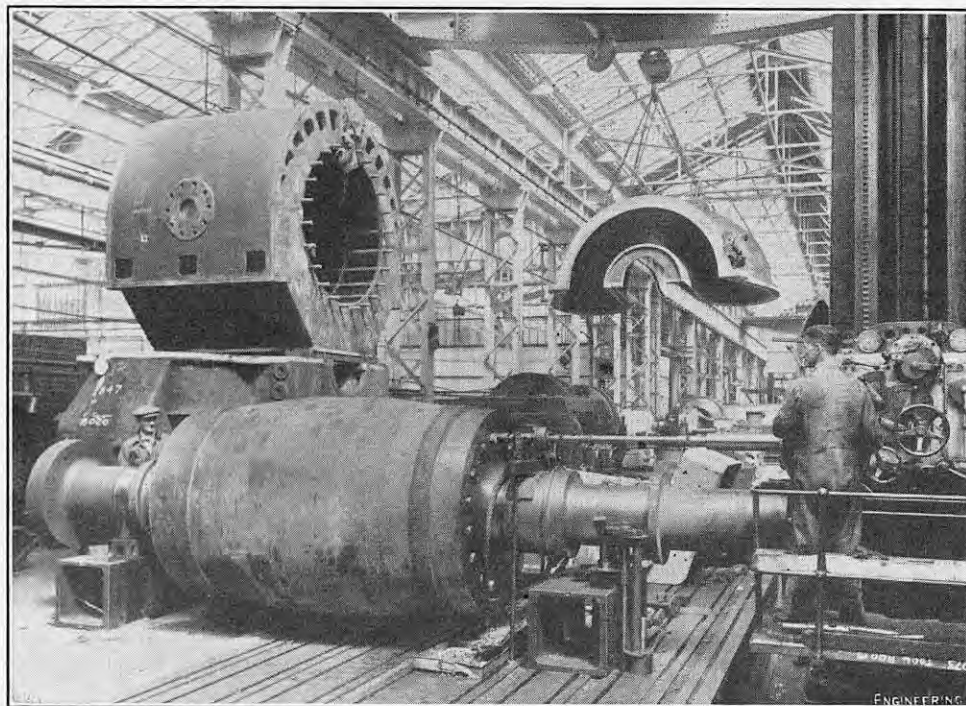


FIG. 3. LOW-PRESSURE ROTOR IN MACHINE SHOP.

During steady load conditions a large proportion of the power oil passes through this valve and joins the main low-pressure supply to the bearings. The entire supply of low-pressure oil is used for lubricating the bearings and thrust blocks.

The auxiliary oil pump is situated at basement floor level and is driven by a small steam turbine. It consists of a combined gear and centrifugal pump which is used when starting or stopping the

main turbine or in an emergency. As in the case of the main oil pumps, the gear portion supplies oil at a pressure of 70 lb. per square inch for operating the valve gear and also feeds the alternator seal system. The centrifugal element delivers oil at a pressure of 15 lb. per square inch for lubricating the bearings and thrust blocks. This pump is controlled by a regulator which automatically starts it when the bearing oil pressure falls below a

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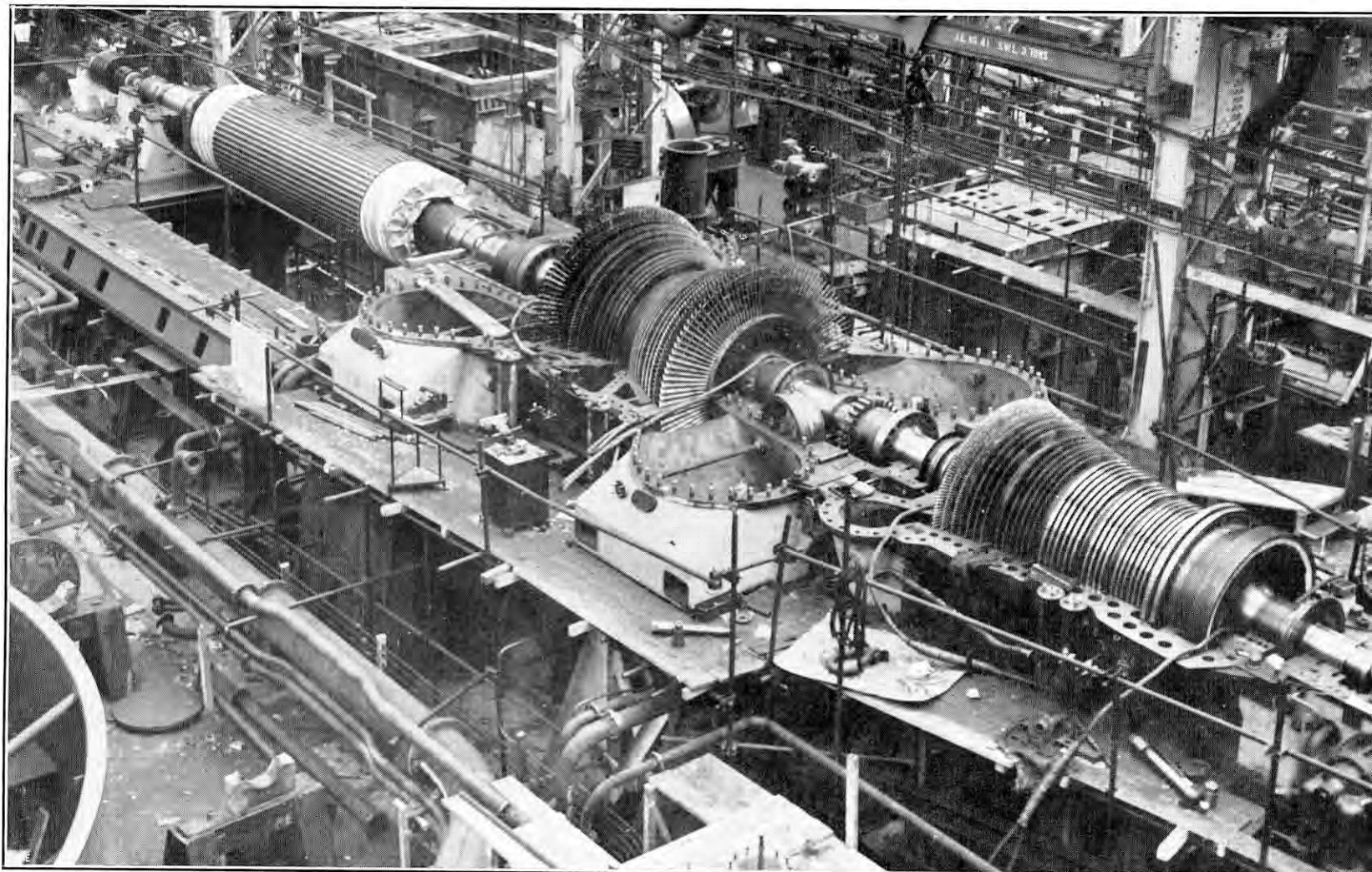
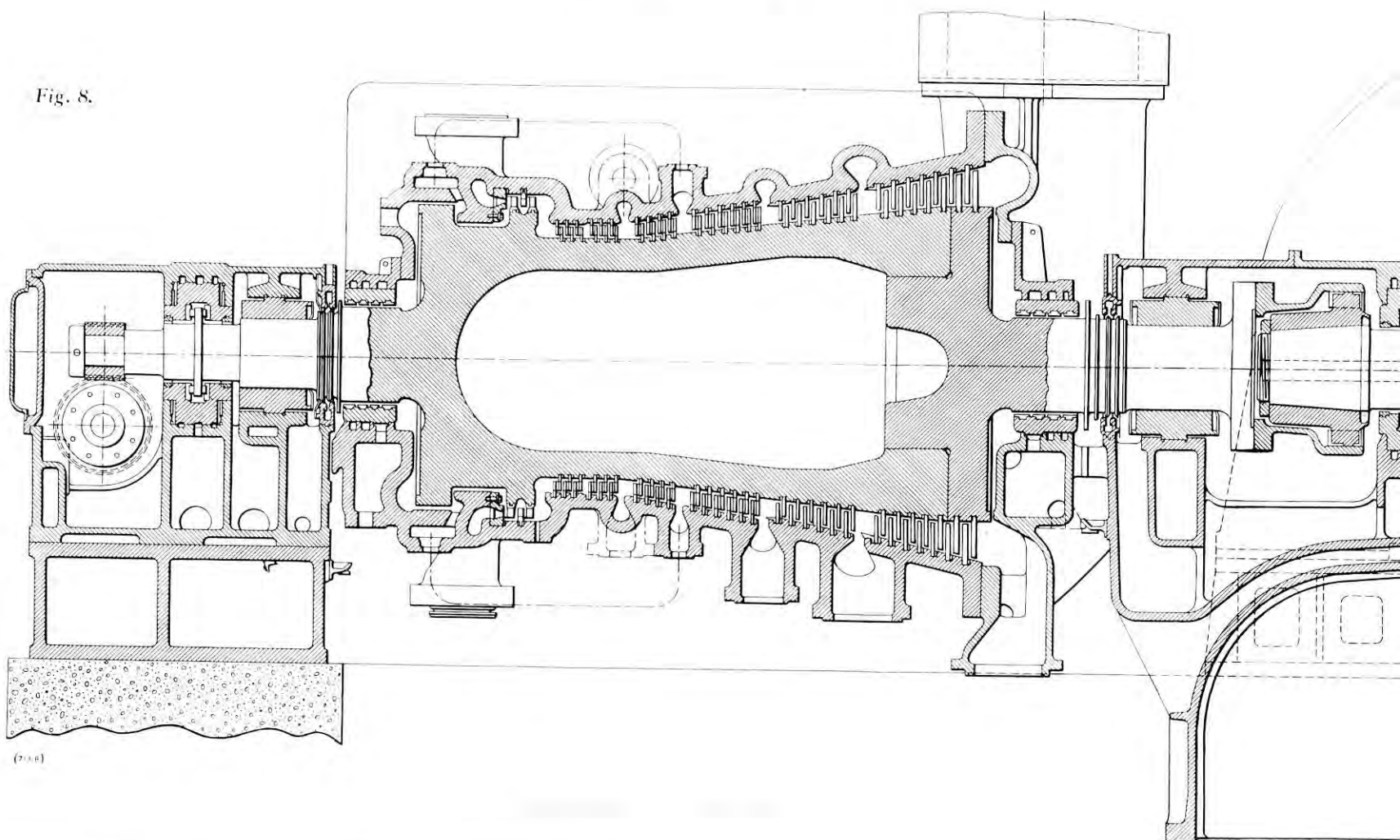


FIG. 6. TURBINE IN COURSE OF ERECTION.

Fig. 8.



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D. L. HEARN POWER STATION, TORONTO.

ATED, NEWCASTLE-ON-TYNE.

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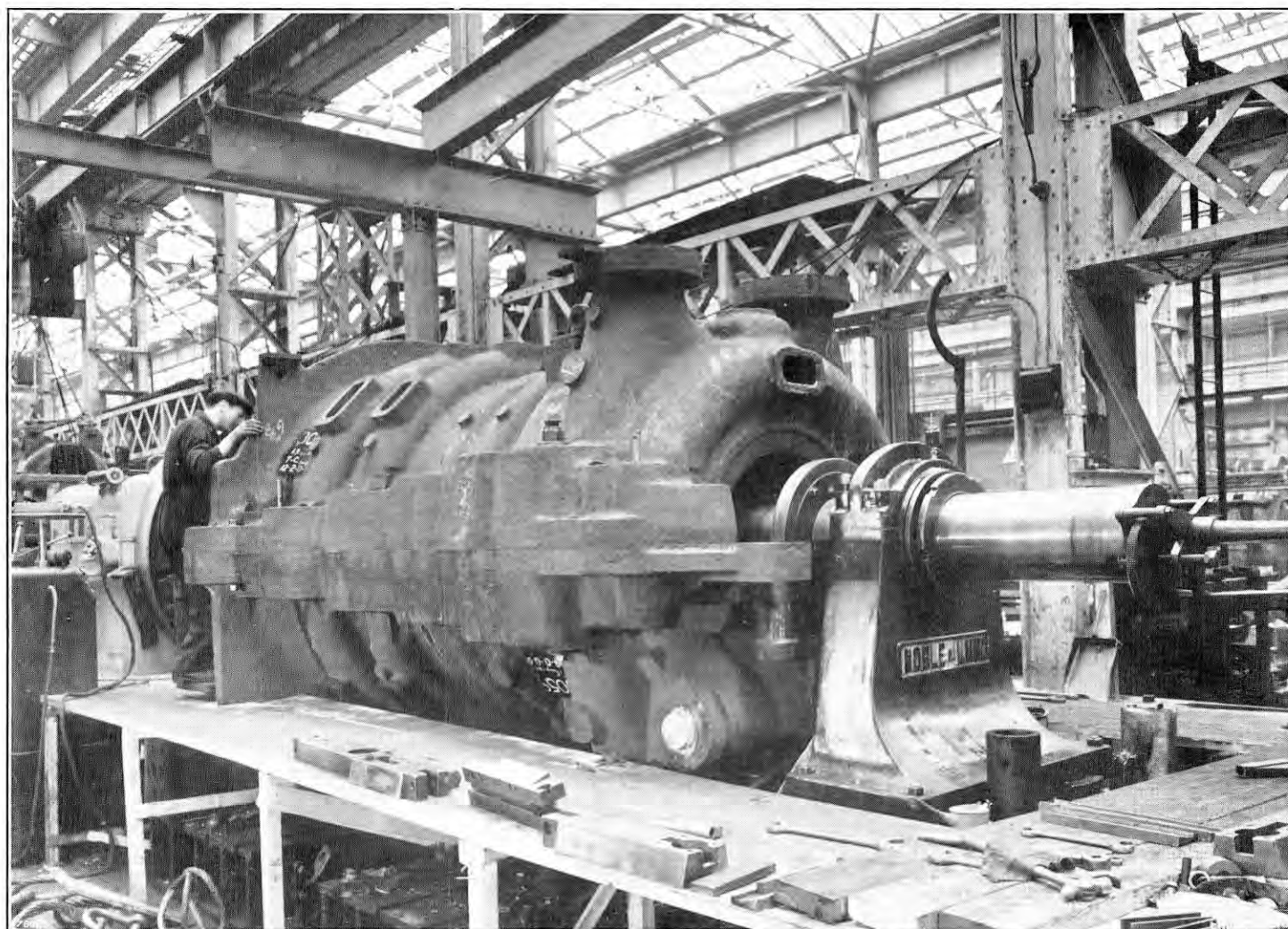
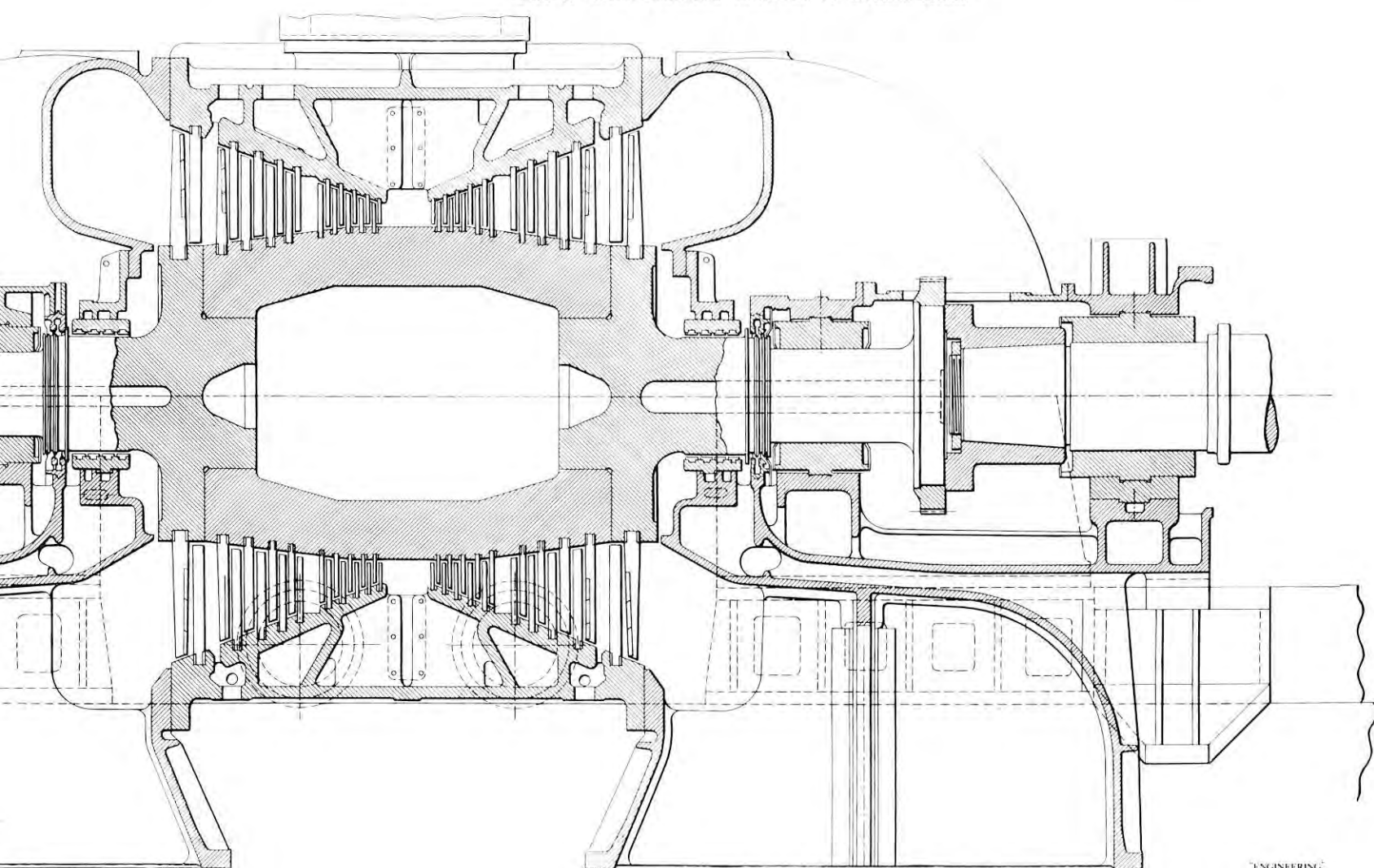


FIG. 7. HIGH-PRESSURE CYLINDER ON BORING MILL.



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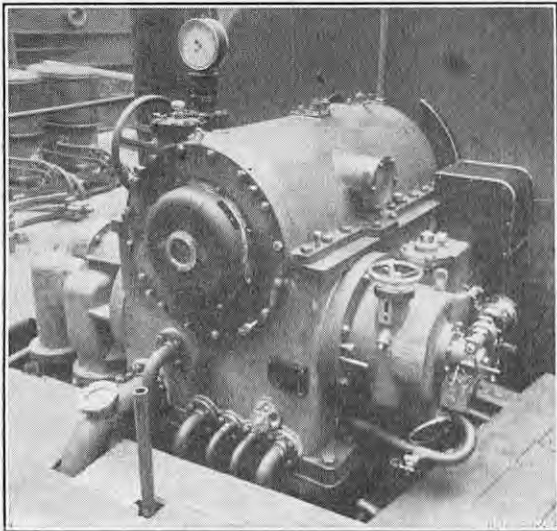


FIG. 4. STEAM-END PEDESTAL.

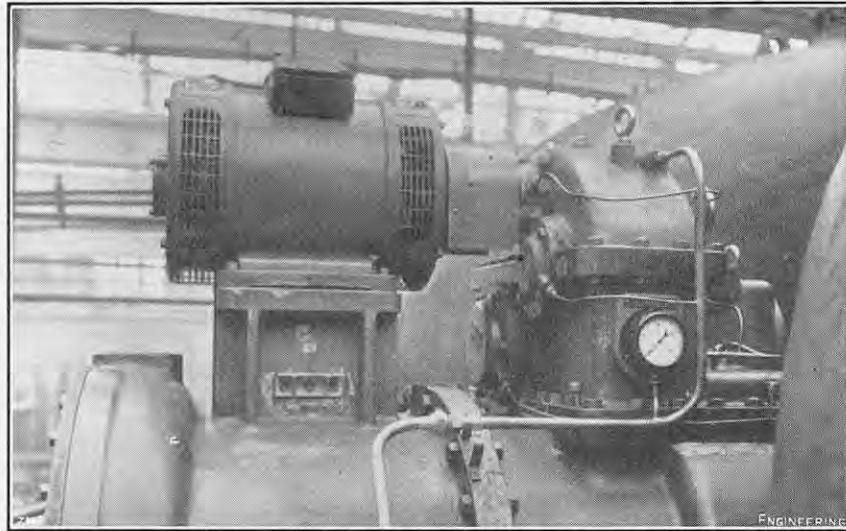


FIG. 5. MOTOR-DRIVEN TURNING GEAR.

predetermined value. In order that the pressure drop across the oil coolers shall not become excessive when starting up from cold, a spring-controlled relief valve by-passes some of the oil from the inlet to the outlet of the coolers.

The governor is mounted on the same spindle as the main oil pump and has an operating range from 5 per cent. below to 10 per cent. above normal speed. Its movement is transmitted by the pilot oil system to the governor valves which control the steam supply to the turbine. Oil from the main oil-pump delivery passes through the pilot-oil regulating valve, shown in Fig. 2, and thence through ports in the regulating bush to drain. The pilot-oil pressure depends upon the area of port in the regulating bush which is uncovered by the governor plunger. As the speed of the turbine increases, the plunger uncovers more of this port, thus allowing more oil to flow to drain, and reducing the pilot-oil pressure. This reduction in pressure causes the governor valves to close in turn by an amount corresponding to the increase in speed.

The runaway trip gear is also illustrated in Fig. 2. All the oil for controlling the valve gear passes through the trip valve, entering by the port *d* and leaving by the port *e*. The valve is held in its working position by the catch *f* against the action of a spring which tends to lift the spindle. If the speed of the turbine should exceed a predetermined limit, the bolt of the emergency governor on the end of the turbine shaft will fly out and strike the end of the lever shown, thus releasing the catch *f*. The trip valve will then rise until its lower part is above the port *e*. The oil in the pilot system can then escape freely through this port, and both the governor valves and the runaway valves will at once close automatically. The lifting of the trip valve also prevents the entrance of further oil through the port *d*, although the full supply of oil to the lubricating system is unaffected. To shut down the machine the catch *f* can be released by a hand tripping lever on the outside of the casing. It may easily be reset by depressing the knob on top of the valve spindle.

In general, the governing system of steam plant is much more responsive to load changes than is that of hydro plant, so that as the load rises the tendency is for most of the increase to be picked up. For this reason, a limiting device has been fitted to the governing system to ensure that the load carried by the steam plant does not exceed a chosen amount. This device is mounted on the governor casing, as shown in Fig. 2, opposite. It consists of a piston-operated oil relief valve which is connected to the pilot oil system of the governor valves. Under normal running conditions the pilot oil pressure increases almost directly with the load, so that by adjusting the relief valve to lift at any predetermined oil pressure the upper limit of load can be fixed.

Vacuum-operated load suppression gear is fitted to reduce the load on the machine if the condenser vacuum should fall below a predetermined figure. It consists of a flexible bellows-type piston carrying a plunger, the movement of which regulates the discharge of oil from the governor system. One side of the piston is connected to the condenser and the other side is open to atmosphere. Any reduction in the condenser vacuum therefore alters the position of the plunger and allows oil to escape from the relays, thus closing the governor valves. In the event of this gear failing to operate a second control is fitted to the condenser to protect the machine. This consists of a quick-acting switch which is connected to a flexible bellows that is held in position by the condenser vacuum. Should the pressure in the condenser rise to $1\frac{1}{2}$ lb. per square inch above atmospheric pressure this switch will close, thus energising a solenoid mounted on the steam-end door of the turbine and closing tripping circuits on the main circuit-breaker and main field switch. The plunger of the solenoid will also strike the hand tripping lever, thus closing the steam-admission valves.

The machine is equipped with motor-driven turning gear by means of which the turbine can be kept in slow rotation during the periods of warming up and cooling. The turning gear is illustrated in Fig. 5, above, and consists of three sets of helical gears contained in a casing mounted on the cylinder exhaust end keep adjacent to the alternator.

(To be continued.)

SCHOLARSHIP ON APPLICATION OF LIGHT ALLOYS TO SHIP CONSTRUCTION.—A research scholarship of the value of 400l. per annum and tenable for two years has been offered by the Aluminium Development Association to encourage and facilitate research in the application of light alloys to ship construction. The scholarship will be administered by a committee of the Institution of Naval Architects and it is hoped to make the award in September, 1952. Further particulars of entry, which closes on June 30, can be obtained from the secretary, Institution of Naval Architects, 10, Upper Belgrave-street, London, S.W.1.

THE IRON AND STEEL INSTITUTE.—The Council of the Iron and Steel Institute have awarded the Bessemer Medal for 1952 to Mr. H. H. Burton, C.B.E., of the English Steel Corporation, Ltd., for his distinguished services to the steel industry and to metallurgy, with particular reference to the development of alloy steels and heavy forgings. The Sir Robert Hadfield Medal has been awarded to Dr. L. Reeve, of the Appleby-Frodingham Steel Co., for his work in the weldability of low-alloy steels and other researches. The Williams Prize has been awarded jointly to Mr. J. A. Bond of the Appleby-Frodingham Steel Co., and Mr. T. Sanderson of the Workington Iron and Steel Co., for their paper on "Full-Scale Blast-Furnace Trials." The awards will be presented at the forthcoming annual general meeting of the Institute, during the morning session on April 30.

LITERATURE.

Tables of the Exponential Function e^x .

National Bureau of Standards: Applied Mathematics Series 14. United States Government Printing Office, Washington, D.C., U.S.A. [Price 3.25 dols.].

Few functions are more frequently encountered in either pure or applied mathematics than the exponential function, and the present volume provides a reliable tabulation of its values, covering a wide range of the argument at sufficiently small intervals, and to a large enough number of decimals, to meet all normal requirements. After careful consideration of the existing tables, the following scheme of tabulation was decided upon. Over the range -2.5000 to 1.0000 , the values are at intervals of 0.0001 to 18 decimal places; between 1.0000 and 2.5000 , values are given, at intervals of 0.0001 , to 15 decimal places; from 2.500 to 5.000 , entries are to 15 decimal places at intervals of 0.001 ; and from 5.00 to 10.00 , to 12 decimal places at intervals of 0.01 . These correspond to the first five tables. Table VI is one of ascending and descending exponentials [0.000000 (0.000001) 0.000100 ; 18 D]. The next two tables are reproduced from a memoir of C. E. Van Orstrand, the first containing ascending and descending exponentials of the integers from 1 to 100, to 19 significant figures, and the second values to 18 places of decimals of e^x and e^{-x} at decimal intervals from 1×10^{-10} to 9×10^{-7} . The final table gives the values of e and its reciprocal computed by the Ballistic Research Laboratories, Aberdeen Proving Ground, Aberdeen, Maryland, to 2,556 places of decimals.

The computation of the tabular entries was made to depend on the values of e^x and e^{-x} for 72 "fundamental key arguments," determined by direct substitution in their power series expansions. Values covering the range $x = 0.01$ to 0.99 at intervals of 10^{-2} , referred to as "major key arguments"; and the range $x = 0.0001$ to 0.0099 at intervals of 10^{-4} , referred to as "minor key arguments," were then computed to 25 places of decimals, using a pair of equations whereby, starting from the value of e^{x+y} , the values of e^{x+2y} and e^x could be simultaneously derived. The process, which could then be repeated, starting from e^{x+2y} , was thus stepwise and self-checking. An additional check was afforded at regular intervals by the independently computed fundamental key values. The remaining entries were obtained by using the recurrence formula $e^{x+y} = e^x \cdot e^y$, where x is a major key argument and y a minor key argument, the computation being carried to five places beyond the last place published. Checking by means of what is termed the "curvature test" was applied to successive groups of three consecutive

values, and enabled the exponential of every even argument to be tested once and that of every odd argument to be tested twice. The values were then rounded to the assigned number of decimal places and reproduced by a photo-offset process. As a final precaution, two further tests were then applied, the first of which consisted in adding the entries in groups of ten and comparing these sums with their precomputed values. The second was a fourth-difference test.

The demand for this comprehensive set of tables is attested by the fact that it now appears in its third edition, while convincing evidence of its reliability is afforded by the statement that only one error in a functional value was found to need correction. In fact, the stringent precautions adopted and outlined above almost certainly justify the claim that its contents are entirely free from error. The volume is attractively produced and moderately priced.

Soil Testing for Engineers.

By PROFESSOR T. WILLIAM LAMBE. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 5 dols.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 40s. net.]

ALTHOUGH not apparent from the title, the scope of this work is limited to soil testing in the laboratory. The author, who is an assistant professor of soil mechanics in the Massachusetts Institute of Technology, gives the detailed procedure for a number of the commoner soil tests, together with full explanation of their principles and of the interpretation of the results. A noteworthy feature is the systematic way in which the subject matter is presented. After an introductory chapter on general laboratory procedure, each of the remaining 13 chapters is devoted to a particular test. Each of these chapters is set out in a uniform sequence, with sections on apparatus and supplies, recommended procedure, discussion of procedure, calculations, results and numerical examples, concluding with a list of references. Specimens of data-calculation sheets are given for every test; the use of these is recommended to save time, to avoid mistakes and to ensure uniformity of procedure.

The book is well produced, and the large size of page, 11 in. by 8½ in., enables charts and data-calculation sheets to be reproduced on a reasonable scale. The spiral type of binding ensures that the pages lie flat when in use, but it seems that the leaves will be liable to tear after the book has had some use. The relegation of less important details to footnotes simplifies the main text and enhances its suitability for use during practical laboratory work, though some readers may wish that they were less numerous. For most of the tests, an estimate is given of the time in which students can be expected to complete their work; information which should be of use to those responsible for organising laboratory courses for the first time.

As might be expected, the procedures for many of the tests described differ in detail from British practice; for example, in the chapter on unconfined compression tests, special apparatus is described. In this country, this test is generally carried out as a field test, using portable apparatus, and when a more accurate laboratory test of this type is required the ordinary tri-axial machine can be used. In this chapter and in the subsequent chapters dealing with the shear strength of cohesive soils, the author's treatment of the controversial subject of cohesion and friction is at variance, in some respects, with the views now generally accepted in this country and by many authorities abroad.

The author, in his preface, states that the primary purpose of the book is to fulfil the need for a textbook for the teaching of soil testing. As such, as regards American practice, the book is admirably suitable. A high standard of technical detail is specified in the various test procedures, perhaps higher than is normally possible under the limitations of time, space and equipment with which the organisers of courses in soil mechanics usually have to contend; nevertheless, the book should be of value in universities, technical colleges and commercial laboratories.

THE ENGINEERING OUTLOOK.

XII.—GENERAL AND CONSTRUCTIONAL.

WHEN the re-armament programme, which made heavy demands on the output of the engineering industry, was launched, it was accepted as part of Government policy that engineering exports should be allowed to decline. It was thought that the balance of payments could be maintained by increased exports of consumer goods, notably textiles. By the end of 1951, however, as was pointed out in the first article in this series, it was clear that, because of a decline in world demand, it would be difficult to maintain exports of consumer goods and certainly would not be possible to increase them. The Government have had to reshape their policy. Limited relief has been obtained from a slowing down of the re-armament programme and a grant of economic aid from the United States, but it has been found necessary to call upon the engineering industry, which already accounts for about two-fifths of total exports, to bear an even greater share of the export burden.

The extent to which the re-armament programme has been slowed down is not yet clear. In the *Statement on Defence* 1952 (Cmd. 8475), published by H.M. Stationery Office in February, it is pointed out that the expanded re-armament programme launched at the beginning of 1951, which was to cost 4,700l. million over the three years April, 1951, to March, 1954, was designed as the biggest the United Kingdom could undertake without going over to a war economy. As a maximum programme "it was inevitably susceptible to delays and by the autumn of 1951 it was apparent that production difficulties would slow down its completion." It is stated, moreover, that the rate of progress must inevitably be affected by the grave worsening of the United Kingdom's balance of payments. The cost of the programme in 1952-53 was estimated at 1,500l. millions; the new estimate at current prices is 1,462l. millions. In view of the increase in prices—the index of wholesale prices (1938 = 100) stood at 325.6 in December, 1951, compared with 237.6 in December, 1949—this represents a considerable fall. The actual amount which will have to be found by the taxpayer has been further reduced to 1,377l. millions by economic aid from the United States. The total aid funds allocated to the United Kingdom in the United States fiscal year ending June 30, 1952, amount to 300 million dollars, 95 per cent. of which is available for meeting defence expenditure. Under the original estimate, 2,000l. millions of the proposed defence expenditure of 4,700l. millions were to be devoted to armament production and about 80 per cent. of this to products of the metal-using industries.

The Defence White Paper states that the necessary conditions for achieving this programme, which include sufficient supplies of labour, raw materials, machine tools and manufacturing capacity, cannot now be fully satisfied. Since, moreover, in consequence of the deterioration of the economic position, "severe measures have had to be taken in the civil sector of the economy," the immediate burden on the metal-using industries has had to be reduced at the cost of extending the re-armament programme over more than three years. The Prime Minister, Mr. Winston Churchill, announced recently that it may now take four years. The load on the engineering industry is, nevertheless, still substantial. Aircraft, which are to be accorded "super priority," are to account for 20 per cent. of the production expenditure in 1952-53, ammunition and general stores for 25 per cent., and tanks and other vehicles for 20 per cent. Other major items included are ship construction, and radio, radar and signals equipment. "Several hundred" Centurion tanks are to be delivered in 1952-53, and capacity for the large-scale production of modern tanks is being expanded. Ammunition requirements are heavy as the result of the growing numbers of new weapons and increased rates of fire. The naval programme provides for the completion of about 40 coastal and inshore minesweepers and acceleration of the building of 18 anti-submarine frigates and five aircraft carriers.

An indication of the extent to which the engi-

neering industry is required to increase exports has been given already in the recent Government announcement that, over the whole field of plant, machinery and vehicles for civil use, home deliveries are to be cut by 150l. to 200l. millions, at current market prices, below the 1950 level. This represents a cut of one-sixth below the 1950 level, but most of it will be provided by a reduction in the supply of motor vehicles. During 1952, the number of cars reaching the home market is to be cut to 60,000, compared with 110,000 in 1951. In other cases, particularly where the cycle of production is long, the level of home supplies must be largely determined by the speed at which manufacturers can switch from home to export orders. The contribution which individual industries may be expected to make is at present a subject of discussion between the Government and the industries concerned, but the Government have meanwhile appealed to all the engineering concerns to give all possible priority to overseas orders.

The Government do not claim that this policy is anything less than regrettable. If, as it is assumed in the March edition of the Treasury's *Bulletin for Industry*, abstracted on page 309, *ante*, there can be little increase in the output of the engineering industries because of the continuing shortages in steel and non-ferrous metals, there is no escape from the necessity of cutting drastically the supply of investment goods to the home market. The prospects for bigger steel allocations, however, now appear to be rather better than was once supposed. There can be little improvement in the first half of 1952, but thereafter there is ground for optimism. In his cautious statement made at the beginning of March, Mr. Duncan Sandys, the Minister of Supply, said that "There is no doubt that, unless something goes seriously wrong with arrangements to obtain steel from America, we shall get a substantial increase in imports of steel in the third and fourth quarters of the year, but I am certainly not going to venture into a forecast as to what allocations we can make until I know a great deal more about the prospects for home production."

Shortage of labour may be as serious a handicap to the engineering industry as the possible shortage of steel. Sir Walter Monckton, the Minister of Labour, said in Parliament on March 3 that 60,000 more persons would be required if the aircraft construction and the Royal Ordnance Factory programme were to be carried out, and that there were 78,000 vacancies in the engineering industries registered at local exchanges. It is clear that the Government are not expecting the Notification of Vacancies Order, made in February, to effect the required movement of workpeople from one job to another without other measures, but Sir Walter Monckton found it inexpedient, so short a time before the Budget, "to discuss comprehensively all the issues affecting employment."

On the whole, despite shortages and difficulties, it may not be rash to forecast an increase in engineering production of up to 3 per cent. higher in 1952. This, however, will be too small to permit any appreciable increase in capital investment at home. Investment in plant and machinery in British industry has never been as high since the war as has been generally thought desirable. This does not mean that it has been low, for it has accounted for about one-fifth of the annual national output, and in real terms has been as high as in the best inter-war year. In the United States, however, investment per head has been twice as great as before the war. Despite physical and financial factors limiting programmes, capital investment in British manufacturing industry did, in fact, increase in each year until 1951.

The estimated quantity of plant and machinery going into the factories in 1949 was 8 per cent. greater than in 1948, and, in 1950, 15 per cent. greater than in 1949. The increase recorded in 1951 was not anticipated on account of re-armament, but it was substantial. It is estimated in the March edition of the *Bulletin for Industry* that the real increases in home-market supplies of plant and machinery, in 1951, excluding imports, have ranged from 4 per cent. for mechanical-handling equipment to 100 per cent. for rotating electrical machines and 300 per cent. for machine tools. Home deliveries of plant and equipment to the chemical industry

in 1951 were 20 per cent. higher than in 1950, and to the textile industry 10 per cent. higher. Largely as a result of increasing investment, productivity was steadily pushed upwards at the rate of 6 per cent. per annum between 1948 and 1950, but the movement appears to have been halted in 1951. Industrial output in 1951 was only 3 per cent. higher than in 1950, and most of this occurred in the first half of the year, whereas the labour force increased by 2 per cent. This is about the same rate of

falling demand for certain consumer goods. They attribute mainly to the shortage of steel the fall in output of goods other than textile clothing and household goods. In many cases, however, it is probable that the shortage of steel merely disguised the underlying weakness of demand in the export markets as well as at home. It is exceedingly difficult to distinguish between falling demand and shortage of raw materials, particularly as manufacturers invariably place emphasis on the latter in

Sir Rowland Smith, the chairman of the Ford Motor Company, writing in the *Financial Times* on January 26, stressed the possibility that large-scale motor manufacture in Great Britain would have to face a general recession in overseas demand and a return to competitive selling. While he was confident about the adaptability of British engineering in meeting new marketing conditions, and of its ability to hold its own where trade was free, he recognised the serious menace of tariff walls and prohibitive trading restrictions. In particular, the industry could not blind itself to the fact that "any anti-inflationary measures that may operate within sterling area countries are likely to cut down their demand for our exports." It has since been announced that Australia, one of the largest markets for engineering goods, is to cut imports by 100l. millions. The full list of items affected by this drastic cut has not yet been disclosed, but it is said to cover a wide range of the less essential goods from Britain and elsewhere, including motor cars, clothing, electrical goods and some light metals.

The output of various engineering products not so far covered in this series is shown in Table I, herewith, adapted from the *Monthly Digest of Statistics*. Particularly striking is the increase in the output of office machinery. As will be seen from Table II, taken from the *Trade and Navigation Accounts*, exports of office machinery in 1951, valued at 9.2l. millions, were 55 per cent. higher than in 1950. Mr. George Strauss, in a written congratulatory message to the President of the Office Appliance and Business Equipment Trades Association, in June, 1951, thought it "true to say that the expansion of this industry in Britain has been more rapid and more successful than that of any other. It is already making ten times the equipment produced before the war and the story is far from complete." Mr. B. B. Dyer, President of the same Association, in an article in the *Financial Times* of February 19, estimated the total output of the industry to exceed 40l. millions per annum. This includes the output of office equipment, furniture, safes and security equipment, valued at 10l. millions. The capacity is still expanding.

Before the war, office machinery was obtained largely from the United States. The expansion of British output, due in no small part to American capital, has therefore been invaluable in conserving dollars. It has been estimated that, since the war, the saving to the Commonwealth in office machinery which would otherwise have had to be imported amounts to 25 million dollars. A significant quantity of office machinery, moreover, is now being exported to the United States and Canada. One American firm, Burroughs Adding Machines, Limited, was granted production facilities in the United Kingdom on the understanding that production of a range of adding machines popular in dollar markets should be undertaken exclusively in the United Kingdom. One factory is already in production and two more are in course of erection. One of these, on the Strathleven trading estate, is expected to be complete in about 18 months and will employ about 2,000 people. International Business Machines, Limited, have acquired a site of 110 acres at Greenock for a factory to employ 5,000 people. A new factory is being built at Hull by the Imperial Typewriter Company, which is expected to employ 1,000 people. Underwood Elliott Fisher and Company are to increase their range of production and have invested 250,000l. in two factories in Brighton which are to employ 1,500 people.

Accounting and similar machinery now constitutes a considerable part of the output of office machinery and nearly a third of the total exports. Important advances have been made in accounting-machine design in recent years and further developments are on the way. Sir Cecil Weir, K.B.E., M.C., D.L., the chairman of the British Tabulating Machine Company, has suggested that, with recent advances in electronics, the ledger accounts of the future may prove to be spots on a magnetic drum or cathode-ray tube. Shortage of steel may have some effect on the output of office machinery in the first half of 1952, but the industry is particularly fortunate in being able to make extensive use of substitute materials, which should greatly ease the comparatively small restriction in steel

TABLE I.—UNITED KINGDOM: OUTPUT OF CERTAIN INDUSTRIES CLASSIFIED AS GENERAL ENGINEERING. (MONTHLY AVERAGES.)

	1949.	1950.	1951.			
			1st Quarter.	2nd Quarter.	3rd Quarter.	4th Quarter.
<i>By Value (1,000L.)</i>						
Steam engines	69	79	102	97	91	69†
Internal-combustion engines	2,816	3,217	3,342	3,950	3,862	2,781†
Pumps and pumping plant	1,393	1,601	1,612	1,842	1,727	2,074†
Air and gas compressors	486	543	578	590	—	—
Portable power tools	690	721	806	901	870	—
Welding machinery	176	216	261	296	244	—
Industrial furnaces	624	730	863	951	884	987†
Water-treatment plant	297	326	321	327	381	512†
Fire-extinguisher and sprinkler plant	401	478	427	565	517	650†
Needles and fish-hooks	130	141	140	177	145	—
Lawn mowers	254	317	450	379	265	—
Typewriters	272	385	542	549	558	663*
Accounting and similar machinery	717	979	1,033	1,235	1,281	1,466*
Other office machinery	342	459	577	605	623	705*
Printing and bookbinding machinery	1,187	1,468	1,478	1,494	1,475	—
Tanning and leatherworking machinery	73	79	87	96	83	100*
Tobacco and cigarette-making machinery	322	299	302	358	274	—
Conveyors and elevators	880	1,005	1,101	1,045	1,016	1,099†
Cranes	1,051	1,091	1,192	1,198	1,288	—
Other mechanical handling equipment	878	1,052	1,129	1,168	—	—
Excavators and parts	735	808	816	943	944	—
Earth-moving equipment	316	488	659	797	850	—
Road rollers	166	158	145	166	180	—
Quarry plant	188	208	197	230	284	—
Pile-driving and well-drilling equipment	100	107	130	119	157	—
Asphalt and tar-macadam plant	123	116	136	147	173	—
Concrete-mixing and handling machinery	291	326	402	416	408	—
<i>By Quantity (thousands)</i>						
Clocks, mechanical	338	405	405	418	362	397†
" electrical	43	43	47	44	39	45†
Watches	74	115	135	149	139	158†
Works trucks, fork-lift	124	146	184	191	141	216†
" other	311	396	380	431	391	398†

* October only.

† October and November only.

TABLE II.—UNITED KINGDOM: EXPORTS OF SOME INDUSTRIES CLASSIFIED AS GENERAL ENGINEERING.

	Volume (Tons).				Value (1,000l.).			
	1938.	1949.	1950.	1951.	1938.	1949.	1950.	1951.
Air and gas compressors and exhausters	3,640	7,326	9,432	10,014	573	3,042	3,803	4,324
Boat and shoe machinery	456	872	931	903	165	624	714	718
Cement-making machinery	951	9,020	11,821	9,584	84	968	1,707	1,506
Centrifugal drying machinery	2,305	1,120	1,793	1,630	209	370	397	566
Concrete-mixing machinery	1,559	4,998	4,918	5,018	129	1,090	1,011	1,182
Condensers	1,998	1,827	1,643	1,998	296	518	492	654
Cranes, hoists and other lifting machinery	19,212	38,660	37,665	38,100	1,597	7,775	8,230	7,642
Dairy machinery	825	2,593	2,730	2,323	235	1,542	1,823	1,921
Excavating and similar digging machinery	5,776	37,911	29,855	37,532	681	7,942	6,859	9,824
Fans, power-driven	—	2,817	2,802	3,623	—	1,538	1,484	2,047
Food-preparation and sterilising machinery	2,331	8,010	10,010	8,380	376	3,511	4,584	4,131
Furnace plant	5,290	4,235	5,531	4,367	357	1,088	1,312	1,064
Gas and chemical machinery	4,166	15,454	12,683	8,686	329	3,668	3,143	2,032
Grain-milling machinery	1,975	6,972	7,698	15,112	326	2,123	2,465	4,386
Hydraulic machinery	2,503	1,813	2,340	5,271	253	508	538	1,255
Laundering and dry-cleaning machinery	1,141	5,436	13,984	20,800	149	2,139	5,121	8,908
Lawn mowers	760	3,320	6,910	752	138	818	1,447	1,835
Office machinery	986	2,585	3,573	4,584	638	3,941	5,968	9,245
Packing, packing and labelling machinery	319	2,070	3,402	3,379	188	2,190	2,797	3,117
Portable power tools	570	2,299	2,784	3,162	345	2,445	2,997	3,550
Printing and bookbinding machinery	4,139	13,170	15,719	13,730	1,039	7,816	10,013	9,816
Pulp and papermaking machinery	7,223	4,985	6,305	5,048	729	1,731	2,054	2,071
Pumps	8,299	19,023	21,416	22,921	1,561	7,327	8,344	9,819
Road rollers	2,709	4,159	4,610	4,184	253	1,015	1,202	1,072
Sewing machines and parts	11,709	15,045	15,731	17,821	1,262	4,979	5,998	7,032
Tobacco and cigarette-making machinery	983	2,166	1,963	2,287	522	2,071	1,945	2,419
Sugar-making and refinery machinery	8,363	18,910	13,390	12,129	566	2,989	2,337	2,327
Weighing machinery	2,138	4,061	4,717	5,612	259	1,063	1,306	1,512
Welding machinery	—	10,273	13,628	12,383	—	2,066	2,422	2,714
Woodworking machinery	1,441	5,688	5,567	5,747	231	2,079	2,053	2,200
Ball and roller bearings	1,691	3,077	3,193	3,199	646	2,513	2,531	2,471
Ophthalmic instruments	—	—	—	—	442	357	565	853
Medical and surgical instruments	—	—	—	—	465	1,973	2,186	2,492
All other scientific instruments	—	—	—	—	903	5,171	6,847	7,796
Clocks and watches	—	—	—	—	104	1,240	1,376	1,350
Total	105,487*	259,805*	278,744*	290,888*	16,050	92,230	108,071	125,851

* Excluding the last four categories.

increase as in the years 1948 to 1950, when industrial output was rising by 8 per cent. per annum. The rate of increase in production in the metals, engineering and vehicles group fell sharply during 1951, and by October output was no higher than in the same period of 1950. In the vehicle industry, it was actually 7 per cent. lower than in the corresponding period of 1950.

The Treasury attribute the fall in industrial output to the two main factors, namely, the shortage of industrial raw materials, mainly steel, and the

periods of allocations. Few large companies have actually reduced output because they lacked steel, and deliveries of most types in 1951 were some 400,000 tons higher than in 1950.

It may be exceedingly difficult to translate the restriction in home deliveries of plant, machinery and vehicles into an equivalent amount of earnings of foreign currency. Much of the onus for increasing engineering exports falls upon the motor-vehicle industry, but manufacturers, while not pessimistic, have no illusions about the difficulty of their task.

supplies that it has suffered. Since the value per ton of the output of office machinery is particularly high, the industry is always likely to obtain sympathetic treatment over its demands for steel. In 1951, the value per ton of exports was about 2,000%, compared with about 350% for cars.

Another industry which has been particularly successful in increasing exports is the cycle and motor-cycle industry; the total value of exports in 1951 was 42.6l. millions, compared with 32.2l. in 1950. The increase in exports of bicycles to the United States has been most spectacular, from 108,000l. in 1949 was 495,000l. in 1950, and 1.0l. million in 1951. The United States cycle manufacturers have been so disturbed by the success of British bicycles that they have asked the United States Tariff Commission to restrict the entry of foreign bicycles and to raise the tariff. It will be some time, however, before a decision is obtained. The results of a similar action taken by the United States motor-cycle industry, at the end of 1951, is still awaited. Because of its export successes, the British industry felt justified in complaining about the severity of the cuts in steel allocation in the first quarter of 1952. This varied in individual cases, but, according to Mr. H. R. Watling, director of the British Cycle and Motor Cycle Manufacturers' and Traders' Union, was about 40 per cent. of current usage. While, however, the cuts were very severe in the first instance, it now appears that the industry will obtain at least enough steel in 1952 to maintain its exports at the 1951 level and the supplies to the home market at about half the 1951 level.

Conditions in the export markets, meanwhile, have been deteriorating. Mr. S. R. Hogg, the chairman of Associated Motor Cycles, Limited, commenting on the cuts in the allocation of motor cycles to the home market by one-third, said, at the beginning of February, that this meant that the motor-cycle industry would have to increase still further its already high proportion of exports to justify an adequate allocation of raw materials to maintain full output. This might not be easy to achieve and he himself "would not like to say how long our export markets will continue to take all we can ship to them, in view of the rapid economic changes which are taking place throughout the world." Growing competition from Germany and Japan may accentuate the marketing difficulties of bicycle manufacturers. German exports are still comparatively small—159,156 bicycles in the period January to September, 1951—but this compares with 59,100 in the whole of 1951, and the increase is continuing. German prices are said to be slightly above the British, though the bicycles are of high quality.

Japanese exports have also been increasing in some markets, though this is thought to have been possible only because British bicycles are not available in sufficient quantity. The quality of Japanese bicycles has improved greatly, but they are 14 lb. or 15 lb. heavier than the British and somewhat more expensive. The growth of bicycle manufacture in the Dominions must, in the long run, restrict demand for British bicycles. Both Tube Investments, Limited, and Raleigh Industries, Limited, have opened factories in India. Raleigh Industries have now started production at a factory in Vereeniging in South Africa. Tube Investments are already making bicycles in that country and the Birmingham Small Arms Company are also planning to start production there.

Another industry which has made great progress in recent years is that producing conveying and handling equipment. Most Productivity Teams which have returned from the United States have emphasised the necessity of improved mechanical handling methods as the first step in increasing productivity in the United Kingdom. A team which visited the United States to investigate freight-handling methods reported in July and found no startling difference in achievement between the two countries. In this particular field, operators in the United States do not have the usual advantage over their British counterparts of longer runs and greater standardisation, since, in spite of the vast quantity of goods in movement at any one time, they cannot specify the size, weight or type of package which they are required to handle. It appears, however, that, though the scope for

mechanisation is thus reduced, it is adopted wherever possible and that "machine-consciousness" in this, as in other industries, is much more highly developed in the United States than in the United Kingdom. This, as the Team recognised, is due to no small extent to the high level of wages in the United States. The American worker in the transport industry, moreover, has little to lose from mechanisation since, unlike many of his British counterparts, he is normally paid on a time basis. This applies with particular force to dock workers, who have resisted mechanisation most, and who are generally paid at piece rates in the United Kingdom. Apart from particular refinements, and the much more extensive use of drag-lines, no types of mechanical handling plant were observed in the United States which were not already known in the United Kingdom.

The most interesting recommendations of the Team are that the potentialities for greater use in general transport of fork-lift trucks should be carefully considered in conjunction with the development of "palletisation" and unit load. "Palletisation" is widely developed in American factories and, as may be seen from the growing

the next 20 years, and, indeed, for some work, the "automatic factory" is already feasible. The Ministry of Supply recently placed contracts for the development of fully automatic machinery for making electronic valves, but the attainment of fully automatic control still requires large numbers of instruments which can only be manufactured at prohibitive cost. At present, only the oil and electricity industries offer wide and fairly immediate scope for automatic "master controllers" which can largely eliminate the human element at present engaged in watching gauges and operating controls.

A less spectacular branch of the instruments industry is that concerned with the manufacture of clocks and watches. As will be seen from Table I, the high level of output achieved in 1950 was fairly well maintained in 1951, despite some falling off in the third and fourth quarters of the year. Exports, valued at 1.3l. millions in 1951, were about the same as in 1950. Smith's English Clocks, Limited, have recently increased their capacity by transferring their alarm-clock production to a new factory at Wishaw, which has been designed to take full advantage of modern flow-production methods.

TABLE III.—UNITED KINGDOM: EXPORTS OF MACHINERY BY VALUE (£1,000).

To.	1938.	1948.	1949.	1950.	1951.
Irish Republic	1,609	7,900	7,560	7,947	9,584
Israel	186	1,376	1,118	1,552	2,004
British West Africa	1,059	3,442	4,297	4,762	5,140
Union of South Africa	7,503	20,528	22,258	22,550	29,477
Southern Rhodesia	442	1,915	3,096	3,217	4,071
British East Africa	505	5,339	6,886	5,525	5,389
India	7,836	36,086	42,298	33,777	31,741
Pakistan				5,505	7,419
British Malaya	1,692	3,393	3,821	3,927	6,988
Australia	4,812	19,306	23,944	30,912	43,956
New Zealand	1,692	7,625	7,281	8,473	10,062
Canada	1,558	4,909	4,961	8,497	12,228
U.S.S.R.	3,348	3,538	6,541	8,549	2,465
Finland	548	2,875	2,987	2,720	3,075
Sweden	1,028	7,434	6,903	9,606	10,790
Norway	405	4,649	5,748	5,564	5,047
Denmark	519	4,598	4,470	3,949	3,564
Poland	1,025	1,120	3,459	2,842	2,471
Netherlands	1,975	10,680	10,647	11,745	12,196
Belgium	894	7,040	6,884	7,202	8,252
France	1,423	8,230	7,115	7,591	10,482
Switzerland	285	2,441	1,933	1,914	2,427
Portugal	307	3,240	3,090	4,364	3,772
Spain	136	1,951	2,086	2,061	2,914
Turkey	608	3,021	2,511	2,478	4,279
Indonesia	330	2,599	2,685	2,171	1,927
Egypt	794	7,027	8,032	6,337	5,855
Iraq	432	3,823	3,265	2,186	2,310
Iran	1,157	3,598	6,073	5,656	3,704
China	1,013	2,447	666	602	658
United States of America	628	3,113	3,119	3,523	6,530
Venezuela	137	3,193	3,701	3,231	3,012
Brazil	1,226	6,455	8,648	9,684	13,064
Argentina	1,339	8,949	8,074	6,369	3,216
Other countries	9,417	19,077	42,524	45,504	52,932
Total	57,868	232,917	278,741	291,772	333,936

output of fork-lift trucks, is increasing in Britain, but its use in general transport in the United States is at as rudimentary a stage as in the United Kingdom. In practice, public ownership of rail and road transport may make it easier to extend palletisation in the United Kingdom. At present, the possibility of extension is being studied by sections of the transport industry, but the Team recommend the establishment of a Central Committee, consisting of representatives of railway, road transport, dock interests, manufacturers and the British Standards Institution, to secure the fullest exchange of information and experience.

The instrument industry has also an important part to play in increasing productivity. At a luncheon of the British Industrial Measuring and Control Apparatus Manufacturers' Association in July, Sir Kenneth Crawford, Controller of Supplies (Munitions), paid tribute to its achievements in this direction, as well as to its part in making possible great fuel economies. The association, which represents 90 per cent. of the industry making industrial instruments, was also congratulated on its performance in directly exporting 30 per cent. of its output. An international conference on automatic control mechanisms, held in August at the College of Aeronautics, Cranfield, received very little publicity. Most of the papers were concerned with particular applications and none attempted to review in general terms the progress of automatic control methods in industry or to assess the prospects for their further applications. Some enthusiasts visualise a second industrial revolution in

Its capacity is 80,000 alarm clocks a week, but, as Mr. Ralph Gordon Smith, chairman and managing director of S. Smith and Sons (England), Limited, said at the company's annual general meeting in December, this output cannot be achieved without the necessary volume and even flow of material, which is by no means assured and is causing the management considerable concern. Smith's watch production has expanded considerably both at Cheltenham and at the Welsh factory of the associated Anglo-Celtic Watch Company.

Structural engineers, who have very full order books, have even more cause for concern over the shortage of materials. Much of the work on hand is on re-armament account and for export, but a good deal of it is for normal civilian purposes such as electricity generating stations, hospitals, schools, offices and bridge building. So far as export work is concerned, the industry is fully committed for at least two years. The rapid industrial development of such countries as India, Pakistan and Brazil ensures the continuance of a high level of orders for a long time. Because of the shortage of steel and the irregular flow of components, the firms in the industry are particularly thankful for their heavy order books, since, if work is interrupted on any contract through a particular shortage, there are plenty of other contracts to fall back on. Rolled steel joists, which are required in large numbers for certain Government projects, are particularly scarce, as are also steel plates, and some types and sizes of nuts and bolts.

Manufacturers of pumps and pumping plant

ELASTO-PLASTIC STRESSES IN TRANSVERSELY-LOADED BEAMS.

145	145	145	145	145	145	147	136	120	126	128	117	108	100	91
-290	-290	-290	-290	-290	-290	-294	-322	-340	-302	-286	-234	-216	-200	-182
0	0	0	0	0	0	0	-50	-100	-50	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	50	200	400	600	800	1,000	1,200
109	109	109	109	109	109	106	87	69	83	94	90	83	77	65
-217	-217	-217	-217	-217	-217	-224	-218	-209	-204	-195	-179	-164	-149	-135
0	0	0	0	0	0	-2	-12	-45	-72	-46	-12	-2	-1	0
0	0	0	0	0	0	-3	-8	-9	-25	-23	18	16	16	16
-255	-1	-255	-1	-255	-1	-255	-8	-255	-7	-253	-2	-239	-8	-180
73	73	73	73	73	72	69	63	49	41	53	67	64	60	57
145	-145	-145	-145	-145	-146	-145	-139	-134	-126	-124	-117	-108	-98	-89
0	0	0	0	0	-2	-7	-13	-37	-48	-38	-17	-5	-2	1
0	0	0	0	0	-1	-3	-5	-3	14	29	32	30	28	27
-293	-1	-293	-1	-293	-5	-293	5	-291	-8	-282	4	-260	7	-201
37	37	37	37	37	36	33	28	19	21	33	40	43	43	40
-74	-74	-74	-74	-74	-73	-72	-70	-62	-58	-58	-59	-57	-53	-49
0	0	0	0	0	-2	-7	-15	-26	-32	-28	-17	-6	-2	0
0	0	0	0	0	-1	-3	-5	-3	14	29	32	30	28	27
-186	1	-186	1	-186	0	-186	3	-185	-5	-182	2	-172	-4	-147
1	1	1	1	1	3	8	16	23	31	34	36	37	36	36
-2	-2	-2	-2	-2	-1	0	2	5	7	6	3	1	0	0
0	0	0	0	0	-1	-2	-6	-11	-19	-20	-14	-5	-2	-1
0	0	0	0	0	1	4	10	18	28	33	36	37	36	36
-5	-5	2	-5	1	-5	4	-4	-3	-1	1	8	0	28	5
36	36	36	36	36	37	38	40	44	44	50	45	43	43	41
72	72	72	72	72	71	72	73	72	71	66	60	55	49	45
0	0	0	0	0	-2	-4	-6	-13	-11	-12	-10	-3	-2	-1
0	0	0	0	0	1	3	6	11	17	24	32	34	34	34
178	0	178	0	178	0	178	7	180	0	186	-11	148	9	223
73	73	73	73	73	73	73	73	72	71	66	60	55	49	45
146	146	146	146	146	144	142	139	135	130	123	114	106	96	87
0	0	0	0	0	-2	-3	-7	-13	-11	-12	-10	-3	-2	-1
0	0	0	0	0	1	3	6	11	17	24	32	34	34	34
289	-1	289	-1	289	-1	289	-8	289	4	291	1	296	11	308
110	110	110	110	110	110	109	108	105	102	97	91	85	78	71
219	219	219	219	219	219	217	214	208	200	190	179	166	153	139
0	0	0	0	0	0	-1	-2	-4	-8	-11	-13	-15	-16	-16
0	0	0	0	0	1	2	4	8	13	18	23	27	27	28
254	0	254	0	254	0	254	0	254	-7	254	-2	255	-4	258
146	146	146	146	146	146	146	145	142	137	130	121	112	103	94
292	292	292	292	292	292	292	290	284	274	260	242	224	206	188
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

is introduced and computed for each point. R is known as the residual, and the problem is solved when the residuals have been reduced to arbitrarily small values. This can be performed quite systematically by means of the relaxation pattern shown in Fig. 2 (a), page 359. It will be seen from equation (4)—remembering that ϕ_0 for any one point will be ϕ_a or ϕ_b and so on for other points—that, if the value of ϕ_0 is changed by one unit, the residual at 0 will be changed by -20 , the residuals at 1, 2, 3, 4 by $+8$, at a, b, c, d by -2 , and at a, b, c, d by -1 .

The numerical total of the residuals is hence unchanged by any relaxation process for a completely internal node; however, if the node is adjacent to a boundary (where the values of ϕ are fixed in the problems presented here), some of the residuals are "lost" on relaxation. Fig. 2 (b), for example, shows the relaxation pattern adjacent to a boundary; the reason for a residual of -21 instead of -20 at the relaxed node is given below. The procedure is, in fact, to work from the centre of the field and to eliminate unwanted residuals at the boundary.

With reference again to Fig. 1: if terms in l^4 and higher are neglected in the Taylor's expansion, the stresses from equation (2) are given with sufficient accuracy by

$$\left. \begin{aligned} \bar{x}x &= \frac{1}{l^2} (\phi_2 + \phi_4 - 2\phi_0) \\ \bar{y}y &= \frac{1}{l^2} (\phi_1 + \phi_3 - 2\phi_0) \\ \bar{x}y &= -\frac{1}{4l^2} (\phi_A - \phi_B + \phi_C - \phi_D) \end{aligned} \right\} \quad (5)$$

These stresses may be determined more exactly by using the values of ϕ at neighbouring points, for example, ϕ_b and ϕ_d in the expression for $\bar{x}x$, or the errors in the finite difference theory may be estimated*; for the present purposes, equations (5) will be used to calculate stresses.

The criterion of yield assumed in this article is that of maximum shear stress with a stress-strain curve of the type shown in Fig. 3, page 359. Yield occurs at a stress q_0 , and further straining produces distortion at constant stress. Yield in the third

Fig. 6.

Max. Shear Stress
xx Stress
yy Stress
Shear Stress
Value of ϕ Residual

(a+b+c)

direction is ignored (plane strain), so that the stresses in the plane under consideration combine to give the breakdown criterion

$$q_0 = \left\{ \left(\frac{\bar{x}x - \bar{y}y}{2} \right)^2 + (\bar{x}y)^2 \right\}^{\frac{1}{2}} \quad (6)$$

On substitution for the stresses from equations (5), this becomes

$$q_0 = \frac{1}{l^2} \left[\frac{1}{4} \{ (\phi_1 + \phi_3) - (\phi_2 + \phi_4) \}^2 + \frac{1}{16} \{ (\phi_A + \phi_C) - (\phi_B + \phi_D) \}^2 \right]^{\frac{1}{2}} \quad (7)$$

Further discussion of the assumptions made in deriving this criterion is given below. For an elasto-plastic distribution of stress, equation (7) overrides $\nabla^4 \phi = 0$ in the portions of the field where yield occurs.

The stress distributions in the two beams of the dimensions shown in Fig. 4, page 359, have been determined by relaxation methods, under the assumption of plane strain. The loads are distributed over short lengths $2l$, since a concentrated force would produce a discontinuity in the ϕ function. Due to symmetry, it is necessary to consider only one half of the beam and the net employed was 28×8 of mesh length l . Approximate solutions were obtained for 7×2 and 14×4 nets, and the additional values of ϕ required for the final relaxa-

tion were interpolated from the values given by these coarser nets.

The boundary conditions for the problems are fairly simple. Considering Fig. 4 (a), for the four-point loading, along an unloaded face of the beam it is required that the normal tensile stress and the shear stress should both be zero. For the face B C, for example,

$$\left. \begin{aligned} \bar{x}x &= 0 \\ \bar{x}y &= 0 \end{aligned} \right\} \quad (8)$$

Substitution of the stresses from equations (2) gives immediately that ϕ is a linear function of y along B C, and, by similar considerations, ϕ is a linear function of x along the unloaded portions of the faces A B and D C. Under the uniformly distributed loads on these faces, ϕ may be expressed in terms of a quadratic in x .

Since the problem is essentially one of obtaining curvatures, some of the constants of integration arising in the determination of the boundary conditions may be chosen arbitrarily, and, for the

examples solved here, ϕ and $\frac{\partial \phi}{\partial x}$ were both made zero at the points A and D, leading to the boundary conditions shown in Fig. 5, on page 359. At the corners B and C, not only must ϕ be continuous, but also $\frac{\partial \phi}{\partial x}$ and $\frac{\partial \phi}{\partial y}$ must be continuous; and, in addition, the value of $\frac{\partial \phi}{\partial x}$ must

be constant along B C, and the value of $\frac{\partial \phi}{\partial y}$ constant along A B and D C, in order that the condition of zero shear on the boundaries may be fulfilled. This condition is achieved by extending the relaxation net to a row of fictitious nodes outside the boundary; the values of ϕ at these fictitious nodes are determined by adding a constant to the values at the corresponding nodes just inside the boundary. (When relaxing a point adjacent to the boundary by one unit, the corresponding fictitious node is also relaxed by one unit, introducing an extra residual of -1 at the point relaxed, so that the total change in residual there is -21 .)

Tables on this and the opposite pages show the completed elastic relaxation of the beam under four-point loading, giving the residuals, rectangular

* L. Fox, *Proc. Royl. Soc. (A)*, 190 (1947).

ELASTO-PLASTIC STRESSES IN TRANSVERSELY-LOADED BEAMS.

82	72	64	55	46	37	27	18	10	5	2	0	0	0
-164	-144	-128	-110	-92	-74	-54	-36	-20	-10	-4	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,400	1,600	1,800	2,000	2,200	2,400	2,600	2,800	3,000	3,200	3,400	3,600	3,800	4,000
60	56	50	44	37	31	25	20	14	9	5	2	1	0
-115	-108	-95	-81	-67	-53	-41	-30	-21	-12	-5	-2	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	16	16	16	16	16	15	14	11	8	5	2	1	0
1,082	-5	1,273	-1	1,464	3	1,655	0	1,846	0	2,037	-10	2,227	1
2,418	-1	2,610	13	2,805	3	3,002	-8	3,200	4	3,400	-6	3,600	0
48	45	41	38	35	32	28	25	18	14	9	5	1	0
-81	-71	-61	-52	-43	-35	-27	-19	-12	-7	-4	-1	0	0
-1	0	1	0	0	0	0	0	0	0	0	0	0	0
27	27	27	28	27	27	25	22	18	14	9	5	1	0
885	7	1,054	-2	1,223	-8	1,391	-2	1,559	-4	1,727	-2	1,895	3
2,066	-2	2,241	-1	2,422	-1	2,609	5	2,802	-2	3,000	-3	3,200	0
39	38	38	37	35	34	31	29	26	18	12	7	3	0
-40	-36	-31	-26	-21	-16	-12	-7	-2	1	1	0	0	0
0	0	1	0	0	0	0	0	0	0	0	0	0	0
34	34	35	35	34	33	31	29	26	17	11	5	2	0
769	-5	906	3	1,043	-3	1,179	-2	1,315	-2	1,452	-10	1,590	2
1,733	-1	1,884	-4	2,046	-5	2,220	-1	2,405	8	2,600	0	2,800	0
36	36	37	37	37	36	35	33	30	23	15	9	4	0
-1	-1	-2	-2	-2	-1	2	4	6	8	7	3	0	0
0	1	1	0	0	0	0	0	0	0	0	0	0	0
36	36	37	37	37	36	35	32	27	18	10	5	1	0
613	-1	794	-3	894	4	993	1	1,092	4	1,193	2	1,297	-11
1,407	-5	1,529	2	1,669	-1	1,830	-11	2,008	3	2,200	9	2,400	0
39	38	38	36	36	36	36	36	34	29	13	11	5	0
37	34	30	24	18	14	10	10	13	13	9	4	1	0
0	1	2	0	-2	-3	-8	-16	-25	-33	-26	-17	-8	0
34	34	34	34	35	35	35	34	28	17	5	-1	-1	0
618	6	683	-2	747	-9	809	1	871	9	935	-1	1,002	11
1,077	6	1,168	-8	1,284	5	1,433	-3	1,608	0	1,800	1	2,000	0
48	44	40	37	34	34	34	37	39	35	22	10	4	1
79	69	60	51	42	32	24	17	17	16	8	1	0	0
1	0	1	0	0	-3	-6	-17	-35	-49	-36	-18	-6	42
28	28	27	27	27	29	30	33	29	14	-1	-5	-2	0
506	-4	538	10	570	4	601	6	632	-1	663	9	697	-5
737	6	794	-7	886	2	1,027	-1	1,204	2	1,399	-4	1,600	0
64	57	51	44	39	32	28	29	38	41	23	8	1	2
124	110	96	83	70	55	39	23	12	8	-1	-6	-3	0
0	0	0	0	1	-1	-3	-11	-46	-72	-45	-13	-3	4
16	16	16	16	16	16	19	24	25	9	-8	-7	-1	0
315	3	324	1	333	4	342	2	351	-7	359	2	368	4
380	-6	403	10	472	-1	513	-3	599	8	698	7	800	0
85	76	67	58	49	41	32	20	22	28	12	1	2	0
170	152	134	116	98	82	64	40	0	-44	-26	0	4	0
0	0	0	0	0	0	0	0	0	-100	-50	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	50	200	400	600	800

stress components and maximum shear stress. The locations on the diagram of these values are shown in Fig. 6, opposite. The numbers giving ϕ were chosen arbitrarily to produce a normal stress of 200 units under the loading points; with these loads, the compressive bending stress at A given by the usual simple theory is 150 units. In fact, it will be seen that the computed stress there is 146. Applying Fox's method of correction, however, brings the stress almost exactly to 150. Since the present work is concerned with a general illustration of the state of stress, it was thought unnecessary to apply the corrections to the results obtained with the relatively coarse net employed.

(To be continued.)

INSTRUCTION IN THE USE OF PORTABLE ELECTRIC TOOLS.

A NOVEL method of attracting the interest of workpeople in the more efficient use of tools—with results that, in the long run, can only be beneficial to themselves, their employers and the nation—has been adopted by Messrs. Wolf Electric Tools, Limited, Hanger-lane, London, W.5, makers of portable electric tools. They have produced a film strip, in colour, which depicts, in an attractive way, a number of significant factors in the productive use of such tools. Plans are being made to show the film strip, accompanied by an address by a representative of the firm, in industrial centres in the United Kingdom. The experiment has already been tried with success; at Reading recently 500 operatives attended a presentation of the film strip. The firm are confident that the novel appeal of the idea will attract workpeople to attend in their own time.

The film strip presents the facts in a readily assimilable form. There is, for example, the importance of using the correct size of electric drill; a tool of the wrong size leads to wasted power and slower drilling. A drill incorrectly ground—and there are many incorrect ways of grinding a drill, but only one right way—likewise wastes power and time. Other relevant factors in using electric drills, such as the proper method of holding them and supporting them, come readily to mind; they are in fact elementary, but they are frequently ignored by operatives, who thus need educating by a method, such as this film strip and address provide, which is at once instructive and acceptable to men who naturally regard themselves as

expert in their trade. Each showing of the film strip is followed by refreshments and a discussion, and a practical demonstration is given of some of the points raised in the address. The firm believe that industrial productivity will be improved by their innovation to an extent which, though small from the national point of view, is by no means negligible in the engineering industry.

KIRK O' SHOTTS TELEVISION TRANSMITTING STATION.

WITH the official opening of the Kirk o' Shotts transmitter of the British Broadcasting Corporation by the Secretary of State for Scotland, on Friday, March 14, a regular television service has been brought to a large area of central Scotland for the first time and the B.B.C. have made a further important advance towards its avowed goal of bringing television within the reach of 80 per cent. of the population of Great Britain by 1954. For the present, the new station is operating on the relatively low power of 5 kW for vision and 2 kW for sound, using transmitters which will ultimately be retained only for emergency use. Preliminary tests of field strength, however, and experimental broadcasts, showed that the power was adequate to provide a satisfactory service over a large area, including the cities of Edinburgh and Glasgow. When the 50-kW vision transmitter and its associated high-power sound transmitter come into operation later in the year, the Kirk o' Shotts installation will be the most powerful television station in the world and will serve a population of over 4,000,000.

The station is situated on high ground between Edinburgh and Glasgow at a distance of about 17 miles from the latter. The site is 900 ft. above sea level and, the mast being 750 ft. high, the sound and vision aërials are both over 1,600 ft. above sea level. Since much of the service area, especially that lying to the north, is hilly, a high aerial is particularly important. The station itself covers an area of about 25 acres. The main building, which is in a local brick with stone dressings, is an L-shaped structure similar in design to those which house the Sutton Coldfield and Holme Moss transmitters, previously described in our columns.* One wing is for the high-power transmitters and their associated equipment, on which installation work is still in progress, and the other contains offices, a staff canteen and a viewing room

in which the quality of the transmission can be assessed. The low-power transmitters are in an annexe and form a completely separate installation.

The aerial masts, of which there are two, were supplied by British Insulated Callender's Construction Company, Limited, Bloomsbury-street, London, W.C.1, who constructed similar masts for the stations at Holme Moss and Sutton Coldfield. The main mast, as already noted, is 750 ft. high and weighs 140 tons. It is stayed at four levels by three locked-coil steel wire ropes spaced at 120 deg. round it, the longest stay being 860 ft. in length. The total weight of the stays, which have circumferences ranging from 4½ in. to 6 in., exceeds 21 tons and the maximum breaking strength is 210 tons. When the components of the tensions in the stay ropes and various additional loads referred to later are added to the weight of the mast, the total downward thrust on the support is 336 tons. The structure has been designed to withstand a wind force of 80 tons, corresponding to an 80-m.p.h. wind at the base rising to 120 m.p.h. at the top, under which conditions the masthead would be displaced 7 ft. 6 in. from the perpendicular. Allowance has also been made for the effect of 2½ tons of ice distributed over the mast as a coating ½ in. thick.

For the first 610 ft., the mast is of triangular section, each side measuring 9 ft. The succeeding portion, extending for 100 ft., is cylindrical and slotted, so that it would form an aerial suitable for sound broadcasting on very high frequencies, should the B.B.C. decide to introduce such a service in the future. The final portion of the mast carries the two tiers of vertical dipoles which form the combined vision and sound aerial. These were supplied by Marconi's Wireless Telegraph Company, Limited, Chelmsford. Each dipole incorporates an electric heater, controllable from the ground, and employed as a safeguard against icing. The 150-ft. mast, which is separate from the other, supports a system of aërials which would be used in an emergency should the main aerial or transmission line fail. The emergency aërials have separate feeders, and switches are provided to effect a rapid change-over from the main to the stand-by system.

At Kirk o' Shotts, as at Holme Moss, the outputs of the main vision and sound transmitters are combined at ground level and a single transmission line is used to convey this combined output to the common aerial system at the top of the mast. The latter transmission line, which was designed and constructed for the B.B.C. by Electric and Musical Industries, Limited, Blythe-road, Hayes, Middlesex, is of novel construction. It is a coaxial cable of the copper-tube type, but the inner tube has been replaced by a locked-coil wire

* ENGINEERING, vol. 168, page 661 (1949), and vol. 172, page 459 (1951).

rope, the outer layer of wires being of high-conductivity copper. This rope, together with the 5-in. diameter copper tube which forms the outer conductor, is suspended as a pendulum from a support at the top of the mast and the lower end of the rope is tensioned by a loading mechanism which applies a load of approximately two tons. The rope is maintained coaxial with the outer conductor by small insulators in the form of rods, spaced at 120 deg. when the cable is viewed endwise, and distributed along its length at suitable intervals. This type of transmission line has a high electrical uniformity which is particularly important when wide-band television signals have to be conveyed.

The low-power transmitters were built by Marconi's Wireless Telegraph Company, Limited, who supplied similar equipment to other television transmitting stations of the B.B.C. and who also supplied the 45-kW high-power transmitter at Holme Moss. The low-power vision transmitter at Kirk o' Shotts is of the low-level modulated type and operates on a frequency of 56.75 megacycles per second; that is, on a wavelength of 5.3 m., approximately. The peak white output-power is 5 kW. The radio-frequency section comprises a crystal-controlled drive which has five stages of amplification of multiplication and provides an output of 5 watts to an amplifier which is the first of four. The second is the modulated amplifier, formed by two tetrodes in push-pull. Its output is twice amplified in two class-B wide-band linear amplifiers, each fitted with two air-cooled triode valves of type BR 191. The main radio-frequency cabinet is illustrated in Fig. 1, which also shows the air ducts leading to the valves. The output circuit and the inter-stage couplings between the modulated, penultimate and final amplifiers incorporate double-tuned circuits with mutual inductive coupling to give maximum bandwidth and the required vestigial characteristic. In the case of the high-power transmitter, the shaping of the vestigial side-band signals will be accomplished in a separate vestigial side-band filter.

The modulator is preceded by a pre-amplifier consisting of three video amplifiers and their associated equipment. The video input passes to the first amplifier by way of an attenuator on the control desk, illustrated in Fig. 2, opposite, which controls the depth of modulation. In the first amplifier, the signal is raised to a level at which black clamping is practicable and then passes to the second amplifier, in which picture pre-distortion is applied to correct for non-linearity in the transmitter. Synchronising pulse stretching is effected by a feedback system from the third to the second amplifier. The modulator consists of an input cathode-follower stage, a fourth amplifier and an output cathode-follower. With the exception of the valves in the modulated amplifier and the linear amplifiers, which derive their heater supplies from metal rectifiers, all the valve filaments are heated by alternating current. The high-voltage supplies for the transmitter are obtained from hot-cathode mercury-vapour rectifiers which provide a maximum of 3,000 volts for the anodes of the linear class-B amplifiers.

The sound transmitter is of conventional design and has an output power of 2 kW. It radiates on a frequency of 53.25 megacycles per second, that is, a wavelength of 5.635 m., approximately. High-level class-B amplitude-modulation is employed. As in the case of the vision transmitter, the crystal-controlled drive and the power conversion equipment are built in as an integral part of the transmitter, and the various circuits are interlocked by means of a system of relays and contactors so as to provide complete protection for the equipment. In addition, an electro-mechanical interlock system ensures full protection for the operators.

The outputs of the two transmitters are fed by $3\frac{1}{4}$ in. diameter rigid coaxial copper feeders to a combining unit located close to the transmitters. In this, the outputs are combined in a bridge network, which acts as a switching filter, and the combined outputs are taken by way of another $3\frac{1}{4}$ in. diameter feeder to a 5-in. diameter coaxial change-over switch situated in the main 5-in. diameter feeder of the aerial. A second change-over switch is situated at the base of the mast. The output feeder and combining filter are illustrated in Fig. 4, opposite.

Both transmitters are contained in sheet-steel cubicles mounted side by side, as illustrated in Fig. 2. The three cubicles on the left of the illustration contain the 2-kW sound transmitter, and the five on the right the 5-kW vision transmitter. The air-blast cooling equipment and the combining filter are situated behind the transmitter cubicles which are built into a soundproof partition wall in order to isolate the noise of the air-blowers from the control desk. The arrangements for valve cooling and ventilation were carried out by Messrs. Rosser and Russell, Limited, 30, Conduit-street, London, W.1; the combining filter unit was supplied by Marconi's Wireless Telegraph Company, Limited.

The two transmitters are controlled and monitored from the control desk which contains a waveform

monitor and two picture-monitors, as well as the conventional controls and meters. The two picture-monitors enable the incoming signals to be compared with those radiated. Programme switching on both the sound and vision circuits is also accomplished at the control desk. The controls of each transmitter are sequence-interlocked, which means that it is impossible to apply the various power supplies otherwise than in the correct order and, when it is important, at the appropriate time intervals. Adjacent to the control desk is the vision and sound input equipment and the waveform-generating equipment, which is used to provide a variety of signals for testing, lining up and maintaining the characteristics and performance of the vision transmitter.

The visual programme is received at the station over a distribution network maintained by the General Post Office Engineering Department. When a programme originating in London is being radiated, the vision signal is conveyed by coaxial cable to Manchester via Birmingham and thence by a micro-wave radio link. Much of the equipment used for this purpose was designed, developed and installed by Standard Tele-

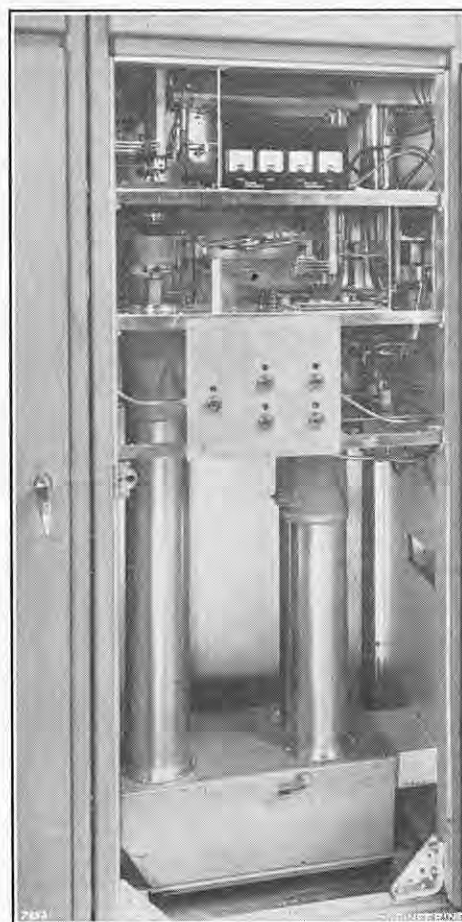


FIG. 1. VISION TRANSMITTER: MAIN RADIO-FREQUENCY CABINET.

phones and Cables, Limited, Connaught House, Aldwych, London, W.C.2. Between London and Birmingham, a distance of just over 121 miles, runs the main cable consisting of two 0.975-in. diameter and four 0.375-in. diameter coaxial tubes. The larger tubes are used for the two-way transmission of 405-line television signals requiring a bandwidth of three megacycles per second and the smaller tubes are used for broadcast telephony, each pair being capable of carrying 600 speech circuits. G.P.O. repeater stations are situated at intervals along the route. From Birmingham to Manchester there is another coaxial cable containing six 0.375-in. diameter tubes, of which two are used for the video signals. As in the previous case, repeater stations are situated along the route. Beyond Manchester, the cable extends through Hyde to Mottram and thence to Holme Moss, the last section consisting of a two-tube coaxial spur cable containing, besides the two 0.375-in. diameter coaxial tubes, four screened pairs for the transmission of music and 24 paper-insulated quads for repeater-station control.

Vestigial sideband terminal equipment, supplied by Standard Telephones and Cables, Limited, is used to translate the video signals to a frequency band suitable for transmission over the coaxial cable. Vestigial side-band control consists in modulating the video band on a carrier, and transmitting over the cable the whole of one side-band and a vestige of the other side-band. This small, but nevertheless significant, relic of the side-band enables the video-frequency band to be

adjusted without increasing the width of the transmitted band much beyond that of the video band. Moreover, it obviates the difficult technical problems involved in transmitting television signals having only one side-band.

The transmission of programmes between Manchester and Kirk o' Shotts is accomplished by means of a two-way micro-wave radio link which operates according to the principles of beamed micro-wave transmission. The carrier frequency is approximately 4,000 megacycles per second, corresponding to a wavelength of 7.5 cms. The whole of the 250-mile path between the two terminal stations is an optical one and was surveyed and calculated beforehand. The distance to be covered made it necessary for there to be seven repeater stations along the route, which runs across England from Manchester to the neighbourhood of Northallerton and thence up the North-East Coast to Edinburgh, and inland to Kirk o' Shotts. Both terminals and all the repeater stations have their own receiving and transmitting antennae and associated equipment. The antennae are supported on steel towers, which range in height from 20 ft. to 200 ft., and consist of wave-guide horns which feed or are fed by circular paraboloidal reflectors of 10 ft. diameter. The photograph reproduced as Fig. 5, opposite, shows the antennae of the final repeater station at the Scottish end of the chain situated on the Blackford Hill, Edinburgh. The arrangement is typical of that at the other repeater stations, the four paraboloids being for transmission and reception in both directions. At the terminal stations, there are, of course, only two paraboloids.

On arrival at the first repeater station, the frequency-modulated wave is passed by means of the waveguide feed from the paraboloidal reflector to a super-heterodyne receiver. This receiver employs a crystal-controlled oscillator operating at a frequency 60 megacycles per second above the mid frequency of the incoming signal, or 57 megacycles per second above the frequency of the incoming synchronising pulses, to produce an intermediate-frequency band centred on a frequency of 60 megacycles per second. The signals at the intermediate frequency are amplified in an amplifier fitted with automatic volume-control and translated to a radio-frequency which is 37 megacycles per second above or below the incoming radio-frequency signals. The second oscillator which accomplishes this is maintained at a frequency 37 megacycles per second above or below that of the first oscillator by means of an automatic frequency-control. The unwanted products of this last frequency conversion are eliminated by means of a filter, and the single side-band required is amplified by means of a travelling-wave amplifier to a power of 1 watt and passed to the transmitting antenna.

This process is repeated at each repeater station until the terminal of the link is reached. Once again, the high-frequency wave-band from the antenna is fed to a superheterodyne receiver, equipped with a crystal-controlled local oscillator, which translates the signals to an intermediate-frequency band centred on a frequency of 60 megacycles per second. Thereafter, however, the output from the intermediate-frequency amplifier is frequency-demodulated in a discriminator which converts the frequency-modulated intermediate-frequency band to a video-frequency. It is then available as an input to a television transmitter or for passing on either directly by means of a further radio link or indirectly, through vestigial side-band equipment, to a coaxial-cable network.

It was mentioned above that the signals transmitted by a repeater station are centred on a radio-frequency which is 37 megacycles above or below that of the incoming signals. This switching up and down of the frequency is employed as a means of avoiding mutual interference, which could result from multiple-path effects. Thus, two basic radio frequencies, differing by 37 megacycles per second, are employed in alternate directions on alternate sections of the micro-wave radio link.

The wave guides and wave-guide circuit elements, such as attenuators, filters, junctions and switches carrying the high-frequency waves, have a rectangular cross-section, measuring 2 in. by 0.5 in., approximately, and are made of either brass or copper. The waveguides which run from the equipment in the repeater and terminal stations to the horn feeds of the paraboloids are filled with dry nitrogen maintained at a pressure slightly above atmospheric in order to preserve the inner surfaces of the guides free from corrosion. Since it would be inconvenient to employ nitrogen for this purpose within the equipment racks, which would then require to be hermetically sealed, the wave-guide surfaces there are protected by gold-plating.

To ensure a high degree of reliability, practically all the equipment, with the exception of the paraboloidal reflectors and the main wave-guides feeding them, is duplicated. The change-over from one set of equipment to the corresponding stand-by set is automatic

KIRK O' SHOTTS TELEVISION TRANSMITTER.



FIG. 2. CONTROL DESK AND MEDIUM-POWER TRANSMITTERS.

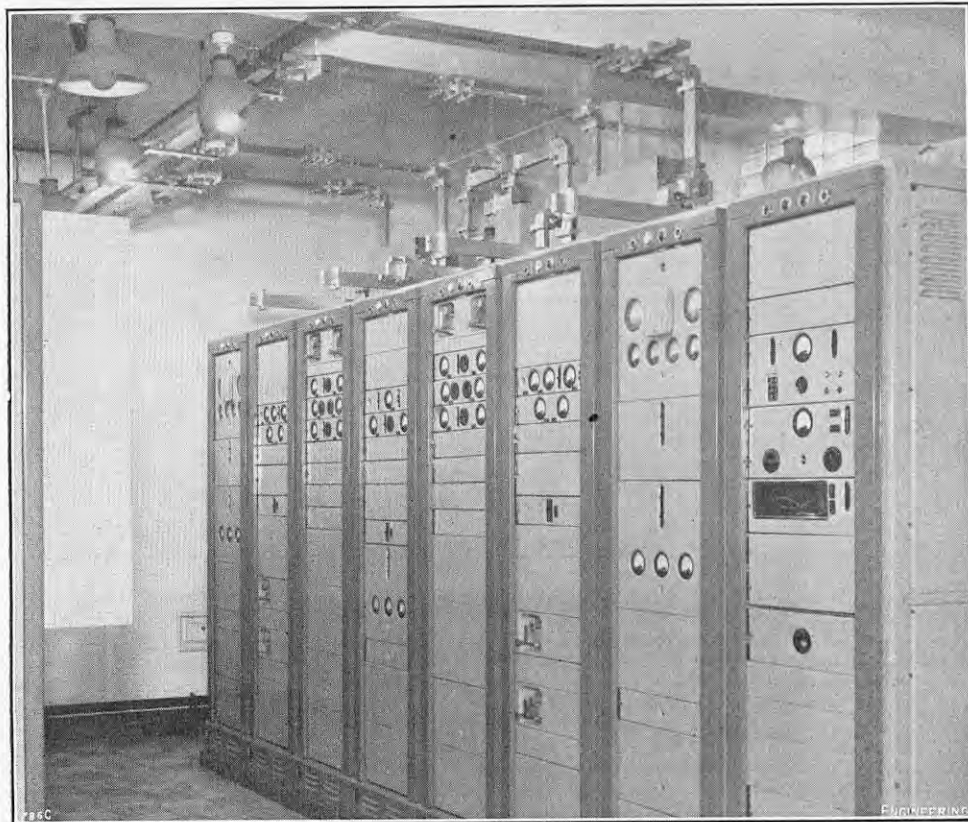


FIG. 3. REPEATER-STATION EQUIPMENT.

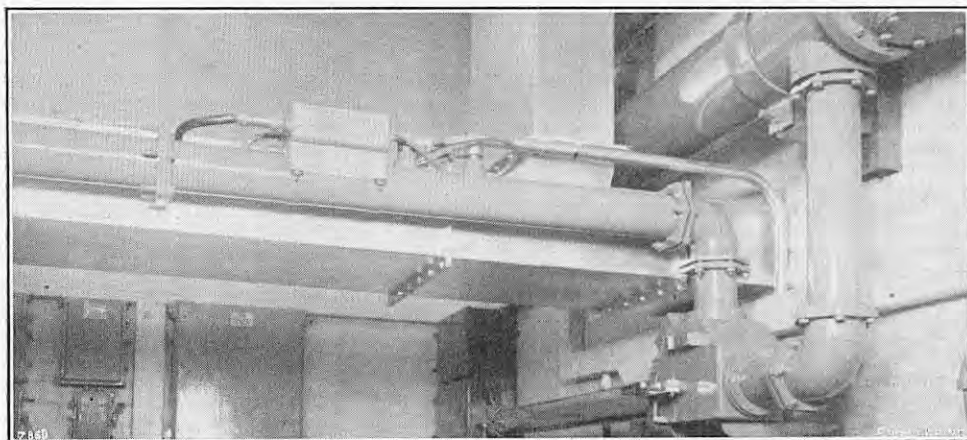


FIG. 4. OUTPUT FEEDER AND COMBINING FILTER.



FIG. 5. MICRO-WAVE ANTENNAE ON BLACKFORD HILL, EDINBURGH.

should a breakdown occur. Automatically-operated Diesel-engine alternator sets have also been provided as stand-by sources of power, in case the power obtained from the local supply-mains should fail. The photograph reproduced as Fig. 3, opposite, is typical of the arrangement of the equipment within a repeater station. The cubicles shown contain a complete set of receiving and re-transmitting equipment for both directions of reception and transmission. The stand-by set of the same equipment is mounted back-to-back with that shown. The arrangement of wave-guides used to convey the signals can be seen above the cubicles. There are four main-line feeders to and from the transmitting and receiving antennae, and wave-guide switches communicating with either the main or the stand-by equipment.

The repeater stations are designed to work unattended, and provision is made for remote switching of the equipment from the control stations at both Kirk o' Shotts and Manchester, where the state of the equipment at each station is displayed on a control board. The remote-control desks incorporate testing and monitoring equipment designed and manufactured by Messrs. Kolster-Brandes, Limited, Foots Cray, Sidcup, Kent. The operation and maintenance of the micro-wave radio link, as of the coaxial-cable relay network, is the responsibility of the Post Office Engineering Department; the terminal building at Kirk o' Shotts is separate from those occupied by the B.B.C.

The power for operating the station is brought by duplicate feeders from the South West Scotland Electricity Board's 11,000-volt, three-phase, 50-cycles per second network, and the pressure is reduced to 415 volts by means of two 500-kVA step-down transformers. These were supplied by the English Electric Company, Limited, Queen's House, Kingsway, London, W.C.2. The high-voltage switchgear was supplied by Switchgear and Cowans, Limited, Elsinore-road, Old Trafford, Manchester, 16, and the main low-voltage switchgear by the Brush Electrical Engineering Company, Limited, Loughborough. The transformers, switchgear and metering equipment are installed in the annexe building mentioned previously.

ACOUSTIC SHROUD FOR LEYLAND "ROYAL TIGER" VEHICLES.—A greater degree of quietness has been obtained on Leyland Royal Tiger underfloor-engined buses and coaches by fitting acoustic shrouds which extend along both sides of the power unit. The shrouds are designed to absorb sound and, at the same time, deflect sound waves which otherwise would strike the surface of the road and echo upwards along the sides of the vehicle. On some road surfaces, such echoes can prove extremely persistent and even a slight mechanical noise can be magnified out of all proportion to its original intensity. The shrouds are made either from 18-gauge aluminium or zinc-coated sheet steel and are lined with thick linoleum. They are supported by steel angle brackets and held in position by spring clips, the design being such that they can be removed easily to gain access to the engine.

PRODUCTION OF MEDIUM-SIZE DIESEL ENGINES.

J. AND H. McLAREN, LIMITED, LEEDS.

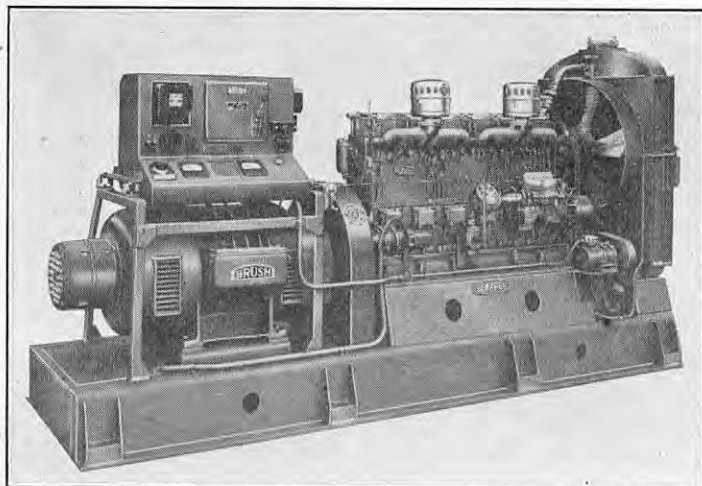


FIG. 1. 85-KW DIESEL GENERATING SET.

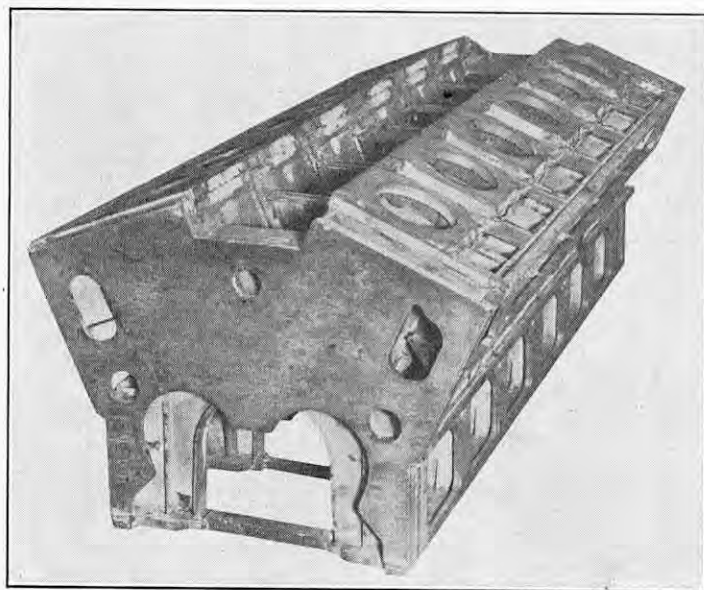


FIG. 2. FABRICATED CYLINDER BLOCK.

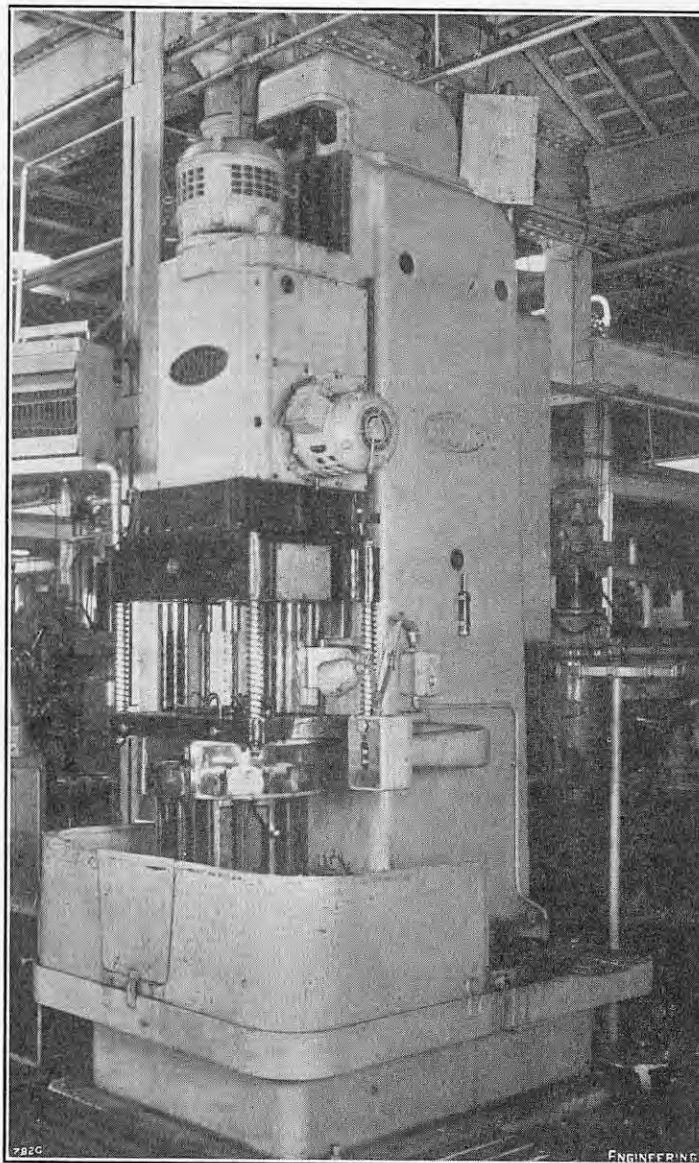


FIG. 3. DRILLING BOLT HOLES IN CONNECTING RODS.

THE AIREDALE WORKS OF J. & H. McLAREN, LIMITED.

THE history of Messrs J. and H. McLaren, Limited, dates back to 1876, when John and Henry McLaren founded the firm and began the manufacture of steam-driven vehicles and machinery at the Midland Engine Works, Leeds. Originally, the emphasis was on the production of agricultural machinery, with particular reference to steam ploughing engines and traction engines, and by 1878 they were exporting traction engines to Zanzibar. As time went by, other activities were taken up and in 1891 the firm commenced the construction of triple-expansion steam engines for the generation of electricity, sets being installed subsequently at Leeds, Huddersfield, Coventry, Wakefield, Oxford and Hammersmith, to mention but a few. In the ensuing period, machinery of all types was exported to many different parts of the world, and, at the same period, the scope of their activities widened to include the production of petrol and paraffin engines. Shortly after the firm celebrated its golden jubilee, an agreement was entered into with Daimler-Benz for the manufacture under licence of the well-known Benz-type airless-injection Diesel engine. This engine was developed steadily over the years and the range of models increased, the duties on which they were employed ranging from marine propulsion to the powering of excavators, cranes, road rollers and light locomotives. The year 1938 saw the introduction of an important modification with the fitting of the Ricardo Comet combustion head to a full series of medium-sized engines ranging in output from 44 brake horse-power from two cylinders to 176 brake horse-power from eight cylinders.

During the second World War, the company were fully occupied in meeting the requirements of the Services, and supplied a large number of Diesel engines for

many different duties. As time went by, it became more and more obvious that the factory would have to be extended considerably if the demand for engines was to be met. In 1945, the opportunity occurred to acquire the adjoining Airedale works of Kitson and Company, a firm which had played a large and important part in the development of the steam locomotive, having produced in their time more than 6,000 main-line locomotives. When Messrs. J. and H. McLaren took over the Airedale works, they retained their original Midland works and had at their disposal, as a consequence, a floor area of approximately 15 acres. They were faced, however, with the task of restoring the old buildings constituting the Airedale works, resiting much of the existing machinery, installing new machine tools and laying down production lines. This work was soon put in hand, and by 1949 the labour force had grown to 1,400 with a weekly output of 200 engines, compared with a labour force of 300 in 1939 and a weekly output of 10 engines. It was also in 1949 that the firm became a member of the Brush-A.B.O.E. group. It is understood that at present the total number of employees exceeds 1,900 and that the turnover is more than twelve times that of 1946.

Although the reorganisation of the Airedale works temporarily prevented alterations to engine design, development was by no means entirely overlooked. Last year, for example, the M.R. series of engines was largely re-designed and the Ricardo Comet head replaced by a direct-injection head. Now designated the M series, the new range of engines is capable of performing a wide variety of duties ranging from driving generators to marine propulsion. Several sizes are available, extending from a two-cylinder model developing 44 h.p. at 1,000 r.p.m. on the twelve-hour rating to an eight-cylinder model developing 176 h.p. at the same speed and rating. The bore and stroke remain constant at 5 $\frac{1}{8}$ in. and 7.9 in., respectively, throughout

the range; as a result, the majority of the parts, such as pistons, cylinder-heads, connecting rods, valve gear, etc., are interchangeable. To extend interchangeability still further, the cylinders are cast in sets of two, a two-cylinder engine, for example, requiring a single block and an eight-cylinder engine four blocks. Notable features of the design are four-valve cylinder heads, lightness of construction, accessibility and the use of fabricated-steel crankcases and sumps for the two-, three- and four-cylinder models. The valves are, of course, divided into two inlet valves and two exhaust valves and the operating gear is arranged so two separate levers operated by push rods each control one pair of valves. A multi-hole fuel-injection atomiser is used, being disposed centrally between the four valves and designed to spray the fuel into a bowl-shaped combustion chamber formed in the crown of the piston. A typical M-type engine is illustrated in Fig. 1, herewith, which shows a six-cylinder unit coupled to an 85-kW generator, the engine and generator being mounted on a common bedplate complete with radiator, switchgear, etc. Other self-contained generating sets produced by Messrs. McLaren include 27-kW, 40-kW, 55-kW, 70-kW and 110-kW machines.

The output of the Airedale factory is not confined to the M range of vertical in-line Diesel engines as the firm also produce the Petter-Fielding horizontal Diesel engine, the Petter "B" series of engine, and, in their fabricating shop, compressed-air storage vessels. In their present form, the Petter-Fielding horizontal series of engines date back to 1947 when McLaren's redesigned the then existing range in conjunction with the associated companies, Messrs. Fielding and Platt, Limited, and Messrs. Petters, Limited. Several sizes of horizontal engine are now manufactured, those available including the D.H. type, a single-cylinder machine rated at 16 brake horse-power at 800 r.p.m.;

DIESEL-ENGINE TEST BEDS.

J. AND H. McLAREN, LIMITED, LEEDS.

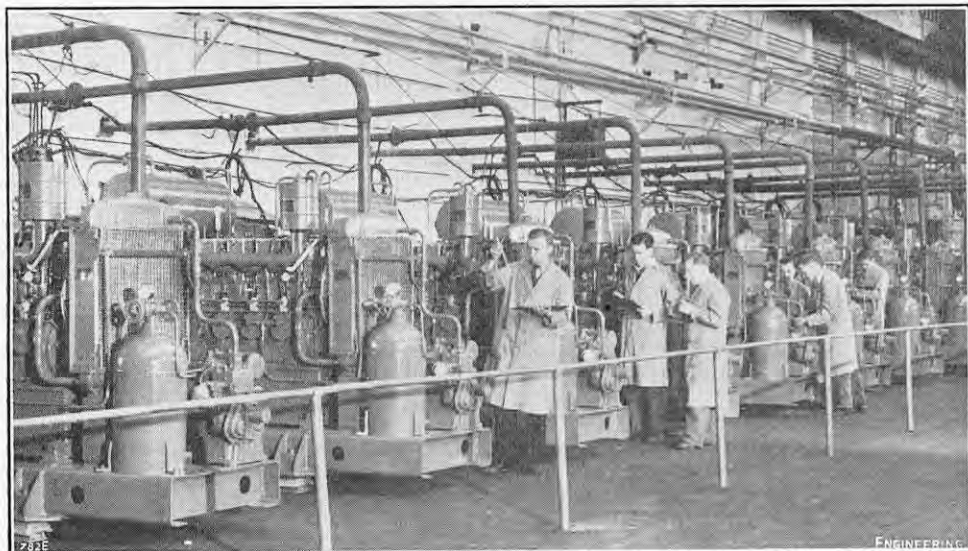


FIG. 4. TESTING DIESEL GENERATING SETS.

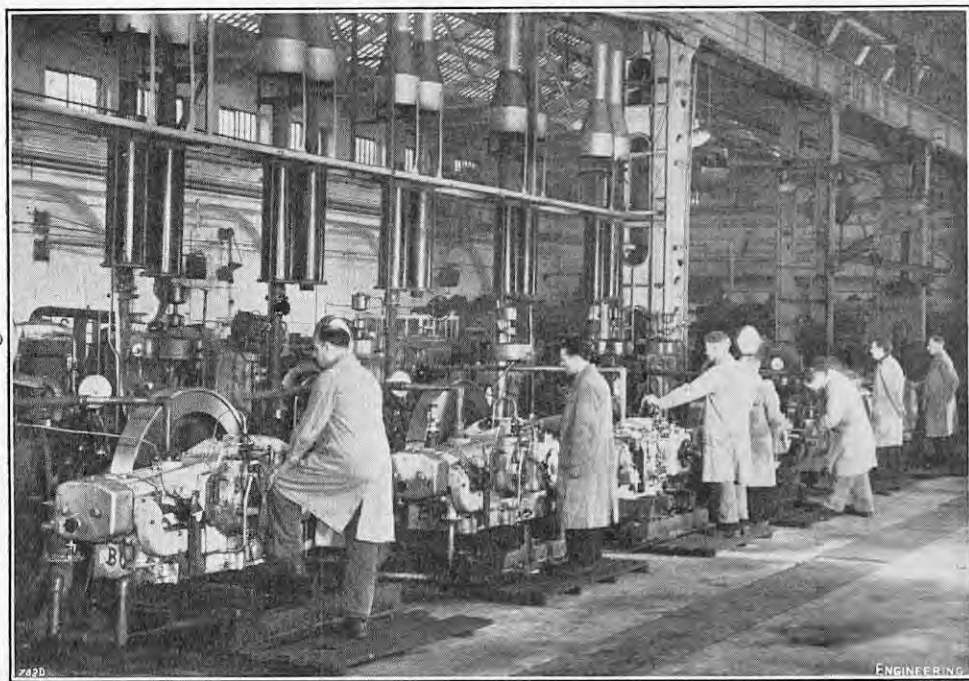


FIG. 5. TESTING HORIZONTAL ENGINES.

the E.H., also a single-cylinder machine, which develops a maximum of 27 h.p. at 650 r.p.m.; the F.H., another single-cylinder model, which develops 40 brake horsepower at 500 r.p.m.; and the F.H.2, a twin-cylinder unit, with outputs of 64 brake horsepower at 400 r.p.m. and 80 brake horsepower at 500 r.p.m. As in the case of the vertical engines, all horizontal units can be supplied in the form of self-contained pumping sets and generating sets, the outputs in the latter application ranging from 16 kW to 50 kW.

Production of the several different types of engines is confined to the Airedale works, which, as previously indicated, have been largely re-equipped with modern machine tools and laid out so far as possible for line production. The final layout, however, is not exactly as McLaren's would have it owing to the shape of some of the shops and the fact that the foundry occupies a central area. Nevertheless, an excellent compromise has been made and the production processes and assembly lines compare favourably with any others for a similar product. Although only supplying a portion of the castings needed in the factory, the foundry performs a valuable function as, being largely unmechanised, it can easily be adapted to supply those castings difficult to obtain elsewhere. It has an output of approximately 50 tons per week and at present is being used mainly for supplying the combined bed-plates and frames and the flywheels for the horizontal engines. On leaving the foundry, the castings pass to the fettling yard, where they are cleaned and given a

coat of priming paint before being dispatched to the machine shops.

The machine shops may be considered as being divided into three main sections, namely, heavy, medium and light, with separate shops for machining the cylinder heads and crankshafts. In the heavy machine shop the frames and crankcases, flywheels and parts of similar size are handled, the machine tools, in general, being of standard patterns. The frames for the horizontal engines, for example, are machined on Cincinnati plano-millers and planing machines, and the flywheels on Colburn, and Webster and Bennett, vertical lathes, the latter being fitted with indexing tool holders. Similarly, the medium and light machine shops contain a wide variety of standard machine tools ranging from Kendall and Gent plano-millers and Kitchen and Wade in-line borers for the main-bearing housings to Alfred Herbert capstan lathes and Sykes gear-cutting machines. Part of the light machine shop is illustrated in Fig. 6, on page 368. Although the majority of the machine tools are of a standard pattern, the works contain several special-purpose machines either constructed to the firm's specification or made in their own tool room. A good example of the latter class of machine is furnished by an inverted drilling machine, located in the cylinder-head section, which drills eight holes in the cylinder heads for horizontal-type engines. Considerable use is made of jigs and fixtures, which in some cases are used in machines adapted for special purposes; Fig. 3, on the opposite

page, for example, shows an Asquith multi-drilling machine arranged for drilling the bolt holes in connecting-rod big ends. A similar method is used for drilling the bolt holes in the little ends. The bores of the big ends are machined in a Warner and Swasey turret lathe, the fixture being bolted to the turret, while the tool, which has two cutters, is held and rotated by the chuck. Actually, the turret head is fitted with three different fixtures so that the lathe can machine three sizes of big end simply by indexing the turret and inserting the appropriate cutting tools for the respective jobs.

As previously mentioned, the crankshafts are machined in a separate shop; this is equipped with a variety of centre lathes, grinding machines, etc., and six Ambrose-Shardlow vertical crankshaft lathes. The Ambrose-Shardlow machines are employed on turning four-cylinder crankshafts and are divided into two groups of three, each group being capable of completing the machining operations on a crankshaft progressively as it is passed from machine to machine. Before being placed in the first machine, however, the two outer and the middle main-bearing journals are machined in a centre lathe, after which the crankpins for the two outer throws and the two inner throws and the remaining main-bearing journals are turned in Nos. 1, 2 and 3 machines, of each group, respectively. All crankpins and main-bearing journals are ground, the former in a Landis machine and the latter in a Churchill machine. The crankshafts are drilled for big-end lubrication, the drilling operation being carried out in special machines constructed by Messrs. H. W. Ward and Company, Limited.

Assembly procedure is more or less the same regardless of the type of engine, the engines being erected on roller conveyors fed with sub-assemblies and components from benches located to one side. The vertical engines are assembled in a separate shop situated close to the machine shops, and the horizontal engines and Petter "B" engines in another shop a short distance away, the two shops together covering an area of approximately 100,000 sq. ft., this figure including the space devoted to testing, packing and dispatch. A separate assembly conveyor is, of course, used for each type of engine; that used for erection of the horizontal engines is illustrated in Fig. 7, on page 368, which shows clearly the location of the sub-assembly benches in relation to the main conveyor. The generating sets are erected in the same shop as the horizontal and Petter "B" engines, and a photograph showing a general view of this area is reproduced in Fig. 8, on page 368. All engines are tested for a period of five hours, being run up to full load during the first hour, after which they are run at full load for three hours and at 10 per cent. overload for one hour. The generating sets are run as complete units, but the horizontal engines and those vertical engines not incorporated in generating sets, such as marine units, are connected to water brakes. The test beds are illustrated in Figs. 4 and 5, on this page, Fig. 4 showing that devoted to Diesel generating sets and Fig. 5, the testing of horizontal engines.

The fabricating shop, which is situated at the far end of the factory, is divided into three departments, namely, a plate-preparation bay, a welding bay, and the press shop. The welding bay and part of the plate-preparation bay are shown in Fig. 9, on page 368. The plate-preparation bay is equipped with mechanical plate cutting and bending machines and a number of oxy-acetylene profile cutting machines. Normal three-roll machines are used to form the cylindrical portions of the air receivers, the edges of the plates being tack-welded together before they are removed from the rolls. The domed ends of the air receivers are pressed out in a Glenfield and Kennedy press located in the press shop. The crankcases for the smaller vertical engines are built up in the welding bay, and on completion are stress relieved in a large annealing furnace installed in the press section. The company also carry out a considerable amount of fabricating work for other members of the group, some of which is of an exceedingly intricate nature; for example, Fig. 2, opposite, shows the combined cylinder block and upper part of the crankcase for a 12-cylinder V-type engine fabricated in their shops for Messrs. Mirreles, Bickerton and Day, Limited, Stockport. All fabricated parts are stress relieved, and, in general, are constructed in accordance with Lloyd's requirements.

OUTPUT FROM IRON FOUNDRIES.—The Council of Ironfoundry Associations, 14, Pall Mall, London, S.W.1, state that this country's output of iron castings in 1951 totalled 3,754,527 tons, compared with 3,486,892 tons in 1950. The output has been obtained by an improvement in productivity, namely, 24·714 tons per man year in 1951, against 23·195 tons in 1950. The castings are required for household purposes, the railways and for the machine-tool, motor-car, Diesel-engine, textile-machinery, steelworks-equipment, and the valve, pump and compressor, and other industries.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

IRON AND STEEL PRODUCTION.—Scottish steel production, while rising last month to the annual equivalent of 2,131,400 tons, as compared with 1,671,500 tons in January, was 10 per cent. below the total for 1951, which was 2,359,300 tons. At that time the first effects of the scrap shortage were beginning to be felt, and the full impact of the cut in imports is more closely seen by a comparison with two years ago. Ingot production in February, 1950, was at a rate of 2,632,400 tons, some 23 per cent. above the present level. Pig-iron production last month, stimulated by the reduction in scrap, was 10 per cent. up on last year and 35 per cent. higher than two years ago, the annual equivalents being 879,500 tons, 795,200 tons, and 648,800 tons, respectively.

COAL OUTPUT AND STOCKS.—Since the commencement of 1952, the weekly Scottish coal production has been about 15,000 tons down on the average for last year, on account of the loss of one Saturday shift a fortnight. Withdrawals from coal stocks, however, have approximately balanced this shortage, and, so far, the encroachment has been comfortably absorbed by an increased reserve of close on 200,000 tons, represented by 1,047,000 tons of total stocks at the beginning of March, against 853,000 tons last year.

WIRE-PATENTING FURNACE, COATBRIDGE.—Current was switched on for the first time on March 13 at a large new electric patenting furnace at the Coatbridge works of Martin Black & Co., Ltd., wire-rod makers. The furnace, which is expected to be in production in a few weeks' time, will be the second at the works, operating in train with pickling, fluxing, and galvanising units.

SALE OF GLASGOW PIPE-FOUNDING FIRM.—Negotiations have been almost completed for the sale of the old-established Glasgow firm of Shaw & M'Innes, cast iron pipe founders, to the Furness Shipbuilding Company, Ltd., Haverton Hill-on-Tees, Co. Durham.

THE LATE MR. THOMAS McMURRAY.—We regret to learn from Messrs. William Simons & Co., Ltd., Renfrew, of the sudden death on March 11 of their London director, Mr. Thomas McMurray. He was in his 80th year. A native of Renfrew, where he received his general education, Mr. McMurray served an engineering apprenticeship in the engineering department of Messrs. Simons's shipyard, after which he spent some time at sea. Subsequently, he was employed in the consulting office of Messrs. Coode, Vaughan-Lee, Frank and Gwyther, Westminster, and by the Admiralty; but his interest in dredging practice led him to return to Messrs. Simons, with whom the rest of his life was spent. He had been a director for 38 years, spent mainly in London, and had travelled extensively for his firm, especially in India, in connection with dredging schemes in the ports and harbours of Calcutta, Bombay, Karachi, Vizagapatam, etc.

CLEVELAND AND THE NORTHERN COUNTIES.

TEES VALLEY WATER BOARD.—We mentioned in these notes, on page 238, *ante*, the difficulties encountered by the Tees Valley Water Board in meeting an increased weekly consumption of 12 million gallons of water, which has arisen during the past 12 months. To ease the situation, and to maintain supplies until the completion of the Board's 600,000l. development scheme at Broken Scar, near Darlington, two emergency schemes have been prepared. These required Government sanction for the steel needed for their execution. On March 10, however, Alderman C. W. Allison, the chairman of the Board, told the members that steel was to be allocated for the schemes, and that Mr. Harold Macmillan, Minister of Housing and Local Government, had decided to allow the Board the full quantity of steel required. The schemes involve the conversion of a cooling pond into a filter bed at Broken Scar and the laying of 4,000 yards of steel main between Lartington and Barnard Castle.

SHORTAGE OF MINING ENGINEERS.—Speaking in Newcastle-upon-Tyne, at the annual dinner of the King's College Mining Society, held on March 8, Mr. W. J. Charlton, the chief mining engineer of the Northern (Northumberland and Cumberland) division of the National Coal Board, referred to the present lack of mining engineers in this country. He said that a considerable increase in coal production was vitally necessary, but that Britain was "desperately short" of mining engineers.

THE MERCANTILE DRY DOCK COMPANY.—The Mercantile Dry Dock Co., Ltd., Jarrow-on-Tyne, will complete in a few months an extensive scheme of works improvement, begun in 1943. The latest stage of the work to

be completed is the construction of a large platers' shop, fitted with hot-water heating and fluorescent lighting. An oil storage installation is also nearing completion.

LANCASHIRE AND SOUTH YORKSHIRE.

EXTENSIONS AND DEVELOPMENTS.—It was stated at the annual meeting of the United Steel Companies, Ltd., at Sheffield, that it would be necessary, during the next five years, to spend between 25,000,000l. and 30,000,000l. on extensions and developments to maintain efficiency. The directors estimated that, at current prices, the average expenditure on extensions and on the preservation of fixed assets at their present level of efficiency and capacity, would be between 5,000,000l. and 6,000,000l. a year. Two additional large blast furnaces are under construction at Scunthorpe, and it is expected that, when these are put into operation, in 1954, sufficient pig-iron will be made at the Appleby-Frodingham works to make up for the deficiency of scrap at all the company's works.

UNEMPLOYMENT REDUCED IN SHEFFIELD.—The seasonal increase in unemployment in the lighter industries of Sheffield is now righting itself. Official figures for February show that the total unemployed in February declined to 1,354 from 1,515 in January. The wholly unemployed included 753 men and 466 women.

FUEL ECONOMY.—The adoption of a new type of graphite lubrication for the 5-ton steam hammers at the Sheffield works of Firth-Vickers Stainless Steels, Ltd., has made it practicable to use the waste steam from the hammers for heating the shops, warehouses and works and administrative offices. This saves at least 60 tons of solid fuel a week in the winter. It has been possible to dispense with nine boilers formerly used for space heating, to discard electric radiators and to provide heating of a more stable character. The managing director, Mr. D. H. Hayes, was responsible for the new system. The waste steam is collected and piped to various parts of the works.

THE MIDLANDS

EFFECT OF THE AUSTRALIAN IMPORT CUTS.—The Australian decision to reduce imports of a wide range of products from this country, though not unexpected in Midland industrial circles, is regarded as a severe blow to certain industries. Most seriously affected will be the motor-vehicle trade of Birmingham and Coventry; Australia took 26 per cent. of the total exports of motor cars last year. Many other local products, including hardware and engineering products made in Birmingham and the Black Country, have also been exported to Australia in considerable quantities, and a number of trades will be unable to escape the effect of the cuts. Some other local factories, particularly in the Black Country, though not directly concerned with export, will also find difficulty in disposing of their products, for this area has for many years been one of the principal sources of supply for motor-vehicle components. Any recession in car production will inevitably have its repercussions among the component suppliers; in fact, the effects have already been felt. It remains to be seen how far the loss of Australian trade can be made up by increasing exports to other countries. At least one local trade is confident that it can be done; this is the motor-cycle trade, which still experiences a world-wide demand for its products.

DECISION ON ANNUAL HOLIDAYS.—As a result of agreements between employers and trades' unions, the majority of the engineering and allied factories in the Wolverhampton and Black Country areas will close for the annual holidays this year from July 25 to August 11.

THE OWNERSHIP OF A BRIDGE.—A problem which arises in the Midlands from time to time is that of the ownership of a piece of property which is required for development, or needs repairing. This question is now under consideration in Tipton, where a small bridge over the river Tame has become unsafe. So far it has proved impossible to trace the owner of the bridge or of the land on either side of it. The bridge cannot be closed, as it is a public right of way, and is used regularly by employees at a nearby foundry. Efforts are still being made to trace the owner, but meanwhile Tipton Council has called for tenders for repairing or replacing the bridge which, it seems probable, will have to be done at the expense of the municipality.

WOLVERHAMPTON AND STAFFORDSHIRE TECHNICAL COLLEGE.—Wolverhampton Education Committee have approved a proposal to change the name of the Wolverhampton and Staffordshire Technical College to the Wolverhampton and Staffordshire College of Technology. The proposal requires the approval of the Staffordshire County Council Education Committee and the Minister of Education.

AMERICAN PRODUCTIVITY TEAM IN BIRMINGHAM.—A productivity team from the American electric supply industry, which is on a six weeks' tour of Britain, visited Birmingham on March 8. The 17 members of the team, which is under the leadership of Mr. Chandler W. Jones, vice-president of the Narragansett Electric Company, of Rhode Island, were entertained to lunch by the Midlands Electricity Board. Afterwards the team was divided into groups to visit Hams Hall power station, the M.E.B. headquarters, and a cable installation at Smethwick.

AN UNUSUAL ACCIDENT.—An old practice in the drop-forging industry recently caused the death of a man at a Wednesbury works. To dislodge a forging which has stuck in the upper die, it has long been customary to place two pieces of steel on the lower die and then to drop the upper die in the hope that the forging will fall out. In the case in question, one of the pieces of steel was flung out and struck a man who was walking by, causing injuries from which he died.

NEW PREMISES FOR LEICESTER COLLEGE OF TECHNOLOGY.—On Tuesday, March 18, Sir Arthur J. G. Smout, J.P., formally opened the Lero Buildings, Leicester, as new premises for the School of Engineering in the Leicester College of Technology and Commerce. The buildings were erected in 1904 as an electric power station for the city's tramway system, and had been used subsequently by the Ministry of Supply as a store. Alderman C. R. Keene, C.B.E., presided at the opening ceremony and introduced Sir Arthur Smout, who then delivered an address and declared the buildings open. A vote of thanks to Sir Arthur was proposed by Mr. B. P. Cooper, M.I.Mech.E., and seconded by Councillor W. S. Russell. The Principal of the College is Dr. H. L. Haslegrave, Wh.Sc., M.I.Mech.E., and the head of the School of Engineering is Mr. F. R. Antcliff, B.Sc.(Eng.), A.M.I.Mech.E.

SOUTH-WEST ENGLAND AND SOUTH WALES.

WELSH COAL INDUSTRY.—Miners at Tynmawr Colliery, near Pontypridd, have raised their output from 25 cwt. per man shift in 1951 to 34.4 cwt. at March this year. On March 4 last 1,631 tons were raised, the highest output per shift achieved since the pit was opened in 1926. There were 16 more pits at work on Saturday, March 8, in South Wales than there were a week earlier. Only 31 pits in the coalfield supported the boycott on the shift and 109 pits were at work, producing 29,286 tons of coal.

METHANE GAS FROM MINE TO SURFACE.—Experiments which have been taking place at Point of Ayr, in Flintshire, in feeding methane gas from the coalface into the main gas grid, may be extended to South Wales shortly. The waste gas is already being piped successfully from the Point of Ayr workings and used to fire colliery boilers. The Wales Gas Board are to approach the South Western Divisional Coal Board on the matter. The application of the process in South Wales is likely to be improved by various new developments which a British fact-finding team hope to learn from their inspection of similar plants in the United States. Commenting on the proposed talks with the Divisional Coal Board, Mr. T. Mervyn Jones, chairman of the Wales Gas Board, said that surveys had already been made of the South Wales coalfield to ascertain the most suitable area for such experiments. He gave an indication of the proposed development at the annual dinner of the South Wales Branch of the Association of Mining, Electrical and Mechanical Engineers.

WELSH IRON AND STEEL PRODUCTS.—The weekly average production of steel ingots and castings in Wales in February last was 69,930 tons, compared with 67,340 tons in January and 68,990 tons in February, 1951. The pig-iron output, however, fell, being 23,560 tons against 28,190 tons in January and 25,730 tons in February, 1951.

DIRECT GOVERNMENT CONTRACTS.—A statement issued by the Ministry of Supply shows that over 500 contracts, valued at 7,200,000l., were placed with private firms in Wales and Monmouthshire during the last six months of 1951. Nearly 100 orders, totalling 3,000,000l., were placed with Royal Ordnance factories and Ministry of Supply agency factories. Since the beginning of the re-armament programme, in August, 1950, 243 firms in Wales and Monmouthshire have participated in direct Government contract work.

CLOSING OF LYDNEY COACH WORKS.—Shortages of steel and other metals has led to the closing of the Lydney Coach Works, Ltd. A statement issued by the company states that, during the past 12 months, every possible avenue had been explored to find alternative work, but without success.

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.

INSTITUTE OF ELECTRICAL ENGINEERS.—Radio Section: Monday, March 24, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. "Radio Controlled Models," by Mr. P. A. Cummins. **Mersey and North Wales Centre:** Monday, March 24, 6.30 p.m., Town Hall, Chester. Joint Meeting with the *North-Western Centre*. "The Protection of Electrical Power Systems: A Critical Review of Present-Day Practice and Recent Progress," by Mr. H. Leyburn and Mr. C. H. W. Lackey. **North Midlands Centre:** Tuesday, March 25, 6.30 p.m., College of Technology, Leeds. Discussion on "The Teaching of Fundamentals." **Thursday, March 27, 7.30 p.m.,** Offices of Yorkshire Electricity Board, Ferensway, Hull. "Modern Developments in Electric Welding," by Dr. H. G. Taylor. **Supply Section:** Wednesday, March 26, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. "The Design of High-Speed Salient-Pole A.C. Generators for Water-Power Plants," by Mr. E. M. Johnson and Mr. C. P. Holder. **Southern Centre:** Wednesday, March 26, 7.30 p.m., R.A.E. College, Farnborough. "Supertension Cables," by Mr. J. Banks. **Education Discussion Circle:** Thursday, March 27, 6 p.m., Savoy-place, Victoria-embankment, W.C.2. Discussion on "The Field for College Laboratory Experiments on Modern Magnetic Materials," opened by Dr. L. G. A. Sims.

INSTITUTE OF MECHANICAL ENGINEERS.—North-Eastern Branch: Monday, March 24, 6 p.m., Neville Hall, Westgate-road, Newcastle-upon-Tyne. Joint Meeting with the *INSTITUTE OF ELECTRICAL ENGINEERS (North-Eastern Branch)*. "The Operation of Dunston Power Station," by Mr. A. Howell and Mr. J. B. Jackson. **Yorkshire Branch:** Wednesday, March 26, 7 p.m., Technical College, Huddersfield. "The Design and Development of an Agricultural Tractor," by Mr. H. E. Ashfield. **Institution:** Friday, March 28, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. Annual Meeting (open to corporate and non-corporate members only). **AUTOMOBILE DIVISION.—Birmingham Centre:** Tuesday, March 25, 6.45 p.m., James Watt Memorial Institute, Birmingham. "The Performance of Crankcase Lubricating Oils," by Mr. A. Towle. **North-Western Centre:** Wednesday, March 26, 7.15 p.m., Grosvenor Hotel, Chester. "Factors Affecting the Utilisation of Anti-Knock Quality in Automobile Engines," by Mr. J. D. Davis. **Western Centre:** Thursday, March 27, 6.45 p.m., Royal Hotel, Bristol. "Shock Absorbers," by Mr. J. W. Kinchin and Mr. C. R. Stock.

INSTITUTE OF METALS.—Monday, March 24, 6 p.m., Royal Institution, 21, Albemarle-street, W.1. May Lecture on "The Place of Plastics in the Order of Matter," by Dr. J. J. P. Staudinger. **Tuesday, Wednesday and Thursday, March 25, 26 and 27, Park Lane Hotel, Piccadilly, W.1.** Annual General Meeting. For programme, see page 236, ante.

JUNIOR INSTITUTE OF ENGINEERS.—Sheffield Section: Monday, March 24, 7.30 p.m., Co-operative Educational Centre, 201, Napier-street, Sheffield, 11. "Snow Clearing and Frost Gritting," by Mr. R. W. T. Norton. **Institution:** Friday, March 28, 6.30 p.m., 39, Victoria-street, S.W.1. "Centrifugal Pumps," by Mr. J. A. Cribb.

INSTITUTE OF REFRIGERATION.—Tuesday, March 25, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "Non-Condensable Gases in Ammonia Plants: Their Effect and Removal," by Mr. E. S. Green and Mr. J. C. E. Lowcock.

INSTITUTE OF CIVIL ENGINEERS.—Structural and Building Division: Tuesday, March 25, 5.30 p.m., Great George-street, S.W.1. "Buoyant Foundations in Soft Clay for Oil-Refinery Structures at Grangemouth," by Mr. C. W. Pike and Mr. B. F. Saurin. **Yorkshire Association:** Friday, March 28, 7 p.m., Great Northern Station Hotel, Leeds. "Recent Developments in the Design of Highway Bridges in Hampshire," by Mr. E. W. H. Gifford.

INSTITUTE OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, March 25, 6.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. "Polyphase Commutator Motors," by Dr. J. E. Parton.

INSTITUTE OF HEATING AND VENTILATING ENGINEERS.—Scottish Branch: Tuesday, March 25, 6.30 p.m., Engineering Centre, 351, Sauchiehall-street, Glasgow, C.2. "Oil Burning," by Mr. P. H. Dixon-Wilson. **Manchester Branch:** Friday, March 28, 6.30 p.m., Engineers' Club, Manchester. Address by the branch chairman.

SOCIETY OF INSTRUMENT TECHNOLOGY.—Tuesday, March 25, 7 p.m., Royal Society of Tropical Medicine and Hygiene, Manson House, Portland-place, W.1. "The Design and Application of a Portable Electrostatic Watt Meter," by Mr. F. R. Axworthy.

ROYAL AERONAUTICAL SOCIETY.—Graduates' and Students' Section: Tuesday, March 25, 7 p.m., 4, Hamilton-place, W.1. Annual Meeting. "Aerodynamic Oscilla-

tions of Suspension Bridges," by Mr. C. Scruton. **Society:** Thursday, March 27, 7 p.m., 4, Hamilton-place, W.1. "Some Aspects of Civil Jet Aircraft Performance," by Mr. D. R. Newman.

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—North-Eastern Centre: Tuesday, March 25, 7 p.m., Dunelm Hotel, Old Elvet, Durham City. "All-Metal Bodies," by Mr. H. A. Cooke.

BRITISH INSTITUTION OF RADIO ENGINEERS.—West Midlands Section: Tuesday, March 25, 7 p.m., Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton. Open Meeting.

INSTITUTE OF PRODUCTION ENGINEERS.—Luton Section: Tuesday, March 25, 7.15 p.m., Town Hall, Luton. "Fundamentals in Press-Tool Design," by Mr. T. A. Stevens. **London Graduate Section:** Wednesday, March 26, 7.15 p.m., 36, Portman-square, W.1. Annual Meeting and Film Evening. **Lincoln Section:** Wednesday, March 26, 7.30 p.m., Staff Canteen, Messrs. Ruston and Hornsby, Ltd., Boultham Works, Lincoln. Annual Meeting. **Shrewsbury Section:** Wednesday, March 26, 7.30 p.m., Technical College, Shrewsbury. "Efficient Production Methods Applied to Iron Foundry," by Mr. G. W. Nicholls. **Coventry Section:** Friday, March 28, 7 p.m., Geisha Café, Hertford-street, Coventry. "The Manufacture of Electric Light Bulbs," by Mr. S. R. Eade. **Luton Graduate Section:** Friday, March 28, 7.30 p.m., St. Albans Court House, St. Albans. Annual Meeting and Film Evening.

INSTITUTE OF BRITISH FOUNDRYMEN.—Slough Section: Tuesday, March 25, 7.30 p.m., Messrs. High Duty Alloys, Ltd., Slough. Annual Meeting. "Die Casting in the United States," by Mr. C. J. Williams. **Birmingham Branch:** Wednesday, March 26, 7.15 p.m., James Watt Memorial Institute, Birmingham. "Developments in Foundry Mechanisation," by Mr. A. S. Beech. **London Branch:** Wednesday, March 26, 7.30 p.m., Waldorf Hotel, Aldwych, W.C.2. "The Buyer's Point of View," by Mr. J. F. Kayser. **West Wales Section:** Friday, March 28, 7 p.m., Canteen of Messrs. Richard Thomas and Baldwins, Ltd., Landore. "Manufacture of Castings for the Smithy and Forge Industry" by W. Spenceley. Also at the *Wales and Monmouth Branch:* Saturday, March 29, 6 p.m., South Wales Institute of Engineers, Park-place, Cardiff.

ROYAL SOCIETY OF ARTS.—Wednesday, March 26, 2.30 p.m., John Adam-street, Adelphi, W.C.2. Thomas Gray Lecture on "The Rolling of Ships," by Professor A. J. Sims.

INSTITUTE OF WATER ENGINEERS.—South-Eastern Section: Wednesday, March 26, 2.30 p.m., Institution of Civil Engineers, Great George-street, S.W.1. "Some Aspects of Valve Engineering in Water Supply," by Dr. P. L. Boucher.

ROYAL STATISTICAL SOCIETY.—Wednesday, March 26, 5.15 p.m., London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. "Consumption of Raw Materials in the United Kingdom, 1851 to 1950," by Mr. C. T. Saunders.

INSTITUTE OF PETROLEUM.—Wednesday, March 26, 5.30 p.m., 26, Portland-place, W.1. "Comparison of the Fixed Bed Liquid-Phase 'Slurry' and Fluidised Bed Techniques in the Fischer-Tropsch Synthesis," by Dr. C. C. Hall, Dr. D. Gall and Mr. S. L. Smith.

LIVERPOOL ENGINEERING SOCIETY.—Wednesday, March 26, 6 p.m., 9, The Temple, 24, Dale-street, Liverpool. "Coast Erosion," by Mr. H. G. Nesbitt.

INSTITUTE OF CHEMICAL ENGINEERS.—Midlands Branch: Wednesday, March 26, 6.30 p.m., Mason Theatre, The University, Edmund-street, Birmingham. Joint Meeting with the *CHEMICAL ENGINEERING GROUP*. "Construction and Personnel Planning at the Esso Refinery, Fawley," by Mr. G. Noble.

ROYAL SOCIETY.—Thursday, March 27, 4.30 p.m., Burlington House, Piccadilly, W.1. (i) "Wave Theory of Plasmas," by Mr. D. Gabor. (ii) "A Model Universe Admitting the Interchangeability of Stress and Mass," by Mr. G. C. McVittie.

INSTITUTE OF STRUCTURAL ENGINEERS.—Thursday, March 27, 6 p.m., 11, Upper Belgrave-street, S.W.1. "Unusual Design for a Large Constructional Shop," by Mr. F. R. Bullen.

CHEMICAL SOCIETY.—Thursday, March 27, 7.30 p.m., Burlington House, Piccadilly, W.1. "The Chemical Exploration of the Stratosphere," by Professor F. A. Paneth, F.R.S.

INSTITUTE OF MARINE ENGINEERS.—Thursday, March 27, 8 p.m., South East London Technical College, Lewisham-way, S.E.4. "Refrigeration at Sea," by Mr. R. R. Strachan.

MANCHESTER ASSOCIATION OF ENGINEERS.—Friday, March 28, 6.45 p.m., Engineers' Club, Manchester. Annual Meeting. "Training for Management," by Mr. F. C. Lawrence.

ROYAL INSTITUTION.—Friday, March 28, 9 p.m., 21, Albemarle-street, W.1. "The Cavendish Laboratory Archives," by Professor Sir Lawrence Bragg, F.R.S.

PERSONAL.

Appointments to the Ports Efficiency Committee comprise LORD LLEWELIN, P.C., C.B.E., M.C., as chairman and SIR ERNEST MURRANT, K.C.M.G., M.B.E. (chairman of Furness Withy & Co.); Mr. F. A. POPE, C.I.E. (a member of the British Transport Commission); SIR DOUGLAS RITCHIE, O.B.E., M.C. (vice-chairman of the Port of London Authority); MAJOR RGLAND THORNTON, M.C., J.P. (deputy chairman of the Mersey Docks and Harbour Board); and Mr. TOM YATES, C.B.E. (general secretary of the National Union of Seamen). The secretary is Mr. S. R. WALTON, of the Ministry of Transport. The committee's terms of reference are to investigate the working of the ports of the United Kingdom and, in particular, those of London and Liverpool, and to secure the co-operation of all interests in ensuring a quicker flow of cargo.

SIR G. STANLEY WHITE, Bt., who has been managing director of the Bristol Aeroplane Co., Ltd., and its predecessor in title, the British and Colonial Aeroplane Co. Ltd., for the past 41 years, has relinquished that position and has been made deputy-chairman of the company. Mr. W. R. VERDON SMITH and Mr. G. S. M. WHITE, hitherto assistant managing directors, have been appointed managing directors.

In consequence of his departure to take up permanent residence as executive chairman of the Wankie Colliery Co., Ltd., in Southern Rhodesia, Mr. R. W. FOOT, O.B.E., M.C., has resigned from the board of Powell Duffryn Ltd. He will retain his association with the company, however, through his appointment to the chairmanship of Powell Duffryn (Rhodesia) Ltd.

VICE-ADMIRAL ERIC LONGLEY-COOK, who retired last September after 40 years of service in the Royal Navy, has been appointed managing director of the Fairfield Shipbuilding and Engineering Co., Ltd., Glasgow.

DR. B. K. BLOUNT, F.R.I.C., at present director of scientific intelligence in the Ministry of Defence, has been appointed a deputy secretary in the Department of Scientific and Industrial Research.

MR. T. A. G. MADDEN, B.Sc. (Tech.), A.M.C.T., A.M.I.Mech.E., A.M.I.E.E., has been appointed engineer in charge of the co-ordinating sub-branch of the generation construction sub-department at the headquarters of the British Electricity Authority, in succession to Mr. E. S. BOOTH.

The Council of the West of Scotland Iron and Steel Institute, 39, Elmbank-crescent, Glasgow, C.2, have nominated PROFESSOR R. HAY, B.Sc., Ph.D., as President, and Mr. P. W. THOMAS, B.Sc. (Eng.), as honorary treasurer, for the session 1952-53. They have also nominated Mr. W. M. SERVICE, B.Sc., as vice-president, and Mr. W. A. J. DINWOODIE, B.Sc., Mr. W. E. J. LEWIS, B.Sc., and Mr. W. B. WRIGHT as councillors for the sessions 1952-55.

MR. H. F. BIBBY, B.Sc. (Tech.), A.M.I.E.E., A.M.I.Mech.E., has been appointed manager of the American division of the Metropolitan-Vickers Electrical Export Co. Ltd., in London.

MR. ERNEST BELCHER, sales manager, and Mr. J. B. SAMSON, M.I.Mech.E., M.I.Prod.E., A.R.Ae.S., works manager, have been elected directors of Ransome and Marles Bearing Co. Ltd., Newark-on-Trent.

The Minister of Transport has appointed Mr. A. J. WRIGHT, M.B.E., J.P., to be a member of the Transport Users' Consultative Committee for the South Eastern area, in succession to Mr. F. C. G. MILLS, who has resigned. Mr. C. S. MUNDY, O.B.E., has been appointed to this committee for the London area in succession to Mr. A. I. ANDERSON, and Mr. J. DELICATE has been appointed to this committee for the West Midlands area, in place of Mr. C. E. JORDAN. Both Mr. Anderson and Mr. Jordan have been appointed to the Central Transport Consultative Committee for Great Britain. On this committee, Mr. A. E. LINES now represents industry and SIR WILLIAM LAWTHORP, K.B.E., J.P., labour.

MR. R. H. HARRY STANGER, A.M.I.C.E., A.M.I.Mech.E., M.I.Struct.E., informs us that his testing and chemical laboratories have been removed to Summerfield House, Barnet-lane, Elstree, Hertfordshire. (Telephone: Elstree 1306.) An office will be maintained at Broadway House, 24-28, Tothill-street, London, S.W.1, for holding consultations and for dealing with inspection work.

Among other changes made in the BRUSH ABOE GROUP OF COMPANIES, ABOE (SCOTLAND) LTD. has been renamed BRUSH ABOE (SCOTLAND) LTD., with registered offices at Wishaw. A new company, BRUSH ABOE (IRELAND) LTD., has been formed with registered offices at 195, Pearse-street, Dublin, C.5. ASSOCIATED BRITISH OIL ENGINES (MARINE) LTD. are now operating on behalf of the marine products of J. & H. MCLAREN LTD.; MIRRLEES, BICKERTON AND DAY LTD.; the NATIONAL GAS AND OIL ENGINE CO. LTD., and also the most recent company to be associated with the Group, H. WIDDOP & CO. LTD., Keighley. The managing director of Associated British Oil Engines (Marine) Ltd., is Mr. J. JONES, M.I.Mech.E., who is also managing director of the National Gas and Oil Engine Co. Ltd.

PRODUCTION OF MEDIUM-SIZE DIESEL ENGINES.

J. AND H. McLAREN, LIMITED, LEEDS.

(For Description, see Page 364.)

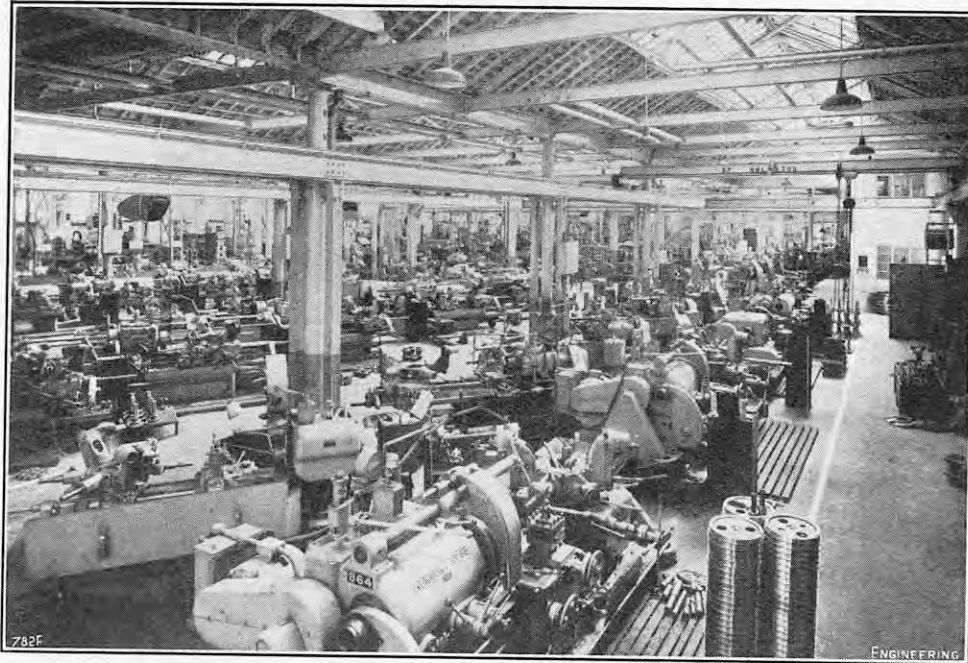


FIG. 6. LIGHT MACHINE SHOP.

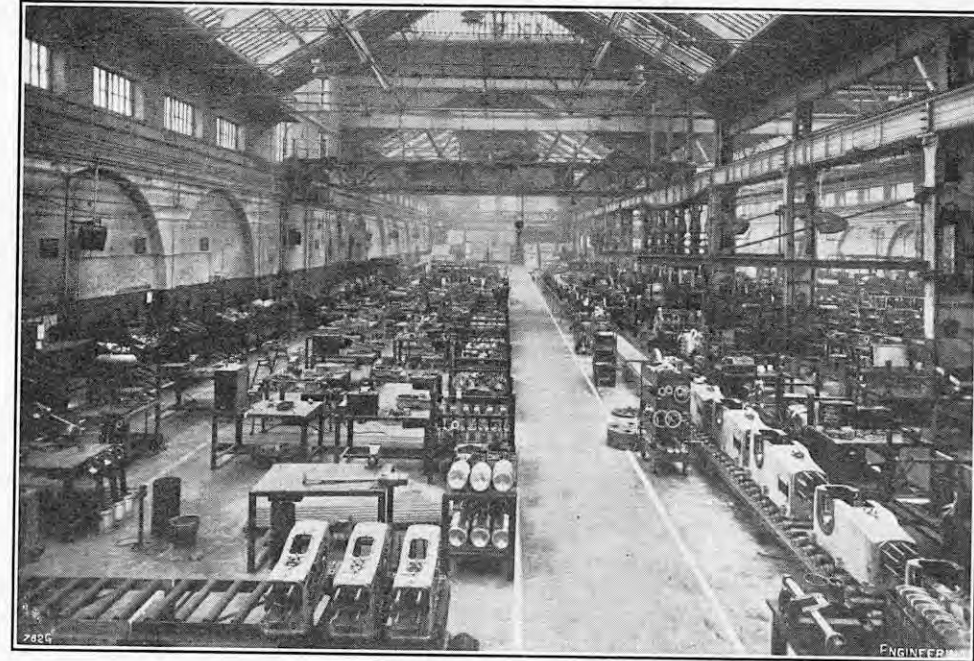


FIG. 7. ERECTION BAY FOR HORIZONTAL ENGINES.

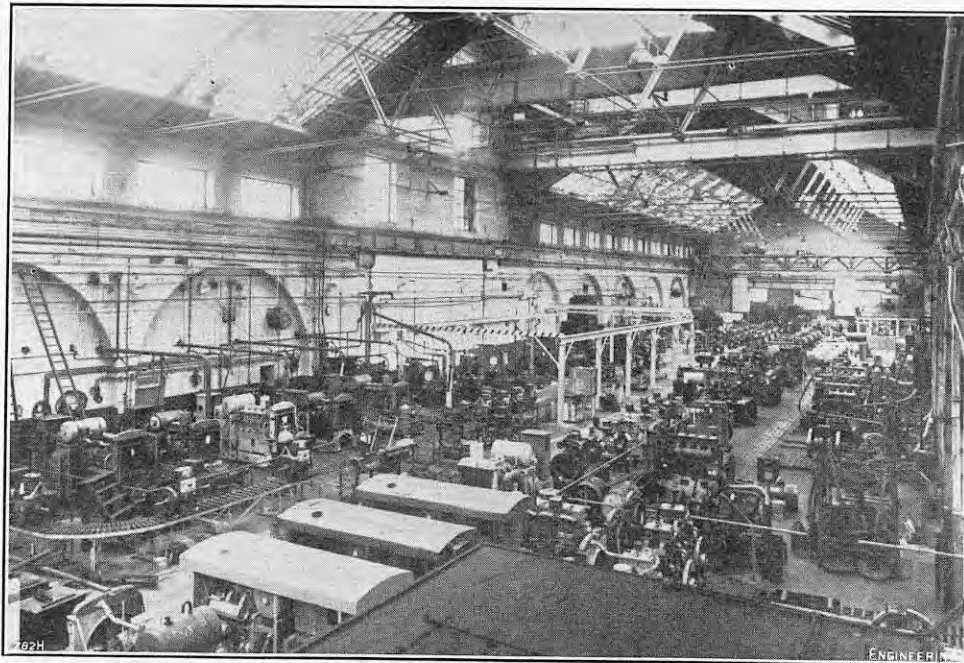


FIG. 8. ERECTION AND TESTING OF GENERATING SETS.



FIG. 9. WELDING AND FABRICATING SHOPS.

ENGINEERING

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

Registered at the General Post Office as a Newspaper.

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SUBSCRIPTIONS.

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For Canada	£5 5 0

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ADVERTISEMENT RATES.

Terms for displayed advertisements on the green art paper wrapper, on the inside black and white pages and in the buff art paper two-colour supplement, as well as for insets, can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2½ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

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

TIME FOR RECEIPT OF ADVERTISEMENTS.

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

"Copy" instructions and alterations to standing advertisements for display announcements must be received at least 10 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

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

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ENGINEERING

FRIDAY, MARCH 21, 1952.

VOL. 173.

No. 4495.

THE SCIENCE OF MEASUREMENT.

"A DIFFERENCE of one millionth of an inch is measured by using four true planes in concert." Thus reads the inscription on the reverse of the medal that is bestowed on holders of Whitworth Scholarships and Exhibitions; but to measure a single piece to within that margin of accuracy is one thing, and to reproduce any desired number of pieces that shall differ by no more than a certain amount, even though that amount may be very much larger than a millionth of an inch, is quite another, as the practitioners of interchangeable manufacture have always realised. It is a truism that war, for all its evils, possesses one good feature, in that it stimulates scientific advances. The reason may be merely that, in war, considerations of cost go by the board—equally good results could be obtained at any time, given a corresponding expenditure of money and effort. It is a fact, however, that war does provide these stimuli more effectively than does peace, and that some of the greatest advances in quantity production of interchangeable components have been made in such circumstances; always excepting the invention and production of movable and interchangeable type for printing, which, however, did not induce, by its adoption, any apparent improvement in other departments of the mechanic arts. However regrettable the circumstances may be, it is unquestionable that the wars of 1914-18 and 1939-45 have done more to promote reproducible accuracy of production and measurement than the intervening or immediately preceding years of peace, when the industrial depression put so many excellent craftsmen out of business.

This much was made abundantly clear at an

early stage in the paper which Mr. F. H. Rolt, O.B.E., Superintendent of the Metrology Division at the National Physical Laboratory, delivered on Wednesday, March 19, to the Institution of Production Engineers. The occasion was a notable one—in effect, the first meeting of that Institution as an Institution, and not merely that of a local section. Hitherto, the Institution has been organised on the apparent principle that, where two or three of its members were gathered together, there should be a Section; London itself, though it contains the administrative headquarters, is designated only as the "London Section" in the complete organisation. The system has a good deal to commend it, and we understand that there is no intention to depart from the principle; but it has the disadvantage that the majority of the great number of papers that are presented to the 40 Sections are liable to be of somewhat limited and local interest. It was felt by the Council of the Institution that something more was needed; that there should be, occasionally, papers presented to the Institution as a whole; and that they could not do better than associate these papers with the personalities of eminent engineers who had been prominent in encouraging the development of this relatively young Institution, and in practising themselves the art and science of engineering production. Hence it comes about that Mr. Rolt's paper is distinguished in the Institution's annals as "The First Sir Alfred Herbert Paper."

For this purpose, there could have been no better choice of an author than the present Superintendent of the Metrology Division, who is distinguished alike by his official position, by his ability as a lecturer on the subject that is fundamental to modern engineering production, and by the close association that he has enjoyed during the past 40 years with the application of the science of precise measurement to industrial purposes. To attempt to review in a short space the extensive field covered by his paper, which was entitled "The Development of Engineering Metrology," is an impossibility; the most that can be done is to pick out a few of the salient points, as he summarised them himself in presenting it. One of these points has been indicated already—the influence of successive wars in promoting accurate repetition manufacture. The Crimean War was fought, so far as the infantry were concerned, with weapons that were already antiquated; but, even before it broke out, the search had begun for something better, and it was in that search that Whitworth began his extensive experiments with rifles, which necessitated accurate gauging. Some of the gauges used on the rifles of the Crimean War period, resurrected from the Royal Small Arms Factory at Enfield, were exhibited in the hall of the Royal Empire Society, where Mr. Rolt's paper was delivered, and remarkable examples of sheer craftsmanship they proved to be. Mr. Rolt himself confessed that he was at a loss to understand the processes by which, so far back as 1853, such workmanship was accomplished.

In spite of this early demonstration of what could be done, even with the relatively few precision tools then available, many years passed before the need for really accurate—and reproducibly accurate—measurement was generally appreciated on the shop floor. In part, this was due to the circumstance that, as Mr. Rolt pointed out, at the beginning of the present century, and apart from armaments, "little other repetitive work calling for precision and interchangeability was going on except the manufacture of the Willans engine, sewing machines, bicycles, sheep-shearing machinery and possibly ball bearings." We should have been tempted to include typewriters in the list, though this branch of production was practically confined to the United States at that time; but the omission does not materially affect the

argument. It is strange that, after virtually a century of productive engineering, more had not been done to raise the standard of accuracy in the manufacture of bolts, nuts and screwing tackle. That was not seriously undertaken until 1901, when the Engineering Standards Committee was formed by the Institutions of Civil, Mechanical, and Electrical Engineers, in conjunction with various other professional bodies; soon to develop into the British Engineering Standards Association, and ultimately into the British Standards Institution.

Carl Johansson, in Sweden, introduced his system of block gauges in 1901, as a result of work that he had carried out in the Swedish State rifle factory, but no comparable production was initiated in England until the first World War brought the question of accurate gauging on a large scale into prominence. Since then, however, this country has taken a leading part in establishing means and standards for ultra-precise measurement, and to this work the Metrology Division of the National Physical Laboratory has made many major contributions. Possibly the most fascinating part of Mr. Rolt's paper was that relating to the efforts to relate the national standard of length—the Imperial yard—to the measurements over the flats of Johansson's block gauges. The tributes paid by Mr. Rolt to the ingenuity of A. J. C. Brookes, E. M. Eden and others, who devised the beautifully direct and unimpeachably accurate methods by which this result and others were achieved must have left many of his hearers wondering why no public honour was paid to them at the time for advances in the technique of metrology which have meant so much in engineering and scientific-instrument production.

The precise determination of length, however, was only a start. Since then, equally elegant methods have been devised for the measurement of angles, the calibration of screw gauges, and many other practical workshop operations in which the estimation of accuracy by feel, sensitive though that method can be in skilled hands, has now been superseded by true measurement to within a margin of a millionth of an inch. It is on the basis of precise determinations of length, however, that the modern industry of gauge and tool making has been built up. The needs of the first World War pointed the way to the subsequent researches, but the quantity production of gauges during that war was achieved by means that appear almost makeshift by comparison with the advances in the industrial promotion of accuracy that have taken place in the past quarter of a century. Fifty years ago, the Johansson block gauges were virtually laboratory instruments, if not curiosities; 25 years ago, they had become tool-room equipment; now they are workshop equipment, together with "a vast progeny"—to use James Nasmyth's favourite expression—of equally precise means of ensuring accuracy.

The benefits thus conferred are cumulative, like the production of machine tools; for it is not sufficient to measure any departures from accuracy—they must also be corrected. The Metrology Division of the N.P.L. has deserved well of British industry—and, indeed, of world industry; but much credit is due also to those production engineers and engineering industrialists who have had the acumen to take full advantage of the resources thus placed at their disposal. Their commemoration by the series of special papers, of which Mr. Rolt's is the first, is no more than is their due; and they in turn, we are confident, would be the first to recognise the peculiar fitness of his subject, to bring home to the members of the Institution of Production Engineers, and to mechanical engineers in general, a sense of the debt that they owe to the ingenuity and the clarity of vision, of the pioneers in the search for accuracy in measurement.

TWO CASES OF EMPLOYER'S LIABILITY.

It is obvious that, notwithstanding the relief afforded to injured workmen by the Industrial Insurance (Personal Injuries) Act, actions for negligence against employers have by no means ceased to occupy the time of the Courts. This is no doubt partly due to the circumstance that the damages recovered in an action are only partly taken into account when a claim against the State is being considered. Where an injured workman is not quite certain which one of two persons is liable, he will sometimes join both in an action, on the chance of succeeding against one. A recent case (*Garrard v. A. E. Southey & Co., and Others*, reported in *The Times* on February 21) is an example. Incidentally, it raised the interesting question: where a man, employed by A., sent to do work on the premises of B., sustains injury in the course of his employment, who is liable—A. or B.?

The plaintiff, an electrician employed by Messrs. Southey, was hired out to install some electrical equipment at the factory premises belonging to another firm—Standard Telephones and Cables, Limited. He brought his small tools with him, but the Standard Telephone Company's foreman told him that he could have all the tools and material he wanted out of the maintenance stores. He also told him, when he asked for a ladder or trestle, that he could look round and find it. He found and used a trestle, but it was defective, and he sustained an accident while using it. He brought an action for damages against both firms. The question was, which firm was liable? In an old case of *Quarman v. Burnett* (1840 6 M. & W. 499) the defendants owned a carriage, but habitually hired from a jobmaster horses to draw it. The jobmaster also supplied a regular driver, who wore a livery provided by the defendants. It was decided that the defendants were not liable for the results of the driver's negligence in handling the horses, on the ground that the defendants had no control over the way in which the horses were driven, though they could direct the driver where and when to drive.

In the case under notice, however, Mr. Justice Parker held that the Standard Telephone Company were liable. In the course of his judgment, he said: "It would be strange if, as here, the person to whom the workman was lent, who was himself the occupier of the factory, providing all the tools and equipment and devising the system of work, was able to fix the responsibility for providing parts of the equipment on the general employers, who had no control over it." He stressed the point that here, in effect, "nothing but labour was lent," and not necessarily highly skilled labour. That being so, it was easy to infer that the hirer should not only control the workman, by telling him what should be done, but also the manner of doing it. In the result, as he held that the hirers were, in effect, the masters of the injured workman, they were responsible in damages. That they were negligent was clear, inasmuch as they had never even examined the trestle which caused the accident. His Lordship also said: "The relationship of master and servant is, in my view, established between the second defendants and the plaintiff."

The important point is that "nothing but labour was lent." If something else is lent, e.g., a machine which is to be worked by the servant of the first employers, they remain liable for his act or default. This was made plain in a case in the House of Lords, namely, *Mersey Docks and Harbour Board v. Coggins and Another* (1946), 62 *Times Law Rep.*, 533. There the Board, who were the owners of docks, also owned a number of mobile cranes, each driven by a skilled man whom they engaged and paid. The cranes were hired out to applicants who had undertaken to load and unload cargo at the docks. The respondents, a firm of stevedores, who had been engaged by a firm of forwarding agents to load a ship, hired from the Board a crane, together with the driver. While the work was in progress, the plaintiff, who was checking the loading of the goods, was injured in consequence of the negligence of the driver of the crane. The Board, against whom the plaintiff obtained judgment for damages for personal

injuries, appealed, contending that the driver, at the time of the accident and for the purpose of the operation on which he was engaged, was not a servant of theirs, but of the stevedores, against whom judgment should be entered. It was held, however, that the test was, who had the right to control the driver of the crane in the way it was to be worked? It was not enough that the task to be performed by the crane should be under the control of such person—he must also control the method by which the driver performed it; and that this right remained with the Board, who were accordingly liable to the plaintiff for their driver's negligence. Referring to that decision in the course of his judgment, Mr. Justice Parker pointed out that it was a case in which a third party had been injured by the negligence of the lent workman and said: "I am not convinced that the approach was necessarily the same in the present case, where the workman himself was injured." That being so, it might be said that the judge has, in effect, made new law, although it seems that his decision accords with that laid down in *Quarman v. Burnett*. Nevertheless, as a Court of review might have a different opinion, it might be well for employers who are "hiring out" men—whether with or without machines—to provide specially, in the hiring agreement, for liability for negligence.

A case of somewhat different character was that of *Latimer v. A.E.C., Ltd.* (1952) (1 All E.R. 443), in which a curious question arose as to the liability of the occupier of a factory for an injury caused to a workman by, indirectly, the incidence of a sudden storm. It seems to show that, in such a case, it is the employer who has to bear the burden. Owing to a downpour of rain of unprecedented character and through no want of reasonable care on the part of the occupiers, a factory was flooded and coolant oil, pumped to machines through channels in the floor, mixed with the water. As the water receded, the floor, which was level and structurally perfect, was left in an oily and slippery state and could not be entirely cleaned at once. In the course of his duty, a workman slipped on the floor and was injured. In these circumstances, he brought an action for damages against his employers.

It is provided by s. 25 (1) of the Factories Act, 1937, that "all floors, steps, stairs, passages and gangways shall be of sound construction and properly maintained." The plaintiff alleged that his employers had committed a breach of this provision because, in allowing the floor to become slippery, they had not properly "maintained" it. Mr. Justice Pilcher, however, rejected this contention, saying that, in its natural and ordinary sense, the word "maintain" meant "maintain in a good state of repair"; and he was quite satisfied that the floor in question was, at all material times, in good repair. That, however, by no means disposed of the claim. The plaintiff alleged that his employers had failed in their common law duty to exercise reasonable care to make their factory safe for the plaintiff, who was their servant. In effect, he said "I was permitted to work in premises which my employers knew to be potentially dangerous." It was argued on his behalf that, as soon as it became apparent to the employers that the premises were potentially dangerous, and could not be rendered safe for some time, they should have sent home the nightshift—including the plaintiff, allowing only such men to enter the premises as were prepared to volunteer to carry on with the cleaning up.

Mr. Justice Pilcher came to the conclusion that the employers were liable. He said: "I think that the defendants, in permitting the plaintiff to do his ordinary work in a part of the factory where the floor was slippery, and, therefore, dangerous, took the risk that he might sustain an injury and are thus liable for the injury he did, in fact, sustain. . . . I do not shrink from the conclusion that the defendant's duty in the particular circumstances may have been to send away all the men who were not prepared to volunteer for cleaning work—and when I use the word 'volunteer' I mean volunteer on such terms as would enable the defendants to rely in the case of accident on the defence of *volenti non fit injuria*."

It is stated, in a well-known text-book on the

law of master and servant, that, in the absence of special agreement, the law presumes that the servant, in entering into the contract of service, undertakes to run the ordinary risks which are incidental to the employment; so, if the plaintiff in the case under notice had slipped on the floor—there being no grease to cause danger—it could be said that he accepted the risk. Similarly, if he had known—that the floor was greasy, it might be said that he took the risk of walking on it. However, in view of the fact that the condition of the floor was brought about by an exceptional storm, it is fairly obvious that the judge's decision cannot be cited as an authority for the proposition that an employer must close his factory whenever there is a shower of rain.

NOTES.

INFORMATION AND INDUSTRY.

A ONE-DAY conference on "Information Services and Industry," organised jointly by the Federation of British Industries (F.B.I.) and Aslib, was held in London on Tuesday, March 18. The morning session was devoted to lectures and a discussion arising out of them. In the afternoon, delegates were able to visit one of several typical industrial information departments in the London area. Mr. A. H. Wilson, F.R.S., chairman of the F.B.I. Industrial Research Committee, was in the chair at the morning session. The first speaker, Sir Alfred Egerton, F.R.S., reviewed the growth of sources of scientific and technological information in a paper entitled "Information and Industry: a General Survey." He thought that many of the methods developed for disseminating scientific knowledge could be applied to the organisation and correlation of information relating to production, distribution and management, as well as to research. Sir Alfred was followed by two speakers, Dr. J. H. Chesters and Dr. J. Farquharson, who each discussed, from the point of view of the industrial research scientist, "The Practical Value of an Information Service." Dr. Chesters thought that the best way to acquire information was to be prepared to give information in return and to discuss it widely. The principal value of an information officer, he said, lay in keeping the research man up-to-date, without flooding him with an excess of literature, in his knowledge of developed techniques. Dr. Farquharson thought that all industrial research work should be properly reported and, if possible, widely published. From the brief discussion which followed, there emerged a general feeling that firms should develop commercial information services in parallel with the technical information service. The morning session concluded with a talk by Mr. L. Wilson on "Aslib's Service to Industry." The ideal, he said, was for each firm to run its own information organisation. In the case of the small firm where this was not possible, Aslib could provide useful guidance on where to find the answers to specific technical, commercial or general inquiries.

THE INSTITUTE OF MARINE ENGINEERS.

In proposing the toast "The Royal and Merchant Navies of the British Commonwealth" at the 49th annual dinner of the Institute of Marine Engineers, Count Eduard Reventlow, G.C.V.O., the Danish Ambassador, referred to the happy relations existing between this country and the United Kingdom, and added that there were no more welcome visitors to Denmark than British sailors. The bonds forged between Great Britain and Denmark during the war had grown even stronger through their common membership of the North Atlantic Treaty Organisation and, although his people were well aware that they would have to reduce their normal standard of life, they were convinced it was necessary, and worth while in the cause of peace. Danish relations with the British merchant navy were as close as possible and he felt that the British people had every reason to feel proud of the ships that sailed under the white and red ensigns. In his reply, the Rt. Hon. J. P. L. Thomas, M.P., First Lord of the Admiralty, said that the co-operation of the navies of the western Powers was of the greatest value in maintaining

peace. Britain's contribution to the peace-loving countries, however, was the Royal and merchant navies not only of these islands but of the Commonwealth as well. In referring to the valuable part played by the shipbuilding and marine-engineering industries in the fight against the adverse balance of trade, Mr. Thomas said that the Government were trying to secure the best possible allocation of steel and to increase the total amount as soon as American steel began to arrive. "The Institute of Marine Engineers" was proposed by the Rt. Hon. J. S. MacLay, C.M.G., M.P., Minister of Transport and Civil Aviation, who, after referring to the co-operation of the Royal and merchant navies during the war, said that it was most important that this collaboration should continue in peace time. He went on to mention the prevailing shortage of sea-going engineers and hoped that the new scheme introduced recently by his department and the shipping industry would encourage men not only to go to sea but to stay at sea. In his reply, Dr. S. F. Dorey, C.B.E., F.R.S., President of the Institute of Marine Engineers said that the Institute continued to grow, the membership being three times that of 30 years ago, and he felt that the formation of local sections had done much towards this development. Dr. Dorey then referred to the international meeting held last year in conjunction with the Institution of Naval Architects and other associated bodies, which had helped in the promotion of personal contacts not only among their own people but also those from abroad. "The Guests" was proposed by Mr. James Turnbull, O.B.E., chairman of the Council, and the reply was made by Mr. T. F. Clarke. The dinner was made the occasion for the presentation to Mr. B. C. Curling, formerly secretary to the Institute of Marine Engineers, of a certificate of honorary membership in acknowledgment of his service to the Institute.

THE JUNIOR INSTITUTION OF ENGINEERS.

The annual dinner of the Junior Institution of Engineers was held at the Connaught Rooms, London, W.C.2, on Friday, March 14. The chair was taken by the President of the Institution, Air Commodore F. R. Banks, C.B., O.B.E., who, it may be remarked, maintained most successfully the "formal informality" which has always characterised this gathering of Juniors of all ages—of whom one, at least, on this occasion, had 54 years of membership. The toast of "The Institution" was proposed by Mr. H. F. Cronin, C.B.E., M.C., vice-president of the Institution of Civil Engineers and chief engineer of the Metropolitan Water Board, who reviewed some early activities of the Junior Institution and adroitly linked its history with an earthquake in Greece and other (less literally) earth-shaking events of 1884. Mr. N. E. Pillinger (chairman of the Institution), in his reply, acknowledged the great benefit that the Juniors had derived from many prominent members of the senior Institutions. The principal guest, Air Chief Marshal Sir Frederick Bowhill, G.B.E., K.C.B., Master of the Honourable Company of Master Mariners, then proposed "Enterprise in Engineering," a subject which afforded him the opportunity for some interesting reminiscences before he coupled with the toast the name of Air Commodore Banks; who, in turn, recounted other activities of Sir Frederick Bowhill as a naval officer and an airman. The evening concluded with the customary toasts to "Our Guests," proposed by Mr. S. R. Broderick, M.I.C.E., vice-chairman of the Institution, and acknowledged by Colonel B. H. Leeson, O.B.E., vice-president of the Institution of Electrical Engineers; and to the chairman of the dinner (Air Commodore Banks), proposed by Mr. A. S. Ladley, who is the other vice-chairman.

THE CANADIAN NICKEL INDUSTRY.

During 1951, the quantity of ore brought out of the mines of the International Nickel Company of Canada, Limited, totalled 11,799,320 tons, compared with 9,849,024 tons in 1950, and with an annual average of 10,500,000 tons during the war years 1940-44 and of 5,300,000 tons during the five years prior to 1939. The output of metallic nickel was gradually increased during 1952 until it stood at 21,000,000 lb. a month by the middle of the year, this total being the average monthly rate of

production achieved during the late war. These figures were mentioned by Dr. J. F. Thompson, chairman and President of the company in the annual report for the year ended December 31, 1951, issued on March 18. In spite of the increased extraction of ore from the company's mines, Dr. Thompson states that the proved ore reserves were 253,704,771 short tons at the end of 1951, compared with 252,859,725 tons at the end of 1950. The exploration of deposits, geological studies and prospecting operations in the Sudbury Basin, elsewhere in Canada, and in other parts of the world, are being actively continued. An important outcome of the research work carried on by the company has been the completion, during the year, of a special type of smelting furnace and auxiliary equipment which will utilise oxygen in place of pulverised coal for the flash smelting of copper concentrates. In connection with this project, a plant for the production of oxygen has also been completed and the new process has been under experimental operation. The gases produced contain a high proportion of sulphur compounds and these will be converted into liquid sulphur dioxide in a plant which is now being erected at the firm's works at Copper Cliff, Ontario. Another matter which is engaging the attention of the firm's research staff is the development of more economical methods for treating nickel-bearing iron sulphide ore (pyrrhotite) now being charged into the smelting plant in large quantities. Pilot plants have been installed, following upon laboratory investigation, and it is hoped to turn out, on a commercial scale, high-grade iron ore as a by-product of the process.

LETTER TO THE EDITOR.

MAN-POWER AND PRODUCTIVITY.

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of March 7, on page 305, *ante*, your editorial article on "Man-power and Productivity" quotes from Mr. Alfred Robens's speech in the recent Parliamentary debate on this subject. After quoting his remark that, when the Labour Government left office, industrial production had risen by 50 per cent. above pre-war, your editorial states that the increase was not likely to have been computed on the basis of weight or volume, and imputes that it had been based on cost. You went on to quote a figure of some 29 per cent. for depreciation of the value of the pound since 1946, and pointed to the greater depreciation that has occurred since 1939. I need hardly point out that the logical conclusion from this would be that industrial production had actually declined in quantity since 1939.

The independent London and Cambridge Economic Survey, which bases its index on the quantity of goods delivered, substantially confirms the 50 per cent. increase in production Mr. Robens mentioned. To avoid any possible reflection of discredit marring the achievement of British industry since the war, especially in the minds of overseas readers, you may feel that some correction is called for.

Yours faithfully,

M. S. FORINTON, B.A., A.M.I.C.E.

105, Park-street,

London, W.1.

March 17, 1952.

[“Quantity,” as used by the London and Cambridge Economic Survey, refers, we believe, to the denomination of quantity of the various specific classes of goods. Without checking each category in the total production of British industry, we fail to see how such figures could be satisfactorily integrated to justify a claim that there had been an overall increase of 50 per cent., or any other percentage, in the national industrial production. It appeared to us, therefore, that Mr. Robens could only be speaking in general terms.—ED., E.]

DEVELOPMENTS IN MECHANICAL COAL-CUTTING.—A German type of coal plough is being tested at Horden Colliery, Co. Durham. The machine, which has cost 40,000*l.*, is working on a face 200 yards long. After being cut, the coal is carried to conveyors at the loading gate. Adjustable steel props and aluminium-alloy roof supports are also in use. It is expected that the machine will be able to cut the face three or four times a shift, each cut bringing down about 70 tons of coal.

OBITUARY.

DR. H. H. BLACHE.

WE regret to learn of the death, on March 17, at the age of 77, of Dr. H. H. Blache, formerly managing director of Messrs. Burmeister and Wain, Copenhagen. Dr. Blache was the recipient, less than a year ago, of the James Watt International Medal, which was presented to him by the President of the Institution of Mechanical Engineers (Mr. A. C. Hartley, C.B.E.), on the nomination of the Danish Institution of Civil Engineers, in recognition of his contributions to the advancement of mechanical engineering, and especially for his pioneer work in the development of the large marine oil engine.

Hans Hendrik Blache was born on September 17, 1874, in Copenhagen, where his father, Professor Christian Vigilius Blache, held the chair of marine painting in the Royal Academy of Art. He studied mechanical engineering in the Royal Technical University at Copenhagen, taking his degree in 1896, and spent the next twelve months in the Royal Danish Naval Yard. At the end of 1897, he entered the design office of Messrs. Burmeister and Wain, with whom he remained for two years before deciding to widen his experience by spending a year or so in England and another in Germany. He returned to Copenhagen in 1901, to be re-engaged by Messrs. Burmeister and Wain, by whom he was employed for the next ten or eleven years on the design and testing of steam reciprocating and turbine machinery. Towards the end of that period, however, the firm had decided, in conjunction with the Danish East Asiatic Company, to investigate the possibilities of the Diesel engine for ship propulsion, and in 1912 they installed their first set in the motor-ship Selandia. Dr. Blache had been closely associated with the design and construction of this engine, and the set fitted in the sister ship Jutlandia, and it may be assumed that the immediate success of these pioneer Burmeister and Wain engines was largely responsible for his appointment, very shortly after their debut, as chief engineer of the company.

For the next seven years, Dr. Blache was kept fully occupied in development work with the large slow-running marine type of engine, and with the introduction of new designs to meet the inquiries which the Selandia had inspired. Soon after the outbreak of war in 1914, the Danish Admiralty decided to fit Diesel engines in submarines, and Dr. Blache designed for this purpose a four-stroke lightweight engine, the successful performance of which pointed the way to many detail improvements in the mercantile types of engine also. It is probable that much of their success was due to the cautious policy followed by Dr. Blache in designing his Diesel engines as far as possible along lines that had proved satisfactory in steam-engine prac-

tice; for example, the use of crossheads. The result was, of course, that the engines were very bulky and heavy in proportion to the power developed; and, for passenger ships in particular, a more compact design was needed. The United Steamship Company, of Copenhagen, therefore asked Dr. Blache to produce an engine, based on submarine practice, for use in their ships on the Harwich-Esbjerg route; thus originated the Burmeister and Wain trunk-piston type of engine.

Dr. Blache was appointed managing director of Messrs. Burmeister and Wain in 1919; but, though this wider field of activity involved much travelling

engine, with positive rotary-blower scavenging.

These double-acting designs brought in their train some complex problems of heat-flow and cooling, and not all superintendent engineers took kindly to them, for that reason; but concurrently Dr. Blache was steadily improving the simpler designs—in which endeavour, it may be added, his efforts were paralleled by those of his British licensees, Messrs. Harland and Wolff, Limited—and before long he was producing very successful single-acting two-stroke engines, first with piston valves and then with poppet valves. Supercharged designs of four-stroke engines followed, with steady improvements in details of all kinds, until it might be said that he had explored practically all the possible combinations of different cycles and working conditions. By then, however, he was more than 60 years of age and had reached the stage when administrative and design work could be relinquished to other hands. He retired from active participation in the operation of Messrs. Burmeister and Wain's marine-engine works at Copenhagen in 1935, and was associated for the next four years with Messrs. Harland and Wolff. In 1939, he returned to Denmark, continuing to practice there as a consultant until his death.

Dr. Blache was a member of several professional institutions in Denmark and elsewhere. For 21 years, from 1915 to 1936, he was chairman of the Danish Society of Marine Engineers and Naval Architects. He was also a member, since 1932, of the Institution of Naval Architects, to which he presented a paper in 1931 on "The Present Position of the Diesel Engine for Marine Purposes." Other papers which he delivered in this country were read before the Institution of Engineers and Shipbuilders in Scotland, in 1925, and the Institute of Marine Engineers, in 1936. The Royal Technical University of Denmark, whence he had graduated in 1896, conferred a doctorate upon him in 1929. Eight years previously, he had been made a Knight of the Order of the Dannebrog, a distinction which was followed by the conferment of the Silver Cross of that Order; and



THE LATE DR. HANS H. BLACHE.

—for, by that time, the engines were being built under licence in most of the shipbuilding countries—he retained his personal interest and control in matters of design. Also, during the industrial depression between the wars, he had to make special efforts to develop land applications for his engines, to compensate for the slump in shipbuilding and, consequently, in the demand for marine engines and auxiliary machinery. In 1925, he brought out his design for a large four-stroke double-acting engine, which he followed, after a comparatively short interval, with the two-stroke double-acting engine. This competition greatly stimulated the designers of steam reciprocating engines and turbines, who rapidly raised their working pressures and steam temperatures to meet it. Dr. Blache countered with the two-stroke double-acting

in 1934 the King of Sweden appointed him a Knight of the Order of the Nordstjärnen. The James Watt Medal, of which he was the eighth recipient, and which is awarded on the recommendation of the principal engineering institutions throughout the world, was an international recognition of his eminence (to quote the citation) as "a brilliant engineer of great courage and resource, backed by sound technical judgment," who was "able to combine his own ideas with the best features of contemporary practice in producing a series of outstanding designs." More than that, however, he was recognised also as "an inspiring leader, drawing the best from those under him and effectively co-ordinating the application of technical knowledge, whatever its source might be," and one who "followed truly in the Watt tradition."

H.M. AIRCRAFT CARRIER "EAGLE".



FIG. 1. H.M.S. "EAGLE" AT SPITHEAD.



FIG. 2. CATAPULTING AN "ATTACKER" JET FIGHTER.

MR. J. H. HARLEY-MASON.

In last week's issue, on page 341, *ante*, we recorded the death, on March 11, of Mr. J. H. Harley-Mason, M.I.C.E., formerly new works engineer of the London Passenger Transport Board. The news was received as that issue was going to press, so that it was necessary to hold over to this week the particulars of his career, which are given below.

John Harley Harley-Mason was born on December 8, 1877, and received his general education at Brighton Grammar School, and his technical training under the late Mr. Maurice Wilson, A.M.I.C.E., of the Crystal Palace School of Engineering, during the three years 1894-96. It was continued during a pupilship of four years with Messrs. Hassard and Tyrrell, consulting engineers, of Victoria-street, Westminster, with whom he obtained a varied experience on water supply and sewerage schemes, railway work, hydro-electric power projects, etc. Among these was an abortive proposal for a tube railway, the East London, City and Peckham Railway; the London United Electric Railways Bill; the City and North-East Suburban Railway Bill; and sundry projects for light railways, more especially in Ireland. In 1907, he was taken into partnership by Mr. R. Hassard, continuing for three years in that capacity.

In 1910, Mr. Harley-Mason left consulting for contracting work, and for the next 12 years he was associated with Messrs. Perry and Company (Bow), Limited. His first employment with them was on the construction of the District Railway's station at Victoria; and the next, on the widening of the railway tunnels at Baker Street station, for which purpose he designed a special form of shield.

Among later works, for the construction of which he was responsible, were the double-deck reinforced concrete jetty at Tilbury, 1,800 ft. long; the subways at the Elephant and Castle road and rail junction in South London; ten miles of line for the Great Western Railway between Wolverhampton and Bridgnorth; and various Government contracts for aerodromes and munition works. In 1917, when Mr. Charles Rowell died, Harley-Mason succeeded him as chief engineer of Perry and Company, retaining that position until 1922, when he was appointed new works assistant to Mr. A. R. Cooper, the civil engineer of the London Underground Railways. In 1938, he was made new works engineer to London Transport, retaining that position until he retired in December, 1942.

In that capacity, he was directly responsible for many important engineering works, including the construction of the rolling-stock depot at Morden, the extension of the Piccadilly line from Hammersmith to Northfields, with the rolling-stock depot at Northfields; improvements to the Metropolitan District Railway; the construction of new stations at Aldgate East and King's Cross; the foundations for the new offices at 55, Broadway, S.W.1, which involved some particularly difficult piling on both sides of St. James's Park station; and the reconstruction of stations and subways at Hammersmith and elsewhere. Various of these undertakings have been described in *ENGINEERING*, and in preparing these descriptions we received the much help and consideration from Mr. Harley-Mason, whose collaboration, always readily forthcoming, we valued greatly. He was a member of the Institution of Civil Engineers and a Fellow of the Royal Geographical Society.

H.M.S. "EAGLE" IN SERVICE.

To be on board H.M.S. Eagle, the Royal Navy's newest aircraft carrier, during a short exercise in the English Channel, is to enjoy a privilege that many would like to be given, but, editorially, its value is somewhat reduced by the restrictions that are inevitably imposed on the release of information. Technically, the most interesting features of the ship are in her fighting equipment, particularly the radar apparatus, but it is just in this field that security regulations are most rigid. No doubt, the experience gained by the designers of such equipment will, to some extent, be used in the design of apparatus for non-secret applications; nevertheless, in the interests of the spread of applied science, it is regrettable that such a vast amount of the work of engineers to-day cannot be fully described and is never likely to be.

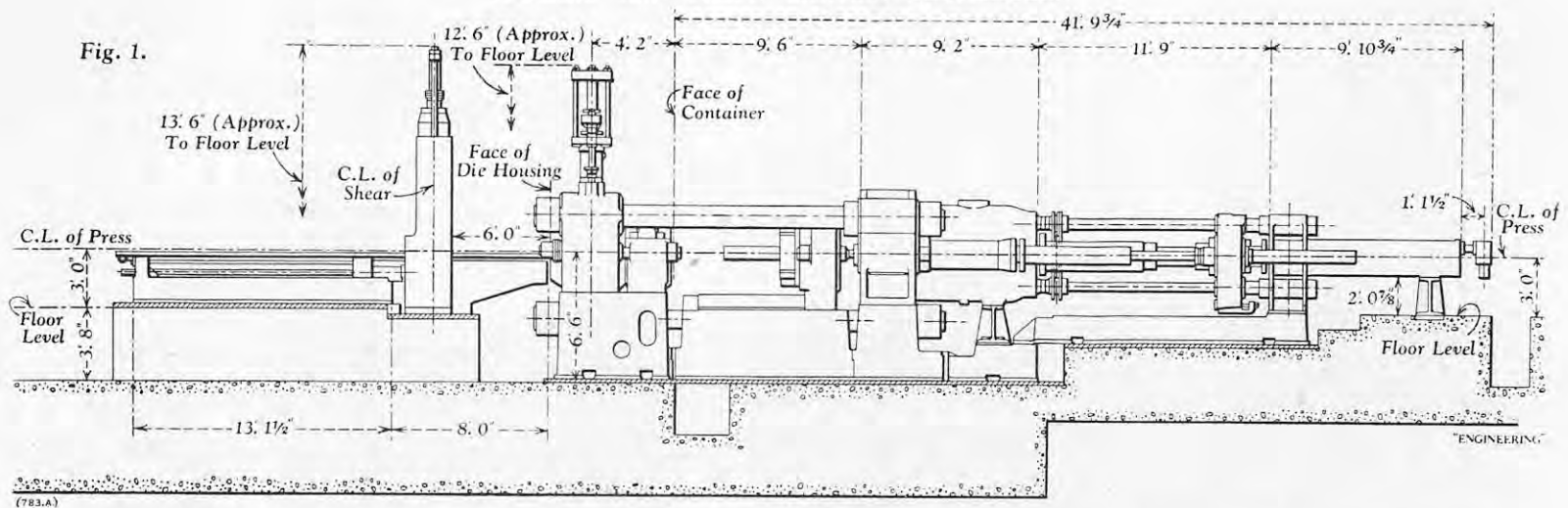
H.M.S. Eagle (Captain Guy Willoughby, R.N.) is the first carrier, in any navy, suitable for the modern naval jet aircraft now in service. At present, she carries Attacker jet fighters of 800 Squadron, and Firebrand torpedo-carrying aircraft of 827 Squadron (to be seen in Fig. 1). Her aircraft capacity is 80 to 110, or, in the words of the official statement, the two hangars could accommodate 263 double-deck 'buses. Armament consists of 16 4.5-in. guns and 61 smaller guns, including multiple and single Bofors guns. The 4.5-in. guns are arranged in four batteries, each equipped with a control system that can engage targets travelling at very high speeds. Radar control is also provided to allow targets to be engaged at night or in low visibility. The Bofors guns are coupled to radar-controlled directors.

The exercise to which the Press were invited on Tuesday, March 18, was part of the normal "working-up" period, during which the aircraft pilots accustom themselves to taking off and landing, and the flight-deck parties, on whom the battle efficiency of the carrier largely depends, become familiar with the precise routine of their work. No attempt was made to give an exhibition of rapid handling, though to a lay observer it did seem that, when the aircraft were returning to the carrier, the flight-deck parties and the lifts operated at a creditable pace. The flight deck covers an area of over two acres, and is fitted with arrestor wires, safety barriers and two catapults of a modern type. It is understood, however, that the catapults will eventually be replaced by others of the newer steam type, invented by Commander (E) C. C. Mitchell, R.N.V.R., of Messrs. Brown Brothers and Company, Limited, Edinburgh.

The position of the two existing catapults at the forward end of the flight deck is shown in Fig. 2.

2,000-TON HORIZONTAL EXTRUSION PRESS.

FIELDING AND PLATT, LIMITED, GLOUCESTER.



Aircraft are positioned for loading into the catapults by an automatic device which will speed up considerably the launching operations. On the exercise this week the Attacker jet fighters took off with the aid of the port catapult, but the Firebrand aircraft took off from the deck unassisted. A wide range of flight-deck transport, such as mobile cranes, fork-lift trucks and tractors, is provided, so that the aircraft and their armament and equipment can be moved about quickly. Two cranes are fitted, one on each side of the flight deck, so that aircraft can be hoisted on board from lighters, or amphibians from the sea. These cranes are also used for hoisting boats and embarking stores and ammunition. The radio, radar and plotting rooms required for the efficient operation and direction of ships and aircraft at sea are housed in the island structure on the starboard side. Flight-deck lighting enables jet aircraft to be operated by night.

The main machinery of the vessel consists of four identical steam-turbine sets, each comprising two Admiralty-pattern three-drum boilers of an improved design (the steam pressure exceeding 400 lb. per square inch); the Parsons-type turbines, with high-pressure and low-pressure cylinders, turbine and Diesel generating sets, distilling plants, etc. Considerable use has been made of electric welding in the construction of the hull, thereby saving weight. The ventilation system has been designed to give the best possible living conditions in both Arctic and tropical waters. Particular attention has been paid to the lessons learned during the war on the control and repair of action damage. Failures of electric power can be quickly rectified and arrangements are provided to enable the ship to be brought upright from large angles of list. The steering gear is stated to be equipped with "many" alternative sources of power.

The total connected electrical load of the ship is nearly 11,500 kW, though the peak demand can be comfortably met by the generating plant with an output of 4,000 kW. This plant consists of eight 500-kW generators, four steam-driven and four Diesel-driven. A 220-volt direct-current ring main is connected to about 300 electrically-operated breakers. Distribution of electricity is controlled from a central switchboard, with four smaller switchboards for emergency use. A 500-line automatic telephone exchange is provided. A main broadcast system is used for general information, warning signals, etc., but in action the various departments of the ship can take over control of appropriate sections of the system. If the normal lighting of the ship is put out of action, battery-operated lanterns come into use automatically.

H.M.S. Eagle was built by Messrs. Harland and Wolff, Limited, Belfast. She was ordered in May, 1942; laid down in October, 1942; launched in March, 1946; completed and commissioned on October 31, 1951; and finally accepted by the Navy on March 1, 1952. The vessel is 720 ft. between perpendiculars; 803 ft. 9 in. overall; and has a beam of 112 ft. 9 in. at the water line. The maximum draught is 36 ft. The peace-time complement is about 2,000 officers and men.

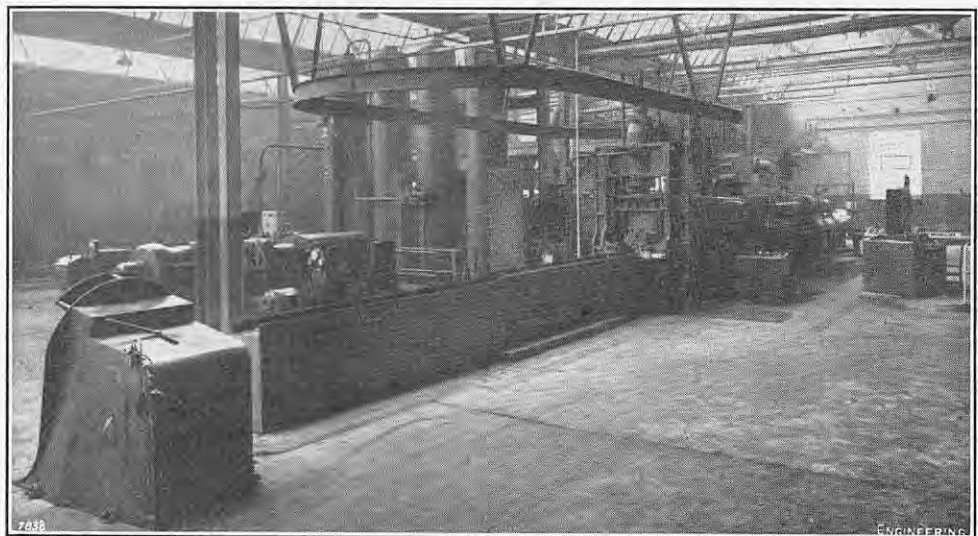


FIG. 2. GENERAL VIEW OF PRESS.

AUTOMATIC EXTRUSION PLANT FOR THE ASTON CHAIN AND HOOK COMPANY.

ALTHOUGH still manufacturing considerable quantities of special chains, the most important activity of the Aston Chain and Hook Company, Limited, Bromford-lane, Erdington, Birmingham, at the present time is the production of extruded brass and copper sections, particularly commutator sections, for the electrical industry. They also produce a number of brass and copper tubes and special hollow sections, such as those used, for example, in the manufacture of petrol-lighter bodies, but their principal work is in meeting the needs of the electrical industry. This side of the business has grown steadily during the past years, and to meet the ever-increasing demands the firm installed recently a new extrusion plant which is capable of accepting billets weighing up to 7 cwt. The new plant is of more than usual interest in that the degree of mechanisation incorporated is, we understand, greater than that of any comparable installation in this country or elsewhere; the billet is mechanically handled from the moment it is placed in the furnace-charging mechanism.

A general view of the complete plant is given in Fig. 2, on this page. It comprises a 2,000-ton hydraulic press, together with ancillary equipment, such as hydraulic accumulators, charging pump, etc.; an oil-fired furnace; servo-operating units; billet-handling equipment; and a compressed-air system. The press, which was constructed by Messrs. Fielding and Platt, Limited, Gloucester, is illustrated in the outline drawing reproduced in Fig. 1, on this page, and in Figs. 3 and 4, opposite, Fig. 3 showing a billet in the loading position, and Fig. 4 a general view of the rear of the machine. It is equipped with independent piercing gear,

hydraulically-operated wedging gear and shears, pre-filling equipment for the main and piercing cylinders, a saw for the removal of the discard from complicated sections, and hydraulically-operated die-shifting equipment. The working pressure is 3,500 lb. per square inch, the maximum power of the main ram is 2,000 tons, and the stroke is 5 ft. 6 in. The piercing ram has a maximum power of 200 tons and a stroke of 7 ft. 6 in. The length of the container which holds the billet during extrusion is 2 ft. 6 in. and the maximum bore of container which can be used is 10 1/2 in.; the billet size, therefore, is limited to 10-in. diameter by 2 ft. 3 in. long, when suitable allowance is made for the pressing pad.

As will be seen from the illustrations, the press is of the horizontal three-column type with two columns disposed at the top and one below, a design, it is claimed, that facilitates changing of the containers. In general, the arrangement of the piercer, die housing, container housing and bolster run-out gear conforms to the makers' standard practice. The columns are located in bosses integral with the main cylinder and are held in position by split-type cast-steel nuts provided with a suitable locking device. The main ram, which is machined to a high polish along its working length, is provided with an integral extension for the piercing gear and is guided and supported by a crosshead fitted to its forward end, the crosshead also being fitted with the thrust rod and main drawback rams. Loading of the billet is effected by a special hydraulic loading gear arranged to bring the billet from floor level to the centre line of the press, the billet being fed from one side of the machine at an angle so that the lifting ram clears the columns, etc. A billet can be seen in the loading position in Fig. 3, opposite. During the next operation, the billet is pushed into the container by a preliminary forward stroke of the thrust rod, which, as stated, is attached to the main ram, and, after the thrust rod is with-

2,000-TON HORIZONTAL EXTRUSION PRESS.

FIELDING AND PLATT, LIMITED, GLOUCESTER.

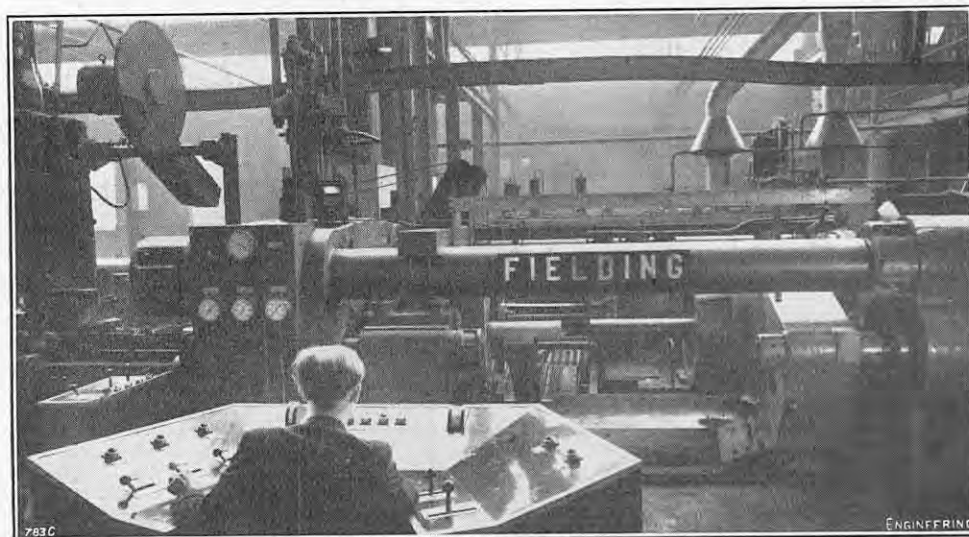


FIG. 3. FEEDING BILLET INTO CONTAINER.

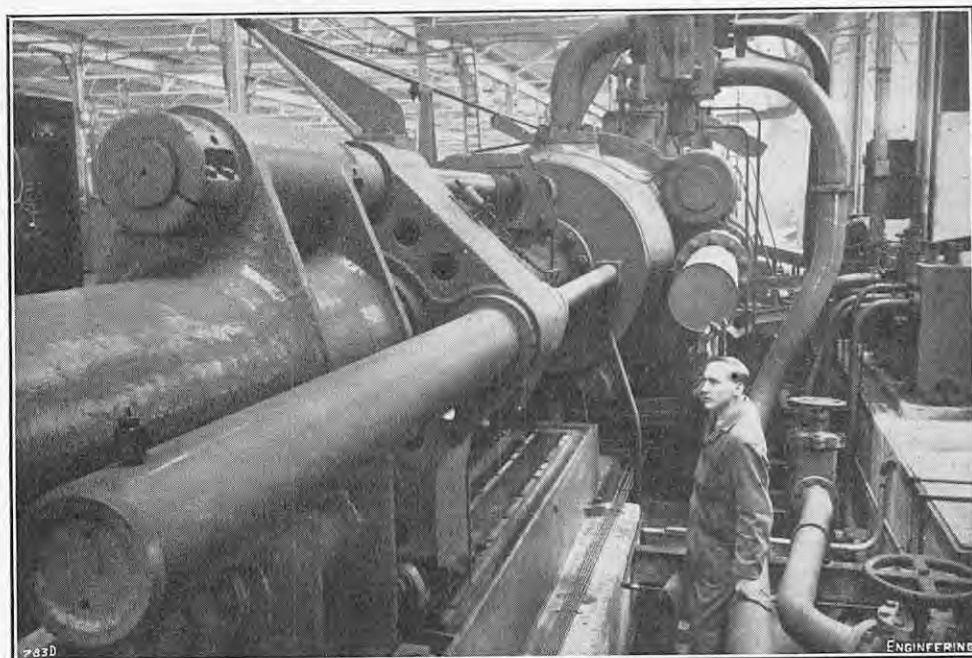


FIG. 4. REAR OF PRESS.

drawn, the pressing pad is brought to the centre line of the machine by the loading gear. The main ram is again brought forward and the pressing pad pushed into the container against the billet, the main ram subsequently continuing its stroke with the result that the billet is extruded through a die located at the opposite end of the container.

The die is accommodated in a special support known as the die-assembly carrier, which, during extrusion, is retained in a die housing located at the end of the container by a hydraulically-operated wedge which presses the die firmly against the container mouth. On completion of extrusion, the wedge is raised to permit the die-assembly carrier to be withdrawn from the die housing for removal of the pressing pad and shearing of the "discard" from the extruded section. Provision has to be made, however, for pressing the discard and pad from the container when extrusion is completed. This is accomplished by limiting the forward movement of the main ram and, therefore, the thrust rod, during the actual extrusion process, by inserting a movable stop between the ram and the face of the container. When extrusion is completed, the ram is withdrawn slightly, the stop block raised and the ram moved forward again until it makes contact this time with the face of the container, the extra travel thus obtained ejecting the pad and discard from the container. The stop

block is of heavy steel-plate construction and is located in vertical guides on the face of the container, the shape being such as to permit free passage of the ram; it is raised in conjunction with the die-locking wedge by wire ropes attached to the wedge-operating ram crosshead.

The discard and pressing-pad are, of course, ejected from the container before the die-assembly carrier can be withdrawn from the die housing. It is also important for the locking wedge to be raised before an attempt is made to eject the discard and pad and it is for this reason that the stop-block and wedge are raised by the same hydraulic cylinder. The die assembly carrier is moved against the container housing, and withdrawn to the run-out channel which guides the extruded metal, by means of two horizontally-opposed hydraulic cylinders and fixed rams mounted on a two-part bedplate secured to the main die-housing. To remove the discard from the extruded metal and the pressing-pad from the discard, the die carrier is withdrawn to the shearing position after extrusion is completed and the discard ejected from the container. When the die carrier reaches the shearing station, a hydraulic support is raised to hold the pressing-pad so that one movement of the shearing blade is sufficient to shear the extrusion from the discard and separate the discard from the pressing-pad. Once it is freed from the extruded metal, the dis-

card drops on to a chute arranged in the frame of the shearing mechanism, which directs it into a bin arranged below floor level. At the same time, the pad is directed into a further chute, or transfer channel, arranged at the back of the press, which returns it to the loading position. When the pad loader is operated, a pad is automatically selected from the stock lying in the pad-transfer channel and raised to the centre-line of the press for loading into the container. The shearing blade for removing the pad and discard is hydraulically operated, the action being controlled from a separate control station located beside the press. The hydraulic cylinder, shearing blade, etc., can be seen in Fig. 2, at the far end of the run-out channel with the control station at its side.

When tubes, or any other form of extrusion that does not readily permit the use of the shears for removal of the discard, are being produced, a pendulum-type saw suspended from a horizontal shaft arranged above the press is brought into use. The saw is located between the die-housing and the vertical shear and is arranged so that it can be kept either in its normal working position, or, when not in use, raised out of harm's way. It can be seen in Fig. 3, where it is shown in the raised position. After removal of the discard, it is necessary to eject the end of the extrusion from the die. To accomplish this, a swinging arm, to the side of which a small peg is fitted, is moved over the rear entrance to the container, the dimensions of the arm being such that, when swung into position, the peg lies along the axis of the press. The die-assembly carrier is then returned from the shearing station towards the rear of the container with the result that the end of the extrusion held by the die strikes the peg and is ejected from the die form. The arm is then moved back and the die-assembly carrier returned to the rear face of the container ready for the next cycle of operations. A similar method is used to eject the die from the die-carrier assembly, but in this case the arm is attached to the shearing frame and the die-carrier assembly withdrawn towards the shears.

The various controls which govern the movements of such parts as the main ram, billet and pad loaders, wedge, die-carrier assembly, etc., are all interlocked so that, should the press operator make a mistake in the sequence of movements, the press and all ancillary equipment are brought to a standstill. Further movement of any part is then rendered impossible until the mistake has been rectified and the particular item restored to its correct position, the cause of the hold-up being signalled on the control panel by means of a system of red lights. Power for operating the press is provided by a Fielding and Platt air-hydraulic accumulator system employing lubricated water, the maximum working pressure being 3,500 lb. per square inch. Control of the press is effected through mitre-seated balanced-type valves which, with the exception of the pad-loading cylinder, are servo-operated, the servo cylinders operating the valves through rocker shafts and being controlled by lever-actuated piston valves fitted in the control desk.

Lockheed hydraulic controls are employed for the servo-operation of the main valves. The pump, which is used in conjunction with a Pneumatic accumulator to provide the pressure, is of the four-cylinder radial type, the pistons deriving their reciprocating motion from an eccentric. It has a swept volume of 0.58 cub. in. and is driven at 324 r.p.m. by a 0.75-h.p. electric motor through reduction gearing. Mushroom-type suction valves are employed and these are housed in counterbores formed in the pistons; the delivery valves are of the rubber-sealed type. Access plugs are fitted over the delivery valves and these are provided with bosses which form the valve guides, the undersides of the plugs acting as abutments for the valve springs. The action of the pump is simple and straightforward, fluid being drawn from the pump body into the cylinder during each piston down-stroke and forced to the main-delivery gallery during the compression stroke. A 250 cub. in. capacity Pneumatic accumulator is connected into the main delivery line from the pump, the separating medium between the air and fluid sides taking the form of a rubber bag instead of the more usual piston. The main operational pressure line

is led to the control valves through a Thrustor-operated valve, which acts as a stop-valve, the valve remaining open only so long as the Thrustor is energised. Current for energising the Thrustor passes through a series of interlocks arranged so that, should the controls be operated in the incorrect sequence, they shut off the current, thus causing the Thrustor to close the valve, and, as a consequence, shut down the whole plant. It will be appreciated that it is the Thrustor-operated valve that gives the safety features referred to in the preceding paragraph.

Nine $\frac{1}{2}$ -in. B.S.P. control valves are used to direct the fluid to the servo cylinders, which actuate the main valves of the press. These are mounted in two control desks, the main control desk accommodating those for the main cylinder, piercing cylinder, billet-loading cylinder, pad-loading cylinder, wedge-operating cylinder and the speed control, and the subsidiary control desk those for the shear-operating cylinder, die-assembly carrier run-out gear and pad-supporting cylinder. Provision is made for individual and combined control of the main and piercing-control valve levers, thus enabling the power of the piercing ram to be used to augment that of the main ram. The speed-control valve, which is operated by a double-acting balanced piston, determines the main ram pressing speed. The piston, in turn, is controlled by a Lockheed metering valve, which, as previously mentioned, is located in the main control desk; when the lever controlling this valve is actuated, fluid at a pressure of 400 lb. per square inch is admitted to one side or the other of the piston according to the direction in which the valve lever is moved. When the valve lever is in the neutral position, the circuit is closed and the piston held in the required position, thus determining the speed of the main ram, an indicator connected to the piston showing its position in the cylinder. The pressing speed is indicated automatically on a Cambridge recorder and any fluctuation can readily be adjusted by manipulation of the metering-valve lever on the main control desk. The servo piston which operates the speed control valve is held at the required setting by two Lockheed "Hydroloc" valves as soon as the metering-valve lever is returned to the neutral position, and the hydraulic lock provided by these two valves is released only when fluid pressure is applied to obtain a variation of the speed.

(To be continued.)

ROOT'S BLOWERS.—The Institution of Mechanical Engineers have issued copies of a paper on "The Expression for Work in a Root's Blower," by Dr. J. Kestin, A.M.I.Mech.E., and Mr. J. A. Owczarek, G.I.Mech.E., on which they invite written communications, to be received at the Institution, Storey's Gate, St. James's Park, London, S.W.1, by May 3, 1952. An expression for the ideal work of compression is derived.

THE DIAMOND TOOL INDUSTRY IN 1951.—A survey of the chief scientific and industrial developments in the diamond-tool industry during 1951 has recently been published in a pamphlet entitled "The Diamond Tool Industry in 1951." It may be obtained *gratis* from the Industrial Diamond Information Bureau, 32-34, Holborn Viaduct, London, E.C.1.

TRAFFIC STATISTICS OF THE BRITISH AIRWAYS CORPORATIONS.—The Ministry of Civil Aviation have recently issued operating and traffic statistics for the British Overseas Airways Corporation (B.O.A.C.) and British European Airways (B.E.A.) for the period April to November, 1951. The short ton (2,000 lb.) is the load unit on which the statistics are based. B.O.A.C. flew a total of 82,367,220 revenue ton-miles, compared with 62,236,670 ton-miles in the corresponding period in 1950, an increase of 32 per cent. Their annual utilisation of aircraft has increased appreciably, from 1,593 hours per annum in 1950 to 2,111 hours per annum in 1951. Both corporations show an increase in overall revenue load factor, B.O.A.C. from 58.5 per cent. in 1950 to 65.8 per cent. in 1951, and B.E.A. from 58.3 per cent. in 1950 to 66.1 per cent. in 1951. The total revenue ton-miles flown by B.E.A. has increased by 27.5 per cent., from 23,377,294 in 1950 to 29,811,547 in 1951. Their average annual utilisation of aircraft is practically unchanged, at 1,632 hours per annum, that of the Continental division having risen slightly from 1,988 hours per annum in 1950 to 2,012 hours per annum in 1951, whereas the utilisation of the British division has fallen from 1,279 hours per annum in 1950 to 1,185 hours per annum in 1951.

LABOUR NOTES.

DURHAM County Council is being allowed until the end of April to give an undertaking that professional people in its employ shall not be subject to its closed-shop policy. The joint emergency committee, recently set up by a number of professional associations, met in London at the end of last week, and decided to send a letter to the Council to that effect, and asking that the undertaking should provide that none of the Council's professional employees should be subject to the compulsory membership of a professional body "in whatever manner, direct or indirect, it may be implied." The joint committee comprises representatives of the Engineers' Guild, the British Medical Association, the British Dental Association, the National Union of Teachers, the Royal College of Midwives, and the Royal College of Nursing.

According to a statement issued by the joint committee on March 15, the committee had reluctantly found it necessary to impose some time limit on further exchanges in this protracted dispute, which had already lasted for more than a year. If no satisfactory undertaking was received by April 30, the committee stated, it would be constrained to take further action to protect the essential principle of personal freedom. It would be pleased to send a deputation to interview the Durham County Council, however, if the Council considered that such a course would serve a useful purpose. The committee claims to represent some 330,000 professional personnel and copies of the letter to the Council have been forwarded to the Ministries of Health, Education, Transport, and Housing and Local Government.

Continued hard work, as the cure for most of Britain's economic troubles, was referred to by Mr. John Boyd-Carpenter, the Financial Secretary to the Treasury, in a speech in London on March 15. He emphasised the need for everyone to make renewed efforts, and urged that all who were prepared to assist in bringing about increased productivity should be adequately recompensed for so doing. He considered that the country was not going to get out of its immense economic difficulties unless an atmosphere was created in which people were encouraged and rewarded for working hard. The aim of the Budget was to help all who worked, including persons who had acquired skill in their work. It provided an added stimulus for them to do their best and, at the same time, it took care of such persons as were unable, for one cause or another, to take full advantage of the opportunities which it offered to the great majority of people in employment. The Budget provided welcome assistance in these hard times for the children, the disabled, and the old folk.

Industrial action for political ends continues to be rejected by responsible trade-union opinion. One of the latest unions to issue warnings against such strikes is the Iron and Steel Trades Confederation. The editor of the union's official journal, *Man and Metal*, writes in the March issue that threats to take industrial action as a protest against the Government's economy cuts have been condemned by all sections of the labour movement. He adds that to talk of taking strike action for such a purpose shows a degree of irresponsibility of which only extreme left-wing elements are capable and the inference to be drawn is obvious. The people who would instigate and support such a measure are no more concerned with the welfare of the British people than they are with the fate of the ten million men and women confined in the corrective labour colonies of the Soviet Union. They are, in fact, concerned only with doing all they can, with whatever means they have at their disposal, "to create a state of poverty and unhappiness, which is the best of all breeding grounds for the communist virus."

Although everyone might not agree that all the cuts have been made in the right places, or even that all of them are completely necessary, the fact cannot be avoided, the article continues, that the situation in which the nation finds itself to-day is such as to demand rigid economies and any Government, whatever its political colour, would have been compelled to make them. Any action that would result in a serious loss of production at this time would defeat the very object for which these economies have had to be made, and might well prove disastrous. The article concludes with a quotation from a recent speech by Sir Vincent Tewson, C.B.E., the general secretary of the Trades Union Congress: "I can understand the emotion which many politically-conscious trade unionists may feel about the Government's proposals for handling the present situation, but, if there were any attempt to disrupt industry because of differences in the political field, we should be blunting the very instrument with

which we are to hew our way out of our present tangle of difficulties."

Similar counsel is given in last Friday's issue of *Post*, the journal of the Union of Post Office Workers. In the course of an article under the title "Time for Cool Heads," the journal states that no Government could fail to meet a challenge to its authority which sprang from other than political sources. So fraught with danger was the situation in some industries, the journal continues, that appeals for restraint have had to be issued by leaders of trade unions and the Labour Party. These, no doubt, would have a steady effect on most workpeople. Should unemployment increase and the standard of living decline, however, it would not be easy to control those who would oppose what they conceive to be reactionary policies with the weapon nearest to their hands.

This might be especially so, the journal feels, when the political struggle was intensified and some labour leaders might be led to abandon the restraint which they now advocated. The temptation to take industrial action was strong but, in the event of such a challenge, the Press and the public would demand the enforcement of measures to ensure that the will of Parliament should prevail. Above all, industrial retaliation against political policies could only worsen an economic situation which was already serious. Even with peace in industry it was going to be difficult to maintain existing standards of living.

A resolution protesting against the Government's Budget proposals was passed unanimously at a special delegate conference of the National Union of Mineworkers, which met in London on March 14. The conference had been summoned to discuss what attitude should be adopted by the union with respect to the extended hours agreement. This agreement between the union and the National Coal Board, under which the working of voluntary shifts in the mines on Saturdays is permitted, is due to end on April 30. It was decided that the conditions of the existing agreement should be fulfilled and that Saturday shifts should be retained until the end of April. The conference also agreed that during the summer months, from the beginning of May until the end of August, the working of extra hours should be allowed to take place only in cases where arrangements to this effect are made locally between representatives of the union and colliery managements.

The executive council of the N.U.M. were instructed to negotiate a new agreement with the N.C.B. for the working of additional hours after September 1, next. This decision will be subject to confirmation by the union's branches and a ballot for this purpose will take place shortly. The conference also passed resolutions calling for higher wages and increases in pay for disabled miners, to offset the effects of the Government's economy cuts. It seems probable that a new wage claim will be presented when the effect of these cuts on the interim index of retail prices is known.

Claims for an increase of 22s. 6d. a week in the wages of certain classes of engineers in South Wales were presented by the trade-union side at a meeting of the Welsh Engineers' and Founders' Conciliation Board in Swansea on March 14. The employers' side expressed its inability to agree to this concession and negotiations on the claim are to continue. The complicated nature of the discussions on these demands is indicated by the fact that no fewer than eleven trade unions are involved, the principal being the Amalgamated Engineering Union and the Electrical Trades Union. The Board decided that another claim, for two weeks' holiday with pay each year, in lieu of one week as at present, should be met in full. Nearly five thousand engineering employees are directly concerned in decisions reached by the Board, but many firms not represented on the Board also abide by its findings.

A small measure of support seems to be accruing in some parts of the country to the Glasgow engineering apprentices who have been on strike since March 10 in an effort to obtain an increase of 20s. a week in their wages. They allege that there has been "delay" on the part of the employers' organisation in dealing with the claims. It was claimed on Monday last that there were about three hundred apprentices on strike at the Birkenhead shipyard of Messrs. Cammell Laird and Company, Limited, and that fifty employed in the machine shop at the Sheffield works of the English Steel Corporation Limited, had ceased work. On Tuesday last, employers in the Manchester district estimated that rather fewer than two thousand apprentices, drawn from fourteen firms, were on strike. There was about the same number of strikers in the Glasgow area at the middle of this week.

DREDGING CRAFT.

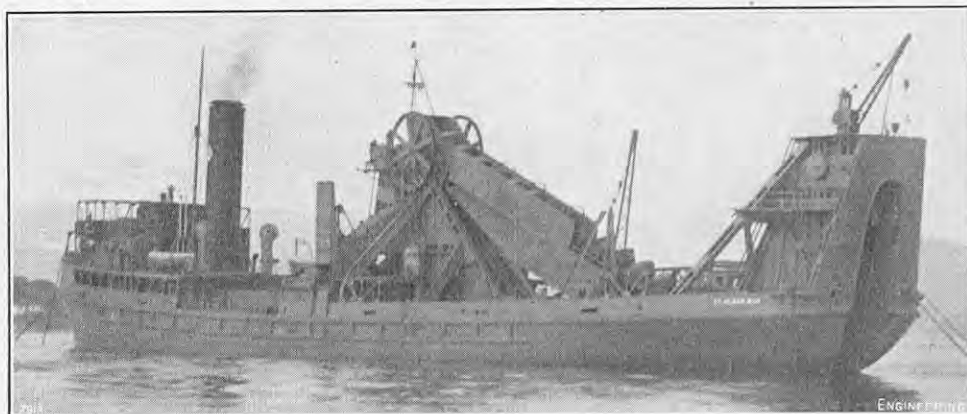


FIG. 1. STERN-WELL MULTI-BUCKET HOPPER DREDGE "ST. DAVID" (EX "ST. ALBAN").

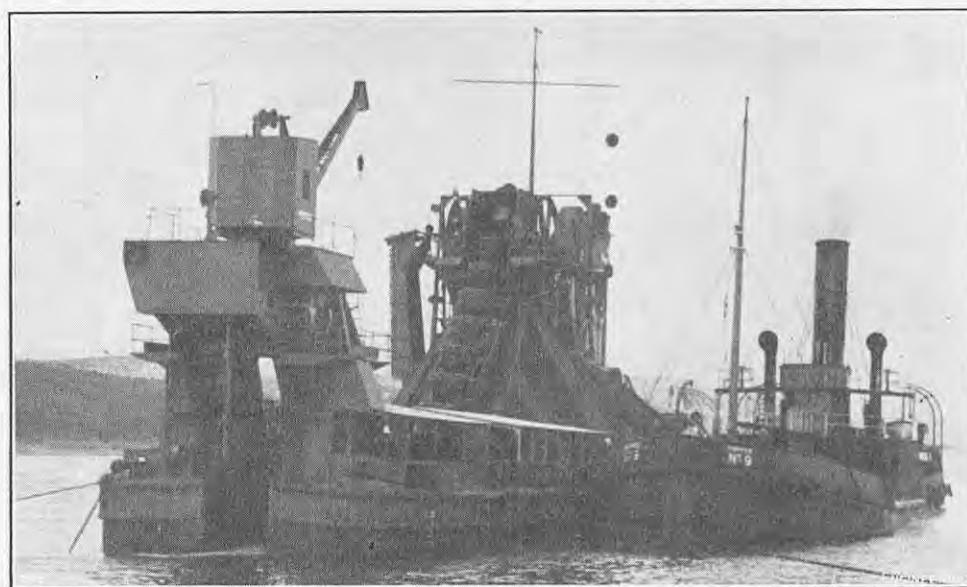


FIG. 2. NON-PROPELLING MULTI-BUCKET DREDGE "A. D. MACKENZIE."

DREDGING CRAFT.*

By D. W. Low, O.B.E., M.I.Mech.E.

DREDGING craft fall into two main types: first, the bucket dredge, which mechanically excavates ground by a digging or grabbing process conducted under water and raises the material above water level for disposal; and, second, the suction dredge, which raises material by suction from below water level and discharges a mixture of spoil and water through a pipe system either to a hopper or to some surface deposit site. Many suction dredges are assisted by equipment designed to break down the ground prior to its entering the suction pipe. Dredging craft are thus machine tools of a special type and, when engaged on harbour, river or estuary works, are invariably under the authority of the civil engineer in charge of these works. He may use the equipment to excavate and create new dock areas or he may deepen an existing navigable channel. In both circumstances he performs capital dredging, work essential to the creation, development, expansion and/or improvement of dock and harbour facilities. Also, the harbour engineer may use his dredging plant for maintenance duties, primarily the removal of deposits lodged by Nature—and in some instances by industry—from navigable waterways, in order to retain existing channel and harbour depths and widths.

Alluvial dredging or dredge mining is not practised in Britain at present, but substantial operations proceed in the Colonies and elsewhere overseas. This form of dredging is applied to processes whereby alluvial deposits are, in large quantities, broken down, conveyed, elevated, passed in association with water through appliances for winning metals, and redeposited on the ground. Dredge mining is usually under the charge of a mining engineer and the most common metals recovered by this means are gold and tin. Other rare and important metals and precious stones

have also been recovered, but not in large quantity. In tin dredging, for each cubic yard of ground dredged the metal recovery after treatment may be of the order of 0.5 lb., and many areas nowadays are being dredged for values below this level. In gold dredging, for each cubic yard of ground dredged, a very satisfactory standard of recovery to-day realises 0.0005 lb. (3.5 grains) of bullion, and many deposits are being worked for bullion values substantially less. These figures indicate how great is the importance of efficient treatment plant and how pressing is the urge for still greater dredge yardages.

BUCKET DREDGES.

There are three groups of bucket dredges, each of which is sub-divided into well-established types, namely, the multi-bucket type, comprising the sea-going hopper dredge, the river and harbour dredge, and the alluvial dredge; the grab-bucket type, comprising the sea-going hopper dredge, and the river and harbour dredge; and the dipper type, comprising the river and harbour dredge, and the rock dredge.

The multi-bucket dredge is the oldest and probably most familiar type of dredge. Widely recognised as a development of this and other European countries, the type has won immense popularity in many parts of the world; yet in the United States of America the multi-bucket dredge has few adherents other than in the dredge mining fields. It has comparatively low power requirements, does not require large quantities of water to carry the spoil as in the suction dredge, and is capable of dredging to great depths. The dependability of the multi-bucket dredge is unchallenged and the ability to dig ground ranging from easy silts and muds to hard clays and certain soft rocks, and to excavate blasted or broken rock, renders it an excellent general-purpose craft. The following remarks concerning the multi-bucket dredge in dock and harbour service are not entirely applicable to the alluvial dredge.

The digging equipment of the multi-bucket dredge includes the open-connected bucket chain, in which each bucket is separated from adjacent buckets by links;

the bucket ladder, upon which rollers are fitted to facilitate the passage of the buckets on the upper side of the ladder; the lower tumbler, located at the bottom end of the bucket ladder; and the upper tumbler, which is fitted on the superstructure near the top end of the bucket ladder. The upper tumbler rotates to drive the chain of buckets. The lower tumbler is an idler, and as the buckets move round it they cut into the dredging face, are filled, and are then elevated to the upper tumbler. As they travel around this tumbler the buckets empty their contents into a drop chute.

For mooring purposes, multi-bucket dredges are usually equipped with six anchors, to which are attached chains or wire ropes. The head and stern anchors locate the dredge in the fore-and-aft direction, the head anchor taking the digging pull of the dredge, which "steps ahead" into the next dredging cut by shortening the headline. The sternline is usually kept slack, but under adverse tidal or weather conditions serves to hold the dredge from being forced too heavily into the dredging face. Transverse movement of the dredge is effected through two forward and two aft sidelines, and anchors suitably positioned. In traversing the dredge from side to side across the dredging face, the main pulls are exerted through the forward sidelines, while the aft sidelines act virtually as followers. All mooring lines are connected to manoeuvring winches on the dredge, the number of these winches ranging from one in the simplest to six in the more elaborate arrangements. The dredge-master sets the dredge longitudinally by adjustment of the headline and connecting winch, controls the dredging depth through the ladder winch, and traverses from side to side across the dredging face by movement of the sideline winches.

In the multi-bucket dredge, all dredged spoil must be raised to a high level for distribution and disposal. In vessels without hoppers, barge loading outside is the most common method of spoil disposal; less popular, but very effective where practicable, is the pumping of the spoil to a reclamation area. Long overboard chutes were used at one period with good effect, but the modern equivalent is to carry the material on conveyors and stack it on shore at a distance well beyond the range practicable for long chutes.

The sea-going multi-bucket hopper dredge was in great demand and has made a major contribution to port development. Arranged with a central hopper and bottom-opening doors, after the hopper is filled it slips and buoys the dredging moorings and proceeds to sea to empty the hopper. Where one dredge is required to service several ports, this type still has a useful function, as it can perform these duties unaided by other craft. Dredging carried out in this manner is, however, costly, as the ratio of dredging time to total hours worked is low. This design, in addition to self-loading chutes, usually includes provision for discharging overboard on both sides. With an appreciable volume to be dredged, it is advantageous to station the vessel for dredging only and use hopper barges for the carriage of spoil.

It may be designed either with a stern well or a bow well. For sea-going qualities and where long sea passages are likely to be frequent, the stern-well craft is superior; but the ladder well aft necessitates twin-screw propelling machinery and, to secure a balanced design in a steamer, the placing of the boilers forward of the hopper, so that the main framing may be accommodated between the fore end of the ladder well and the after end of the hopper. Fig. 1, herewith, illustrates a dredge, completed in 1940, which has accomplished great work in many ports of the world under conditions of peace and war. The principal particulars are: length between perpendiculars, 265 ft.; breadth, moulded, 47.5 ft.; depth, moulded, 18 ft.; hopper capacity, 1,000 cub. yd.; normal dredging depth below waterline, 60 ft.; maximum dredging depth below waterline, 75 ft.; bucket capacity, 28 cub. ft.; rated output, 700 cub. yd. per hour; loaded service speed, 10 knots.

The ladder gantry at the after end is unusually high, to meet the requirement that, with the ladder housed, the catenary of the bucket chain must be clear of the water when propelling. The gantry carries the suspension gear for the bucket ladder and the driving mechanism by which the ladder is raised and lowered, and forms a strong tie to bind those sections of the hull which, running from the main framing to the stern, create the ladder well. The upper tumbler is driven by shafting and gearing and 700 i.h.p. is available for dredging duty. The dredge is equipped for rock dredging with a second bucket chain, each bucket having a capacity of 14 cub. ft., which is interspersed with ripping claws. The specified definition of rock was "the hardest material which can be dredged in normal bucket dredge practice without previous blasting." In service, the dredge has far exceeded this definition and, in one instance, gave very satisfactory results when dredging elvan and shillet in the natural state.

The river and harbour multi-bucket dredge is not equipped with a hopper and is designed in three forms,

* Paper, entitled "Considering Dredging Craft," read before the Institution of Engineers and Shipbuilders in Scotland, in Glasgow, on March 11, 1952. Abridged.

non-propelling, bow-well self-propelled, and stern-well self-propelled. The non-propelling form requires the lowest capital outlay and is a popular and useful dredge, arranged to discharge the dredged material into hopper barges moored alongside. An additional feature of pronounced value that can be introduced is a sand pump for the disposal of spoil through a pipeline. The bucket contents are emptied into a central sump, into which water is admitted; the sand pump draws from this sump and discharges the mixture of spoil and water through a floating and shore pipeline to a reclamation area. Before reaching the sump the spoil is passed through a disintegrating medium to reduce the possibility of choking in the sump. Where practicable, this method of disposal is more efficient and economical than the use of attendant hopper barges; there is a saving in man-power and fuel, and land may be reclaimed for future development. In the non-propelling dredge, a transverse dredging engine can be arranged to drive the upper tumbler through belts and gearing.

The multi-bucket dredge illustrated in Fig. 2, on page 377, was completed in 1951 and is the fifth of this size and type built by the author's firm, Lobnitz and Company, Limited, since 1946. The salient particulars are: length between perpendiculars, 178 ft.; breadth, moulded, 36 ft.; depth, moulded (mean at midships), 12.5 ft.; normal dredging depth below waterline, 46 ft.; maximum dredging depth below waterline, 60 ft.; bucket capacity, 28 cub. ft.; rated output, 700 cub. yd. per hour. The hull has a droop of keel which allows for the loss of buoyancy due to the ladder well and for the substantial difference in weight which exists with the heavy digging equipment forward and the relatively light boiler and engine-room components aft. The ocean voyage condition under tow with the bucket chain dismantled and stowed on deck and in the holds is an important limiting factor in the design. A range of stability of about 45 deg. is acceptable to the Ministry of Transport for ocean passages and, having attained this condition, it is usually found that ample stability exists for the dredging conditions, in which there is a fair change of trim between the extreme positions of the bucket ladder—up and on the bottom.

The machinery is steam-driven. A triple-expansion enclosed pressure-lubricated engine is placed transversely in the engine room and drives the upper gearing and tumbler through two belts. For normal dredging conditions, the bucket speed is 18 per minute and, should it be desired to carry out arduous dredging in very hard ground, an alternative bucket speed of 14 per minute is available. Both the upper and lower tumblers are annealed steel castings with integral shafts, and the faces upon which the buckets ride are hard-surfaced with weld deposit. This design of upper tumbler has disposed of the old problem of key slackening, common in two-piece tumblers. The lower tumbler revolves in bearings designed to exclude sand and other foreign matter, and this arrangement has displaced the fixed-shaft design, so long established. All rollers on the bucket ladder and the lower tumbler are coupled to an elaborate lubrication system, which is automatically controlled.

The buckets are one-piece steel castings, with hard-surfacing deposits applied to the cutting edge, maintained by welding rod only. Their superiority over the composite and riveted bucket has been well proved in service. The design of the bucket is simplified by having single eyes for the bucket pins. Adjacent buckets are thus connected together by four links instead of two, which is a distinct advantage in the maintenance handling of the bucket chain. Freely rotating manganese-steel bucket pins close the chain. The bucket ladder is entirely welded; the top suspension eyes and the bottom tumbler bearings are neatly welded into the steelwork and displace the steel castings which, in previous designs, were riveted at these points. Fitted at the top of the ladder is an auxiliary ladder which, at shallow dredging depths, improves the running conditions for the buckets as they approach the upper tumbler, while, at dredging depths between 46 ft. and the maximum at 60 ft., it is the support for the upper end of the bucket chain. The top end of the ladder and the framing are designed to permit the ladder to slide down and up without interference with the auxiliary ladder.

For manoeuvring purposes, the dredge is equipped with one headline winch, two forward sideline winches and one winch aft which handles the stern anchor and two aft side anchors. The bucket ladder is suspended by wire ropes from a barrel mounted in the ladder gantry, which also accommodates the ladder winch. The dredgemaster's operating position is forward on the port side and from this point he operates the headline winch by remote control, is in close proximity to the forward sideline winches and their winchmen, the controls for the ladder winch and the dredging depth indicator, and, on two telegraphs, signals respectively to the engine room and to the after winch. An emergency control is arranged so that the dredgemaster may stop the dredging engine instantly. In

DREDGING CRAFT.

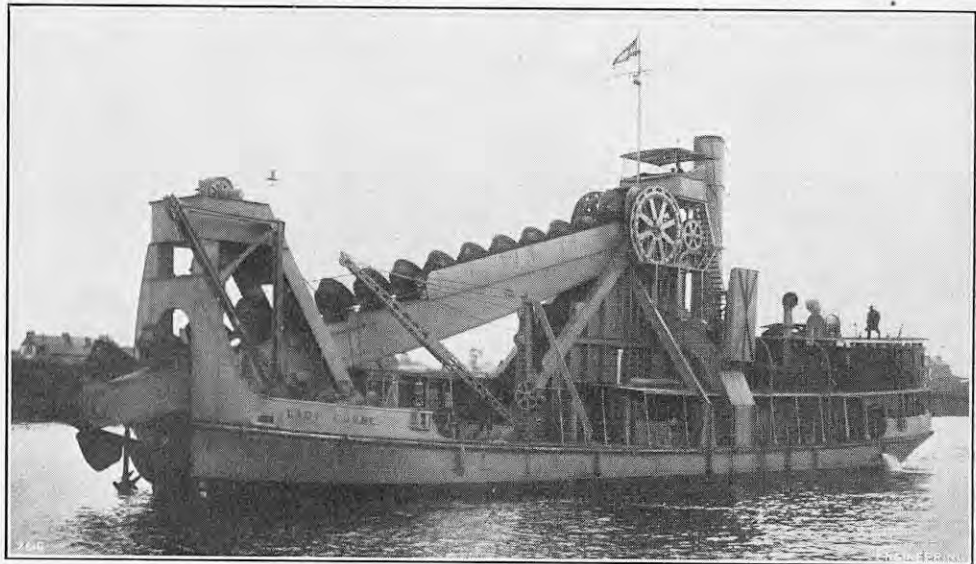


FIG. 3. BOW-WELL MULTI-BUCKET DREDGE "LADY COMBE."



FIG. 4. STERN-WELL MULTI-BUCKET DREDGE "BELOMORSKAYA."



FIG. 5. ALLUVIAL GOLD DREDGE "BREMANG No. 3."

practice, this control is frequently used for routine stoppages and the engineer on watch merely resets a trip mechanism so that the engine is ready to be started on command.

A typical bow-well self-propelled multi-bucket dredge is shown in Fig. 3, herewith. This type is not primarily intended for ocean passages, but is equipped with propulsion equipment to facilitate movement between dredging areas within closed or coastal waters and is usually fitted with a single engine which, with an arrangement of clutches, drives either the propeller or the dredging gear. In most instances, the drive to the upper gearing and tumbler is by shafting, a system now considered outmoded. Opinions on the merits of shaft drives and belt drives are sharply divided, but the author is a staunch supporter of the belt drive. It will be observed that the bow-well type produces a

balanced ship arrangement, with the engine and boiler rooms aft, the main framing roughly amidships and the ladder well forward. Many dredges of this type have given satisfactory service, but some criticism can be offered. Generally, the installed power is low, hence the speed is low and manoeuvrability weak. This feature is accentuated by a full hull form, while the inclusion of statutory Ministry of Transport requirements for self-propelled vessels adds nothing to the dredging efficiency and this, in the final issue, is the feature that matters most. Bow-well dredges can be arranged to have an adequate ladder overhang for bank dredging ahead.

The stern-well self-propelled multi-bucket dredge illustrated in Fig. 4, herewith, was designed for service in Arctic Russia. This dredge first operated in Murmansk and later served in a number of White Sea

DREDGING CRAFT.



FIG. 6. GRAB-BUCKET HOPPER DREDGE "MERSEY NO. 14."

ports. The ability to move freely between ports was essential and, as weather conditions there are frequently bad, the dredge had to be very seaworthy. In certain ports, barge loading was not used and the arrangements for spoil disposal included two sand pumps capable of series working, to discharge the spoil ashore through long pipelines. The machinery installation included one central engine, directly connected to a shaft drive for upper gearing and tumbler, and two wing engines, arranged with clutches for driving either the propeller shafting or the sand pumps. This class of dredge is used for bank dredging in capital works, but there is always a danger that the propellers may be damaged when breaking down the dredging face.

Alluvial or mining dredges are invariably multi-bucket dredges with close-connected bucket chains, in which each bucket is directly connected to the adjacent buckets, without the intervention of links as in harbour dredging practice. The close-connected bucket chain is capable of a much higher throughput, causes less surge when digging at the lower tumbler, has a much greater weight and, in general, produces a more uniform and effective dredging load. There are several obstacles to the use of this chain for harbour work and, of the more important, cost and an unbending outlook to changes rank high. Nevertheless, harbours and rivers frequently produce a motley collection of old anchors, chains and other weighty or voluminous oddments; these and boulders or loose rock of large dimension might not be friendly to a close-connected bucket chain. Standard practice for dredge mining is to use manganese-steel buckets having three connecting eyes and renewable rivetless manganese-steel lips. Some recent bucket designs have eliminated such lips in favour of weld deposition as wear takes place.

Among many dredges operating in mining fields overseas are a few capable of digging to a depth of around 130 ft. below water level. These deep-digging dredges have reached mammoth dimensions and capacity, and correspondingly high capital costs. So serious has this feature become that, in an effort to reduce the outlay, experiments are being made to dredge to deep depths with grab buckets, but some time must yet elapse before convincing results are obtained. Several attempts have been made to apply suction dredges to mining, but so far none is known to have been successful.

In dredge mining, as in harbour practice, the capacity of the bucket is an important indication of dredge size and output. To the author's knowledge, the largest bucket capacity yet used in a close-connected chain is 20 cub. ft. and the largest in an open-connected chain 54 cub. ft. The former is a modern size, while the latter has not been repeated for many years. The normal maximum bucket size used in current harbour practice is around 30 cub. ft., though consideration was recently given to a 54-cub. ft. close-connected bucket chain for the excavation of blasted or broken rock in a capital dredging scheme.

The digging equipment of an alluvial dredge consists of the same components as in the harbour dredge, but the design of the buckets and lower and upper tumblers differs. The lower tumbler is usually circular and the upper tumbler hexagonal, with an advanced design stepping up to seven sides. For mooring purposes, wire ropes are used, generally attached to solid anchorages on shore. The headline dredge operates with five lines, a long headline being run out and the dredge traversed laterally by four sidelines about the headline anchorage as a centre. The dredging face thus forms an arc of a circle with the convex side towards the dredge. The spud dredge is an alternative which uses four sidelines and has one or two spuds fitted at the after end. In operation, it swivels about one spud and is traversed across the face by the forward sidelines.

The after sidelines are invariably laid out to give a forward movement to the dredge when required, but, in the ordinary way, they lie slack. This method of dredging also introduces an arc into the dredging face, but of small radius and having the concave side towards the dredge. For hard digging conditions, as in cemented gravels, hard clay, boulders, etc., the spud dredge gives an excellent performance and higher throughput than the headline dredge. Modern alluvial dredges are invariably electrically operated and this feature permits easy centralisation of all dredging controls in the operating house. Manoeuvring winches number from one to five. The recent trend to use a number of winches has arisen mainly to keep the deck clear of spreading wires and fairleads and to secure superior operating control.

In mining, each dredge has three main functions: first, excavation of the metal-bearing ground; second, the washing and treatment of that material in order to recover the valuable metals; and third, the rejection of the waste overside after treatment. The dredging procedure is sometimes known as movable pond dredging. The dredge floats in a pond into which water either flows or is pumped and, as excavation takes place ahead, so the dredge moves forward, depositing as it moves the reject tailings to fill in the space already dredged out. River dredging also takes place in this sphere of mining.

When the buckets empty their contents over the upper tumbler and into the drop chute, the material passes aft into a revolving screen in which high-pressure water jets break it down until the small particles pass through the screen perforations, while the oversize reject travels down the screen to be conveyed astern of the dredge. After being washed and separated in the screen, the fine materials are collected for distribution and treatment, either in jigs or on tables where metallic recovery is effected. In association with water, the reject fine material is passed overboard on trailing chutes, which deposit well astern of the dredge. The volume of concentrates recovered from jigs or tables is subjected to further treatment on board the dredge in order to reduce the non-metallic content, and to bring either the tin or the gold to a stage ready for still more processing. Tin is invariably capable of recovery in the raw state, but gold is frequently recovered with the aid of mercury, the union producing an amalgam which may average a 50:50 mixture of gold and mercury. Fig. 5, opposite, illustrates a mining dredge at work in tropical Africa on the recovery of gold from large alluvial deposits.

A word should perhaps be included regarding a small dredge recently despatched overseas for re-erection, and now completing extensive trials. This dredge is electrically operated by a power supply at 500 volts, direct current. It was built on the shores of a trona lake in which reconstitution of the trona, a mixture of soda and salt, takes place within a few months. The dredge floats on a liquor having a specific gravity varying seasonally from 1.1 to 1.3 and digs trona from about 7 ft. below liquor surface. The trona is elevated and delivered into a three-stage crushing plant from which it emerges in condition to be pumped through a floating pipeline to the shore plant, where further treatment takes place. Dredging operations have been continuous on this lake for over 30 years.

The grab-bucket dredge has an important place in the dredging world, being used extensively in harbour works where siltation is a problem and where "hole and corner" cleaning of dock bottoms and other waterways must be accomplished. It is particularly useful for removing silt alongside quay walls, positions to which most other dredges cannot gain access. Its

ability to take up a dredging position and to withdraw speedily is a valuable attribute. Because there is no horizontal digging thrust, as a rule no headline is required and dredging is carried out on four sidelines. However, a strong current may demand a head anchor or other means of holding position. The grab dredge is well suited to perform many requirements of maintenance dredging and will give a good performance in easy dredging conditions of mud, loose sand and silt. It has a low capital cost and is economical to operate. Maintenance, too, is cheap, due to the small number of wearing parts in the digging equipment. It is not, however, a suitable type for large-scale capital works, is not inherently suited to hard dredging conditions, and lacks the range of dredging capability which exists either in the multi-bucket or in the dipper dredge.

The self-propelled hopper dredge, fitted with one or more grab cranes, has proved an eminently practicable type within the limits described. Except probably in the single-grab dredge, the size and number of grabs should be dictated by two features, the dredging cycle and the deposit cycle. The former includes the time to take up and let go moorings and the time to fill the hopper—which is, of course, related to the grab bucket capacity and speed of operation, and the hopper volume; the latter covers propelling time to and from the deposit site and the time to empty the hopper. Single-grab dredges are invariably designed with limitations on their dimensions and capacity, with the intention of making them do sundry jobbing. Most single-grab and multiple-grab dredges are designed to operate round the bows, a most desirable feature and, in the multiple-grab types, preference appears to be for the twin-crane or triple-crane installation. The beam of these craft is influenced by the angle of heel created by the grabbing pull exerted when the crane is working at a fixed radius athwart ship, and by the rolling motion set up by the rapid cycle of digging and slewing. Various types of grab buckets are available for service in different conditions, but the ability of the bucket to penetrate the ground as it makes contact, to gather the ground as the sides close together, and to hold the ground while being raised to the surface, are important criteria in the dredging efficiency.

The Diesel-electric self-propelled dredge, Fig. 6, herewith, is a recent addition to the fleet of a major port authority. The main particulars are: length between perpendiculars, 143 ft.; breadth, moulded, 32 ft.; depth, moulded, 12.75 ft.; hopper capacity, 300 cub. yd.; maximum dredging depth below waterline, 50 ft.; bucket capacity, 50 cub. ft.; rated output, 130 cub. yd. per hour; loaded service speed, 10 knots. This dredge operates on the constant-current system, with the main electric generators, propelling motors, deck machinery and grab-crane hoisting and slewing motors connected in a series loop. The current is kept at a constant level by a motor-driven exciter set, and this system automatically prevents any overloading of the Diesel engines, generators or motors, however rapidly the controls are operated. Voltage to earth at any point in the system is limited to 600. The engine-room auxiliaries, excitation and lighting circuits are supplied from constant-voltage generators, coupled in tandem with the main generators so that all services are supplied without the necessity of running an auxiliary set.

Non-propelling dredges having a grab-crane fitted to a pontoon exist in vast numbers. These craft usually load into dumb hopper barges which are towed either to a deposit site, where the hopper contents are disposed by opening the bottom doors, or to a pumping station which extracts the contents from the hopper and discharges them to a reclamation area. Manoeuvring on this class of craft is frequently by hand winches and everything practicable is done to keep to bare essentials.

(To be continued.)

SHEET AND STRIP METAL USERS' TECHNICAL ASSOCIATION.—The spring meeting of the Sheet and Strip Metal Users' Technical Association will be held at the Charing Cross Hotel, London, W.C.2, on Thursday, April 3, when, at 6.45 p.m., Mr. A. B. Harvey, of Briggs Motor Bodies, Ltd., will read a paper on "The Finishing of Motor-Car Bodies." The meeting will be preceded by afternoon visits to Briggs Motor Bodies, Ltd., Dagenham, Essex, and to the A.P.V. Co., Ltd., Wandsworth.

BRITISH ELECTRICAL POWER CONVENTION.—Owing to the lack of facilities for showing lantern slides at the Town Hall, Bournemouth, the papers on research which were to have been presented at the meeting of the British Electrical Power Convention on Monday afternoon, June 16, will now be considered at the Pavilion on Tuesday afternoon, June 17. The papers on the electric water-heating, cooking and heating loads will, in consequence, be dealt with at the meeting on Monday afternoon.

BASIC ENGINEERING STANDARDS.*

By CAPTAIN G. C. ADAMS, R.N. (ret.),
A.M.I.Mech.E.

This paper is concerned with the logical approach to that rather despised part of engineering which is concerned with completing the detailed design of the parts of mechanisms. It is maintained that this can be fitted into a logical framework which aids economy and makes the task both rational and interesting. Modern needs usually demand that articles shall not only be efficient, but also that they shall be cheaply made in large quantities. They must be cheap not only in their first cost, but also in their maintenance. This implies manufacture with economy in labour and tools, and the provision of interchangeable spares. The idea follows that the smallest practicable range of articles should be used to meet the full range of functional needs. This gives rise to the standardisation of, say, nuts and bolts, that is, to standards for concrete articles. This paper, however, is concerned with the standards for abstract things. These are conveniently termed the "Basic Engineering Standards" since they should form the logical basic framework which helps the designer to economise in the details of his design. They should be the starting point in standardisation.

An engineering design stands or falls by its success in production and in actual use. The ultimate detailed form is a compromise between conflicting needs of function, production, and use, in their broadest senses. The final product derives from the finished design, and it is with the details of this finished design that the basic engineering standards are mainly concerned. The duty of an efficient designer is to state on the drawing what he really wants, in the simplest possible terms, and to let this be no more than he really needs. Nearly all bad drawings are bad because the designer has failed to observe these simple rules. The basic engineering standards should help him to observe them, and it will be easiest to see what these standards should be by following through the logical processes of design. The standards which will be examined are shown in Fig. 1, herewith.

Before doing this, however, it is best to decide what is meant by a standard. There does not appear to be any accepted definition, and any complete definition is difficult to frame. The following rudimentary definitions, however, contain the main essentials: a Standard is a unique document which defines something which it is desired to use whenever the design permits, or for a particular purpose; and a Standard Thing is something which complies with the definition in a particular standard. It is true that some few standards refer to a unique article also, such as the Imperial Standard Yard, as a basis of comparison, but normally a standard is a document.

It will be noticed that the examination of the problem has not even started before the need has arisen for definitions. It would be fair, therefore, to give "Engineering Definitions" as the first basic standard. Unless such definitions are framed, learnt, and used, misunderstanding will continue. The words in this paper are used in the sense of the definitions prepared by the British Standards Institution, where such definitions exist.

A new design may arise as the result of invention or to meet a stated need. It will be most convenient to assume a stated need and, perhaps optimistically, that this need has been fully stated in relation to function, conditions of use, maintenance, and any limitations in production resources. In most commercial designs, the nature of the production facilities is well known. In most Service designs it is much more doubtful, and the design has often to be made in a large variety of works, by personnel not used to the class of product. Very complete detailing, and a specialised approach to the problem of interchangeability, is a natural outcome of this diverse and difficult background.

When the parts of a mechanism are set down on paper, the designer is first concerned with the form and size of the part. Size can be related to the appropriate "ultimate standard of length." Form, if it is to be precisely interpreted, requires, in practice, certain conventions. These are closely concerned with geometric analysis of the design, but probably will be most conveniently included as part of drawing practice.

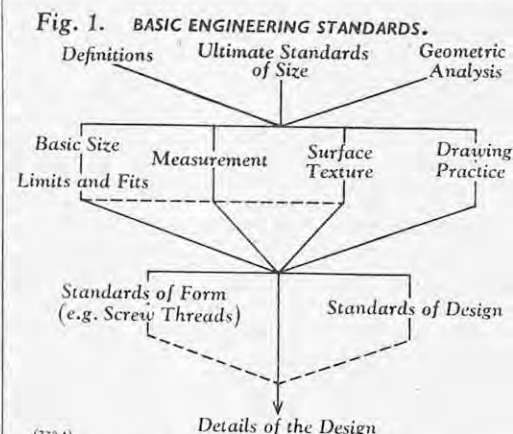
The geometric analysis requires some degree of standardisation, since some conventions are needed to avoid confusion, and a clear view is necessary of how the geometry will influence both function and production. It is probable that the conventions will find a home in "Drawing Practice" and the agreed geometric methods in a text-book, rather than a "Standard." In the course of the geometric analysis, the functional

datum surfaces can be found and the most efficient allocation of sizes determined. Basic sizes will be selected. The Standard for basic sizes is one of the most important, since it is the basis of any standard tool series and the starting point in any rational series of standard articles. It does not exist at present in Britain.

The allocation of clearances and tolerances derives partly from functional and partly from geometric considerations. Here the "Standards of Limits and Fits" comes in. This again affects tools and gauges. The designer, when he has allocated sizes to the various limits, still wants to be sure what will be the actual limiting sizes of the articles. Some "Standard of Measurement," that is, of the appropriate permissible error of comparison, is required. It may be necessary to specify surface texture and machining process. With an adequate "Standard of Drawing Practice," a clear, unambiguous and complete statement of requirements can be made.

Efficiency, however, still requires some additional and more complex basic standards. The most obvious are those for screw threads, which standardise both the forms and recommended basic diameter-pitch series. Similar standards exist for gears, splines, and other specialised forms in common use. All these standards must be regarded as falling within the definition of basic standards, but they are closely allied to the simpler standards for articles such as bolts. There is a further class of basic standard which can help the designer to act rationally and consistently. This may be described as "Standards of Design." They give rules, or recommendations, for the design of articles, or assemblies, which have frequently to be designed but which are not suitable for detailed standardisation.

This brief statement of design needs appears to hedge in the designer with a mass of rules and restrictions. It is hoped that a more detailed examination



of the individual standards will show that this is not so. The difficulty now is that many intelligent men have been applying their own rules and conventions for so long that much confusion occurs. The lack of common guidance makes any consistent and rational action difficult, except quite parochially.

The object, therefore, in these standards is to provide a rational framework from which all designers can draw common methods, sizes, etc., in so far as their particular problems permit. The obligation to use them derives from the fact that it will be rational to use them. No standards must be allowed to cramp progress or to unduly restrict the designer. It is difficult to discuss any one standard by itself, since they interlock very closely and the details of one may greatly affect another. Their separation is mainly a matter of custom or convenience. They should really be regarded as a single complete code of practice.

Definitions.—This basic standard hardly needs discussion. A dictionary of terms is essential to accurate statement and clear understanding. It is convenient to group definitions in relation to different subjects, but many cross-references may then be needed. Such a word as "basic" has wide application and, too often, is not understood. Definitions are best presented in a simple general form, and special applications, or permissible usage, given in footnotes.

Ultimate Standards of Size.—These standards are of long standing and are the subject of continued consideration. It is not proposed to enter into discussion of inch-pound *v.* metric systems. Each is well established in its own sphere and each can have its own appropriate variation in basic standards. Unification of these standards presents an economic, psychological, and political tangle which is a subject in itself. It is suggested, however, that the disadvantages of dual linear standards, at least, are often overstressed. One universal system would, of course, be rational, and has been recommended recently as a long-term project.

Geometric Analysis.—Geometric analysis may properly be regarded as the subject of a text-book, and any necessary conventions be lifted out into an appro-

priate standard. It is essential to any proper use of basic engineering standards. There appears to be only one recent and comprehensive attempt to cover this subject.* It has many faults, but it offers a logical approach to the straightforward geometry of normal design in relation to the tools and gauges used to make and prove the product. Most of the geometry involved is extremely simple. Its value lies in the logical approach and in the way in which it connects and relates the effects of linear and angular tolerances. The conventions recommended are useful in avoiding some of the practical difficulties of linking pure geometry with engineering practice.

Its main use to the designer is to find out what are the largest possible linear and angular tolerances, and thereby avoid trouble in production. It leads him to the functional datum surfaces, from which only can he dimension to permit the maximum tolerance, and it enables him to compute the effects, and practicable sizes, of the relevant linear and angular tolerances. In fact, it helps him to find out what he really wants, to reduce this to its simplest terms and to ensure that it is no more than he really needs. A complete analysis can be lengthy, but practice soon reduces the time, and much straightforward work does not need one. An eye for the difficult spot is soon formed and rigorous analysis can be comparatively limited.

When the analysis is complete, it is possible to state on the drawing, clearly and unambiguously, what is really required. It is true that it is not always necessary, or economical, to state all the details. It is, however, important only to omit those which can be safely omitted. This analysis is a draughtsman's tool and trouble finder. More than that, it is an essential rational background to the efficient application of the basic engineering standards. Without such an agreed approach, the everlasting detailed difficulties cannot be avoided when the time comes for articles to be standardised. Standards for articles should be the natural by-product of sound design methods, and not a scratch compromise selected from a list of unco-ordinated designs.

Basic Sizes.—Linear basic sizes are usually and conveniently associated with limits and fits, but the general subject covers a wider field and is properly considered separately. Simple linear basic sizes are the starting point in finding the limits of size for a fit. They are also a guide to the sizes to be selected for any purpose, when it is desired to select a size which is likely to be commonly used. Their object, in fact, is to ensure that as few sizes as possible are used, and that the number of sizes of tools and gauges is also kept as small as possible.

In Britain, no real agreed series exists on the inch system. A simple series of binary fractions has been commonly arrived at in, for instance, standards for tools and for many articles. There was a tentative agreement to use the American "Preferred Number" fractional series. There is also a tendency to use some kind of decimal series. It is not proposed to argue the merits of the fractional as against decimal series, or of a preferred number series as against a plain binary fractional series. There is an excellent British Standards Institution report on the subject,† which covers most aspects of the use of preferred numbers. Attention is called, however, to the convenience of a binary system for most design purposes. Halving is the simple, natural procedure and for many purposes gives more convenient increments of size than does the preferred number series.

The object of recommending a series of basic sizes is to reduce the number of sizes used, and therefore of the tools and gauges. If the designer were concerned with rather crude mechanisms in which space and weight were of small moment, he might feel content with such a series of sizes as $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$, $\frac{7}{8}$, 1, and seldom find it imperative to go outside it. Steps of $\frac{1}{8}$, however, are obviously too large for many purposes in general engineering. Steps of $\frac{1}{16}$, in this range of sizes, would be far more suitable and, often, almost entirely adequate. In almost any precise form of design, smaller steps still would be needed.

It is commonly argued that such a series as that in steps of $\frac{1}{16}$ will meet a very large proportion of the sizes needed in engineering, and that the remaining "special" sizes needed are very few in any organisation. There is a great deal in this argument, but it is seldom realised how many different sizes are likely to be written down if no guidance is given. An obvious extreme example is a rifle or machine gun. Here weight is of first importance and the designer must remove any metal surplus to strict requirements of function and safety. The starting point for size in the design, namely, the size of the round, is arbitrarily determined by functional needs, and the designer

* H.M. Stationery Office: *Dimensional Analysis of Engineering Designs*, vol. I, part I (1948).

† B.S. 1638, *Report on the Selection of Ranges of Types and Sizes (Preferred Numbers)*, by J. E. Sears. British Standards Institution, 28, Victoria-street, London, S.W.1. [Price 3s. net, including postage.]

* Paper entitled "Basic Engineering Standards and Their Place in Design," presented at a meeting of the Institution of Mechanical Engineers, held in London on Friday, March 14, 1952. Abridged.

would be lucky if he succeeded in using more than an odd size from the above $\frac{1}{16}$ series in the whole design.

The author analysed a list of plain "GO" plug gauges, which was probably the largest ever prepared. It covered a vast range of products, and bore internal evidence that a conventional fractional series of the type discussed had been freely used in design. In spite of this, the number of sizes of gauge used was incredibly large; there were over 300 sizes between $\frac{1}{8}$ in. and $\frac{1}{16}$ in., that is, at the rate of 2,600 per inch. At 1 in. they were at the rate of 1,000 per inch, and at 2 in. at the rate of 500 per inch. This kind of fault will continue unless adequate guidance is given. Basic standards are not concerned with only one class of engineering, but with engineering as a whole.

TABLE I.—Series of Choices.

First Choice, In.	Second Choice, In.	Third Choice, In.	Fourth Choice, In.
$\frac{3}{16}$	$\frac{13}{32}$	$\frac{25}{64}$	Nearest 0.005
$\frac{7}{16}$	$\frac{15}{32}$	$\frac{27}{64}$	
$\frac{1}{2}$	$\frac{17}{32}$	$\frac{29}{64}$	
$\frac{9}{16}$		$\frac{31}{64}$	

The solution is easy and, in principle, is of profound importance to the future of standardisation. It is to write down the series in a number of choices, say, first, second, third, and fourth choices. For instance, a crude and simple series might be of the type given in Table I, herewith. The $\frac{3}{16}$ -in. and $\frac{1}{16}$ -in. values are inconvenient, since they are five-figure and six-figure decimals, and would probably be replaced by some simple decimal value in any actual series. At some point above $\frac{9}{16}$ -in. size, the first-choice increment would become $\frac{1}{8}$ in. and the columns would move to the right. The second choice would be $\frac{1}{16}$ -in., the third $\frac{1}{32}$ in., and the fourth probably in 0.01-in. increments.

The point of this arrangement is that the number of choices actually used in any one design office can be conditioned to the class of work. It takes no great intelligence to learn to use always the highest choice which can be used. However, the design office which needs a third choice once a month will still be using the same sizes as does the designer who uses one once a day. In the aggregate, the reduction in the number of sizes can be immense. Since these are definitely canalised, any growth in closer types of design will be reflected in the self-creation of standard ranges of tools and gauges, which will fall into natural "choices." The difficulty at present is that the designer cannot be rational without the guidance given by such standards as that for basic sizes. A large number of series can be constructed, all having merits and none being perfect. The time has long passed for fighting about which is the best, and also for one to be published which is sufficiently large to cover all reasonable needs of all engineers, now and for some time to come. Standardisation must always look ahead.

Another kind of linear basic size occurs in the various sheet metal and wire "gauges." There is a tendency at present to try to simplify these. There is also a tendency to ignore gauges for sheet metal and strip, and to order to any appropriate size in thousandths of an inch. Where large orders are concerned, this causes no inconvenience to anyone, and no "gauge" series is needed. There are, however, many small users to whom a "gauge" series, in effect a first-choice series, is a convenience for designs, orders, and stocks. There are other fairly obvious conveniences in having such a first-choice series, and this illustrates that such a standard can be justified even if it is regularly, and legitimately, ignored by many of the biggest users.

In principle, recommended basic size series should be framed for other than linear dimensions; for example, angular sizes. The need here is very much less, and the size used is perhaps more often determined by function. However, there is little doubt that a series could be prepared, at least for angles of taper, and that it might reduce unnecessary variation. It is common practice to determine series of sizes, such as a series of horse-powers for electric motors for some type of use. Here the $\sqrt{10}$ preferred-number series forms an excellent guide to the selection of sizes in suitable approximated values. All such series are of the nature of recommended basic sizes. Series of articles, such as nuts and bolts and ball bearings, naturally arise, or should arise, from the basic linear sizes which should control their important functional dimensions.

(To be continued.)

HYDRAULIC SHOCK-ABSORBERS FOR AUTOMOBILES.

THE characteristics of hydraulic dampers for automobile suspension systems were discussed in a paper entitled "Shock Absorbers," read by Mr. J. W. Kinchin and Mr. C. R. Stock before a meeting in London of the Automobile Division of the Institution of Mechanical Engineers on Tuesday, March 11. The shock absorber, or suspension damper, the authors said, formed an essential part of modern automobile suspension systems. The vane type of hydraulic damper, in which a rotor operated in a chamber split by a reaction block, had a high temperature "fade" characteristic, and had been superseded in this country by the lever-operated piston damper, discharging to a recuperation chamber and thence to the opposite working chamber through valves in the damper body. In America, this type had been largely superseded by the telescopic damper, and a similar trend was evident in this country.

In its simplest form, the telescopic damper comprised a cylinder attached to one part of the suspension system, and a piston and rod attached to the opposite side of the suspension spring; it had been found that such dampers went out of action immediately the surface of the rod became slightly damaged. To overcome this, a concentric tube arrangement had been adopted in which a pressure tube was enclosed in a reserve chamber. When using two-way flow through the piston, two valves were necessary, one in the piston and one in the base of the cylinder through which the displaced volume of the piston rod was discharged into the reserve chamber. To ensure that the chamber above the piston, i.e., on the rod side, was completely filled, a greater pressure drop was required across the base valve than across the piston. In general it was convenient on road vehicles to use a lightly-loaded plate valve on the piston, with a pressure drop of 10 lb. to 30 lb. per square inch, and to use a highly-loaded valve to control the discharge to the reserve chamber. Thus, on compression, the effective area was reduced to that of the rod only. If, however, it was necessary to provide equal resistance on compression and rebound, the piston had to be provided with a valve capable of giving a big pressure drop, usually about 15 to 25 per cent. lower than that of the base valve. In either case, any air which might have been absorbed in the fluid was subjected to a positive pressure in the working cylinder on the rod side of the piston.

In the working chamber on the large-area side of the piston, it was inevitable that on extension there should be a negative pressure relative to that in the reserve chamber. During this condition, air absorbed in the fluid would expand. Owing to the displacement of the rod, a fairly large air space was required in the reserve chamber, and it was not possible to prevent the fluid from mixing with this air, especially at high speed and temperature. It was necessary, therefore, to allow for this air to escape from the working cylinder, between the piston rod and guide, and drain back into the reserve chamber. At high temperatures, excessive flow through the relief hole might tend to promote aeration of the fluid, which might increase so that the resistance on compression could completely disappear. To avoid this, a closed-circuit drain was provided from the piston-rod guide. A baffle system was required to restrain the agitation of fluid in the reserve chamber.

After discussing some of the types of valve and seal employed in hydraulic dampers, the authors outlined the characteristics desirable in a hydraulic fluid. The fluid should have a flat viscosity-temperature curve, to be suitable for all climatic conditions and to eliminate temperature "fade." Some synthetic oils had this characteristic, but were unstable and broke down in service. A suitable mineral oil had a viscosity ratio of not more than 30 to 1 between 100 deg. and 0 deg. F. If the fluid were too thin, it was not easy to prevent leakage, whereas if the fluid were very thick it was difficult to get complete recuperation at high piston speeds. The lubricating qualities had to be reasonably good to prevent wear; it was usual to introduce an additive to obtain sufficient film strength. Vegetable and animal oils, which tended to gum and cause valve sticking, were unsuitable.

Discussing noise in dampers, the authors said that hydraulic knock could be caused by aeration, or by cavitation. Mechanical knock was generally associated with lever-operated dampers having all-metal bearings, usually at the rocker shaft and the connection between the rocker-arm and the piston. Seal knock, on telescopic dampers, could be cured temporarily by lubricating the seal lip or by changing the seal; the composition of the latter and the concentricity of assembly affected noise. "Swish," a hissing effect, was caused by fluid issuing through the valve at high velocity and agitating the fluid on the discharge side. A plain, short hole was probably the noisiest form of orifice; where laminar flow took place, there was no noise. Large-diameter valves, opening uniformly, gave

the best results. "Squeak" resulted from valve instability, and could be avoided by designing the valve and its ports so that rapid fluctuations did not occur.

In testing a new design of damper, the parts of the damper were flow-tested individually on a test-rig and were then combined, one at a time; and, finally, the complete assembly was tested. Where spring-loaded valves were employed, the rate of the spring was determined on the flow rig. Tests were performed in transparent Perspex casings so that the operating conditions could be checked and recorded photographically. Dynamometer tests were carried out on the complete damper to obtain work diagrams at various speeds over the full range of settings. A number of dampers were tested for endurance on a single machine, under their maximum load, through a stroke of 5 in. for 1,500,000 cycles. Finally, service tests were carried out on road vehicles to check the effects of corrosion and weathering. Road tests were also carried out to determine the settings to give the riding qualities specified by the car makers. A record of the damper movements on selected sections of the test route was obtained with a Kelvin and Hughes four-pen recorder, from which the used stroke length of the damper, the roll angle between the axle and body, and the average work output of the damper could be determined. The paper ended with a brief discussion of the damping characteristics required, from which it was concluded that the double-acting damper, in which the compression and rebound valves were independent, offered the most practical solution of the problem.

THE EXTENSION OF TAKORADI HARBOUR.

A COLOUR film, which has been produced by the Orion Picture Corporation, gives a good idea of what has been done by Messrs. Taylor Woodrow (West Africa), Limited, in extending the harbour at Takoradi for the Gold Coast Railway and Harbour Authority.

Takoradi is the main outlet for timber, bauxite, manganese and other produce from the West Coast of Africa. During little more than 25 years it has grown from a fishing village to an important port, and is, in fact, the only harbour on the Gold Coast that can offer berthing and protected anchorage facilities to ocean-going vessels. Development began in 1928, when a breakwater $1\frac{1}{2}$ miles long was constructed to enclose a water area of 220 acres. Quays for berthing three ocean-going vessels up to 30 ft. draught and for lighter and harbour craft were also constructed; and anchorage accommodation was provided for six ocean-going vessels and 20 tugs and lighters. The latest extension will enable six ships, instead of three, to be tied up alongside the main quay, which is being extended by 1,400 ft., pre-cast concrete blocks, the largest of which weighs 15 tons, being used for the purpose. In addition a new timber depot consisting of about 4,000 ft. of mass-concrete quay wall, varying in thickness from 10 to 15 ft., is being built at the southern end of the harbour to form two docks 500 ft. long. Two sheds, 150 ft. by 404 ft. 6 in., for sawn timber and two double-storey transit sheds, one of which includes facilities for passenger traffic, are also being erected. The bauxite loading berth, which was on the harbour side of the Lee Breakwater, has been dismantled and re-erected on concrete piers outside the breakwater, and a new oil berth and extensive railway sidings are also to be constructed. Finally, the work has included the removal of a well-known local landmark, known as Cox's Fort Hill, the 1,750,000 tons of spoil from which have been used to reclaim an area of about 49 acres from the sea.

As may be appreciated, a number of difficulties had to be overcome in carrying out this improvement. All the cement, steel and contractor's plant had to be taken out from England. Indeed, only the sand, aggregate and timber could be obtained locally. A large stock of spare parts had to be maintained and experienced personnel had to be employed for repairs. As the film shows, a high degree of mechanisation was employed, and for this purpose it was necessary to train African personnel to use heavy plant.

The contract for the extension work was carried out in 2½ years under the supervision of the consulting engineers, Messrs. Rendel, Palmer and Tritton.

DURHAM UNIVERSITY.—A proposal that the title of Durham University should be changed to "The University of Durham and Newcastle" was considered at a special Convocation of the University's graduates at King's College, Newcastle-upon-Tyne, on Tuesday last. It was decided by 135 votes to 129 to make representations to the Court of the University that, in the opinion of the Convocation, the University's title should not be changed. A suggestion that a postal ballot of the University's graduates should be taken on the issue was rejected.

BRITISH STANDARD SPECIFICATIONS.

THE following publications of engineering interest have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 24, Victoria-street, London, S.W.1, at the price quoted at the end of each paragraph.

Handbook on Mechanical Tests for Metals.—Specifications dealing solely with mechanical testing, together with extracts from other specifications illustrating particular applications of tests, have been collected under one cover to form "Handbook No. 13 on Mechanical Tests for Metals." This will provide a work of reference useful not only to industry, but also to universities and technical colleges in connection with the subject of the strength of materials. The development of standard methods of test and their importance in the field of mechanical testing are reviewed in an introduction contributed by Dr. H. J. Gough, F.R.S., who is a member of the Mechanical Engineering Industry Standards Committee and was for many years closely connected with the work. The subject-matter of the book is arranged in ten sections, dealing, respectively, with tensile tests, hardness tests, impact tests, ductility tests, tests on thin metal, creep tests, the verification of testing machines, transverse tests, miscellaneous tests, and conversion factors. The final section contains a comprehensive series of conversion factors and tables which include values of stresses and moments of inertia converted from inch-pound units to metric units and vice versa. A general list of contents, a separate list of contents for each section, and a general index are furnished to facilitate reference. [Price 17s. 6d., postage included.]

Small Boiler Systems, Using Solid Fuel.—The Council for Codes of Practice for Buildings, Construction and Engineering Services, Lambeth Bridge House, London, S.E.1, have now issued, in final form, Code No. 403.101, concerning small boiler systems using solid fuel. It deals with the installation of hot-water supply systems and combined heating and hot-water supply systems employing solid fuel. The Code applies to independent boilers having from 2 sq. ft. to 5 sq. ft. of heating surface or back boilers having 1 sq. ft. to 5 sq. ft. of heating surface, fitted in open fires, cooking ranges or stoves. The Code gives the basic design requirements for installations in small dwelling houses having a floor area of up to about 1,500 sq. ft. Advice is given on the sizes of storage vessels, on pipe connections to them, and on the thermal insulation of pipes, cisterns, and storage vessels to conserve heat and to give protection from frost. The piping installation is dealt with very fully and there is information on valves, radiators, towel rails, mixing valves and water blenders. [Price 4s., postage included.]

Analysis of Manganese in Iron and Steel.—A new publication in the series of "Methods for the Analysis of Iron and Steel" has now been published. This, B.S. No. 1121: Part 23, concerns the determination of manganese by the absorptiometric method. The principle of the method consists in the solution of the sample for analysis in phosphoric-sulphuric acid, followed by oxidation by dropwise addition of nitric acid and the conversion of the manganese to the permanganic state by boiling with potassium periodate. The determination is then finished absorptiometrically. [Price 1s., postage included.]

Textile Screening Cloths.—A new specification, B.S. No. 1812, covers textile screening cloths. It has been common practice in the past to base ranges of sieves and screening cloths on the number of meshes per inch. This specification, however, is based on aperture sizes. A single series of aperture sizes is specified ranging from 50 microns to 1,600 microns, i.e., from 0.00197 in. to 0.0630 in., and applying to each of three weights of cloth which may be made. This will enable the user to select the appropriate aperture for his purpose and then, quite independently, to choose the most suitable of the weights of cloth specified. The specification stipulates the methods by which the aperture width should be measured and also the method of checking the aperture width of any given cloth. [Price 2s., postage included.]

Ring Doubling Frame Bobbins for Cotton and Spun Rayon.—The objective of the work put into the preparation of a new specification, B.S. No. 1809, covering ring doubling frame bobbins for cotton and spun rayon, has been to establish, by agreement between machine and spindle makers and bobbin makers and users, standard dimensions for ranges of ring doubling frame bobbins. Thus, the bobbins may be made of wood, light alloys, plastics or other suitable materials, and will be interchangeable. Consideration has been given to providing the user with maximum yarn capacity consistent with bobbin strength. The range of bobbins dealt with covers the light, medium, heavy and cabling trades. The range of light sizes is 6 in. to 9 in., for use with ring sizes $1\frac{1}{2}$ in. to $5\frac{1}{2}$ in. in diameter. [Price 4s., postage included.]

THE FUTURE OF THE FLYING BOAT.

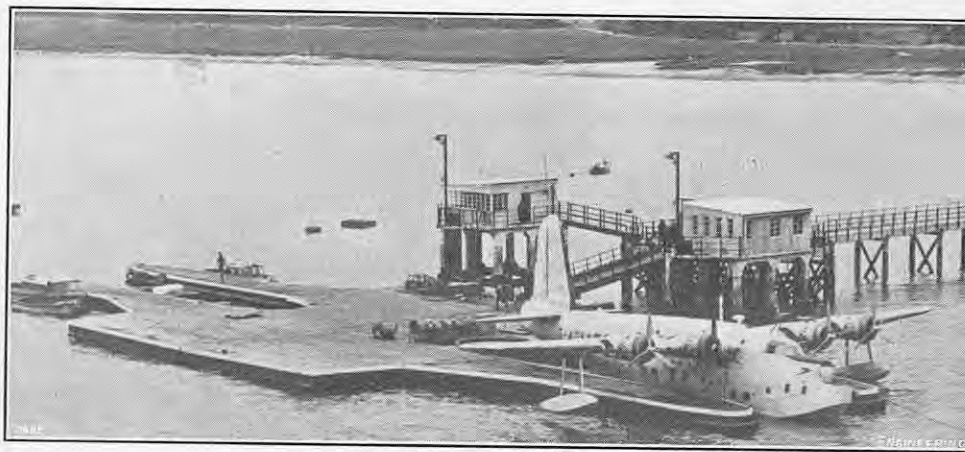


FIG. 5. FLYING-BOAT DOCK.

THE FUTURE OF THE FLYING BOAT.*

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

(Concluded from page 331.)

THE sea in which the flying boat is to alight will most probably have a major swell interfered with by a lesser swell from another direction, on which are superimposed waves running in the direction of the local wind. The length-to-height ratio of waves varies from over 100 to 1 down to 7 to 1; below this the waves are unstable and break. Long swells exceeding, say, 750 ft. and of moderate height are not dangerous provided that the wind component along the swell is less than 20 knots, for then the flying boat can run parallel to the wave crests. If the wind exceeds 20 knots, operation into wind is probably essential because of directional stability, drift and reserve buoyancy considerations. In contrast, severe impact loads and bouncing can occur in relatively short steep seas. A long shallow swell can also produce high accelerations if the craft is thrown off the crest. The most critical wavelength for any particular hull appears to be between two and three times the hull length. If the sea has a predominant heavy swell in a given direction, it may be preferable to alight along the swell even when the local wind is on the beam. With a suitable hull design it has been found possible to alight safely in seas up to 9 ft. from trough to crest.

In the United Kingdom theoretical estimates of peak accelerations have given values agreeing well with full-scale results obtained in calm and rough waters. This work has made it possible to approach, with confidence, an assessment of the impact loads necessary for the structural design of future flying boats. Calm water landings of a Sunderland V, which recorded impact accelerations of 1.0 to 1.3 g, gave mean pressures between 12 and 15 lb. per square inch, with peak pressures of about 25 lb. per square inch recorded locally. These pressures are of very short duration, of the order of $\frac{1}{2}$ second. Tests on a Sikorsky S.43, showing a similar acceleration (1.3 g), recorded average bottom pressures of about 9 to 10 lb. per square inch, with peak pressures which vary from 15 lb. per square inch at the keel to 18 lb. per square inch at the chine. These values are representative of normal landing cases, but in rough seas, particularly with heavy swell, much higher accelerations have been recorded. In some notable tests recently made on a Mariner and Mars, where landings were made into exceptionally heavy seas, accelerations as high as 5 g were measured. At the same time, rotational angular accelerations were recorded, sufficient to produce accompanying accelerations at the bow or tail of 9 g and, in one case, 11 g. It is noteworthy that the structures of the two aircraft concerned were capable of withstanding the abnormal loads. It is unusual, in normal practice, for accelerations to be developed which exceed 2.5 g at the centre of gravity.

Statistics of structure-weight percentages covering the past ten years have shown that the upward trend, predicted by the square/cube law, has not so far been realised; in fact, the largest aircraft, in the 300,000 lb. range, show a lower percentage than the average medium-sized aircraft. Factors contributing to this are as follows. (i) The increase of wing loading with size: the maximum limit in wing loading has not yet

been reached, and this assistance to weight alleviation will continue for further size increases.

(ii) Materials of higher specific strength can be employed advantageously in large aircraft, where it pays to design each part exactly to suit the load, whereas the size of many parts on small aircraft is decided by the necessity for handling or general sturdiness.

(iii) In the past, lower strength factors have been found to be permissible with large aircraft since, owing to the slower acceptable rate of control response, the accelerations to be met in flight are less. Recent gust requirements, however, show a tendency to increase, and new ideas on the cumulative effect of repeated loading may result in increases in structural weight.

(iv) By more careful consideration being given to the disposition of the main structural members on large aircraft, it has been found possible to use material more economically.

(v) A number of items included in the structure weight are common to all sizes of aircraft.

In modern designs of flying boats, the ratio of profile drag to all-up weight shows a progressive improvement as the size increases. This can be ascribed to the trend towards higher loading as size increases; the proportionately smaller body surface area required to contain the payload; more easily controlled parasitic and interference drag; and, in the larger aircraft, the power plant can be buried. There is, therefore, much to be gained by increasing the size of aircraft.

Flying boats should remain in the water for as long as possible, and all short-period maintenance work, refuelling, etc., should be done afloat. The floating pontoon dock, Fig. 5, appears to be the best solution to this problem, preferably U-shaped so that there is access to both sides of the boat. If the dock is connected to the shore it is relatively simple to run refuelling and electrical-supply lines to points on the dock. All loading and unloading can be done at the dock and facilities can be provided for maintenance access. All major overhaul work should, however, be done out of the water, at the maintenance base, which should have a slipway, hard standing, hangars and stores. It will also have a number of permanent pontoon docks with all necessary supplies piped from the shore. Emergency bases, which could only be used infrequently, need not be equipped with more than fuel storage and means of supply.

It is quite usual for flying boats to be landed at sea in emergency or for rescue purposes. By special design, regular landing in the open sea can be included in the aircraft's military duties, thus extending considerably the localities in which the aircraft can be operated.

Capability of long range is one of the flying boat's most valuable assets. Future long-range aircraft will almost certainly use propellers. The choice lies between propeller turbines, piston engines and compound engines. The propeller turbine is suitable for the transport aircraft where high-speed operation at high altitudes is permissible. This type of engine, however, lacks flexibility in operation and a strict flight plan must be followed, using maximum cruising power at the maximum altitude throughout the flight. The piston engine is obsolescent for long-range aircraft, although it still has a future for feeder-line aircraft or amphibians. The newest development in the compound engine is exemplified in the Napier "Nomad," which has an exceptionally low specific consumption. Its flexibility makes it particularly suitable for ocean-patrol flying boats which are required to operate over a wide range of altitude and speed.

* 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.

THE FUTURE OF THE FLYING BOAT.



FIG. 6. JET-PROPELLED AIR-LINER DESIGN.

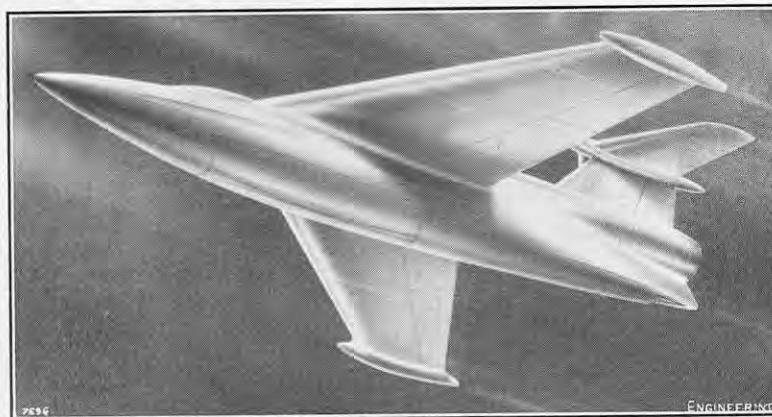


FIG. 7. "CONVAIR" WATER-BASED FIGHTER-BOMBER DESIGN.



FIG. 8. SAUNDERS-ROE WATER-BASED FIGHTER DESIGN.

The transport of troops by air, probably in converted civil air liners, will become universal in the future, not only because of the advantage in rapid reinforcement but in order to eliminate the loss of effectiveness while troops are on long journeys by sea.

Aircraft designed for passenger-carrying are, however, incapable of accommodating the equipment and supplies which must be available to the airborne troops. The transport flying boat appears to be the answer to this problem, since it is virtually unrestricted in size and does not require prepared aerodromes. Placing the main doors in the bows simplifies loading and makes it possible to use the flying boat as an assault craft, which can be run, bow first, on to a suitable beach. Flying boats of 330,000 lb. total weight are soon to fly in Great Britain, and in America a boat of 450,000 lb. has been built. The limiting factor in size in the future will probably be the availability of engine power and the difficulty of converting high shaft power efficiently into thrust. For this reason the author would set a limit to the upward rise in weight at about 600,000 lb., for some time to come.

The qualities the passenger will expect in order to attract him to a particular airline are considered to be a smooth ride, short duration journey, quietness, and comfort. The smooth ride means operating at heights above 20,000 to 25,000 ft. A short duration of flight calls for both a high cruising speed and long range, two attributes difficult to attain simultaneously. Without sufficient range, refuelling stops must be made, which greatly reduce the average speed on the overall journey. It is perhaps easier to obtain a quiet aircraft with propeller-turbine power plants than with other types of power; by the use of a large aircraft, the distances between sources of noise and the cabin walls can be increased, with beneficial results. The amount of comfort provided should increase with the duration of the trip. It has been found possible to meet many of these desired qualities in designing the Princess, by reason of its size and the use of propeller turbines, which show their most economical operation at high altitude and at relatively high speed.

For medium ranges the jet aircraft can be a better economic proposition than a propeller-driven aircraft, especially if a return journey can be made in one day on a route where the lower-speed aircraft can only schedule a one-way trip. It is thought that the jet-engined passenger aircraft will eventually become universal for stage distances of 1,000 to 2,000 miles. Fig. 6 shows a flying-boat project designed to

operate on stage distances of about 1,500 miles at a cruising speed of 450 m.p.h. The maximum take-off weight is 130,000 lb. and the aircraft is fitted with six de Havilland Ghost engines. There does not appear to be a great gain in operating a passenger aircraft with a higher cruising speed than 500 m.p.h., and it is probable that future development will be in range and size.

The operation of intruder-bomber flying-boat squadrons from remote parts of the world is being considered. By using improvised bases, the radius of action can be reduced to distances which permit the design to be primarily for speed. This form of bomber can also be used for minelaying.

If a water-based fighter is to compete on equal terms with a land-based fighter, no concession can be made during flight to hydrodynamic requirements. The conventional flying-boat hull must be discarded. Fortunately, the power necessary for high performance in flight makes it possible to adopt low-efficiency hydrodynamic systems for water operation, and to concentrate on a blending of the characteristics which contribute to both high-speed flight and satisfactory water behaviour. Fig. 7 shows the Convair solution for an attack fighter-bomber. Messrs. Saunders-Roe, Limited, have designed a high-speed water-based fighter, shown in Fig. 8, above, in which hydro-skis are used. Although capable of taking off from water, it is no longer a flying boat in form. In this design the jet engine has its air intake above the fuselage in a form of Pitot entry of high overall efficiency. These water-based fighters illustrate the future possibilities of aircraft which are independent of runway construction and, therefore, are capable of use in any area of the world, provided that there is sheltered water from which to operate.

It has recently been announced in the United States that work has been initiated on an aircraft deriving its power from nuclear fission. Its initial application might well be associated with a flying boat, for the following reasons. It is probably safe to assume that only the heat energy of nuclear reaction can be used and that vapour-driven turbine engines with propellers will form the power units in early installations. The weight of reactor unit, controls, and screening will be high. This part of the installation takes the place of the fuel load in the conventional aircraft. A very approximate approach to the aircraft weight indicates that for structure, engines, take-off assistance and useful load, roughly 60 per cent. of the total weight will be required. Therefore, for a reactor unit weigh-

ing, say, 100 tons, an aircraft of from 500,000 lb. to 600,000 lb. weight will be necessary.

The atomic-powered aircraft will cruise at constant weight and power throughout the flight, and it can be assumed that, for economic reasons, the cruising power will approach the maximum of which the plant is capable. As a consequence, for take-off and initial climb, assistance from some other form of energy, such as liquid rockets, will be necessary. In order to reduce power assistance as much as possible it will be wise to make the take-off from water, where runway length is unrestricted.

Since the weight of fuel consumed is insignificant, the optimum aerodynamic conditions should prevail throughout the flight, and the take-off and landing weight will be the same. The possibility of landing flying boats at their take-off weight has always been recognised as an acceptable manoeuvre. The unobstructed approach run, unrestricted landing area, and short run after touch-down reduce the landing hazard, and the shock-absorbing properties of a V-bottom ensure low landing accelerations even at overload weights.

CONTRACTS.

VICKERS-ARMSTRONGS LTD., Vickers House, Broadway, London, S.W.1, have received an order for a further single-screw oil-tank motorship for Mr. Jorgen P. Jensen, Norway. This will constitute the third tanker of 25,000 tons deadweight for the same owner. The first vessel, the Credo, was handed over in March, 1951. The new ship will be constructed at the firm's Naval Yard, Newcastle-upon-Tyne, and will be 606 ft. in length, 80 ft. in breadth (moulded), and 42 ft. 6 in. in depth. The propelling machinery will be built at the Barrow-in-Furness Works of the firm and will consist of a single-screw Vickers-Doxford Diesel engine, developing a service power of 6,600 b.h.p., and giving the vessel a speed of 13 knots.

ALEXANDER STEPHEN AND SONS, LTD., Linthouse, Govan, Glasgow, are to build three vessels for the Peninsular and Oriental Steam Navigation Company, 122, Leadenhall-street, London, E.C.3. All are cargo steamers, the first two being of 11,500 tons deadweight capacity each, and the third of 10,500 tons deadweight capacity. The first two ships will be fitted with machinery identical with that installed in the Surat, Shillong and Singapore namely, 13,000 s.h.p. single-screw turbines, the high-pressure turbines being double-reduction and the intermediate and low-pressure turbines, single-reduction. These two vessels will be capable of a service speed of 18 knots. The third ship will have double-reduction geared turbines which will give her a service speed of 16 knots, and there will be 430,000 cub. ft. of space for refrigerated cargo. The machinery for all three vessels will be constructed by the builders.

THE BURNISLAND SHIPBUILDING CO., LTD., Burntisland, Fife, have secured a contract to build a cargo motorship of 11,000 tons deadweight capacity for the Currie Line Ltd., Leith, Edinburgh. She will have a length of 420 ft., a beam of 59 ft. 3 in., a depth of 36 ft. 6 in., and a speed of 12 knots. Her 3,500-h.p. twin turbo-charged, four-stroke cycle engines of V-design will drive a single-screw propeller through hydraulic couplings and reverse-reduction gearing.

BULL'S METAL AND MELLOID CO. LTD., Glasgow, have received orders for windows and for equipping ships' superstructures with glass. Thus, they are to supply windows for two ore carriers to be built for the Broken Hill Pty. Co. Ltd., Whyalla, Australia. They have also received window contracts for two Peninsular and Oriental ships now building.

NOTES ON NEW BOOKS.

Heat and Thermodynamics.

By PROFESSOR MARK W. ZEMANSKY. Third edition. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 6 dols.]; and McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 42s. 6d.]

THOSE who are interested in thermodynamics as a fundamental science, rather than merely for its use in the understanding of heat engines, will find this an excellent text-book. It has been written mainly for students preparing for a career in theoretical physics or chemistry, and already equipped with some knowledge of physics and the calculus. The treatment is "classical" in the sense that the reasoning is based on perceptible and measurable phenomena, which, as the author remarks, will remain unchanged, however much theories as to their ultimate causes may alter in the course of time. Hence, except for references to a few of the more important formulae derived from statistical mechanics, that subject is hardly mentioned. With this reservation, it may be said that the book covers the whole field of thermodynamics from basic principles to the discussion of heat capacities, the Joule-Thomson effect, surface tension, the thermo-electric and piezo-electric effects, galvanic batteries and other subjects. Three of the 19 chapters are concerned particularly with chemical matters, including ideal gas reactions and the thermodynamics of systems comprising two or more phases. In a new and most interesting chapter on the physics of very low temperatures, reference is made to the recent production at Leiden of a temperature of only 0.0014 deg. C. absolute by the demagnetisation of a paramagnetic salt after cooling it by liquid helium. Low as this temperature is, an infinite number of repetitions of any such process would theoretically be required to reach the absolute zero. It has been deduced from this that the absolute zero of temperature is unattainable, which is one of the many attempted formulations of a Third Law of Thermodynamics. The book, as a whole, gives so clear and attractive a presentation of the principles of thermodynamics that any criticism is made reluctantly. In connection with enthalpy, it is stated, on page 217, that the area $\int V dP$ of the theoretical indicator diagram for an adiabatic process "does not represent work" and the assertion is emphasised by printing the word "not" in italics. No further explanation is given. Work, of course, is the only thing that could be represented by the area of any P V diagram, and if the intention was to warn the student that the theoretical indicator card merely depicted the performance of an ideally perfect engine or compressor, not subject to the losses of an actual machine, this might have been expressed more accurately.

Synthetic Resins and Allied Plastics.

Edited by H. M. LANGTON. Third edition. Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4. [Price 50s. net.]

WITH the death, late in 1946, of Dr. R. S. Morrell, who was responsible for the original style and scope of this book and was its general editor for some ten years, during which it attained the status of a standard work on its subject, the formidable task of supervising a third edition was undertaken by Mr. Langton, who has completed it with conspicuous success. This revised edition, like the earlier ones, is a compilation, now comprising 18 chapters, each of which is the work of one or two authorities on some particular branch of a subject that has grown too vast and intricate to be encompassed in detail by a single mind. The general structure and sub-divisions of the previous edition have been retained, but the relevant chapters now incorporate much new knowledge, some of which has been released for publication only since the war ended. Among the new matter are details of important developments in manufacturing techniques, especially of silicones and fluorocarbons, while an additional chapter is now devoted exclusively to shellac. The other resins, natural and synthetic, are discussed, under group headings, from the standpoints of chemical composition, methods of processing, physical properties, industrial production, and applications. Valuable concluding chapters deal with problems, common to all resins, of resinification, electrical and physical testing, and methods of analysis and identification. In the main, of course, the treatment is predominantly chemical, and only chemists intimately concerned with the fundamental composition and synthesis of resins will be able to take complete advantage of the compact, orderly information and the abundant bibliographies presented in this book. Nevertheless, since much of the text and almost all the numerous illustrations and graphical data will prove instructive to technologists of quite modest attainments in chemistry, the book is assured of useful service throughout the growing diversity of industries in which resins and plastics now play a significant part.

RADIUS TOOL FOR GRINDING WHEELS.

FOR generating truly-formed radii on the corners of grinding wheels, the tool illustrated below has been introduced by Engineering Diamonds, Limited, 26, Warwick-row, Coventry. A diamond, mounted on an arcuate slide, can be swung by hand to form a radius of up to $1\frac{1}{2}$ in. with an included angle of 90 deg. The tool is made in three sizes, for radii of, respectively, 0 to $\frac{1}{2}$ in., 0 to 1 in., and 0 to $1\frac{1}{2}$ in., and it is suitable for wheels of cylindrical-grinding and surface-grinding machines.

By limiting the movement of the diamond to an angle of 90 deg., undercutting of the wheel is avoided and setting up is simplified. Moreover, the tool produces a radius which blends well with the periphery and face of the grinding wheel—a feature of importance in plunge grinding where a ridge left on the wheel



periphery would produce a ridge on the workpiece. The tool is provided with a hardened and ground datum face by which the radius is set. The face is a prescribed distance from the centre of rotation of the diamond so that, by measuring over the diamond and the face with a micrometer, the radial position of the diamond can be adjusted to the correct value. For mass-production work it would, in some cases, be worth while to provide a gap gauge in lieu of the micrometer so that the radius can be kept constant. The tool is provided with hardened and protected centres, as shown in the illustration, for mounting between the headstock and tailstock of cylindrical grinding machines, and spirit levels are fitted to both faces so that the tool can be levelled for truing either a right or left grinding-wheel radius. When used on a surface-grinding machine, the tool is clamped to any suitable support to bring the axis of the diamond in line with the grinding-wheel centre. The working parts of the tool are protected from dust and abrasive particles by a spring-steel sliding leaf which moves with the diamond.

LAUNCHES AND TRIAL TRIPS.

M.S. "KURNTAL."—Single-screw cargo liner, built and engined by Alexander Stephen & Sons, Ltd., Glasgow, for the New Zealand to Australia service of the Union Steam Ship Co. of New Zealand, Ltd., Wellington, New Zealand. Fifth vessel of a series for these owners. Main dimensions: 325 ft. by 50 ft. by 26 ft.; gross tonnage, 3,550; deadweight capacity, about 5,300 tons on a draught of 22 ft. 4 in. Stephen-Sulzer six-cylinder Diesel engine to develop 3,000 b.h.p. at 150 r.p.m. and a speed of 12 knots in service, fully loaded. Launch, February 26.

S.S. "BRITISH TALENT."—Single-screw oil tanker, built and engined by R. and W. Hawthorn, Leslie & Co., Ltd., Hebburn-on-Tyne, County Durham, for the British Tanker Co., Ltd., London, E.C.2. Main dimensions: 643 ft. overall by 81 ft. by 44 ft. 6 in. to upper deck; deadweight capacity, about 28,100 tons. Steam turbines with double-reduction gearing developing a maximum of 13,750 s.h.p., and two Foster Wheeler water-tube boilers. Trial trip, February 27 and 28.

M.S. "IDENA."—Single-screw trawler, built by Cook, Welton and Gemmell, Ltd., Beverley, Yorkshire, for J. Marr & Son, Ltd., Fleetwood. Last vessel of a series of four for these owners. Main dimensions: 123 ft. 6 in. between perpendiculars by 26 ft. 6 in. by 13 ft.; gross tonnage, about 330; fishroom capacity, 7,000 cub. ft. Mirreles seven-cylinder Diesel engine, developing 700 b.h.p. at 228 r.p.m., constructed by Mirreles, Bickerton & Day, Ltd., Stockport, Cheshire, and installed by Charles D. Holmes & Co., Ltd., Hull. Launch, February 28.

M.S. "KING MALCOLM."—Single-screw cargo vessel, built and engined by Harland and Wolff, Ltd., Belfast, for the King Line, Ltd., London, E.C.3. First vessel of a series of three. Main dimensions: 435 ft. between perpendiculars by 59 ft. by 39 ft. 9 in. to shelter deck; gross tonnage, about 5,770. Harland-B. and W. six-cylinder single-acting four-stroke Diesel engine. Trial trip, February 29.

BOOKS RECEIVED.

Coast Erosion and Protection. Studies in Causes and Remedies. By R. R. MINIKIN. Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 30s. net.]

Chemical and Electro-Plated Finishes. By H. SILMAN. Second revised edition. Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 50s. net.]

The Directory of Shipowners, Shipbuilders and Marine Engineers, 1952. Tothill Press Limited, 33, Tothill-street, London, S.W.1. [Price 40s. net.]

Telford Clarence Batchelor (1857-1947). A Memoir Describing his Invention and Development of Locked-Coil and Flattened-Strand Wire Ropes. By T. H. DAVIES. Courier Press, Leamington Spa. [Price 10s. post free.]

Machinery's Yellow Back Series. No. 28. Electronic Fundamentals. By A. PRITCHARD LIPSCOMBE. No. 28A. *Electronic Applications. No. 30. Jig, Fixture and Clamp Design.* The Machinery Publishing Company, Limited, National House, West-street, Brighton, 1. [Price 4s. each.]

Definitions and Formulae for Students. Light and Sound. By P. K. BOWES. Second edition, revised by L. S. POWELL. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 1s. 6d.]

Principles of Machine Woodworking. Spindle Moulding. By A. H. HAYCOCK. The Technical Press, Limited, Gloucester-road, Kingston Hill, Surrey. [Price 10s. 6d. net.]

Practical Metal Turning for Engineers. By J. G. HORNER. Fourth edition, revised by PHILIP GATES. (Third impression.) The Technical Press, Limited, Gloucester-road, Kingston Hill, Surrey. [Price 20s. net.]

The A.S.E.E. Guide to the Twelfth Edition of the I.E.E. Regulations for the Electrical Equipment of Buildings, 1950. The Association of Supervising Electrical Engineers, 54, Station-road, New Barnet, Hertfordshire. [Price 3s. 9d., post free, in paper covers; 5s. 3d., post free, cloth bound.]

Ohio State University. Engineering Experiment Station. Bulletin No. 146. Differential Thermal Analysis of Clay Minerals under Controlled Thermodynamic Conditions. By ROBERT L. STONE. The Director, Engineering Experiment Station, Ohio State University, Columbus, Ohio, U.S.A. [Price 2 dols.]

TRADE PUBLICATIONS.

Current Transformers.—Leaflets recently issued by the English Electric Co., Ltd., Kingsway, London, W.C.2, deal with the firm's Type FKB, Mark VII, and Type FKO current transformers.

Searchlight Projectors and Floodlighting Fittings.—Messrs. Clarke, Chapman & Co., Ltd., Victoria Works, Gateshead, 8, have sent us a number of pamphlets dealing with their searchlight projectors and floodlighting fittings.

Electronically-Controlled Spot Welder.—Details of a 4-kVA electronically-controlled spot welder manufactured by them are given in a leaflet received from the General Electric Co., Ltd., Kingsway, London, W.C.2.

Electrical Equipment for Strip Mills.—Ateliers de Constructions Electriques de Charleroi, Charleroi, Belgium, have sent us a well-illustrated pamphlet in English dealing with the electrical equipment they manufacture for driving both hot and cold strip mills.

Infra-red Heating for Wood Finishing.—The General Electric Co., Ltd., Kingsway, London, W.C.2, have sent us a leaflet describing the infra-red lamp plant made by them for quickly drying finishing materials in general use after their application to furniture and other wooden objects.

Water-Cooling Units.—The Visco Engineering Co., Ltd., Stafford-road, Croydon, have sent us a copy of the latest brochure dealing with their steel-shell water cooling units. These are designed for cooling small or medium quantities of water in connection with the operation of such plant as heat exchangers, Diesel engines, diecasting machines and electric furnaces.

Pyrometers.—A copy of the firm's catalogue No. 103, covering thermo-electric pyrometers, has been received from the Foster Instrument Co., Ltd., Letchworth, Hertfordshire. In addition to some useful technical notes, it contains particulars of thermocouples and their sheaths and accessories, indicating and recording instruments, potentiometers, instrument panels and specimen scales and record charts.

Furnaces and Furnace Atmospheres.—Two publications relating to furnaces have been issued by Birlec, Ltd., Tyburn-road, Erdington, Birmingham, 24. The first (Ref. No. 65) deals with the firm's standard range of rocking arc melting furnaces for alloy cast iron, copper and nickel alloys and other materials. The second publication, catalogue No. 81, is concerned with furnace atmospheres, and describes atmosphere generators and their operation and applications.