

BLACK-BOLT HEADING PLANT WITH INDUCTION HEATING.

IN the manufacture of black bolts by hot forging, bar stock is first cropped into suitable lengths, which are known as "pins." These are heated at one end to the forging temperature of about

working conditions, and, from a production point of view, it leaves much to be desired. Accurate heating control is impossible, since it must, of necessity, be left to the judgment of the operator; and the fact that the ends of the pins project into the combustion chamber causes heavy scaling and waste of material.

To provide improved working conditions, and to obtain closer control over the process of heading,

has been increased by about 100 per cent., as compared with the same number of presses working with the old layout and heating equipment. The labour requirements at the presses are the same as before, but the heating units are automatic in operation, and only need the services of two women to keep the magazines of all the heaters loaded. Automatic control of heating has reduced scaling to a negligible amount, with a consequent saving of material equivalent to $\frac{1}{8}$ in. on the length of each pin. Freedom from scaling has also increased the tool life by about 25 per cent. In addition, as a result of accurate heat control, it has become possible to produce certain of the simpler forms of bolt head, such as cup, or countersunk, completely free from forging flash.

The shop is designed for an output of 500,000 headed bolt blanks a week. Any type of head in normal demand can be produced, and the sizes of pins which can be handled vary between $\frac{1}{2}$ in. and $\frac{3}{4}$ in. in diameter, and 2½ in. and 8 in. in length. There are 12 induction heaters, six double-ended forging presses (equivalent to 12 single machines), and 12 stripping presses. The machines are arranged in three lines, with a loading gallery alongside the induction heaters, and a gangway beside the stripping presses. The flow of material is by gravity, the three lines of machines being built in tiers, so that the highest point in the shop is the loading gallery, and the lowest the gangway. Pins are cut from bar stock, two or more at a time, in cropping machines at the end of the shop, and are loaded by hand into small wheeled containers. These are elevated by fork-lift truck to the loading gallery, as shown in Fig. 1, herewith, and are wheeled to the induction heaters. One of the two operators places the pins in the heater magazines by hand (Fig. 2) and then wheels the container back to the end of the gallery for re-filling.

Each heater feeds the pins automatically into the inductor coils, heats them, and then discharges them on to a chute leading to a forging press. The operator there places a heated pin in the press, forges the head, and passes the headed blank to a second chute, leading to a stripping press, where the flash is removed. Finished blanks and the scrap flash fall, by separate chutes, into containers in the gangway, shown in Fig. 3, page 194, whence they are removed by fork-lift truck.

The induction heaters were made by Birlec, Limited, Tyburn-road, Birmingham, 24. Each occupies about 4 ft. by 3 ft. of floor space. Fig. 4, on page 194, shows one of the heaters, which consists of a magazine, six inductor coils, six sets of automatic feeding and ejecting apparatus, and a motor-driven timing device, which causes the coils to be fed in numerical sequence. The inductor coils are mounted in a row at the front of the heater; above them are the feeding mechanisms and the magazine, and below, in the fabricated-steel cabinet, is the timing device. Feeding is by compressed air, and the timing device consists of a motor-driven cam assembly, with a variable-speed friction drive and an Opperman gearbox. There are six slots in the magazine to supply pins to the six inductor coils, and beneath each slot is a cross-over slide, operated by compressed air. This works in conjunction with a loading slide, also actuated by compressed air, to feed the pins into the inductor coils, hold them while they are heated, and eject them ready for forging when the correct temperature is reached.

Under the control of the cam gear, the cross-over slide moves under the slot in the magazine until a groove in the surface of the slide picks up a pin. The slide then moves in an arc to push the pin into the spring-loaded jaws of the loading slide, which moves forward and causes the end of the pin to enter the inductor coil. At the conclusion of the heating period, the loading slide returns. When it comes to rest, the cross-over slide moves again, depositing a cold pin in the jaws, and displacing

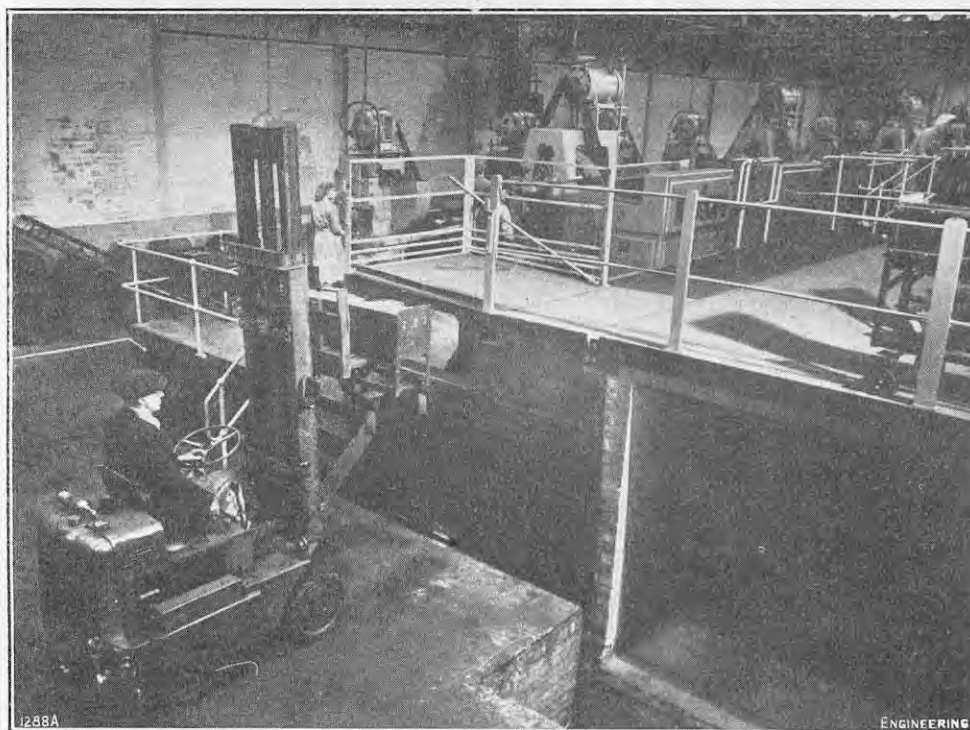


FIG. 1. LOADING GALLERY.

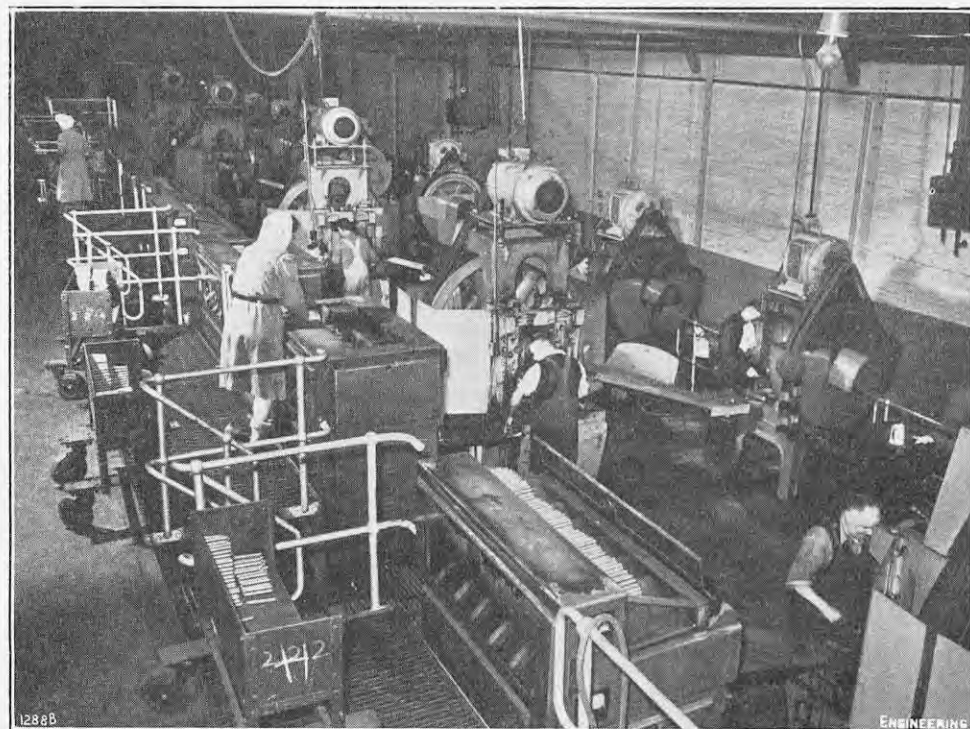


FIG. 2. CHARGING THE HEATER MAGAZINES.

1,200 deg. C., and passed to the press, where, by single-stroke or double-stroke upsetting, as required, the head is forged. The final operation is to remove the forging flash in a stripping press.

Various methods of heating the pins have been used in the past, the commonest for a number of years being the gas-fired or oil-fired furnace. This type of furnace has two or more side walls with perforations to allow the ends of the pins to be inserted into the combustion chamber. The furnace is the cause of hot, dirty and unpleasant

Guest Keen and Nettlefolds (Midlands), Limited, have built at their Darlaston works a new bolt-heading shop with high-frequency electric induction heating. The forging and stripping presses are of the orthodox type, but in building the shop the opportunity was taken to improve the layout, to mechanise some of the operations, and to simplify the flow of material through the machines. The advantages gained, apart from the obvious improvement in working conditions, are many. With induction heating and improved layout, production

BLACK-BOLT HEATING BY INDUCTION FURNACE.

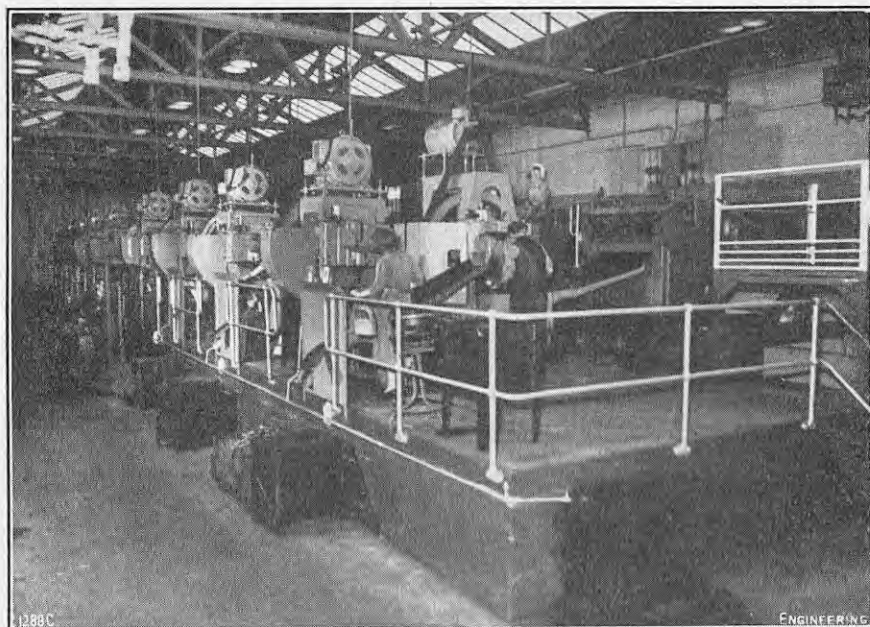


FIG. 3. DELIVERY SIDE OF HEADING PRESSES.



FIG. 4. INDUCTION HEATER.

the heated one. The heated pin falls down a chute at the front of the heater, and, as it leaves the chute, trips an interlock gate. The function of this gate is to stop the operation of the heater should a pin fail to be ejected after heating, and so to prevent it entering the inductor coil twice. To ensure that there shall be no arching or sticking of the pins in the magazine, which might occur if they were loaded carelessly, a mechanical agitator is provided, adjacent to each discharge slot. This is operated by the forward movement of the loading slide.

The heater unit is protected in the usual way against electrical overload, and there is an additional safety feature in the form of an automatic cut-out, which operates in case of failure of the cooling-water supply to the inductor coils. Operation of the heater unit is controlled by "start" and "stop" push buttons, a current regulator which controls the supply of high-frequency current to the inductor coils, and a small handwheel controlling the variable-speed gear driving the timing device. A graduated scale shows the number of pins per hour which the heater is set to handle. The current consumption will, of course, vary with the size of pin being heated, and the rate of operation. The accompanying table shows typical operating results for three

Diameter of pin	$\frac{3}{8}$ in.	$\frac{5}{8}$ in.	$\frac{1}{2}$ in.
Heated length	2½ in.	2½ in.	2½ in.
Temperature on ejection ..	1,250 deg. C.	1,250 deg. C.	1,250 deg. C.
Output per hour	1,953	1,360	1,080
High-frequency power loading ..	60 kW	50 kW	42 kW
Type of forging	Single-blow	Single-blow	Double-blow

sizes of pins. The heaters are actually capable of higher outputs than those quoted, but in practice they are operated well within their capacity, the high-frequency power loading being kept to a maximum of 60 kW.

Power for the heaters is supplied by two motor-driven alternator sets, housed in an adjacent substation, which were designed and installed by Birlec, Limited, and constructed by the British Thomson-Houston Company, Limited. One of the sets is illustrated in Fig. 5, opposite. Each consists of a 550-h.p. motor, taking three-phase 50-cycles current from the mains at 400 volts, and two direct-coupled alternators, one at each end of the motor shaft, generating at 500 volts and 10,000 cycles. Each alternator has a capacity of 150 kW. The motor is arranged for direct-on-line starting, and runs at 3,000 r.p.m. B.T.H. thyatron-type voltage

regulators control the current output to within ± 1 per cent. Because of the very small air-gap required, the bearings are of the Michell marine type. Current from the alternators is distributed to the induction heaters by high-frequency co-axial cables, laid in underground trenches.

The discharge chutes of the induction heaters terminate at the forging presses. These are double-ended machines of a type commonly used for bolt-heading, but they have been modified to improve production. Each press has two vertical slides carrying the heading tools, and the cranks are set at 180 deg. to each other, so that, while one side of the press is heading, the other is making the return stroke. Two operators are required, but they work independently of each other; the press can, in fact, be considered as two separate machines. Push-button controls are provided for starting and stopping the presses, but they normally operate continuously.

The vertical slide of the press can carry two heading tools, and on the bed there is provision for mounting two bottom tools. In single-blow work only one pair of tools is used, but double-blow forging can be carried out when required, by setting up the second pair of tools. In the past, this type of press has been provided with hand levers to move the slide-mounted bottom tools into the forging position, and to retract them after the working stroke had been made. This can be heavy work for the operator, so the movement of the tools has been mechanised. The operator still has to move a hand lever, but this now controls an air valve, and a compressed-air cylinder moves the tools into the working position and returns them. From the operator's point of view, the layout of the press is similar to that of the older type.

The operation of the press is simple. A heated pin is delivered to a convenient position at the operator's hand. He lifts the pin with a small pair of tongs, places it, heated end upward, in the bottom tool, and moves the lever. The bottom tool travels inward until it is under the heading tool, and, as the press makes its downward stroke, the head is forged. The operator then retracts the bottom tool, and, at the outer limit of its travel, an automatic ejector lifts the forging so that it can be grasped by tongs. If the forging requires second-blow work, it is placed in the other bottom tool, and the cycle is repeated. Otherwise, it is thrown by the operator into the chute leading to the stripping press.

Stripping—the removal of the forging flash—is a simple operation, and requires no special comment. It might be added, however, that the stripping-press clutch, which, in the past, has been actuated by a foot lever in the normal way, has been converted to compressed-air operation. The air cylinder is mounted under the press, and connected to the clutch lever; no other modification has been made. Control of the cylinder is by means of a small hand-operated air valve, mounted on the bed of the press. This not only makes the work much less fatiguing, but, as a result of the positive action of the air cylinder, considerably lengthens the life of the clutch. Fig. 6, opposite, shows the whole sequence of operations in progress. To the right is an induction heater, with a heated pin just falling from it, in the centre is a forging press, and on the left is a stripping press.

RAIL AND AIR FACILITIES IN CO. DURHAM.—The Tees-side and South-West Durham Chamber of Commerce have suggested that, in any scheme of reorganisation for British Railways, the north-eastern area should be made a separate Region. The Chamber are asking the Newcastle and Hull Chambers of Commerce to support this proposal. At present, it is stated, the North-Eastern superintendent at York comes under the authority of London headquarters. The Tees-side and South-West Durham Chamber of Commerce, after considering the impending closing down of Greatham airport, West Hartlepool, have asked the North-East Airport Joint Committee for a report on the actual and potential air traffic from Tees-side. When Greatham closes, all North-East air traffic will have to go from Woolsington airport, Newcastle-on-Tyne, until the proposed Boldon airport (now postponed on the grounds of economy) is ready.

SUMMER SCHOOL ON THE SOLID STATE AND HETEROGENEOUS CATALYSIS.—A summer school on the physical chemistry of the solid state, with particular reference to its relation to catalysis, will be held in the Chemistry Department of the University of Bristol from Wednesday, July 15, to Wednesday, July 22, 1953. The course is intended for persons engaged in research at Government, university and private laboratories, and will cover theoretical considerations, reactions at metal surfaces, properties of oxides, oxide reactions, and other properties of the solid state. Accommodation will be available at Wills Hall, Stoke Bishop, Bristol, 9, one of the University's halls of residence, and hotel accommodation can also be arranged. The school fee will be ten guineas. Arrangements have been made for an informal guest-night dinner on Saturday, July 18. Applications should be made, before April 30, to the director of the Department of Adult Education, The University, Bristol, 8.

BLACK-BOLT HEATING BY INDUCTION FURNACE.

(For Description, see Opposite Page.)

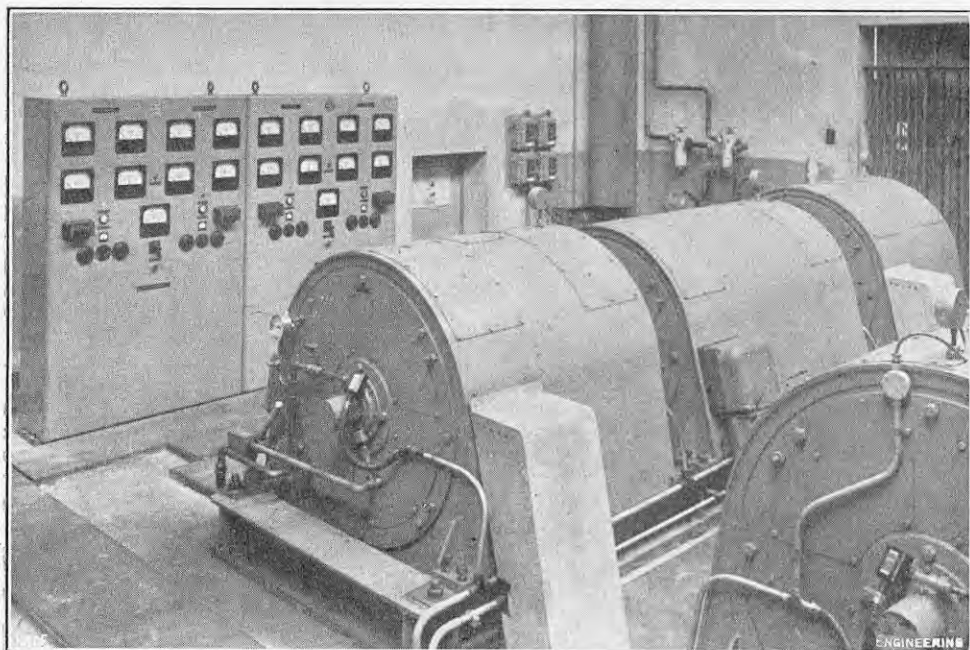


FIG. 5. ALTERNATOR SET SUPPLYING HEATING CURRENT.

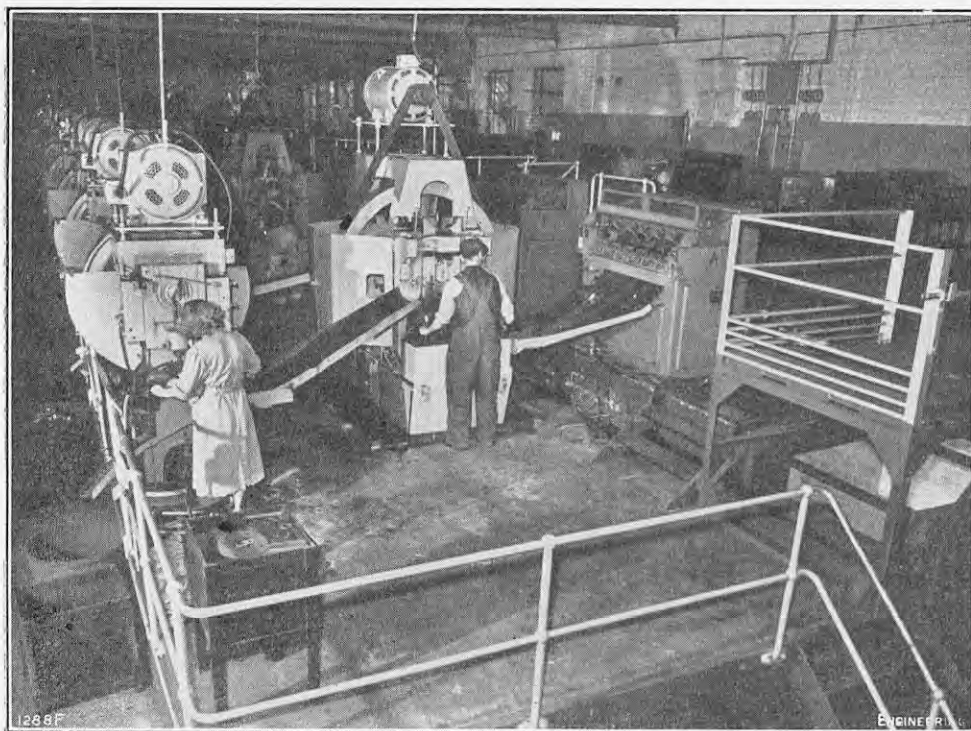


FIG. 6. GENERAL VIEW OF BOLT-HEADING SHOP.

LITERATURE.

Underpinning and Strengthening of Structures.

By L. E. HUNTER, M.Sc., M.I.Struct.E., A.M.I.C.E.
 "Contractors' Record and Municipal Engineering,"
 Lennox House, Norfolk-street, London, W.C.2.
 [Price 25s.]

UNDERPINNING—the construction of new foundations under an existing building without disturbing its stability or that of the surrounding structures—is a frequent expedient of the civil engineer, and the allied problems of strengthening the structure itself encountered equally often. In this book, the author deals with both subjects, describing many typical problems to be found in normal constructional experience. The method of design is indicated for each example, but the full details of the calculations are not given—according to the preface,

to save space; but the author's clarity of exposition is such that the loss is small. When such detailed knowledge is required, the many excellent textbooks on the theory of structures will supply it. For the same reason, no mention is made of soil mechanics; but, while a case might be made for leaving out detailed reference to soil stability analyses, some reference to soil stabilisation processes might well have been included. An unusual section that has been included, however, is one on subsoils subjected to heat, such as might be met in dealing with foundations of ovens and furnaces, or in mining areas where the subsoil is itself combustible.

On the design side of the underpinning or strengthening of structures, the author draws attention to a considerable amount of practical detail regarding the general arrangement of the work and the order

of procedure, this latter being of prime importance. In contrast with his liberality in this respect, however, the book gives scant information on some essential matters that have great bearing on the efficacy of the work when completed. For example, no advice is given on making a good bond between old and new concrete, or on the use of grouting pans or the preparation of really quick-setting mortars. In dealing with the strengthening of steel structures, either bridges or buildings, the principal method considered is the addition of reinforced-concrete casings or of supporting concrete beams; nothing is said about either riveting or welding extra plates on to the existing sections. Another branch of the subject which might have been discussed with advantage is the strengthening of cast-iron bridges, often a more economical course than their replacement. The book is not long—162 pages—but an index, and a running chapter heading at the top of each page, would make reference to its contents much easier.

High-Speed Photography.

By G. A. JONES. Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 42s. net.]

THE deplorable practice of starting a book at the end is usually associated with female readers of romantic literature, but few students of this book will be able to resist the temptation, offered by the picture on its dust cover and the frontispiece, to look at once, with admiration, at the other remarkable photographs which Mr. Jones has selected to illustrate his concluding review of the scientific, industrial and commercial applications of high-speed photography. They display, more convincingly if less comprehensively than the extensive bibliographies which he has appended to his text, the beauty as well as the power and the scope of photography over almost the entire field of technological research.

A corresponding variety of apparatus, and methods of using it to advantage in different types and circumstances of scientific investigation, are described with critical detail in the main part of the book. Mr. Jones was for some years on the staff of the Kodak Research Laboratories in this country, and his experience has rightly induced him to emphasise the important part played by photographic materials, both in the advance of high-speed photography generally and in achieving the optimum results in a particular application. Similar importance attaches to the sources and methods of illumination, more especially in the case of short-duration flash production, about which Mr. Jones writes most instructively. The associated techniques of high-speed still photography are competently handled, in relation both to the types of scientific investigation for which they are best suited and to the optical systems that have been found most successful. Cinematography of rapidly-moving subjects is treated very fully as regards the high-speed range, which extends nowadays from a few hundred up to 100 million frames per second. The author deals in succession with the general design requisites of cinematograph equipment, with the details of standard makes of camera available on the market, and with the outstanding forms of specialised equipment that have been described after successful use during recent years. From similar published sources he has compiled a chapter on cinematographic techniques, recommendations for the arrangement and illumination of apparatus, and procedures for developing, printing and examining the photographic film; all of which are of great practical importance to the scientist, whose main concern is the behaviour of the matter under experiment, to which the photographic technique is only incidental.

This last consideration underlies the design of most of the highly specialised recording cameras for

investigating such phenomena as explosions and electric discharges. Mr. Jones, after describing representative apparatus of these types, discusses the difficulties of correctly analysing the traces or pictures obtained with them, and elsewhere, with reference to the often simpler use of high-speed photography for industrial research, suggests that the occasional problem of this sort is often undertaken more economically, as well as with better hope of success, by an outside specialist in such work rather than by the firm's technicians, with expensive equipment bought for the purpose. This is, of course, as much beyond dispute as the corollary that the fullest use of this book can be made only by technicians intending to specialise in the art and practice of high-speed photography. Only slightly less, however, is its value to scientists of almost every class, over a field ranging from medicine to aerodynamics, while engineers as a body, and more particularly experimental workers engaged on mechanical, electrical and metallurgical problems, will find in it an abundant source of stimulating and reliable information.

A History of Civil Engineering: An Outline from Ancient to Modern Times.

By HANS STRAUB. English translation by E. ROCKWELL. Leonard Hill, Limited, 9, Eden-street, London, N.W.1. [Price 25s.]

THE original edition of this careful and scholarly book, in the German language, was published by the Verlag Birkhauser, of Basle, Switzerland, and appeared in 1950 under the title *Die Geschichte der Bauingenieurkunst: ein Ueberblick von der Antike bis in die Neuzeit*. It was reviewed in our issue of June 30, 1950 (vol. 169, page 719). The basis of the work is a series of articles which the author contributed between 1938 and 1944 to the Swiss journal, *Schweizerische Bauzeitung*, which was expanded into a book designed to form one of the Swiss publishers' "Science and Culture" library. It is addressed primarily to engineering students and practising engineers, but should be of interest also to most architects and to many laymen, for the main theme, as is emphasised in the preface to the present edition, is "the description of the mutual relationship between civil engineering proper and the art of building at large." The opportunity has been taken to correct a few errors in the first edition, but in general the original text has been followed closely, as also has been the division into nine chapters, ranging from "The Ancient World" to "The Present." The chronological tables (1450-1900), bibliography, and indexes (of which there are three—general, personal names and place names) add greatly to the reference value of the book.

ENGINEER BUYERS' AND REPRESENTATIVES' ASSOCIATION.—The annual luncheon of the London and Home Counties Branch of the Engineer Buyers' and Representatives' Association will take place on Thursday, February 19, at the Connaught Rooms, Great Queen-street, London, W.C.2, at 12.30 for 1 p.m. Further information respecting this and other luncheons organised by the Association may be obtained from the general secretary, Captain A. J. Dronsfield, 47, Victoria-street, London, S.W.1.

ROYAL AERONAUTICAL SOCIETY LECTURES.—The ninth British Empire and Commonwealth Lecture of the Royal Aeronautical Society will be delivered by Sir Hubert Walker, C.B.E., chairman of the West African Airways Corporation, on Thursday, June 11. It will be entitled "Some Problems in the Development of Air Transport in West Africa." The Society's 41st Wilbur Wright Lecture will be given by Professor N. J. Hoff, F.R.Ae.S., Head of the Department of Aeronautical Engineering and Applied Mechanics, Polytechnic Institute of Brooklyn, New York, on Monday, September 14. He will speak on "Structures." Both lectures will be delivered at the Institution of Mechanical Engineers, Storey's-gate, St. James's Park, London, S.W.1, and will commence at 6 p.m. Further particulars may be obtained from the Society's offices, 4, Hamilton-place, London, W.1.

THE ENGINEERING OUTLOOK.

III.—THE MACHINE-TOOL INDUSTRY.

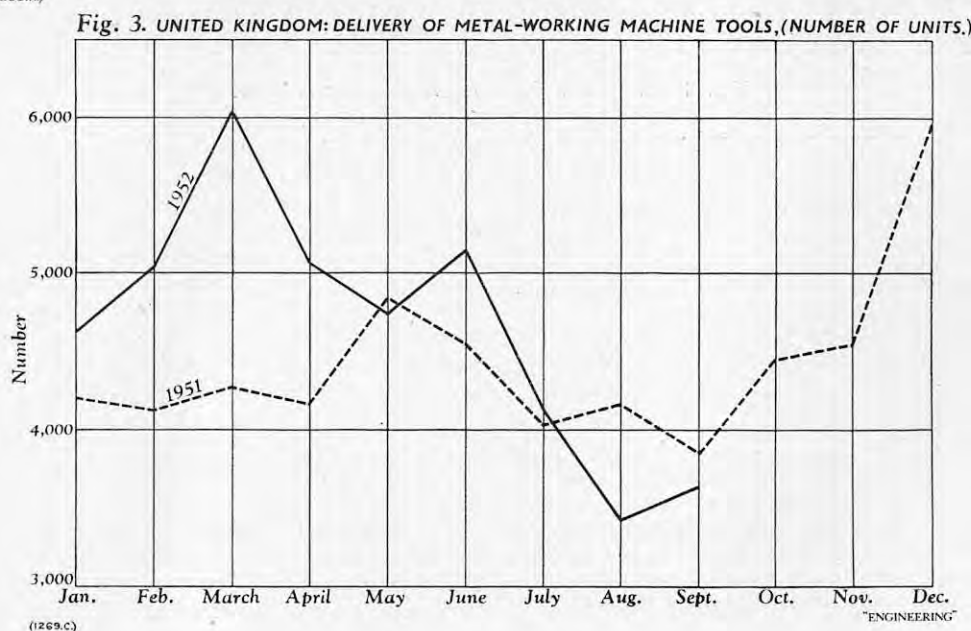
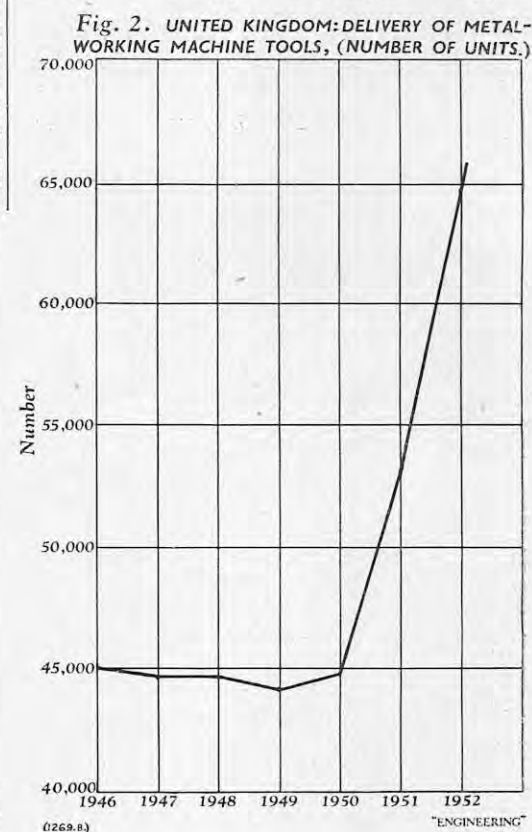
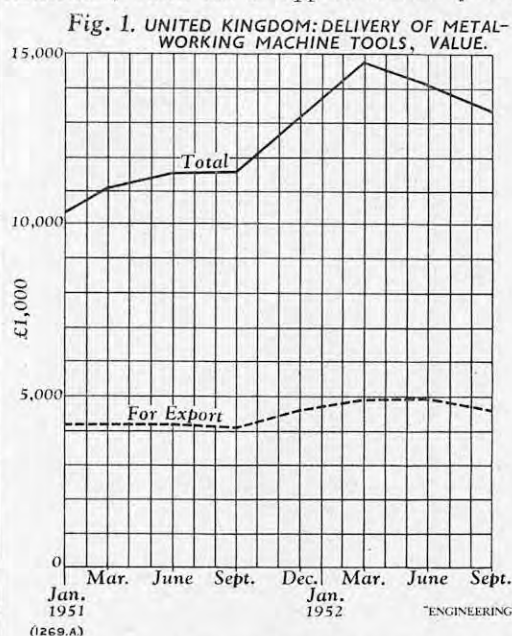
No industry is more deeply affected by vicissitudes in trading conditions than is the manufacture of machine tools. The deterioration in the general market outlook for engineering products is, therefore, a matter for more than common concern. It is all the more serious that this should happen at a time when re-armament work, which has caused the industry to work at extended capacity for the past two years, is almost completed. Continuing expansion of the aircraft industry, both on the civil and on the military sides, will help to sustain sales, but unless there is a reversal of present economic trends, the overall demand for machine tools must be expected to fall off considerably in 1953, both at home and abroad.

British manufacturers, who are currently exporting about 40 per cent. of their output, face a particularly critical situation in the export markets, where competition from European, United States and Japanese manufacturers is becoming intense. The quality of British machine tools is high, however, and the makers are keeping abreast of technological change and are more than keeping pace with their foreign competitors in the development of new tools and the improvement of existing ones; in a buyers' market, the British share is more likely to increase than diminish, and the manufacturers are confident of their prospects. Though orders are becoming harder to get, they regard this as a return to healthier conditions and welcome a reduction in order books, since it allows them to quote better delivery dates. Nevertheless, they are powerless against import restrictions, which can be applied arbitrarily and

with little warning. So far, machine tools have enjoyed a high priority on the import lists of most countries, and exports from Britain were still increasing at the end of 1952, when those of many other types of engineering equipment were declining. Manufacturers have been particularly successful in dollar markets. The high priority given to imports of machine tools is often due to the importance attached to plans for industrial development in primary producing countries. Falling markets may help to bring home to some Governments the unsoundness of such schemes, with serious consequences for British exports of machine tools.

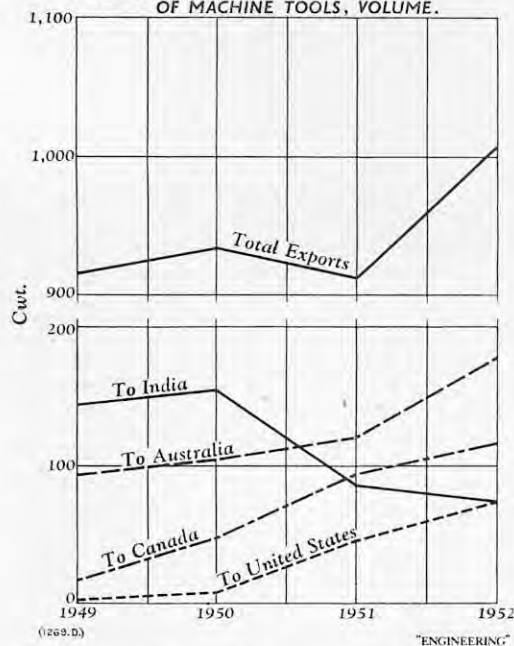
MACHINE TOOLS AND DEFENCE.

When planning the re-armament programme, the Government deliberately sought to lessen the burden on the British machine-tool industry. It was thought advisable, in the long-term interests of the industry, that exports should be maintained in order to build up goodwill in overseas markets. This meant that the greater part of the machine tools required for re-armament had to come from abroad. The original estimate of requirements was a total of 35,000 machines, of which about 19,000 were ordered abroad. Even so, it was expected that the British machine-tool industry would have great difficulty in supplying the remainder. Accordingly, it was arranged that supplies



to civilian users should be cut by 35 per cent. The level of output achieved by the industry, however, has surprised the Government and perhaps even the makers themselves. The trend of output is shown in Figs. 1, 2 and 3, herewith. Home deliveries of machine tools in 1951 and 1952 totalled 77,000 units, or about 20,000 more than if they had continued at the level of 1950. The number of machine tools which the industry has had to supply for defence production may have been rather higher than was originally expected—probably about 18,000—but it is clear that these additional demands have been met without any restriction in normal deliveries to the home market. In fact, these may have increased slightly. This does not mean that there has been no interference with civilian supplies. Machine-tool manufacturers disclosed the contents of their order books to the Government to ensure that first priority was given to most "essential" defence users. The seven Machine Tool Technical Advisory Panels set up by the Machine Tool Trades Association and the Institution of Production Engineers have had to carry out investigations in order to advise on priority in individual cases.

Fig. 4. UNITED KINGDOM-EXPORTS OF MACHINE TOOLS, VOLUME.



There are still some defence orders for machine tools outstanding, and, in some instances, they will not be completed before 1954. Mr. Duncan Sandys, the Minister of Supply, made it clear, however, on September 18 at the Machine Tool Exhibition that, with the exception of certain specialised machines and some repeat orders, "the heavy task of equipping industry for the current defence programme would by the end of this year [1952] be largely completed." Mr. W. J. Morgan, the general manager of the Machine Tool Trades Association, writing in the *Financial Times* of September 19, said that, by the first quarter of 1953, at least 90 per cent. of the 18,500 imported machine tools and an almost equal number delivered from home sources would be installed and at work on defence contracts.

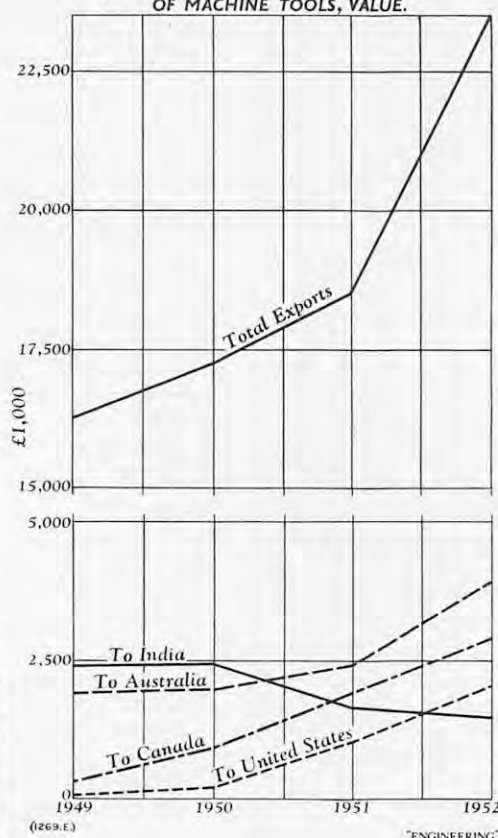
The machine-tool industry thus has no convenient buffer to protect itself against adverse trading conditions in 1953. The completion of re-armament work, however, need not necessarily leave the industry with excess capacity. Manufacturers have learned by long experience that the only way to preserve stability in face of the wide fluctuations in demand to which the industry is subject is to maintain capacity fairly constant at a reasonable level and to rely upon sub-contractors in times of exceptional demand. On the whole, the results have justified this policy. During the war, production rapidly expanded to a peak of 96,000 units in 1942, and fell back without ill consequences to 42,000 in 1949. Sub-contracting again expeditiously expanded production to 65,000 units in 1952. The capacity of the industry has increased somewhat since 1949, largely in response to the increased export demand, and, if this is not maintained or compensated for by increased home demand, excess

capacity may well emerge towards the end of the present year.

INADEQUATE REPLACEMENT OF MACHINE TOOLS.

British engineering firms certainly cannot afford to reduce their demand for machine tools if their products are to sell at competitive prices overseas. Indeed, unless there is a substantial increase in the rate of replacement which has obtained since the war, some loss of efficiency seems inevitable. The number of major machine tools delivered to the home market by the British machine-tool industry since the war has averaged about 28,000 per annum. Making allowance for imports, the total supplies to the home market have been only about 30,000 per annum. The total stock of machine tools in the United Kingdom, however, is about 900,000; so that, even if the average life of a machine were as much as 20 years, annual requirements for replacement should be about 45,000 per annum, or 50 per cent. more than the actual level. Replacement is probably not as inadequate as these figures suggest, since a few large and highly specialised modern machines may replace several smaller obso-

Fig. 5. UNITED KINGDOM-EXPORTS OF MACHINE TOOLS, VALUE.



lescent types; it is very likely, however, that the national stock of machine tools is deteriorating. In the national interest, therefore, the home demand for machine tools should increase, and should certainly not fall off at the first hint of a recession. In 1951 and in 1952, orders came flooding in from engineering firms anxious to secure their needs when it seemed that supplies to civilian users would be drastically reduced. In many cases, orders were placed with several makers, who, as a result, now find it difficult to determine the true state of their order books. The Treasury also bears some responsibility; little blame attaches to manufacturers who rushed to place orders in order not to lose the advantage of the initial allowances, which the Treasury had decided to discontinue from April, 1952.

Since the end of the war, each recurring crisis in the national finances has been met by curtailing home investment; and an almost penal level of taxation supports this policy. Even so, it is hardly the best instrument for the purpose; high interest rates, for example, are more direct and are less damaging to the ordinary business incentives. The wisdom of the policy of restricting investment may be questioned, moreover, though there can be no doubt about its effectiveness. A joint statement by the Federation of British Industries and the National

Union of Manufacturers, issued on January 19, 1953, and summarised on page 115, *ante*, acknowledged the success of the Government's taxation measures in arresting the drain on the financial reserves and averting national bankruptcy, but made the important point that "being restrictionist in nature, they militate against the expansion of trade, which is fundamental to the correction of economic instability."

In the opinion of the employers' organisations, taxation has been eating so heavily into profits as to leave industry with insufficient funds to maintain efficiently even the existing scale of operations. It has undermined the ability to save in individuals as well as in companies, and, while Government borrowing has increased immensely, industry has been unable to obtain sufficient funds from the traditional sources. It is possible that a less restrictive policy might have yielded better returns; positive encouragement of investment at home might have increased output, efficiency, and exports, and avoided crises in the balance of payments. Such a policy was admittedly unwise while shortages restricted output and hampered efficiency, but physical shortages had ceased to set a ceiling on production in most industries some time before the outbreak of war in Korea—though then they again became acute. In present conditions, where demand is the limiting factor, there can be no question about the over-riding need for increased investment to improve efficiency and competitive ability.

One of the most serious consequences of the present tax system is that it militates more heavily against replacement with improved types of equipment than against replacement with the older types. An engineering concern faced with the necessity of replacing two outworn general-purpose machine tools may, for example, be faced with the alternative of buying one special-purpose machine, the output of which may substantially exceed that of the two machine tools already installed, or two new machine tools of the existing type. The latter will generally cost considerably less than the special-purpose machine, but even so, due to Inland Revenue practice, the price will be in excess of the sums which have been set aside for replacement. On the other hand, the price of the special machine will very greatly exceed the sum set aside for replacement and, taking into consideration the tax which will have to be paid on the additional profits, there is little incentive to buy it. If, however, the general-purpose machines are bought, in ten years' time they may have become obsolete.

The whole blame for inadequate replacement of machine tools cannot, of course, lie with Government policy. Some of it must be ascribed to lack of enterprise among some of the engineering manufacturers. Even in this, however, the record of the United Kingdom is better than those of most other countries. A survey conducted about two years ago indicated that, in the United States, where extreme importance is attached to keeping abreast of technological change, a very high proportion of the machine tools in use are over 20 years old.

THE MAINTENANCE OF EXPORTS.

Figs. 4 and 5, herewith, show that the exports of machine tools increased substantially in 1952 (13 per cent. in volume, 27 per cent. in value). A detailed record of the types of machine tools exported and the countries of destination is given in Tables I and II, on page 198, taken from the *Trade and Navigation Accounts*. In general, exports to the major markets increased, though India was an exception; but exports to some of the smaller markets, particularly in Europe and South America, have declined. This trend reflects the growth of foreign competition. In the sterling area, with the exception of India, the position of the British machine-tool manufacturers is at present almost unassailable; elsewhere, they must compete solely on the price and quality of their products. In many cases, they are handicapped by being unable to offer credit terms as favourable as those of their German competitors. There are, however, good reasons for believing that British machine-tool makers need not be unduly alarmed by increasing competition. Not the least of these is the success which has been achieved in the difficult North

American markets, which, in 1952, took more than a fifth of British exports, and 35 per cent. more in quantity than in 1951.

It is still uncertain how far this striking success is due to the preoccupation of the machine-tool builders in the United States with re-armament. Under a Government Order which became effective on February 1, 1952, retooling by producers of ordinary civilian goods was forbidden, and the entire output of the machine-tool industry was reserved for military and "defence supporting industries." The output of machine tools in the United States is now, however, at the rate of about 1,200 million dols. a year, or double the normal, and tooling-up

TABLE I.—United Kingdom Exports of Metal-Working Machine Tools by Types (January to December).

	Quantities. (1,000 Cwt.)			Value. (1,000£.)		
	1950.	1951.	1952.	1950.	1951.	1952.
New Complete Tools:						
Boring ..	56	31	38	1,018	691	905
Drilling ..	91	87	100	1,452	1,421	1,906
Grinding ..	74	66	77	1,632	1,605	2,241
Lathes:						
Automatic ..	31	42	51	936	1,492	1,830
Capstan and turret ..	64	65	64	1,625	1,776	2,149
Other ..	123	108	126	2,358	2,293	3,082
Screwing and treading ..	12	14	14	499	537	634
Milling and gear cutting ..	56	51	48	1,407	1,381	1,607
Planing, shaping and slotting ..	57	58	63	900	944	1,190
Presses:						
Hydraulic ..	41	75	56	572	851	791
Others ..	73	99	131	844	1,198	1,633
Punching and shearing ..	61	63	63	783	857	886
Sawing ..	13	11	11	197	185	206
Others ..	81	64	86	1,229	1,209	1,852
Used, complete tools ..	64	39	47	515	452	568
Parts ..	34	38	47	857	1,160	1,421
Total ..	931	911	1,022	16,824	18,052	22,901

TABLE II.—United Kingdom Exports of Metal-Working Machine Tools by Countries (January to December).

	Quantities. (1,000 cwt.)			Value. (1,000£.)		
	1950.	1951.	1952.	1950.	1951.	1952.
Union of S. Africa ..	80	83	105	1,233	1,504	2,153
British East Africa ..	10	9	11	159	153	230
India ..	154	84	72	2,471	1,422	1,334
Pakistan ..	34	19	15	665	373	355
Australia ..	105	120	176	1,946	2,425	3,822
New Zealand ..	17	16	20	360	368	474
Canada ..	47	91	114	934	1,910	2,962
Other Common-wealth countries and Irish Republic ..	47	39	51	818	804	1,123
Soviet Union ..	69	97	109	828	999	1,216
Sweden ..	31	29	24	643	766	754
Norway ..	21	11	11	352	203	220
Denmark ..	7	7	10	183	168	209
Poland ..	38	15	8	616	206	144
Netherlands ..	39	24	18	700	537	477
Belgium ..	22	18	12	364	427	328
France ..	32	29	31	718	747	912
Switzerland ..	10	8	6	222	231	230
Spain ..	9	8	7	161	158	201
Italy ..	6	24	43	170	564	1,052
Egypt ..	16	14	7	283	287	128
United States of America ..	9	46	73	212	1,084	2,003
Brazil ..	24	35	30	576	846	751
Argentine Republic ..	11	6	4	213	156	110
Other foreign countries ..	93	79	64	1,996	1,713	1,712
Total ..	931	911	1,021	16,823	18,051	22,900

for re-armament is already slowing down. Manufacturers have fairly long order books, but are acutely conscious of the danger that, in twelve months' time, output may be far below the capacity which has been built up. They are, therefore, fully aware of the threat of foreign competition. Some months ago, they lodged an official protest about the admission of large quantities of foreign machine tools. The State Department was not very sympathetic, however, pointing out that the matter should be viewed in a proper perspective. It is true that the total imports of machine tools have increased from about 1 million dols. a year before the outbreak of war in Korea to 50 million dols. a year at present, but this is only 4 per cent. of the current output of machine tools in the United States. The total capacity of all the European

producers, moreover, is so small in relation to that of the United States that the level of imports is never likely to be a serious threat to manufacturers in that country.

The United Kingdom accounts for an overwhelming proportion of imports of machine tools into the United States, and it is with British competition that American manufacturers are most concerned. Most of them, however, consider that their British competitors have still a long way to go before they overcome what they believe to be a world-wide preference for American-built machine tools. The recent exhibitions at Olympia and Hanover, on the other hand, seem to have opened their eyes to some of their own shortcomings. Mr. J. A. Rateman, president of the Monarch Machine Tool Company, of Ohio, is reported in *Business Week* to have told a sales conference, on his return to the United States, that "European machine-tool makers are going to give us some stiff competition," and urged his hearers to "get out and sell." He was greatly impressed by the improvement in quality of European machine tools over the past few years, and noted that, though they have evolved no new metal-working principles, European manufacturers have been paying much closer attention than the Americans to such selling points as careful finish and pleasing appearance. This is of special interest in view of the opinions expressed in the recently-published report of the Productivity Team on machine tools, that British makers are devoting too much attention to these factors.

British manufacturers, on the whole, are confident that, because of the high quality of their products, they will be able to maintain the present high level of exports to the United States. In their opinion, the exceptional conditions of the past two years have enabled them to lay down a solid foundation of goodwill upon which they should be able to build. There appears, therefore, to be a good case for a joint sales and service organisation; since the resources of most manufacturers are limited, this would undoubtedly be the best way to stimulate further British exports. Not all manufacturers, however, are convinced as yet that there is a permanent market for British machine tools in the United States; some take the view that the market is one which must be exploited while the present exceptional conditions persist, but that large-scale selling outlay is not justified. The next few months should show which of these views is the more realistic.

MACHINE TOOLS IN THE COMMONWEALTH.

In the Commonwealth, also, there is some uncertainty about the future course of British exports of machine tools. In all of these countries, with the exception of India, sales have been increasing rapidly in recent years. Even the import restrictions imposed by Australia in March to correct a most serious deficit in the balance of payments have not affected machine tools, the exports of which increased in volume by about 47 per cent. in 1952. Indian experience, however, has been much less encouraging; exports to that country in 1952 were less than half those of 1950. Despite ambitious plans for the development of manufacturing industries, it is becoming increasingly clear that financial circumstances will not permit any rapid growth even of those industries whose existence can be justified economically. There are no natural advantages in India which might justify a large metal-working industry. Indian steel production is still only 370,000 tons. Under the Five Year Plan presented to Parliament in December, it is proposed to increase this to 1.37 million tons, but, in view of the Indian balance of payments, and the low prices obtaining for primary produce, it remains to be seen whether this will be achieved.

It would be difficult, also, to justify metal-working industries of any size in Australia and New Zealand, though steel production in Australia is scheduled to increase by 500,000 tons, or 50 per cent., by 1956. At the recent Commonwealth Conference, moreover, the Dominions appear to have accepted the principle that the individual countries in the sterling area should concentrate their investment upon those industries which are best adapted to local conditions. It will be a long time, of course, before there is any concrete evidence

of this change in the traditional attitude of the Dominions, who have long tended to associate the idea of progress with the growth of manufacturing industries, and particularly engineering. The Australian Tariff Board, who, in the past, have been strongly influenced by arguments advocating the necessity for protecting "infant industries," have now made it clear that protection will not be granted as readily as hitherto. In their annual report, they point out that they would recommend protection only for efficient industries, which had taken all possible steps to secure the lowest possible costs of production, adding that, while costs in Australia have been rising, in the United Kingdom they have been falling; and that, even in some of the more efficient industries, Australian costs were substantially above world levels. In future, it is hinted, an industry will be regarded as economic, and will qualify for protection, not by Australian standards of efficiency, but by its ability to supply goods at prices approximating to world levels.

These trends will not affect the British exports of machine tools for a long time. When they do, British manufacturers should not suffer. There should be a corresponding expansion in the home market for the supply of machines for the manufacture in the United Kingdom of earth-moving equipment, agricultural, and other machinery which can be put to profitable use in Australia. Some economists consider that development along these lines would be in the best interests of Australia as well as of the United Kingdom.

THE GROWTH OF COMPETITION.

However good the quality of British machine tools, it will be difficult to avoid losing some ground during 1953 under the sheer weight of foreign competition. In the European markets, moreover, where British exports have been declining already, and where competition is most intense, the overall demand may fall off seriously in the next few months. Speculation about the future trend of exports to the Soviet Union is most unwarranted, since it is hedged about by so much political uncertainty. It is encouraging, however, to note that exports to Russia increased substantially in 1952, and that British manufacturers expect to continue to do a large volume of business there in 1953. These exports, of course, are confined to types of tools which will not add directly to the war potential of the Soviet Union. Pressure from the United States has now succeeded in reducing substantially the number of machine tools from the Western world which are finding their way behind the Iron Curtain. This has not always been done without some sacrifice on the part of the United States. Recently, for instance, an agreement was made with Switzerland whereby Swiss manufacturers undertook not to export any machine tools to Eastern Europe, but only on condition that the United States Government forbade exports of competing American machine tools to Switzerland.

The stiffest competition which British manufacturers have to meet is from Germany. The German machine-tool industry is now about as large as that of Britain and is almost as large as it was in the whole of Germany before the war. German manufacturers, who have been able to give immediate delivery and to quote very favourable credit terms, have scored considerable success in export markets. Although, however, their prices have been falling lately, they are not generally lower than the British. The finish on British machines, moreover, tends to be better, and the two exhibitions held simultaneously at Olympia and at Hanover in September made it clear that British machine tools compare very favourably with the products of all the other countries. It is unfortunate, however, that the hall at Olympia cannot accommodate successfully very heavy engineering equipment. In view of the fact that the Germans went out of their way to display at Hanover their very heaviest machine tools, it may have created the impression in the minds of some buyers that British manufacturers are paying less attention to the development of heavy types.

At Olympia, machine tools from European and American manufacturers were on view. British manufacturers, however, found it impossible to accept the stipulation of the European Committee for Co-operation in Machine Tool Industries, who

organised the Hanover exhibition, that machine tools cannot be displayed by dealers, or by manufacturers who are also dealers. In consequence, few British machine tools were on view there. United States manufacturers, only four of whom exhibited at Hanover, were as poorly represented as the British. The lack of understanding between the British and Continental manufacturers, which the organisation of the two exhibitions shows, is symptomatic of a weakness in the structure of the European machine-tool industry. Machine-tool production on the Continent has expanded rapidly since the war. Despite its rapid growth, the West German industry now accounts for less than one-third of European production, compared with nearly a half before the war. France, Sweden, Belgium and Italy have all increased their relative shares of the European output, and new industries have developed in such countries as Denmark, Greece, Norway and Austria. The production of machine tools by a very large proportion of the manufacturers in these countries is hardly economic under the best conditions; in times of falling demand, national ambitions to maintain machine-tool industries, at whatever cost, is likely to undermine seriously the position of even the most efficient producers. Rationalisation is clearly required if intra-European trade is to be given more freedom, but international agreement is not likely to be easily achieved. If sacrifices are to be made, it is understandable that the Continental manufacturers should expect British manufacturers to share them. On the other hand, British manufacturers can legitimately claim that their share in the total European output is no larger than before the war, and that, therefore, capacity reductions should be confined to Continental Europe. For this reason, British manufacturers do not consider that it would be in their interests to join the European Committee for Co-operation in the Machine Tool Industries; on the contrary, they see in this organisation the potential threat of a Continental cartel whose policies may be directed against them. At present, there would seem to be little ground for such fears; Continental manufacturers are competing fiercely with each other, and, in view of the diversity of interests, it is difficult to believe that anything more than the very loosest of working agreements is possible.

The threat of Japanese competition cannot be dismissed, but it is not as serious as has been generally imagined. The total capacity of the industry is about 9,800 units, but, so far, working to capacity has not been achieved. Exports, moreover, which have been confined to Far Eastern markets (Formosa and Siam), have been only about 27 per cent. of the total output. Exports to India have been less than 3 per cent. of British exports to that country. Competition from United States manufacturers is quite another matter. These, of course, think primarily in terms of their own home market, and have been exporting only about 6 per cent. of their total output. American manufacturers, faced with a declining demand at home, might well decide, however, to devote more attention to exports, and if they were supported by a Government policy under which large sums were made available for foreign investment, they might prove formidable competitors. Extensive foreign investment by the United States would stimulate primarily a demand for types of engineering equipment other than machine tools; orders for some of this would be placed with British manufacturers, whose needs for new machine tools would therefore be increased.

British machine-tool makers have been greatly strengthened in their ability to meet difficult conditions in the export market by the Government's decision not to let re-armament interfere with the course of exports. The goodwill which, in consequence, the machine-tool industry has been able to build up, however, has been bought at a price. As will be seen from Table III, herewith, the imports of machine tools in 1952 were valued at 59.5l. millions, which was 44.3l. millions more than in 1951. Nearly half of the total imports have come from the United States. While Defence Aid has been available for the purchase of these tools, they constitute a large dollar outlay, since the defence funds could have been spent in other directions.

It is up to the machine-tool industry to make the most of the advantages which have been won. From the point of view of efficiency, British manufacturers are second to none in the world. The report of the Productivity Team which recently visited the United States was published in January, shortly after that of the team on woodworking machine tools. Both reports agree that the difference between British and American practice are not very outstanding. Where "custom-built" machinery is concerned, United States makers cannot employ the production methods which give them such a great advantage in other fields. The woodworking machinery team were in unanimous agreement that the British industry is better housed and equipped than the American. Manufacturers in the United States generally employ more lifting devices, and they are fortunate, perhaps, in being able to retain their labour more easily. This latter advantage arises from the fact that, generally, the labour is of the upgraded unskilled type, fewer than 20 per cent. of the total force having served an apprenticeship. Operatives are trained to the requirements of the company, and not to those of a particular craft. Transfer to another company is not easy, since the work is generally very different, and, in any case, the loss of seniority involved is serious.

There is a higher degree of rationalisation in the industry in the United States, manufacturers generally concentrating on a fairly narrow range of products. In the United Kingdom, it is probably true that manufacturers think too much of maintaining a complete range, and that productivity could

TABLE III.—United Kingdom Imports of Metal-Working Machine Tools by Countries (January to December).

	Quantities. (1,000 cwt.)			Value. (1,000l.)		
	1950.	1951.	1952.	1950.	1951.	1952.
Commonwealth countries and Irish Republic ..	4	1	10	100	64	264
Germany ..	174	112	385	539	2,325	13,143
Belgium ..	12	34	95	254	824	2,998
Switzerland ..	12	35	68	775	2,171	4,442
United States of America ..	73	133	442	3,651	7,298	27,137
Other foreign countries ..	18	86	273	478	2,586	11,529
Total ..	293	401	1,273	5,797	15,268	59,513

be increased by greater specialisation. At the same time, there is already a fair degree of specialisation on the part of individual makers, and the possibility of narrowing the range further without damaging export prospects may well be less than is commonly supposed. In any case, greater specialisation could not easily be brought about without an intensive study of the market. The woodworking machinery team report that their experience has forcibly reminded them that sales have a very big influence, not only on the types in production, but also on productivity. They recommend that all companies should undertake careful sales surveys to ascertain the sales potential for various types of machines, and that these surveys should apply not only to future developments, but also to machines already in production.

The metal-working machine-tool team believe that one of the quickest ways of increasing productivity in their industry is to pay less attention to appearance and finish, and to concentrate simply upon making machine tools fit to do the job for which they were designed. They recommend, therefore, that manufacturers should revert to "war-time" finish and should work to the broadest possible tolerances commensurate with correct functioning. Finish is, however, a good selling point, and British machine tools have been commended for their superior finish by many buyers and even by their American competitors. In a sellers' market, finish may be of great importance, even though, as the team recommend, something is done to educate customers to judge machine tools on performance rather than on appearance. The need for greater standardisation is also emphasised by the team, who consider that a system of "standardised unit" construction should be developed in order to

achieve volume production for the bulk of machine tools. A necessary preliminary to this would be a considerable reduction in the number of independent companies in the industry by absorption or amalgamation.

So far as new developments in metal working are concerned, British manufacturers are certainly keeping pace with those in other countries. Mr. Duncan Sandys, the Minister of Supply, in his speech at Olympia in September, previously quoted, prophesied that, in the next ten years, new developments would open up possibilities of industrial productivity undreamed of to-day, and that drastic changes in technique, which might revolutionise the ancient art of shaping metal, were to be expected. He pointed out that machines were now under development in which orthodox cutting instruments had been entirely discarded. These, by new systems of transforming electric power, or by inducing vibrations in metal by air pressure or by sonic waves, could so concentrate forces on a tiny spot that, he predicted, the machines of the future would be able to cut metal without actually touching it. By keeping abreast of these and other technological developments, by close attention to costs and market requirements, and by imaginative and energetic selling, British machine-tool manufacturers need have little to fear from the buyers' market.

16-MM. SOUND FILM PROJECTOR.

THE British Thomson-Houston Company, Limited, Rugby, have designed a new 16-mm. sound film projector (Type 401) which contains a number of improvements compared with the 301 projector introduced some seven years ago. These improvements have resulted in a considerable reduction in mechanical noise and a saving in weight, while the provision of a new amplifier gives an output of 30 watts. The need for replacing the claw due to wear has also been eliminated by the inclusion of diamond-hard "Ardoloy" peckers. The source of light is a 750-watt 115-volt lamp which, when fitted with a 2-in. f 1.5 projection lens, provides an illumination of over 300 lumens. The mechanical noise has been reduced by replacing the gearing driving the picture head by a belt, by the use of a compressed-cotton gearwheel in the intermittent mechanism, and by re-designing the cam to decrease "film click." The result is that a sound-absorbing case is no longer necessary and both accessibility and appearance have been improved.

The omission of the case, as well as the removal of the mains amplifier, has reduced the weight by about 15 lb. The transformer is now incorporated in the main's unit without any appreciable increase in the weight and size of the latter. The size of the speaker cabinet and its weight have also been cut down owing to this change. Further, the cabinet has been designed as a "ported" baffle with a closed back to eliminate undesirable sound reflections from the back walls, the result being an improvement in efficiency and bass response.

The removal of the amplifier mains transformer from the projector has enabled space to be saved and has allowed much larger output valves to be used in push-pull with a consequent improvement in the sound quality, as is shown by the fact that output at full volume is obtainable with only 5 per cent. distortion. The lower valve tray is mounted on resilient rubber bushes to prevent microphony, the tone-control arrangements have been altered to give improved frequency response and the sound-optical system has been re-designed with the result that the scanning beam illumination is more uniform and the signal to noise ratio better.

ENGINEERING GRADUATES IN THE GENERAL ELECTRIC COMPANY.—Young men who have obtained their first degree in engineering and are uncertain where to take their practical training will find useful advice in a booklet entitled "The Graduate in the G.E.C.," which has been issued by the General Electric Co., Ltd., Kingsway, London, W.C.2. This explains the facilities for gaining further knowledge which are available in the various branches of the organisation, gives details of the different courses, and adds concise accounts of the factories operated by the company.

MECHANICAL TESTING OF GEAR LUBRICANTS.

By J. R. HUGHES, B.Eng., G.I.Mech.E., and
R. TOURET, B.Sc.(Eng.), G.I.Mech.E.

IN general, industrial gears operate under moderate loads and at comparatively low speeds. In the automobile field, however, rear-axle drives (particularly hypoid and worm gears) present special problems because of high longitudinal sliding velocities. Marine reduction gears must operate continuously for long periods at high pitch-line velocities; and, in aviation applications, the reduction gears of propeller-turbine engines may represent as much as 30 per cent. of the total engine weight and, therefore, must be kept small, with a consequent high specific loading. Gear failures may be caused by overload or a sudden shock load, leading to tooth breakage; by fatigue, which may also lead to breakage, or, at least, to pitting of the teeth; by continuous impact loading or chatter, leading to peening of the tooth faces; or by failure of the lubricant, resulting in heavy wear or "scuffing." The conditions in gear operation are generally a mixture of boundary and hydrodynamic lubrication.

It has been suggested by Professor H. Blok* that the frictional heat developed between two surfaces in loaded sliding contact causes a "temperature flash" in the contact zone, the magnitude of which may be estimated by considering the contact zone as a moving heat source; and he has further postulated that every lubricant has a critical temperature for failure in any given system and that, when the total temperature in the contact zone reaches this critical temperature, film breakdown occurs. Asperities on one tooth surface become welded to those on the mating surface and, as the gears continue to move, the welds are broken, leaving a roughened surface. This is known as "scuffing" (Fig. 1) and the load-carrying capacity of a lubricant is assessed in terms of ability to prevent its occurrence.

Ideally, lubricants should be developed on the type of gear unit for which they are intended, but this is not always possible. However, by studying the effect of service variables separately, on a simple machine controlled and operated under laboratory conditions, performance of the lubricant under service conditions can be estimated. The use of a standard test machine also enables lubricants to be compared under fixed conditions. Because of the difficulty of manufacturing highly accurate gears, gear rigs usually employ only spur gears as test-pieces; but spur-gear rigs cannot cover all possible operating conditions. Also, to ensure reasonable repeatability, the gears used must be highly accurate (say, profiles within ± 0.0001 in. of true involute) and such gears are very expensive. It is common practice, therefore, to use simulation rigs, employing test-pieces of simple geometric shape, such as spheres or discs (e.g., bearing balls) which can be easily made or cheaply bought.

In the contact region of spur gears, the surfaces are subjected to combined sliding and rolling, and these conditions may be simulated by two discs, in loaded peripheral contact, rotating at different velocities; this principle is used in the S.A.E. machine† and the David Brown disc machine‡.

* *Jl. S.A.E.*, vol. 44, page 194 (1939) and vol. 46, page 54 (1940); also "Measurement of Temperature Flashes on Gear Teeth under Extreme Pressure Conditions," *I.Mech.E. General Discussion on Lubrication*, vol. 2, page 14 (1937).

† "Apparatus for Determining the Load-carrying Capacity of E.P. Lubricants," by S. A. McKee, F. G. Bitner and T. R. McKee, *Jl. S.A.E.*, vol. 32, page 402 (1933).

‡ "A Machine for Testing Gear Materials and Lubricants," by E. M. Loxley, David Brown and Sons (Huddersfield), Ltd., Dept. of Research and Development Report No. 96477 (E.R. 499), June, 1947.

Some workers in this field prefer to separate the portion of the load-carrying capacity due to hydrodynamic wedge formation in the gear contact from that due to extreme-pressure properties of the lubricant. The Shell four-ball machine,* for example, in which a steel bearing ball is rotated in loaded contact with the cup formed by three stationary balls touching each other, is designed to measure the extreme-pressure property of an oil by reducing the hydrodynamic component to a negligible proportion. At the Thornton Research Centre of the Shell Petroleum Company, new machines of both the gear type and the simulation type have been developed and extensively tested. They are known, respectively, as the Thornton high-speed gear rig and the Thornton cam scuffing rig.

THE THORNTON HIGH-SPEED GEAR RIG.

This rig, a general view of which is shown in Fig. 2, opposite, is an example of a machine using

together, so that there is a locked-up torque in the system. The two sets of gears are loaded against each other, but, as the loads are balanced, there is no resultant rotation. The gears may now be rotated, and the horse-power transmitted by the test-gears is returned by the "power-return" gears. The external drive, therefore, has only to overcome the friction in the system; thus this method economises in both capital and running costs over the "straight-through" type of rig, in which large power-supplying and power-absorbing equipment is required.

The arrangement of the rig is shown diagrammatically in Fig. 3, opposite. A 30-h.p. variable-speed direct-current motor drives a 4:1 speed-increasing unit, consisting of two double-helical gear sets, coupled in parallel. The high-speed shaft is coupled to one shaft of the test machine, which consists of two gearboxes bolted to a large casting, one carrying a pair of power-return gears and the other a pair of test gears. Fig. 4, opposite, shows

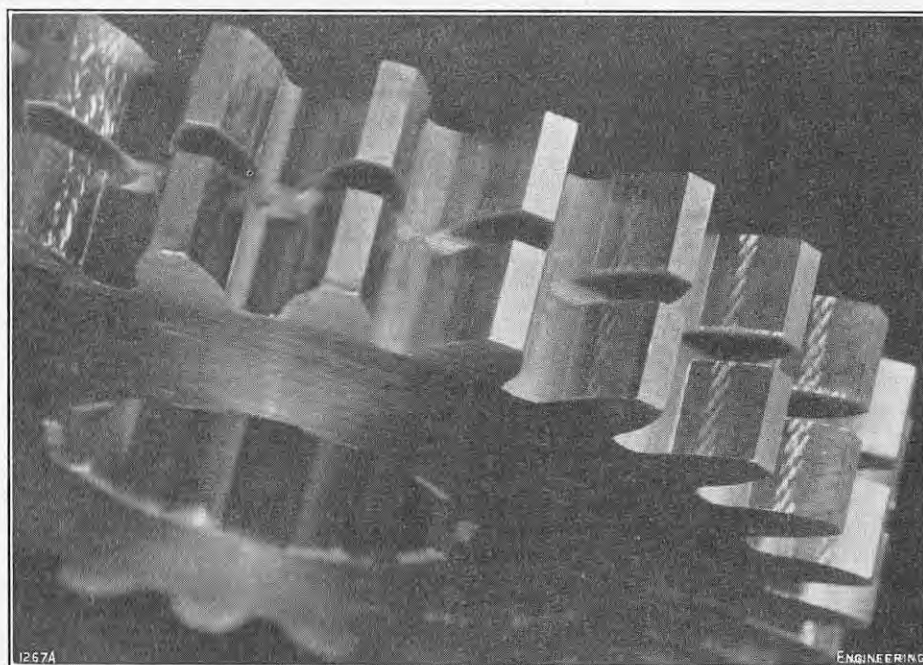


FIG. 1. TYPICAL EXAMPLE OF "SCUFFING."

spur gears as test-pieces and was developed to measure the load-carrying capacity of aviation-turbine lubricants under high sliding velocities (similar to those experienced in the reduction gears of aircraft propeller-turbine engines) and to study the behaviour of oils under high-speed conditions generally. To expedite its construction, the rig was built from existing equipment and hence certain details are not ideal. Nevertheless, useful results have been obtained from it, and the rig as it stands is a valuable research tool.

The rig operates on the well-known "four-square" power-circulating system in which a pair of test gears is coupled by two shafts to a pair of "power-return" gears of much greater face-width. For a given applied load, the test gears will be subjected to a higher specific load and, therefore, will fail without risk of damaging the power-return gears. One of the two shafts carries a split coupling, the two halves of which may be bolted together. The bolts pass through elongated holes in one half of the coupling so that the two halves may be twisted relatively to each other. With the shafts stationary, one half of the coupling is locked in position and a torque is applied to the other half by means of a lever arm and weights. This twists the shafts and loads the gears. In the loaded position, the two halves of the coupling are bolted

the test machine in more detail, and also the application of the load. Although an oil pressure gauge is shown mounted near the test-box, it has since been found preferable to use a remote-reading type, because of the vibration experienced. The gears are lubricated by an oil jet, directed vertically downwards towards the meshing point of the gears. At high speeds it is considered desirable to lubricate the bearings as well, and this is done by force-feeding with the same lubricant. (The thermocouples shown were intended to detect incipient bearing failures, but no such failures have been experienced to date.) Separate lubrication systems, each consisting of a pump, filters, heating-tank and jet, are provided for the test gears and the power-return gears. The test-gear system is designed to provide control of both rate of flow and oil temperature.

The test gearbox, shown in Figs. 5 and 6, on page 201, consists of a casting which is bolted to the main bed of the machine. Referring to Fig. 6, the gears g_1 and g_2 are carried on splined shafts and mounted between ball and roller bearings b_1 , r_1 and r_2 . The gears are located by the collars c . The essential particulars of the test gears used are given in Table I. As can be seen in Fig. 5, each gear is divided into two parallel sets of teeth by a groove cut in the periphery. Only one set is used for each test, the gears being mounted so that one set of teeth on each gear is in mesh. By using the two sets, and the reverse faces of each set, four tests may be carried out with each pair of gears.

* "Four-Ball Testing Apparatus for Extreme-Pressure Lubricants," by G. R. Boerlage, *ENGINEERING*, vol. 136, page 46 (1933).

MECHANICAL TESTING OF GEAR LUBRICANTS.

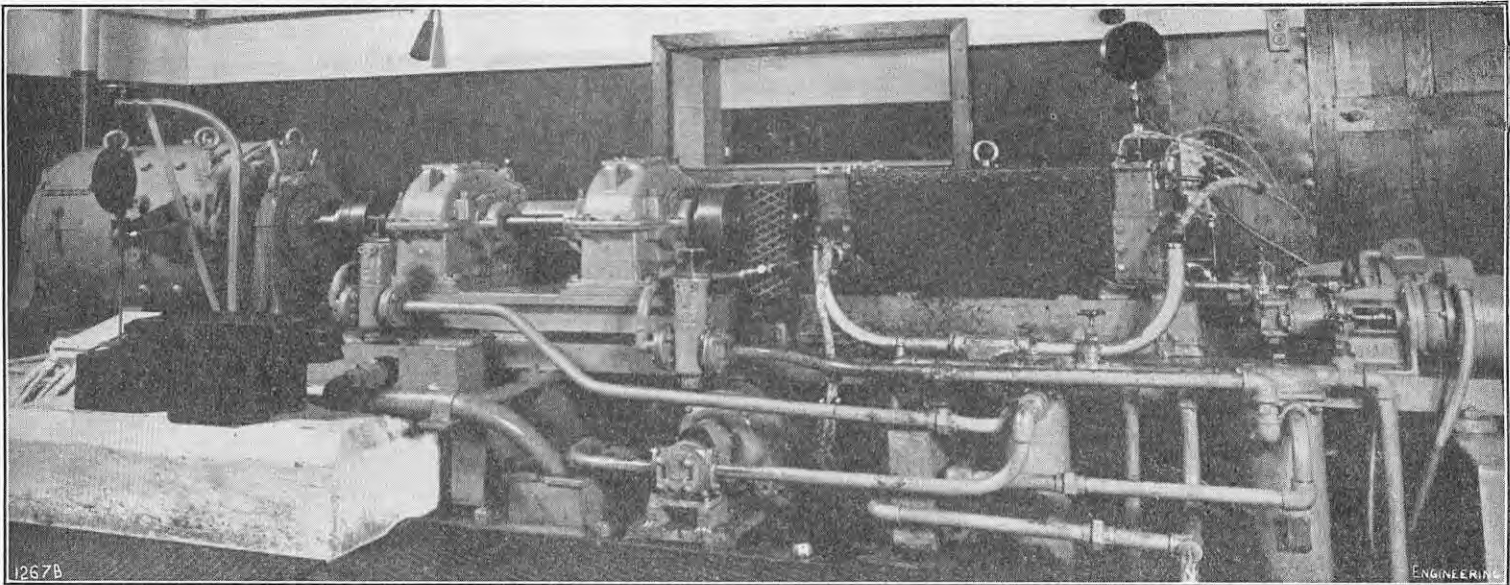


FIG. 2. GENERAL VIEW OF HIGH-SPEED GEAR RIG.

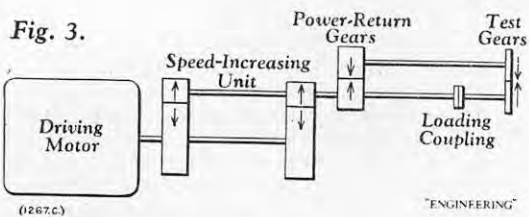


Fig. 6. TEST GEARBOX.

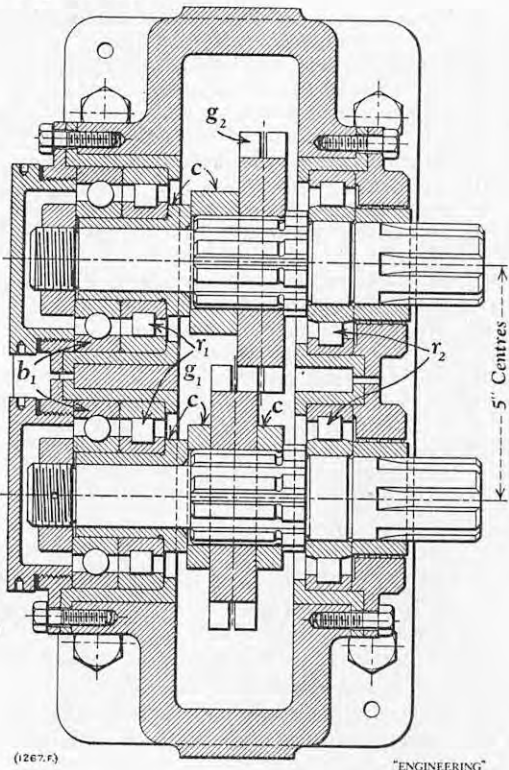


TABLE I.—Particulars of Test Gears.

Ratio	24	12:13	26
Number of teeth	4·800	5·200	4·886
Working pitch-circle diameter, in. .. .	4·511	20	5
Base-circle diameter, in. .. .	0·428		
Working pressure angle, deg. .. .			
Diametrical pitch			
Face-width, in.			
Gear material	En 34 (2 per cent, Ni-Mo) steel		

The tooth profiles are modified to relieve the tips $0\cdot0003 \pm 0\cdot0001$ in., the maximum modification being at the tip and decreasing to zero at the point where two-pair contact ends. This follows the normal practice in highly loaded gears to compensate for tooth deflection, though the modifica-

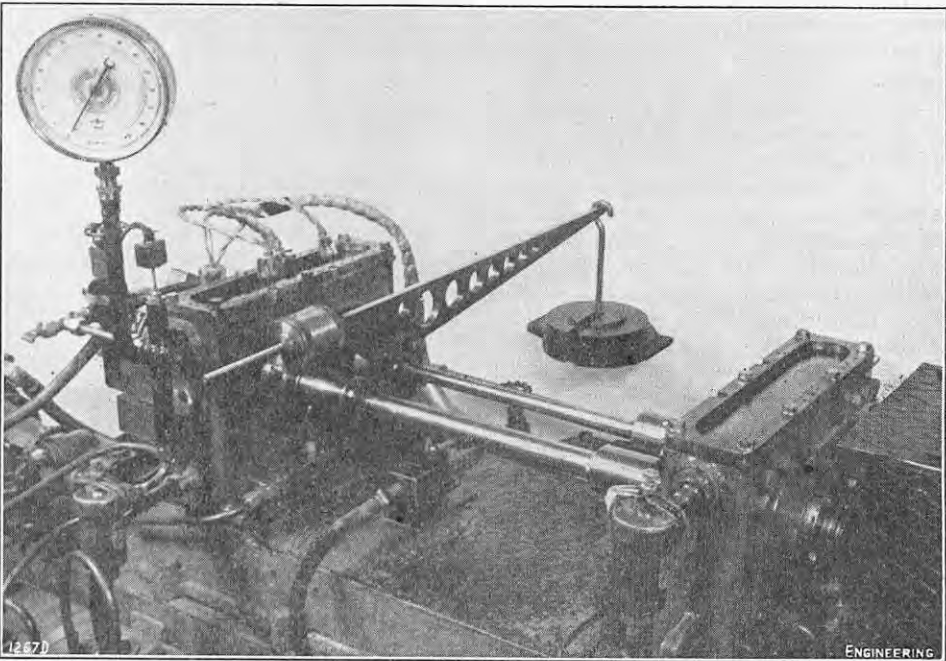


FIG. 4. APPLICATION OF LOAD.

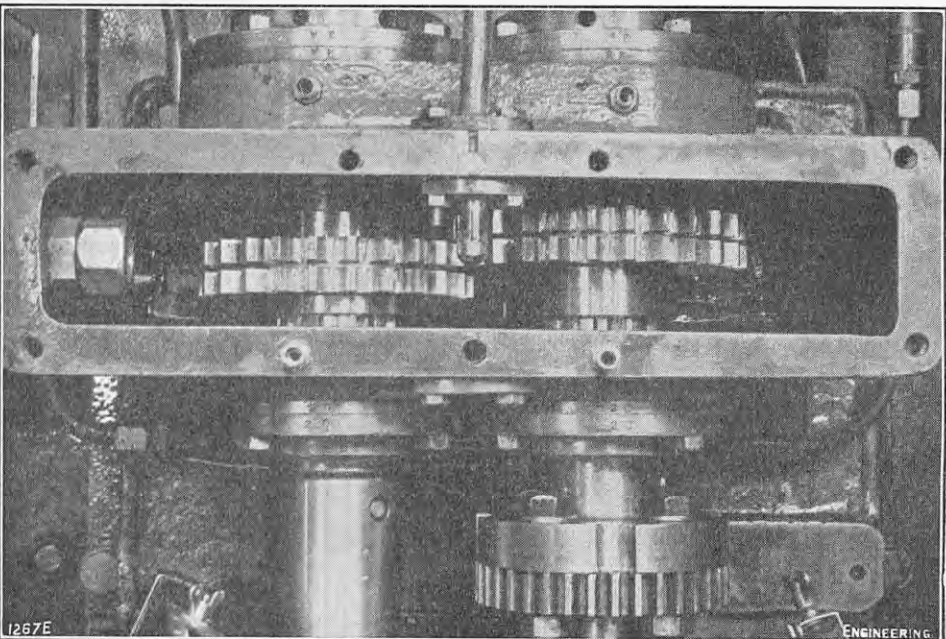


FIG. 5. TEST GEARBOX.

MECHANICAL TESTING OF GEAR LUBRICANTS.

Fig. 7. INFLUENCE OF SPEED ON SCUFFING LOAD.

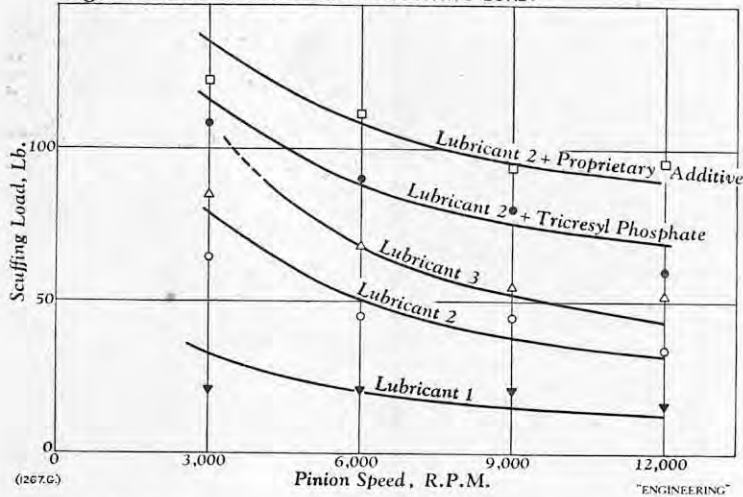
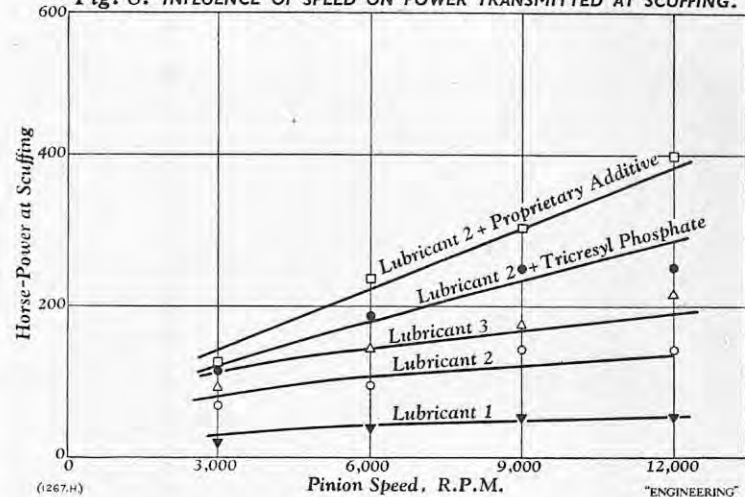


Fig. 8. INFLUENCE OF SPEED ON POWER TRANSMITTED AT SCUFFING.



tion is only fully effective at one load. The accuracy of the profile is to ± 0.0001 in. of the true involute over the non-relieved part of the teeth. Before use, the profiles are checked for accuracy on a "DBS" involute testing instrument.* Gears of other ratios could be used, but for lubricant testing it is desirable to standardise on one type as far as possible, and the ratio 24 : 26 has been adopted for the present.

The operating conditions of the machine are limited by the mechanical layout. The top speed is restricted to 12,000 r.p.m. (15,000 ft. per minute pitch-line speed) because instability and whirling of the shafts occur at slightly higher speeds. The loading limit is 50 lb. on the lever arm (500 lb.-ft. torque) representing about 5,000 lb. per inch of tooth width on the 24 : 26 ratio gears. At this load the loading shaft is stressed very nearly to its elastic limit. Unfortunately, no further increase in its diameter is immediately practicable. The rig, in its present form, covers sliding speeds as high as those in any known present-day propeller-turbine reduction gears.

TEST TECHNIQUE.

The standard test carried out on this rig is to determine the scuffing load, i.e., the load which causes scuffing during a 15-minute test run. This load is taken as a measure of the load-carrying capacity of the lubricant tested. The method of carrying out a scuffing test is, first, to run the machine for 15 minutes under the lowest possible lever load. It is then stopped and the gear faces are examined. If the gears are undamaged, the load is increased by one increment and the machine is run for a further 15 minutes. This sequence of operations is repeated until the gear faces are scuffed, the load then applied being the "scuffing load." The test conditions, under which the results quoted below were obtained, were standardised for early test work on the rig and have proved satisfactory. They are summarised in Table II, herewith. As a general rule, an oil is tested at the four speeds, using the four test faces of a single pair of gears, with at least one set of repeat tests on a second pair of gears.

TEST RESULTS.

Figs. 7 and 8, herewith, show the results obtained on straight mineral oils, with and without extreme-

pressure additives. The main purpose of these tests was to check the efficacy of additives under high sliding-speed conditions; but it is of interest to consider the effect of speed on load-carrying capacity and transmissible power for doped and undoped oils separately. The results show that the load-carrying capacity of undoped oils decreases with increased speed. The oils tested range in viscosity from 45 seconds to 330 seconds Redwood I at 140 deg. F. The power which may be transmitted increases with increased speed.

TABLE II.—Test Conditions for Thornton High-Speed Gear Rig.

Pinion speeds	3,000, 6,000, 9,000 and 12,000 r.p.m.
Oil temperature	90 deg. C. (194 deg. F.).
Rate of flow	4 imp. pints per min. (2.27 litres per min.).
Initial load on 2-ft. lever arm ..	15 lb.
Increment of load	5 lb. (first test sequence). 10 lb. (if oil is found to have high breakdown load, necessitating an unduly lengthy test sequence).
Running time at each load increment	15 min.
Time between end of one load period and start of next ..	10 min.

It is found that, approximately,

$$W \propto n^{-\frac{2}{3}} \quad (1)$$

$$P \propto n^{+\frac{1}{2}} \quad (2)$$

where W is the load-carrying capacity, n is the speed, and P is the power; and this can be shown to be in agreement with the hypothesis put forward by Blok,* that breakdown occurs when a critical temperature, which is different for each oil, is reached. The curves drawn are to equations (1) and (2), and it will be seen that the experimental points agree with the theoretical curve.

Three additives were tested, two being proprietary products and the third the well-known tricresyl phosphate. The relative rating of the additives remained the same over the whole speed range, and their efficacy, reckoned as a percentage increase over the base oil performance, increased with increased speed. The results of only two of the additives have been plotted as curves, the third having proved beyond the range of the machine. At the top speed of the machine, when this additive was being tested, all the teeth of one gear were removed by fatigue failure before any scuffing could occur.

The work carried out on the Thornton high-speed gear rig has shown that smaller lower-speed machines rate lubricants satisfactorily for high-speed conditions; but much is still unknown about the behaviour of oils at high speeds, and the rig is now being used for more general investigations.

EFFECT OF SPEED ON THE LOAD-CARRYING AND POWER-TRANSMITTING CAPACITY OF GEARS.

List of Symbols.—

- $a = \frac{\lambda}{\gamma s}$
 $b =$ face-width of gears.
 $e =$ base of Napierian logarithms.
 $n =$ speed of gear, r.p.m.
 $q =$ heat supplied per unit area per unit time by heat source.
 $s =$ specific heat of gear material.
 $t =$ time from start of motion.
 $v =$ speed of heat source across surface.
 $v_1 =$ speed of point of contact across pinion-tooth face.
 $v_2 =$ speed of point of contact across wheel-tooth face.
 $A, B, C, D, F, K =$ constants.
 $L = \frac{1}{2}$ (width of contact).
 $P =$ transmitted horse-power.
 $W =$ load per inch of face-width of gears.
 $\beta =$ proportion of heat received by pinion.
 $\gamma =$ density of gear material.
 $\theta =$ temperature in contact.
 $\theta_c =$ critical temperature for failure of lubricant.
 $\theta_F =$ temperature rise above $(\theta_o + \theta_s)$ due to temperature "flash."
 $\theta'_F =$ temperature rise for pinion.
 $\theta''_F =$ temperature rise for wheel.
 $\theta_o =$ ambient temperature.
 $\theta_s =$ temperature rise of surface layers of tooth above θ_o .
 $\lambda =$ thermal conductivity of gear material.
 $\mu =$ coefficient of friction.
 $\psi = \sqrt{\frac{4a}{vL}}$

It has been postulated that a gear lubricant fails when the temperature between the teeth at the contact exceeds a critical value θ_c for the lubricant. The temperature in the contact, θ , may be expressed as $\theta = \theta_o + \theta_s + \theta_F$.

It has been demonstrated at Thornton that, for given gears operating under given conditions, $\theta_s = \theta_F (A - B e^{-Ct})$.

When the gears have been running for a long time, i.e., when t is large, and thermal equilibrium has been reached, $\theta_s = K \theta_F$, $\theta = \theta_o + D \theta_F$.

Failure will occur when $\theta \geq \theta_c$ for the lubricant concerned. For a constant value of θ_o , $D \theta_F = \theta_c - \theta_o = F =$ constant for given oil, and, therefore, under these conditions, θ_F is constant also.

Blok has developed an expression for the temperature flash due to a moving source of heat, which is of the form $O_F \propto \psi \frac{V_q L}{\lambda}$.

For the two contacting gear surfaces in the zone of contact, the temperatures on each tooth will be the same. Let the total heat supplied be q , and

* This involute tester operates on the principle of rolling the base circle along a straight-edge. The gear is mounted on a disc of the same diameter as its base-circle, and a stylus, mounted above the straight edge, is placed in contact with the tooth flank. The stylus is mounted on a carriage connected to a dial gauge, so that any movement of the stylus can be measured. The base-circle is rolled without slip along the straight edge, when the stylus in contact with the tooth should show no movement if the tooth shape is a true involute. Any departure from the true involute is indicated on the dial gauge.

* Loc. cit.

let βq be received by the pinion and $(1 - \beta)q$ by the wheel. Then for pinion

$$\theta'_F \propto \sqrt{\frac{4a}{L}} \frac{1}{\sqrt{v_1}} \frac{\beta q L}{\lambda},$$

and for wheel

$$\theta''_F \propto \sqrt{\frac{4a}{L}} \frac{1}{\sqrt{v_2}} \frac{(1 - \beta) q L}{\lambda}.$$

But $\theta'_F = \theta''_F = \theta_F$. Hence,

$$\beta = \frac{\sqrt{v_1}}{\sqrt{v_1} + \sqrt{v_2}},$$

$$\text{whence } \theta_F \propto \sqrt{\frac{4a}{L}} \frac{q L}{\lambda} \frac{1}{\sqrt{v_1} + \sqrt{v_2}}.$$

Heat produced per unit area at contact,

$$q, \propto \frac{W b}{L b} \mu (v_1 - v_2),$$

therefore

$$\theta_F \propto \sqrt{\frac{4a}{L}} \frac{W b \mu}{L b} (v_1 - v_2) \frac{L}{\lambda} \frac{1}{\sqrt{v_1} + \sqrt{v_2}}$$

i.e.,

$$\theta_F \propto \sqrt{\frac{4a}{L}} \frac{\mu W}{\lambda} \left| \sqrt{v_1} - \sqrt{v_2} \right|$$

From the Hertz equations for the deformation of two cylinders in contact $L \propto W^{\frac{1}{2}}$. Hence,

$$\theta_F \propto \frac{\mu}{\lambda} \sqrt{4a} W^{\frac{1}{2}} \left| \sqrt{v_1} - \sqrt{v_2} \right|$$

For given gears, λ and $\sqrt{4a}$ are constant, and assuming the value of μ does not vary with load or speed, this may also be considered as constant.

Also, $\sqrt{v_1} - \sqrt{v_2} \propto \sqrt{n}$, so that $\theta_F \propto W^{\frac{1}{2}} n^{\frac{1}{2}}$.

Now, from the original assumptions made, it was found that, for a given lubricant at a given ambient temperature, lubricant failure would occur at a fixed value of θ_F .

Hence, at failure, $W^{\frac{1}{2}} n^{\frac{1}{2}} = \text{constant}$, or $W \propto n^{-2}$. The power transmitted at failure, P , varies as $W n$; hence $P \propto n^{-1}$.

(To be continued.)

ELECTRICAL CONTROL OF FISH MOVEMENTS.

At a meeting of the Royal Society of Edinburgh, on Monday, February 2, a paper was presented by Mr. Norman G. Lethlean, a member of the research staff of the North of Scotland Hydro-Electric Board, on electrical methods of controlling the movements of salmon and trout in Highland rivers where hydro-electric schemes may be in operation. The experiments have resulted in the development of an electric screen which has been completely successful in preventing salmon and sea trout from swimming into the tailrace of a power station when going upstream; a device which counts fish on their way up and down fish passes, but does not record the passage of debris; and an electric screen which shows promise, after further development, of being able to divert smolts away from an aqueduct leading to the turbines of a power station.

Experiments were carried out at Dundee to observe the reaction of trout to electric currents, and afterwards, experiments with electric screens to deter salmon and sea trout from entering tailraces were carried out at Morar in 1950, 1951 and, again, with improved electrical equipment, in the spring of 1952, when an observer was in constant attendance to observe fish movements in the electrified zone. The screen at Morar consisted of a row of aluminium electrodes, each about 14 ft. in length, extending to 3 in. from the bottom of the channel, with two electrodes, about 16 ft. apart, placed 7 ft. downstream from the main screen. A pulsating electric current was applied across the electrodes.

The Morar experiments were completely successful, and all ascending fish were kept out of the tailrace and went upstream through the fish pass.

Salmon experienced obvious discomfort when about 5 ft. to 6 ft. from the outer electrodes of the screen, and, at that distance, turned and swam upstream past the end of the tailrace. Sea trout found conditions too disagreeable to progress into the tailrace at 2 ft. to 4 ft. (depending on their size) from the inner row of electrodes. All fish behaved in a perfectly normal way after leaving the electrified zone, showing no sign of distress, or inclination to remain inactive afterwards.

The automatic electrical counter, designed by Mr. Lethlean, has been in operation in fish passes at the dams at Clunie and at Pitlochry since the start of the salmon run in 1951. The counter was developed on the basis of the difference in the resistance to electrical current of salmon or sea trout, and water. It consists of an underwater electrical "bridge" which is influenced by the passage of the fish through the submerged orifice or pipe in the fish pass. The counter can be adjusted so that only fish over a certain size are counted, and it is possible to operate the equipment in waters of widely varying chemical content. The counter records on separate dials the passage of salmon going upstream and of kelts going downstream. If a fish does not complete its journey through the pipe, it is not recorded. Peat, branches of trees, leaves and other debris, such as logs of wood, milk bottles and empty food tins, thrown or washed from the river upstream have not disturbed the dial readings. Daily checks during 1952 on the number of salmon and kelts observed to pass through the detector tunnel installed at Pitlochry have shown practically 100 per cent. accuracy in recording fish. The number of fish counted going up the pass from April to the end of October, 1952, was 5,697.

Experiments were also carried out with electric screens to divert descending salmon smolts in 1950, 1951 and 1952 above the dam at Dunalastair on the River Tummel in Perthshire. The purpose was to prevent the smolts from entering the water in front of the mechanical screens at the intake to the aqueduct which conveys water to the Tummel Bridge power station and to divert them into the fish pass. The screen consisted of two parallel rows of aluminium tubes, strung diagonally across the lower end of the reservoir. The downstream row consisted of 272 tubes, 1 ft. apart, and the second row, 6 ft. upstream, of 34 groups, each 8 ft. apart. Electrical pulses were applied across the screen as in the case of the tailrace screen. This type of screen shows promise of success, diverting a large proportion of the smolts; in 1952, 70 per cent. of them used the fish pass instead of the alternative course through the electric screens during the period of the test. No injuries to the smolts could be attributed to electric shock at any stage in the experiments. The tests at Dunalastair are being continued this year, with improved equipment.

Mr. Lethlean also carried out investigations in attracting fish with direct current applied across electrodes in sea water, and in other waters containing various amounts of impurities, but explained that the method was not expected to operate so well in waters of great purity from Highland and other sources. Mechanical vibrations within the sonic range were found ineffective in disturbing fish in experimental tanks after the first few seconds of exposure to them. Lights of various colours in combination with electric screens gave negative results.

"THE STORM AND AFTER": ERRATUM.—On page 177, *ante*, the statement appears, with reference to the loss of the M.V. Princess Victoria, that "a depth of water of 1 ft. over the area of the car deck would represent a weight of 2,000 tons." The figure should have been 200 tons. We regret the error, which was detected too late for correction, but believe that it is sufficiently obvious not to be misleading.

UNITED KINGDOM IRON AND STEEL PRODUCTION.—The production of steel in Great Britain in January attained an annual rate of 18,009,000 tons, compared with 16,314,000 tons in December, 1952, and 15,234,000 tons in January, 1952. This last figure, however, was affected by the New Year holidays. The output of pig iron in January was at an annual rate of 11,121,000 tons, against 10,728,000 tons in December, 1952, and 10,319,000 tons in January, 1952.

PACKING THE "PRINCESS" FLYING BOATS FOR STORAGE.

To ensure that the second and third Saunders-Roe Princess flying boats will be preserved without deterioration during the considerable period that is expected to elapse before the delivery of their Bristol Proteus power plants, the aircraft are being "cocooned" by the plastic-spraying packaging process developed by Messrs. R. A. Brand and Company, Limited, "Cocoon" Division, Field House, Brems Buildings, Chancery-lane, London, E.C.4. (It may be mentioned that this firm are also responsible for preserving the Reserve Fleet for the Admiralty by the cocooning process.) Early this week the second Princess, completely cocooned, was standing on the slipway at Cowes, ready for launching and towing to Calshot Flying Boat Station, about six miles away, where the boats are to be stored. Weather permitting, it was hoped to dispatch the aircraft on Wednesday morning. Although still awaiting the assembly of the outer wings and fin tip, which have to be carried out on the slipway, the cocooning process has already been commenced on the third Princess inside the assembly shed.

The cocooned aircraft, it is believed, will be the largest single "packages" in existence. Each aircraft has a surface area of 25,000 sq. ft., and the weight of the plastic covering amounts to approximately 9 tons. Since the plastic covering hermetically seals the aircraft, the interior has to be dried thoroughly to prevent internal corrosion, and for this purpose 18,000 lb. of dessicant—silica gel and pelleted quicklime—have been used. In the forward freight compartment, 5 tons of quicklime are placed in sealed trays stacked in a framework built into the aircraft. The quicklime, in addition to absorbing moisture from the air trapped in the fuselage, acts as ballast. The trays, each holding about 1 cwt., are designed to allow for the expansion of the lime as it takes up moisture. In the wings, 2,592 lb. of quicklime and 840 lb. of silica gel are distributed in trays throughout the wing interior, including the fuel tanks and engine bays; 112 lb. of silica gel, in 3-lb. bags, are hung in each float. The total weight of dessicant dispersed throughout the tail unit is 360 lb. of quicklime and 196 lb. of silica gel. To indicate the relative humidity inside the packaged aircraft, 18 hygrometers are installed—two in each engine bay and six in the hull.

A standard spray gun operating at low pressure is used to apply the fluid plastic, which emerges as a continuous filament and has the appearance of a cocoon as it forms and before it shrinks to form a smooth coating. Before the plastic was applied, a sealing compound was brushed over the wings, tailplane and nose and under-surfaces of the hull, to form a grid to which the heavy plastic covering could adhere. The wing trailing edges and other sharp projections were covered with a plastic sheet to ensure adequate strength to resist the considerable load which the sprayed coating imposes on the structure as it shrinks into position. Three coats of plastic were sprayed, to give a thickness of 0.04 in. The resulting coating is tough and ductile. A bitumen coat was then applied, to give added protection against moisture, and the area along the chine was reinforced with a band of hessian to safeguard the coating against abrasion during towing. Another bitumen coating, of a different texture, was then applied to the hull and upper surfaces, giving a total thickness of protective coating of 0.01 in. Finally, an aluminium coating was sprayed on to reduce the effects of heat radiation on the coating.

ALMANACS AND CALENDARS.—We have received monthly tear-off wall calendars from Termomeccanica Italiana, La Spezia, Italy, and the United States Information Service, Grosvenor-square, London, W.1. The latter calendar contains many photographic illustrations, particulars of special dates in the United States and details of the Service. The "At-a-Glance" Calendar Co., Ltd., Beechfield-road, London, N.4, have sent us specimen calendars incorporating their patent date-indicator attachment.

20-TON ELECTRIC ARC FURNACE FOR HADFIELDS LIMITED, SHEFFIELD.

BIRLEC, LIMITED, BIRMINGHAM.

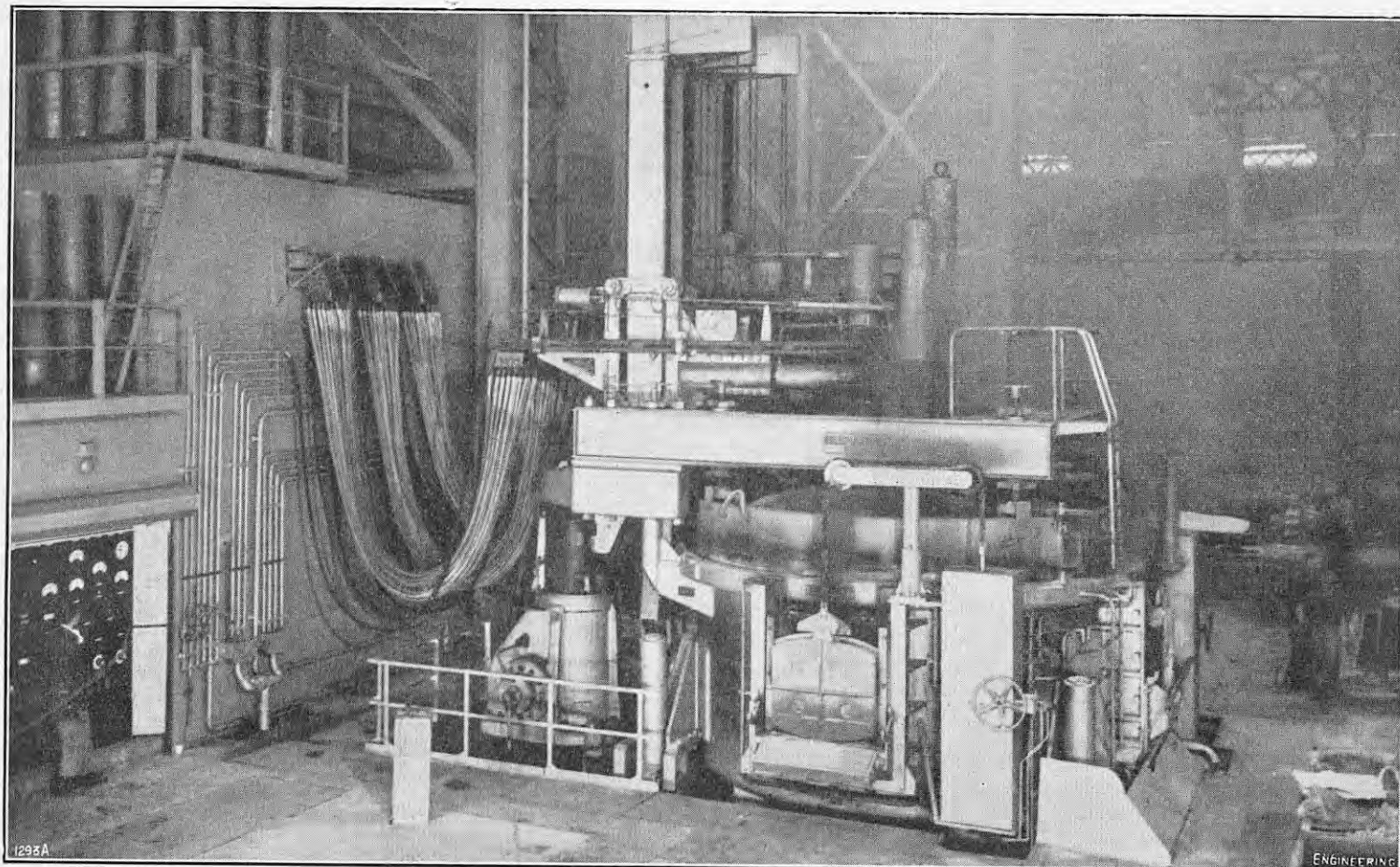


FIG. 1. GENERAL VIEW OF FURNACE AND CONTROL PANEL.

20-TON ELECTRIC ARC FURNACE AT EAST HECLA WORKS, SHEFFIELD.

THE 20-ton electric arc steel-melting furnace which has been installed in the East Hecla Works of Hadfields Limited, Sheffield, and is normally operated continuously for the production of high-quality steels, forms part of a development in the foundry which has been taking place since 1947. Its erection involved the construction of a melting shop equipped with two 40-ton electric overhead cranes, one of which is used for charging and the other for handling the pouring ladle. There are also a number of 10-ton auxiliary hoists, as well as pouring, ingot casting and scrap bucket pits and accommodation for the electrical equipment.

The furnace, of which a general view is given in Fig. 1, on this page, was constructed by Birlec Limited, Tyburn-road, Erdington, Birmingham, 24, its design being based on the well-established principles of the LECTROMELT Corporation, Pittsburgh. It consists of a cylindrical shell with a diameter of about 14 ft., to provide a large slag-contact area. This shell is constructed of heavy-gauge steel plates, which are reinforced with structural-steel members, and is lined with metal-cased magnesite bricks, as shown in Fig. 3, Plate IV. A top stiffening bezel ring, which is water-cooled, is provided to prevent distortion under heat. There are two openings in the furnace, one opposite the pouring spout and the other at 90 deg. to this diameter opposite the electrode masts. The first of these doors is used for slagging, oxygen lancing, fettling and other operations, and the second, which is shown in Fig. 2, for making alloy additions to the melt. Both openings have vertical sliding doors which are lined with refractory and are operated pneumatically, control being by push buttons. The pouring spout, which is also lined with refractory, is attached to reinforcements on the shell.

The two water-cooled roof rings are constructed

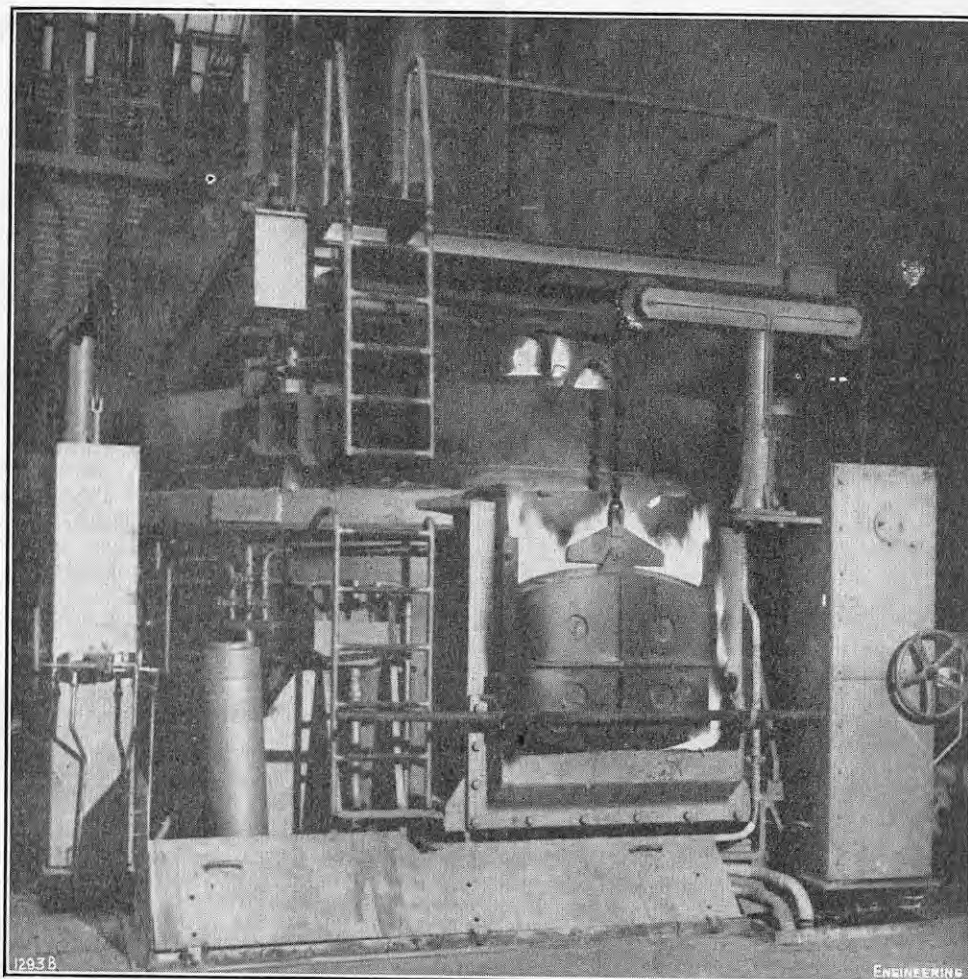


FIG. 2. SIDE DOOR FOR ALLOY ADDITIONS.

20-TON ELECTRIC ARC FURNACE FOR HADFIELDS, LIMITED.

BIRLEC, LIMITED, BIRMINGHAM.

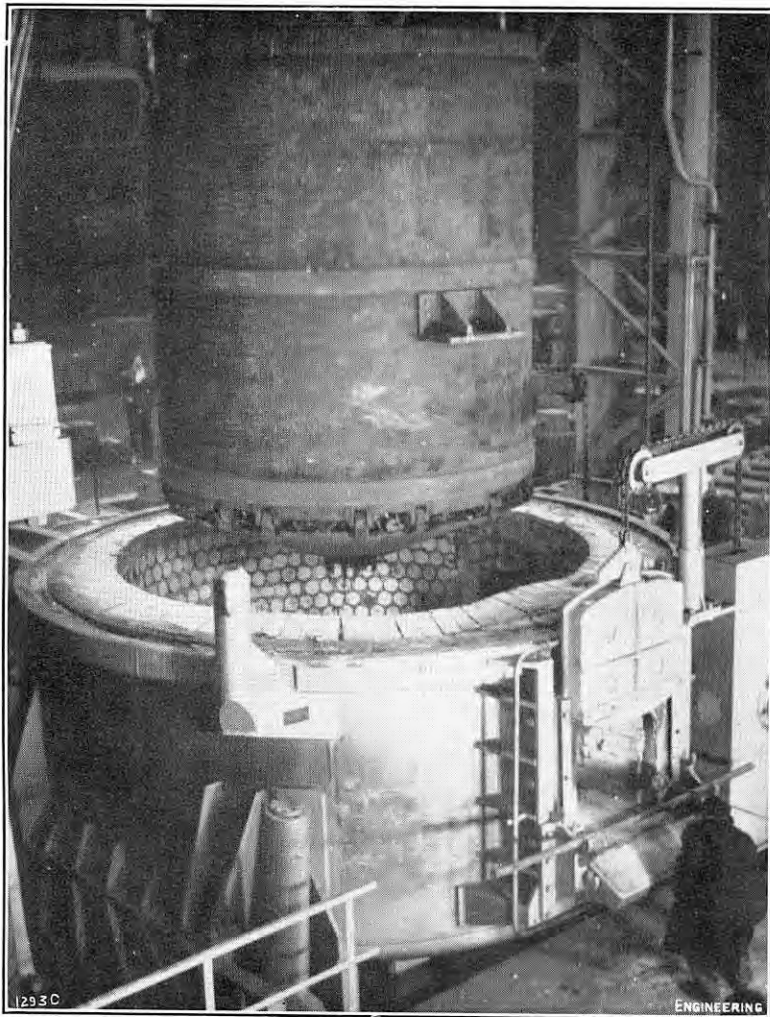
(For Description, see Page 204.)

FIG. 3. FURNACE SHELL UNDER CONSTRUCTION.

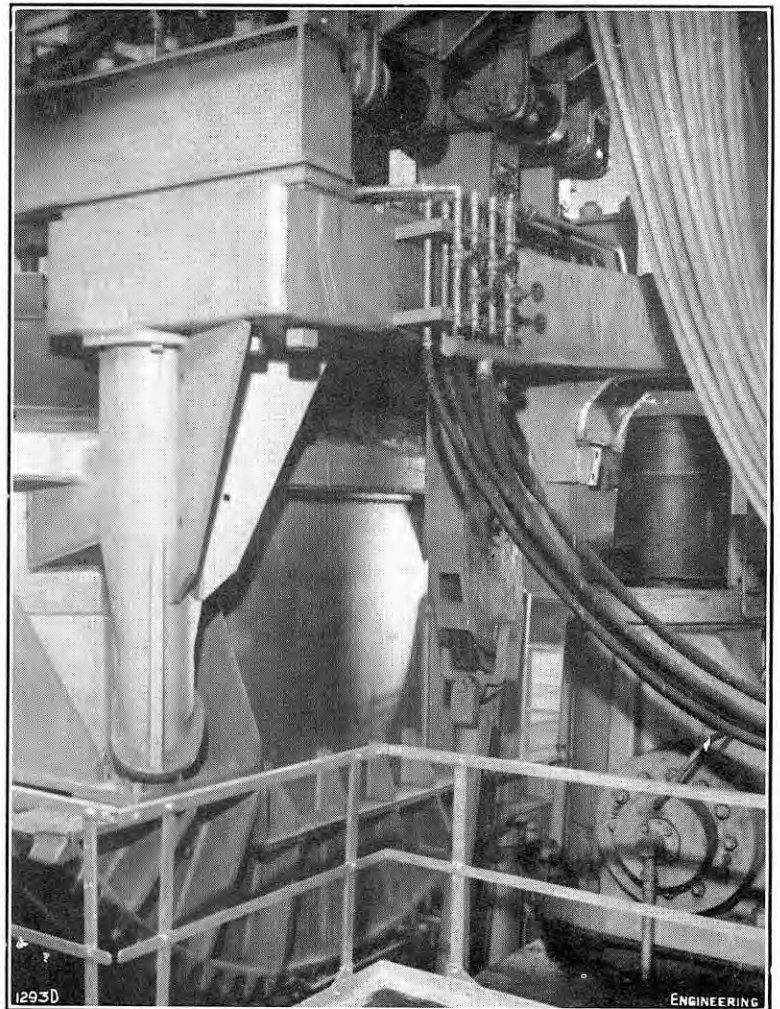


FIG. 4. LIFTING RAM AND TILTING ROCKER.

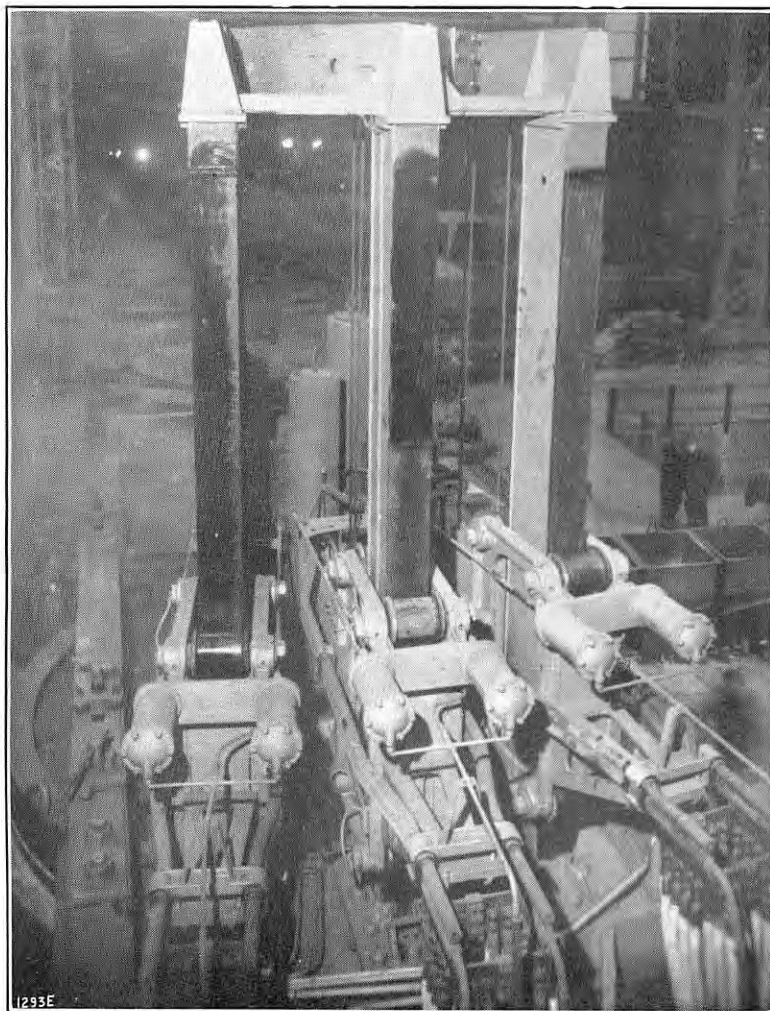


FIG. 5. PNEUMATIC ELECTRODE-CLAMPING GEAR.

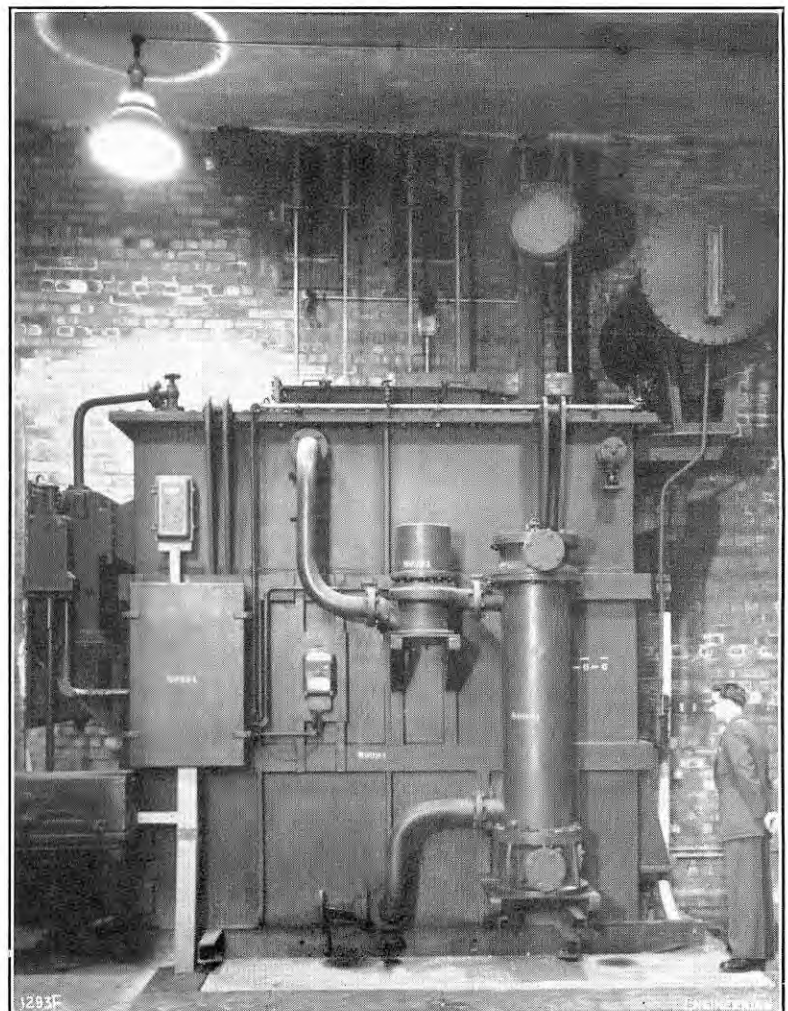


FIG. 6. FURNACE TRANSFORMER.

20-TON ELECTRIC ARC FURNACE.

BIRLEC, LIMITED, BIRMINGHAM.

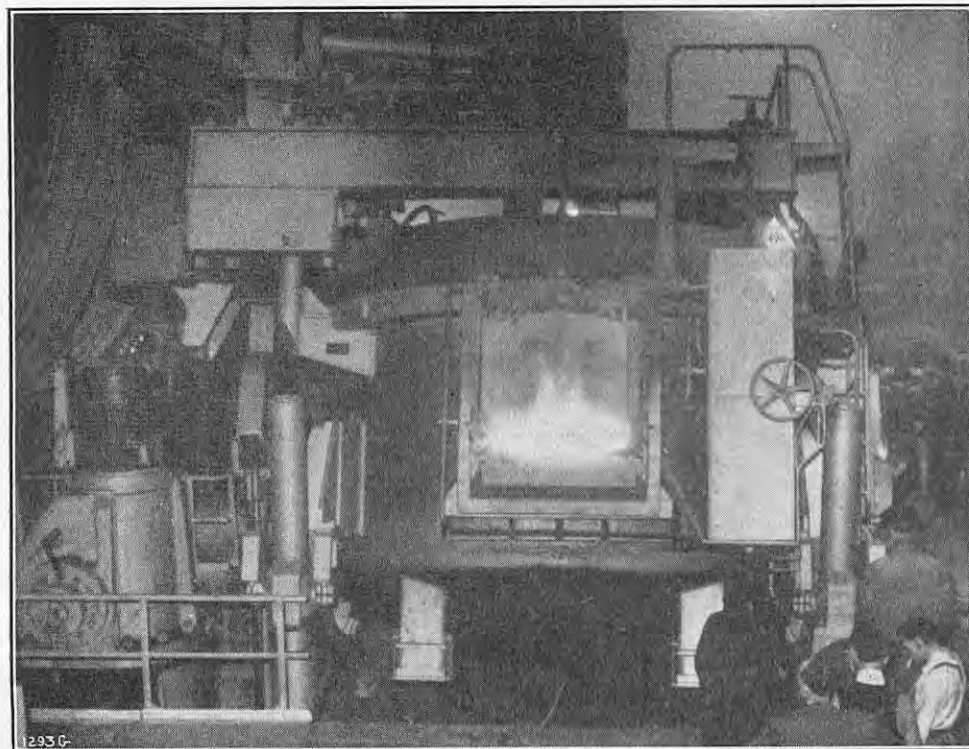


FIG. 7. REAR OF FURNACE.

of channel section steel and are of larger diameter than the shell, to prolong the life of the skew-back bricks by removing them from the heat of the molten metal. The roof is suspended at four points from two structural-steel beams, an arrangement which facilitates removal and replacement and obviates any trouble in aligning the electrode ports and electrodes. It is understood to be the first time that this design has been used on a 20-ton arc furnace.

LIFTING AND TILTING MECHANISM.

The roof structure is secured in a casting, weighing over 10 tons, and has an eye attached to the roof beams, as shown in Fig. 4, Plate IV. This eye engages in a vertical ram, the cylinder of which is supplied with oil under pressure carried on a mounting separate from the furnace body, so that the furnace shell is not subjected to severe stresses when the roof is lifted. The formation of a hot spot on the cylindrical body, which might be caused by any impediment to uniform heat dissipation, is also prevented. The roof is raised from the shell by the ram engaging in the eye-casting and lifting it clear. It is swung round through an angle of nearly 90 deg. to expose the hearth. Loading can then be effected by lowering a drop-bottom bucket into the shell. As the bucket is swung clear, the roof returns to its original position and can be lowered on to the shell. These operations are effected by interlocked mechanism to ensure that they take place in the correct sequence and to prevent the furnace from being tilted except when the roof is in the working position or is being lifted when the furnace is tilted.

Tilting is effected by steel rocker trunnions which gear into horizontal tracks on each side of the shell, as can be seen in Fig. 4, Plate IV. The total weight of this gear is more than 12 tons, and it is operated by a pair of rams which are arranged away from the furnace so that any damage from a metal break-through is eliminated. The oil pressure for actuating these rams and for the roof lifting mechanism is generated in a self-contained electrically-driven pump. A view of the furnace when starting to tilt is given in Fig. 7.

ELECTRICITY SUPPLY.

Power for operating the furnace is obtained from the public mains on the three-phase system at 11.2 kV, through a metal-clad switch with a

rupturing capacity of 150 MVA, which was manufactured by A. Reyrolle and Company, Limited, Hebburn-on-Tyne. This switch controls the supply to a 6-MVA, 11,200/220-volt transformer constructed by C. A. Parsons and Company, Limited, Newcastle-on-Tyne. This transformer, a view of which is given in Fig. 6, Plate IV, is contained in a tank of mild-steel boiler plates stiffened by steel sections and has specially-braced windings to enable it to withstand heavy current fluctuations. Its temperature rise, measured in the oil, does not exceed 50 deg. C. under continuous full load and its water-cooling system is equipped with a temperature alarm device. The secondary winding is provided with eight tapplings and an on-load tap-changing switch. This switch, however, is at present arranged for off-load operation and can be actuated either by a motor or manually. Its position is shown on an illuminated indicator on the furnace instrument panel. An interlocking relay is fitted to ensure that the main circuit-breaker trips whenever the tapping switch or the furnace interlocks operate.

ELECTRODE GEAR.

The furnace is provided with three 14-in. diameter graphite electrodes, which were supplied by British Acheson Electrodes, Limited, Sheffield. These electrodes are secured in water-cooled copper clamps and project vertically through the furnace roof, as can be seen in Fig. 5, Plate IV. They can be raised or lowered by remotely controlled pneumatic mechanism, thus facilitating charging and adjustment of their height. The clamps are mounted on the ends of horizontal arms which carry the electrical and water connections and are designed so as to minimise the eddy-current losses. These arms are, in turn, connected to the vertical masts by crossheads which are fitted with hardened-steel rollers. These rollers are adjustable in anti-friction bearings which engage with flat machined surfaces on the masts, thus allowing smooth up and down movements without lateral play. The masts themselves are mounted at the rear of the furnace shell in the same eye casting that carries the beams supporting the roof. The crossheads are suspended from flexible steel cables which pass over sheaves running in ball bearings to compensate for furnace tilt, and then through ducts in the furnace foundation to individual winches. These winches are installed below the furnace floor and are provided

with friction bands over which the cables pass to terminate in counterweights.

AMPLIDYNE CONTROL SYSTEM.

Each winch is driven through gearing by a direct-current motor, the field of which is permanently excited at a constant voltage and the speed and direction of which depends on the magnitude and polarity of the output voltage of an Amplidyne constructed by the British Thomson-Houston Company, Limited, Rugby. The control field of this Amplidyne is connected between the slider of a potentiometer rheostat and the outer end of a resistor, which is in series with the latter. The potentiometer rheostat is supplied with direct-current from a full-wave rectifier, the alternating current side of which is connected in series with a resistor in a circuit between the electrode that is being controlled and the furnace hearth. The hearth is solidly earthed and forms the neutral of the three-phase arc circuit. Thus the direct-current voltage developed across the potentiometer rheostat is a measure of the arc voltage. The resistor, which is in series with the potentiometer rheostat, is supplied with direct-current from a second full-wave rectifier. This rectifier is connected across the secondary of a current transformer in such a way that the current through, and hence the voltage drop across, the resistor is proportional to the arc current. As a result, for a given arc voltage and position of the potentiometer slider there will be a certain arc current at which no current will flow through the field of the Amplidyne. The latter machine will, therefore, provide no output so that the winch motor will not rotate and the corresponding electrode will remain stationary. Any deviation in arc current from this value will, however, give rise to a potential difference across the potentiometer and resistor, with the result that current will flow in the Amplidyne field and it will begin to generate. The motor will then raise or lower the electrode depending on whether the arc current has increased or decreased, and will continue to run until the desired current has been re-established. The greater the deviation from the required current the greater will be the rate of correction. For instance, when a charge "falls in" upon an electrode during the melting down stage, and thus short-circuits the arc, withdrawal occurs at top speed. The system therefore provides smooth and stepless movement of the electrodes without hunting and without the use of relays and gives maximum sensitivity and accuracy of control.

METERING SYSTEM.

All the controls and metering equipment for the furnace are situated on a board on the wall of the transformer substation, near the furnace, as can be seen on the left of Fig. 1. On it are mounted lamps and voltmeters for showing the electrode voltage and the voltage of the auxiliary electrical supplies. There are also ammeters for each electrode circuit as well as a kilowatt-hour meter and a transformer tapping-switch indicator. The control switches for the electrode winch motors, the manually-operated rheostats for obtaining the correct arcing conditions, and the isolators for the various alternating and direct-current auxiliary circuits are also mounted on the board, which is in telephone communication with the rest of the works.

FILM ON RADIO VALVES AND TELEVISION PICTURE TUBES.—The complex automatic machines and mechanical handling equipment used in the mass production of radio valves and television picture tubes—including glass-working, wiredrawing, fine welding, sealing and vacuum-pumping machines—are the subject of a film which has been produced by National Screen Service, Ltd., for Mullard, Ltd., Century House, Shaftesbury-avenue, London, W.C.2. The film is primarily for showing to retailers and service engineers, so that they may appreciate to some extent the highly-developed techniques employed, but it will be of interest to other technical audiences, and an adaptation of it is now being prepared for use in technical colleges and schools. Among the special techniques illustrated by the film is the firm's vertical method of producing glass tubing for valves—the method described in *ENGINEERING*, vol. 173, page 701 (1952). Further particulars of the film, which is called "It's a Good Sign," can be obtained from Mullard, Ltd.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

THE COAL POSITION IN INDUSTRY.—Improved outputs from the divisional mines, compared with a year ago, together with less severe weather conditions, have recently slowed down a heavy rate of depletion of coal stocks in Scotland. At the beginning of the year, withdrawals reached 90,000 tons a week, but this figure has lately been reduced to 26,000 tons. The latter contrasted with 52,000 tons at the corresponding period last year, when, however, a short spell of extremely cold weather was experienced. At the latest appraisal, distributed stocks totalled 1,071,000 tons, against 1,218,000 tons in 1952. Iron and steel works had 75,000 tons in reserve, compared with 96,000 tons; engineering and metal trades 41,000 tons, the same quantity as last year; and other industries 264,000 tons, against 308,000 tons last year.

APPROACHING EXHAUSTION OF SHOTTS COLLIERIES.—Coal seams which have sustained a thriving mining industry in the Shotts district of Lanarkshire for several generations are nearing exhaustion, and National Coal Board officials have told Lanarkshire Joint Trades Council Industrial Committee that they may be worked out within ten years. This would mean the closure of the six collieries around the town of Shotts by 1963. The pits produce about 2,000 tons of coal a day and give employment to 2,000 miners.

MEASURES TO INCREASE STEEL-PLATE OUTPUT.—In order to increase the output of steel plates, of which there has been an acute shortage in Scotland following the recent rapid advances in welding and prefabrication techniques in shipbuilding and other structural trades, a scheme for the electrification of a rolling mill and the reconstruction of heating furnaces has been prepared at the Steel Company of Scotland's Blochairs Works, Glasgow. The slabs required are now being produced at Clydebridge steelworks, where the extended melting plant is in full operation, using hot metal from the Clyde Iron Works. This was mentioned by Sir John Craig, C.B.E., chairman and joint managing director of Colvilles, Ltd., in his annual review of the results of the undertakings comprising the group.

IMPROVEMENTS AT ROTHESAY DOCK, CLYDEBANK.—A scheme involving the conversion of the rail layout of the south quay at Rothesay Dock, Clydebank, for four instead of five berths, was approved at a meeting of the Clyde Navigation Trust on February 3. The rearrangement is to cater for the increased size of ships. The engineer estimated that the work would occupy three years and cost 179,000*l.* if completed during ordinary working hours, and about 200,000*l.* if overtime and week-end working were done when conditions were suitable, a course which would reduce the completion time by from three to six months. This latter alternative has been authorised.

ATTEMPT TO SALVAGE STRANDED SHIP.—The stranded Clan Macquarrie, belonging to the Clan Line, Ltd., which went ashore at Borve, Lewis, during the recent stormy weather at sea, is to be patched with cement in preparation for a possible salvage attempt with the next springtide.

CLEVELAND AND THE NORTHERN COUNTIES.

COMPETITION IN THE SHIPBUILDING INDUSTRY.—Sir William Gray, chairman of William Gray & Co., Ltd., West Hartlepool, shipbuilders and marine-engine builders, writing in the *Journal* of the works Joint Production Committee, has referred to increasing competition from Germany and Japan. It would be necessary, he stated, to use every means in their power to reduce costs. This did not mean an attack on earnings, but wasteful habits, such as bad timekeeping, waste of material, and so forth, would have to be cut out. The year 1952 had been a disappointing one for the firm. Only seven ships, totalling 60,865 tons, had been delivered, compared with nine vessels, making together 73,441 tons, in 1951.

CLEVELAND INSTITUTION OF ENGINEERS.—Speaking at the annual dinner of the Cleveland Institution of Engineers at Stockton-on-Tees, Captain H. Leighton Davies, C.B.E., President of the Iron and Steel Institute, chairman of the Iron and Steel Federation's scrap committee, and joint managing director of the Steel Company of Wales, Ltd., referred to the scrap position. He asserted that a 6 per cent. yield of scrap from the 5,000,000 tons of slag tips in the country would remove the necessity for importing scrap. He complimented the Tees-side firms of Dorman, Long &

Co., Ltd., and the Cargo Fleet Iron Co., Ltd., for the care they took in removing scrap from their tips. Captain Davies also urged firms to discard some of the surplus spares which, he said, would never be used. Industry, during the past few years, had had a happy and prosperous period, but the time was coming when it would have to set its wits against foreign competition. With hard work and courage, however, this competition could be beaten. Mr. A. McLeod, director and general manager of Dorman, Long & Co.'s iron and steel works, recalled the fact that the Cleveland Institution of Engineers, formed 89 years ago, was one of the oldest organisations of its kind, if not the oldest, in the country.

BRICK-MAKING STATISTICS.—At a meeting, at Newcastle-on-Tyne, of the North of England Brick Makers' Association, Mr. T. L. Sutton, the secretary, said that production last year had reached 410 million bricks, compared with 260 millions in 1946. Despite this increase, however, it would still be necessary to import 55 million bricks from Belgium and to purchase large quantities from other parts of Britain. Mr. C. Siddle, deputy principal officer of the Ministry of Housing, has stated that about 562 million bricks will be needed in the Northern Region this year, including 317 millions for housing.

EXTENSIONS TO AEROPLANE FACTORY AT PALLION.—North-Eastern Trading Estates, Ltd., are to carry out extensions to the Bristol Aeroplane Company's No. 2 factory at Pallion, Sunderland. The extension will cover about 65,000 sq. ft., and will provide work for another 250 men, bringing the firm's labour force to about 1,000 men. No tenders have yet been invited for the proposed extension.

THE LATE MR. G. FRENCH.—Mr. George French, a retired mining engineer, has died at his home at Howden-le-Wear, Co. Durham, at the age of 79. He was employed by the North Bitchburn Coal Co., Ltd., at North Bitchburn Colliery for 50 years.

LANCASHIRE AND SOUTH YORKSHIRE.

RAILWAY ELECTRIFICATION.—A new electricity substation, built at a cost of between 25,000*l.* and 30,000*l.* by the Yorkshire Electricity Board, has been brought into service at Sheffield. One of its main purposes will be to supply current to the section of electrified railway between Wath and Penistone. When the whole of the Sheffield to Manchester line is electrified by the end of the year, it will be one of three 33,000-volt substations which will supply the power. British Railways have yet to build overhead cables over part of the route and to complete alterations to the Woodhead tunnel.

A CUTLERY HANDICAP.—Sheffield cutlery manufacturers complain that there is still in operation an Order which prohibits the use of nickel in pen and pocket knives. The Order was made at the height of the nickel shortage, which, it is pointed out, no longer obtains to any marked extent.

UNEMPLOYMENT IN CUTLERY TRADE.—Sheffield cutlery manufacturers dispute a statement made by the Board of Trade to the Regional Board of Industry that the cutlery trade is slowly recovering. The Sheffield Employment Exchange discloses that short time was being worked, in January, by 439 cutlery employees, compared with 331 in December, and that unemployment has been rising since the January statistics. Mr. E. A. Tuxford, secretary of the Sheffield Cutlery Manufacturers' Association, says that it may be correct to state that there has been a very slight improvement, but, in some directions, matters are worse now than in the worst period of the 1930's.

THE MIDLANDS.

DEVELOPMENTS AT ELMDON AIRPORT, BIRMINGHAM.—The Ministry of Civil Aviation have authorised the operation, by Aer Lingus, of up to two services a day from Elmdon airport, with Bristol Wayfarer aircraft. The Bristol Wayfarer, with an all-up weight of 45,000 lb., is slightly heavier than the largest aircraft hitherto allowed to use the runways at Elmdon. The Ministry have also decided, in view of complaints last year about congestion and delays in the Customs and terminal building, to provide an extra waiting room.

COLLIERY EXPLOSION IN NORTH STAFFORDSHIRE.—Six men were killed, and one injured, in an explosion at Dales Green Colliery, Harsiehead, Stoke-on-Trent, on February 2. Dales Green Colliery is a small drift pit, or "footrill," operated by Mr. A. Birchall under licence from the National Coal Board. The mine

employs 20 men underground, in two shifts, and produces about 300 tons of coal a week. The cause of the explosion is not yet known.

CLOSURE OF BRANCH RAILWAY LINES.—The Abbeydore-Dorstone branch railway line in Herefordshire, belonging to the Western Region of British Railways, was closed to all traffic, and the Corwen-Ruthin line of the London Midland Region, in North Wales, ceased to carry passengers, on January 31. The Abbeydore-Dorstone line was opened in 1881, and the line from Corwen to Ruthin in 1862.

GAS PRICES.—At a meeting in Birmingham, on February 1, of the West Midlands Gas Consultative Council, it was announced that there is to be no change in the price of gas in the three Midland counties of Herefordshire, Shropshire and Staffordshire. A deputation had asked the Council in December if the question of gas prices in the three counties could be investigated. This was done, and the West Midlands Gas Board had stated that the principles approved by the Council had been correctly and reasonably applied in each of the districts named.

BRANCH FACTORY IN AUSTRALIA.—Another Midland firm are to open a branch factory in Australia, to overcome the difficulties arising out of the Australian ban on imports from this country. Wilkins and Mitchell, Ltd., of Darlaston, who make power presses and washing machines, have sent a director and three officials to Australia by air, to start a factory which will assemble washing machines from parts made in Darlaston.

FACTORY EXTENSIONS.—The Laystall Engineering Co., Ltd., Aldersley, Wolverhampton, have nearly completed an extension to their factory. The works are almost entirely concerned with the production of crankshafts for petrol and Diesel engines, and for air compressors. The extension, which has cost over 100,000*l.*, will practically double the company's capacity, and will find employment for an additional 50 or 60 skilled workers.

SOUTH-WEST ENGLAND AND SOUTH WALES.

SHORT-TIME WORKING IN EAST WALES.—Between 4,200 and 4,700 employees in the light-alloys and steel-sheet industries in East Wales have been working short time recently, the East Wales District Committee of the Welsh Board for Industry was told at a meeting at Chepstow. Other industries affected, but to a lesser degree, were those producing tin-plate, furniture, textiles, scientific glassware, and stationers' goods.

EMPLOYMENT POSITION AT ROGERSTONE.—A deputation of Welsh M.P.s has told the Minister of Supply, Mr. Duncan Sandys, of the concern felt among employees at the Northern Aluminium factory at Rogerstone, near Newport, following the dismissal of 150 men and the placing of the factory on four days a week. They received assurances that the district would continue to receive preferential treatment, in regard to the supply of materials and the allocation of orders accorded to development areas. The reduced labour demand was due to a falling off in the demand from industries using aluminium.

EROSION AND SILTING IN PORT OF CARDIFF.—When asked to approve a grant not exceeding 2,000*l.* towards the cost of a preliminary survey to be made by the Port of Cardiff Development Association in connection with a scheme to prevent erosion and silting of the docks-entrance channel in the River Taff, the city finance committee decided to recommend that a strong deputation be sent to the Minister of Transport to urge that something be done at once.

SALARIES OF COLLIERY MANAGERS.—The first salary dispute between the South Western Divisional Coal Board and the British Association of Colliery Management to be taken to arbitration has been decided in favour of the Association. The dispute concerned the salary scale to be paid to colliery agents and senior production officials under a national agreement. The Board held that these should be paid on a scale with a maximum of 2,250*l.*, but the Association successfully maintained that the upper limit should be 2,750*l.*

TRADE FOR SOUTH-WALES PORTS.—Figures issued by the Docks and Inland Waterways Executive on February 7 show that the trade of the South Wales ports in the first four weeks of this year was 65,934 tons below that in the corresponding period of 1952, the totals being 1,677,610 tons and 1,743,544 tons, respectively. The western ports of Swansea and Port Talbot enjoyed a larger trade, but this was more than offset by falls in the volume of traffic dealt with at the Eastern Ports of Cardiff, Barry and Newport.

NOTICES OF MEETINGS.

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

INSTITUTION OF ELECTRICAL ENGINEERS.—*Mersey and North Wales Centre*: Monday, February 16, 6.30 p.m., Royal Institution, Colquitt-street, Liverpool. "The Toughened-Glass Power Line Insulator," by Mr. E. F. Johnston. *Southern Centre*: Monday, February 16, 6.30 p.m., Guildhall, Southampton. Faraday Lecture on "Light from the Dark Ages or the Evolution of Electricity Supply," by Mr. A. R. Cooper. *Measurements Section*: Tuesday, February 17, 5.30 p.m., Victoria-embankment, W.C.2. (i) "Measurement of Blade-Tip Clearances in Aircraft Turbines," by Mr. I. A. Mossop and Mr. F. D. Gill; and (ii) "Photographic Exposure Timers Providing Compensation for Supply Voltage Variations," by Mr. R. J. Herecock and Mr. D. M. Neale. *Institution*: Wednesday, February 18, 6.30 p.m., Central Hall, Westminster, S.W.1. Faraday Lecture. *Utilization Section*: Thursday, February 19, 5.30 p.m., Victoria-embankment, W.C.2. "Fluorescent Discharge-Tube Circuits and Operating Problems," by Mr. J. Cates. *Education Discussion Circle*: Friday, February 20, 6 p.m., Victoria-embankment, W.C.2. Discussion on "Circuit Conventions," opened by Mr. J. G. Fleming.

SHEFFIELD METALLURGICAL ASSOCIATION and SHEFFIELD SOCIETY OF ENGINEERS and METALLURGISTS.—Monday, February 16, 7 p.m., University Building, St. George's-square, Sheffield. "Constitution and Properties of Some Titanium-Base Alloys," by Mr. W. A. Baker.

INSTITUTION OF THE RUBBER INDUSTRY.—*Merseyside Section*: Monday, February 16, 7 p.m., Electricity Showrooms, Whitechapel, Liverpool. "Testing of Materials and Products," by Mr. J. M. Buist.

INSTITUTION OF PRODUCTION ENGINEERS.—*Derby Section*: Monday, February 16, 7 p.m., School of Art, Derby. "Work Study," by Mr. R. M. Currie. *North-Eastern Section*: Monday, February 16, 7 p.m., Neville Hall, Newcastle-upon-Tyne. "Manufacture of Large Turbo-Alternators," by Mr. J. Henderson and Mr. J. W. Taylor. *Coventry Section*: Tuesday, February 17, 7 p.m., Geisha Café, Hertford-street, Coventry. "Textile Machinery," by Mr. A. E. Riley. *Birmingham Section*: Wednesday, February 18, 7 p.m., James Watt Memorial Institute, Birmingham. "Application of Hydraulics to Profile Milling Machines," by Mr. S. C. Fenton. *Edinburgh Section*: Wednesday, February 18, 7.30 p.m., North British Station Hotel, Edinburgh. "Cost Control and Production," by Mr. C. W. Higgins. *Southern Section*: Thursday, February 19, 7 p.m., Polygon Hotel, Southampton. "Press Tools," by Mr. G. V. Bevan. *Glasgow Section*: Thursday, February 19, 7.30 p.m., 39, Elmbank-crescent, Glasgow. "American Valve Industry," by Mr. J. Wark.

INCORPORATED PLANT ENGINEERS.—*Liverpool and North Wales Branch*: Monday, February 16, 7.15 p.m., Radiant House, Bold-street, Liverpool. "Conditioning of Slack," by Dr. A. C. Dunningham. *Glasgow Branch*: Tuesday, February 17, 7 p.m., 351, Sauchiehall-street, Glasgow. "Heat Transfer," by Mr. R. A. Brecknell. *Kent Branch*: Wednesday, February 18, 7 p.m., Bull Hotel, Rochester. Discussion on "Safety and the Factory Acts." *Western Branch*: Wednesday, February 18, 7.15 p.m., Grand Hotel, Bristol. "Steam Flow Measurement," by Mr. W. M. Barber. *Blackburn Branch*: Thursday, February 19, 7.30 p.m., Chamber of Commerce, Blackburn. "Steam Trapping," by Mr. N. P. G. Hoole.

ROYAL INSTITUTION.—Tuesday, February 17, 5.15 p.m., 21, Albemarle-street, W.1. "Behaviour of Engineering Structures—I," by Professor A. J. S. Pippard. Friday, February 20, 9 p.m., "The Birth of Flight," by Lord Brabazon of Tara.

INSTITUTION OF CIVIL ENGINEERS.—Tuesday, February 17, 5.30 p.m., Great George-street, S.W.1. "Modern Developments in Surveying Methods and Instruments," by Mr. Alfred Stephenson.

INSTITUTE OF REFRIGERATION and PHYSICAL SOCIETY (Low Temperature Group).—Tuesday, February 17, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. Discussion on "Novel Refrigeration Cycles."

INSTITUTE OF FUEL.—*Midland Section*: Tuesday, February 17, 6 p.m., James Watt Memorial Institute, Birmingham. "Refractories," by Dr. J. White. *Yorkshire Section*: Wednesday, February 18, 6.30 p.m., The University, Leeds. Various short papers. *North-Western Section*: Wednesday, February 18, 7.30 p.m., Grosvenor Hotel, Chester. "Methane at Point of Ayr Colliery," by Mr. S. J. Young.

INSTITUTION OF STRUCTURAL ENGINEERS.—*Wales and Monmouthshire Branch*: Tuesday, February 17, 6.30 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Fourth Congress, International Association

of Bridge and Structural Engineering," by Mr. D. Manolopoulos. *Midland Counties Branch*: Tuesday, February 17, 7 p.m., King's Hall, Queen-street, Derby. "Reinforced-Concrete Foundations, Structures and Plant at Shotton, Chester," by Mr. O. W. Jones. *Yorkshire Branch*: Wednesday, February 18, 6.30 p.m., The University, Leeds. "Secondary Stresses in Steel Bridge Girders," by Dr. S. Mackey.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—Tuesday, February 17, 6.30 p.m., 2, Savoy-hill, Strand, W.C.2. "Electronic Speed Control of Motors," by Mr. J. C. Rankin. *Coventry Branch*: Wednesday, February 18, 7.30 p.m., Technical College, Coventry. "Man or Machine," by Mr. A. P. Young.

ROYAL AERONAUTICAL SOCIETY.—Tuesday, February 17, 7 p.m., 4, Hamilton-place, W.1. "Recent Developments in Gliding," by Mr. A. H. Yates.

INSTITUTE OF BRITISH FOUNDRYMEN.—*East Anglian Section*: Tuesday, February 17, 7 p.m., Public Library, Ipswich. "Flow of Metal," by Mr. R. W. Ruddle. *Slough Section*: Tuesday, February 17, 7.30 p.m., Offices, High Duty Alloys, Ltd., Slough. "Surface Finish and Facing Sands," by Mr. F. R. Pell. *North East Scottish Section*: Wednesday, February 18, 7.30 p.m., Imperial Hotel, Arbroath. "Quality of Iron Castings," by Mr. R. R. Taylor. *Bristol and West of England Branch*: Saturday, February 21, 3 p.m., Grand Hotel, Bristol. "Patternmaking," by Mr. B. Levy.

ROYAL SOCIETY OF ARTS.—Wednesday, February 18, 2.30 p.m., John Adam-street, W.C.2. "British Inland Waterways To-day and To-morrow," by Mr. Robert Aickman.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—Wednesday, February 18, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "Operating Experiences with Two Gas-Turbine Locomotives," by Mr. A. W. J. Dymond.

INSTITUTION OF SANITARY ENGINEERS.—Wednesday, February 18, 6 p.m., Caxton Hall, Victoria-street, S.W.1. "Law Relating to River Pollution Prevention," by Mr. G. E. Walker.

REINFORCED CONCRETE ASSOCIATION.—Wednesday, February 18, 6 p.m., 11, Upper Belgrave-street, S.W.1. Discussion on "Problems of the Reinforced-Concrete Industry."

INSTITUTION OF ENGINEERS-IN-CHARGE.—Wednesday, February 18, 6.30 p.m., 2, Savoy-hill, W.C.2. "Hospital Lighting," by Mr. R. L. C. Tate.

INSTITUTION OF HEATING and VENTILATING ENGINEERS.—*Birmingham Branch*: Wednesday, February 18, 6.30 p.m., Imperial Hotel, Birmingham. "Heating and Ventilating and the Architect," by Mr. C. C. Handiside. *Liverpool Branch*: Wednesday, February 18, 6.30 p.m., Radiant House, Bold-street, Liverpool. "Wiring and Switchgear," by Mr. L. I. Brainwood.

BRITISH ASSOCIATION OF CHEMISTS.—*London Section*: Wednesday, February 18, 6.30 p.m., 183, Euston-road, N.W.1. Various papers on "Education in Chemistry."

MANCHESTER METALLURGICAL SOCIETY.—Wednesday, February 18, 6.30 p.m., Engineers' Club, Manchester. "Metallurgical Aspects of Lubricating Problems," by Mr. A. L. H. Perry.

INSTITUTE OF WELDING.—Wednesday, February 18, 6.30 p.m., Institution of Civil Engineers, Great George-street, S.W.1. Sir William J. Larke Medal Paper.

INSTITUTION OF ENGINEERING INSPECTION.—*Dundee Branch*: Wednesday, February 18, 7.15 p.m., School of Economics, Dundee. Film Evening.

INSTITUTION OF MECHANICAL ENGINEERS.—*East Midlands Branch*: Wednesday, February 18, 7.30 p.m., College of Technology, Leicester. "Industrial Design and Machine Design," by Mr. H. G. Conway. *Midland Branch*: Thursday, February 19, 6 p.m., James Watt Memorial Institute, Birmingham. Thomas Hawksley Lecture on "Work-Hardening in Metals," by Professor N. F. Mott, F.R.S. *North Western Branch*: Thursday, February 19, 6.45 p.m., Engineers' Club, Manchester. "Steel Castings," by Mr. J. F. B. Jackson. *Scottish Branch*: Thursday, February 19, 7.30 p.m., Royal Technical College, Glasgow. "Mechanical Vibrations," by Professor R. N. Arnold. *Institution*: Friday, February 20, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Investigation of Fretting Corrosion," by Dr. K. H. R. Wright. *AUTOMOBILE DIVISION.*—*Scottish Centre*: Monday, February 16, 7.30 p.m., 39, Elmbank-crescent, Glasgow. "Instrumentation," by Mr. J. A. Singleton. *North-Western Centre*: Wednesday, February 18, 7.15 p.m., Engineers' Club, Manchester. "Safety Glass," by Mr. H. Irwin.

INSTITUTION OF MINING and METALLURGY.—Thursday, February 19, 5 p.m., Geological Society, Burlington House, Piccadilly, W.1. (i) "Precise Azimuths from Steep Sights," by Mr. J. S. Sheppard; and (ii) "Diamond-Mining Practice in Kimberley," by Mr. R. Daniel.

JUNIOR INSTITUTION OF ENGINEERS.—Friday, February 20, 7.30 p.m., Townsend House, Greycoat-place, S.W.1. "Whole House Heating," by Colonel H. S. Walter.

PERSONAL.

MR. D. F. ANDERSON, M.A.(Oxon.), has been nominated President of the Chamber of Shipping of the United Kingdom, 3-6, Bury-court, St. Mary Axe, London, E.C.3, for the current year. MR. J. C. DENHOLM, C.B.E., has been nominated vice-president.

MR. D. T. BARRITT, MR. H. CLARKE and MR. J. P. V. WOOLLAM, directors of Simon-Carves Ltd., Cheadle Heath, Stockport, have been appointed joint managing directors of the company.

MR. JOHN ASPINALL, M.B.E., M.I.Mech.E., works director, Hick, Hargreaves & Co., Ltd., Soho Iron-works, Bolton, has been appointed assistant managing director of the company.

MR. P. L. OSBORN has been elected a director of Osborn-Musket Tools Ltd., a subsidiary company of Samuel Osborn & Co., Ltd., Sheffield.

MR. J. T. SMITH, a director in charge of engineering on the board of the Metals Division of Imperial Chemical Industries Ltd., retired on January 31.

MR. NORMAN TATTERSALL, M.I.Mech.E., previously acting chief engineer, Leyland Motors Ltd., Leyland, Lancashire, has been appointed chief engineer. DR. ING. A. MUELLER has been made chief development and research engineer.

MR. G. S. HELME, T.D., A.M.I.E.E., manager in Scotland for Lancashire Dynamo and Crypto Ltd., has retired after 21 years of service in that capacity. His successor is MR. W. J. A. GEMMELL, B.Sc.

MR. P. B. HIGGINS, A.C.A., A.M.I.Prod.E., has been elected to the boards of Specialoid Ltd., and Aero Piston Ring Co. Ltd. MR. R. H. HAINSWORTH, director and general manager, has been made managing director of Specialoid Ltd., and MR. T. O. HUNT, chief designer and technical manager, has been appointed technical director of this firm.

MR. M. W. THRING, M.A.(Cantab.), F.Inst.F., F.Inst.P., has been appointed an assistant director of research of the British Iron and Steel Research Association. He will continue as head of the Association's physics department.

LT.-COL. E. A. PARR-DUDLEY, T.D., A.M.I.E.E., hitherto London sales manager, Newman Industries Ltd., Yate, Bristol, has taken over control and direction of home sales. MR. A. N. D. KERR, A.M.I.E.E., has joined the firm and taken over the post of London sales manager. MR. A. C. COAD has been made manager of the firm's Manchester office. MR. V. P. HENDERSON has joined the London sales staff, and MR. M. C. DE ROEMER has returned after an 18-months' period of service in the Royal Navy.

MR. R. L. PACKER has taken up his duties as London branch manager of British Insulated Callender's Cables Ltd., in succession to MR. F. SAMUEL, who is retiring on March 8.

MR. R. BOOLE, A.M.I.Mech.E., has been appointed technical manager of Brynmawr Rubber Ltd., and took up his appointment on February 2.

MR. EDMUND SAYERS has retired from the management of the aero and auto equipment sales department of the British Thomson-Houston Co., Ltd., Rugby, after 48 years of service with the company. His successor, as from February 2, is MR. V. A. HIGGS, B.Sc.(Hons.), A.M.I.E.E., A.F.R.Ae.S.

MR. L. SOULAL has been appointed manager of the Birkenhead works of the Vacuum Oil Co. Ltd., in succession to the late MR. E. R. SLATER.

COVENTRY DIESEL ENGINES LTD., Friars-road, Coventry, announce that the telephone number of their head office and works in Widdington-road is now Coventry 62607. That of "service and spares" is now Coventry 5051-2-3.

THOS. W. WARD LTD., Albion Works, Sheffield, have been appointed official distributors of the "Staffa" 2.3-ton mobile crane, and of the $\frac{3}{4}$, 1 and $1\frac{1}{2}$ -cub. yard "WETHERILL HYDRAULIC" loading shovels.

ALUMINIUM WIRE and CABLE CO. LTD. have opened a branch office at Transreef House, 66, Marshall-street, Johannesburg. MR. E. HALL is in charge.

THE BRITISH ALUMINIUM CO. LTD. have transferred their Leeds branch office from 66, Kirkstall-road to Martin's Bank Chambers, Vicar-lane, Leeds, 1. MR. A. E. HEELEY continues as branch manager.

THE HOFFMANN MANUFACTURING CO. LTD., Chelmsford, Essex, have moved their Cardiff office and stockroom from 4, Salisbury-square to 121, Cathedral-road.

The section of KENNEDY and DONKIN's work previously handled at Post Office Chambers, 26, Brown-street, Manchester, 2, is now to be executed at 64, Royal Exchange, Manchester, 2.

MOORE'S PLANT LTD. have moved to new premises at 101-129, Markfield-road, Tottenham, London, N.15.

SMITHS INDUSTRIAL INSTRUMENTS LTD., Cricklewood Works, London, N.W.2, have opened a northern sales office at York House, 12, York-street, Manchester, 2.

150-TON LIGHT-ALLOY BARGE.

FAIRMILE CONSTRUCTION CO., LTD., COBHAM, SURREY.

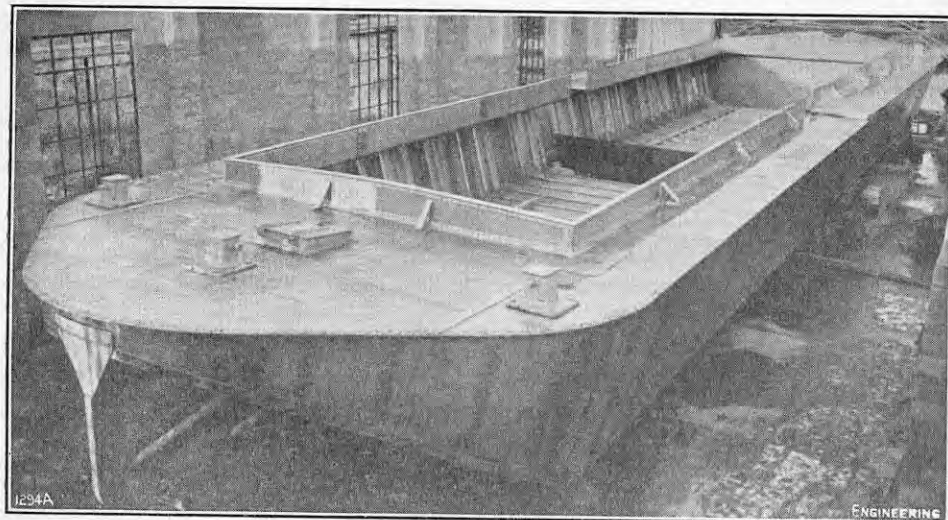


FIG. 1. FLOATABLE HALVES OF BARGE SEPARATED.

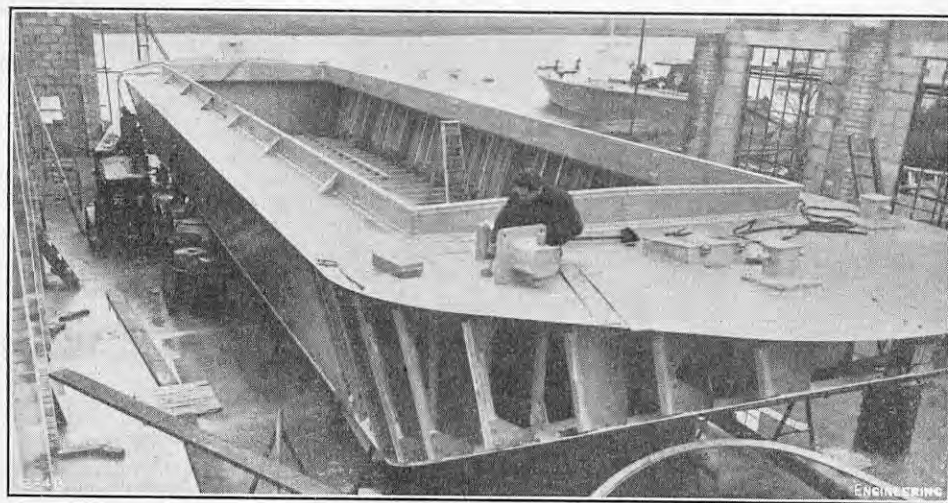


FIG. 2. BARGE UNDER CONSTRUCTION.

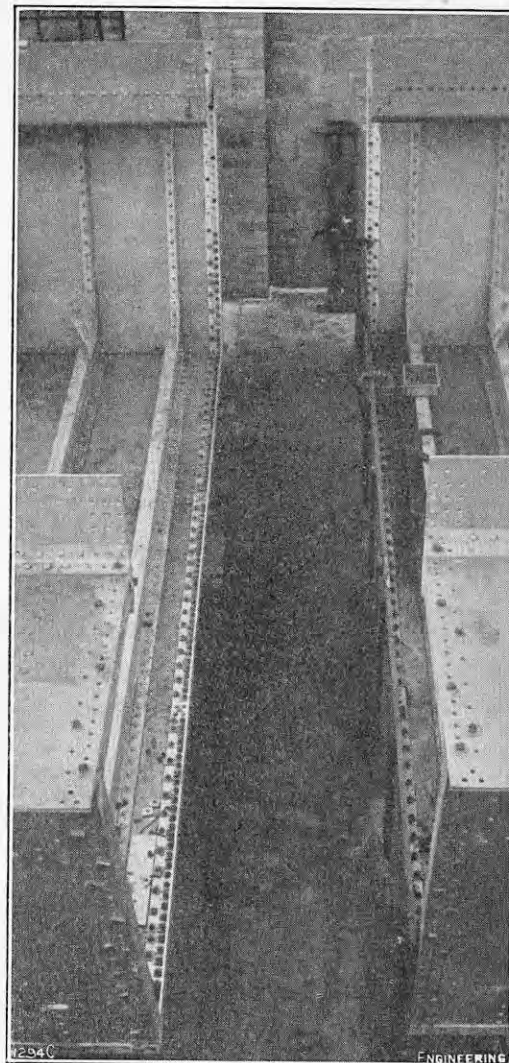


FIG. 3. HALVES PREPARED FOR JOINING.

LIGHT-ALLOY BARGE.

THE aluminium-alloy barge shown in the accompanying illustrations is the first of four, of 150 tons capacity, which the Fairmile Construction Company, Limited, Cobham, Surrey, are building for service in the Middle East. It has been designed to the requirements of Lloyd's Register of Shipping and measures 80 ft. in length overall, with a beam of 20 ft. 6 in. and a depth of 5 ft. 9 in. It is of aluminium alloy, supplied by the Northern Aluminium Company, Limited, Banbury, Oxfordshire. To facilitate shipment it is built in two parts, weighing 5½ tons each. Temporary wooden bulkheads are bolted to the mid frames, so that the halves can be floated from the slip to a lifting crane for loading. For assembly, the halves are first connected by ½-in. bolts through the joining angles on the sides, bottom and deck, after which tie plates, 16 in. wide, are riveted in position on the sides and bottom, with butt straps of 7 in. by ½ in. in between. The deck and coaming are also joined by butt straps, but the deck plating is to be butt-welded on future vessels. Finally, two 6-ft. lengths of extruded aluminium, of U section, are riveted to the edge of the coaming, and the closing lengths of the centre and outer keelsons are fitted. Bostik cement is used for the joint filler. The shell and deck of the barge are ¼ in. thick. Aluminium rivets, ½ in. in diameter, are used throughout. The bottom framing consists of Z bars, 7 in. by 3 in. by 3 in., spaced 1 ft. 9 in. apart. At each end of the hold, a lifting eye is bolted between the side frame and Z bar, to be replaced by a knee plate on final assembly. The hatch coaming has the lower edge bent under the deck, as shown in Fig. 4, and welded coaming knees are fitted, six each side and two at each end. The



FIG. 4. COAMING AND JOINING ANGLE.

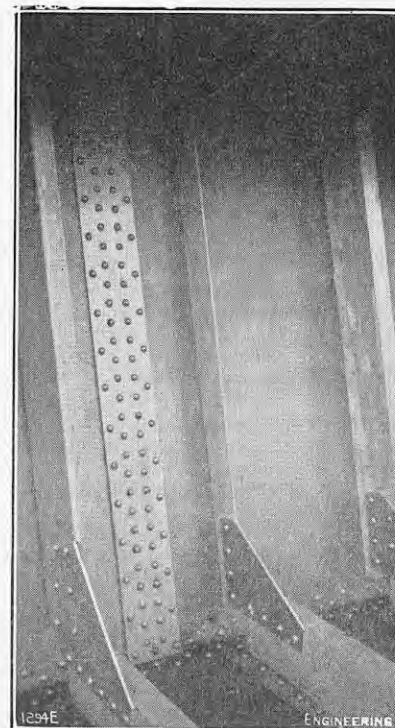


FIG. 5. BUTT-STRAP INSIDE JOINT OF HALVES.

deck is completely flush, the gunwale angle being turned outward and the deck extended over it. A wooden rubber is fitted. It is claimed that the barge will carry 18 tons more cargo than a steel barge on the same draught. Its first cost is about 50 per cent. more than that of a steel barge.

ENGINEERING

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

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

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PLATE.

Plate IV.—20-TON ELECTRIC ARC FURNACE FOR HADFIELD'S LIMITED.

ENGINEERING

FRIDAY, FEBRUARY 13, 1953.

VOL. 175.

No. 4542.

THE HEYDAY OF THE STEAM LOCOMOTIVE.

THE steam locomotives built prior to 1914 have acquired in the past half century an almost saintly halo of virtue and perfection; so much so that even young students of locomotive design and performance to-day conclude that their Victorian and Edwardian splendour vanished with them as surely as Victorian and Edwardian splendour in social life was erased by the first World War. Tales of the Aberdeen Races of 1895 and of other mighty exploits on the Iron Road read like some Odyssey of antiquity rather than as significant events in the development of railway travel, enacted within living memory. Those celebrated engines, with their small boilers and large driving wheels, are now regarded with affection by many who are not old enough to have watched them at work. Their variety and novelty are now seen to have been characteristic of the variety and inventiveness of the many chief mechanical engineers—famous names all—who dictated the policies (not always confined to locomotive design) of the pre-grouping railway companies.

Those were the days of experiment in locomotive proportions. In the Nineteenth Century, the locomotive developed like engineering generally, by empirical trial and error, and by that engineer's intuition which is now in danger of being overshadowed and discouraged by scientific research. The variables were the size and shape of boilers, their heating surfaces, numbers and proportions of tubes, grate areas and pressures; also the number, diameter and stroke of cylinders; the size and number of coupled wheels and carrying wheels;

the proportions of steam chests and passages, and of blast pipes and chimneys; and the choice of valve gear and valve events. Superheating and piston valves were important innovations which caused designers to think again about these variables, and compounding raised hopes of increases in efficiency which were not, from an economic point of view, borne out in practice. With so much to vary, and with so little experimental evidence that would be regarded to-day as scientifically acceptable, the chief mechanical engineers had glorious opportunities which they were not slow to seize upon. They were fortunate, too, in that commercial conditions were relatively favourable to railway development.

In the competitive atmosphere at the close of the Nineteenth Century, speed was sought before power. Train weights were reduced on special "flyers" in order that speeds could be increased, journey times cut, and passenger traffic gained at the expense of a rival company. Thus, for example, the West Coast express from Euston to Aberdeen on the night of August 22-23, 1895, was divided so that a train weighing only 70·5 tons could establish a new record for the 540 miles. The time achieved was 512 minutes, which was 3 hours 18 minutes less than the 11 hours 50 minutes required before the competition started. Meanwhile, however, there was a demand for locomotives of greater power. Before this demand could be fully met, many of the old small engines were severely over-worked, consuming coal at grossly uneconomic rates, but thereby establishing records of performance which, in later years, have become the delight and source of material for many writers on steam locomotive performance.

Of the books on this subject which have appeared in the past year, one by Mr. E. C. Poultney and a reprint of the late E. L. Ahrons' *Railway Magazine* articles on "Locomotive and Train Working in the Latter Part of the Nineteenth Century" deserve special praise.* Mr. Poultney, whose book first appeared as a series of articles in *Modern Transport*, takes up the history at the point where Ahrons left off, but whereas Ahrons wrote, in his inimitable way, on those details of locomotive and train working which, during that period, were so full of interest, Mr. Poultney has turned his attention to an engineer's interpretation of developments in design, using records of performance to substantiate his arguments.

The records which Ahrons compiled with such precision, and with a wealth of detail which enabled him to admit freely his own occasional lack of knowledge or experience, are a legacy of continuing value and interest, and their latest publisher has done a great service by issuing them in a convenient form, with well-selected and carefully reproduced illustrations. The original articles appeared in *The Railway Magazine* over a period of 12 years, commencing in January, 1915, and in the form in which they are now published they are divided into six books, each covering a group of railways which to-day constitutes a Region on British Railways. Considering the extraordinary range and variety of railway companies, of locomotives and trains, of methods of working and a host of other facets of the subject, it is remarkable how Ahrons managed to observe so much of it, to receive accounts from friends of other parts of it, and then to sift all the information and present it in a style which avoided the deadening effect of too many statistics. Fact

* *British Express Locomotive Development, 1896-1948*. By Edward Cecil Poultney, O.B.E., M.I.Loco.E. George Allen and Unwin, Limited, Ruskin House, 40, Museum-street, London, W.C.1. [Price 21s.] *Locomotive and Train Working in the Latter Part of the Nineteenth Century*. By the late E. L. Ahrons, edited by L. L. Asher. Reprinted from *The Railway Magazine*. W. Heffer and Sons, Limited, Cambridge. In six volumes. [Prices: vols. 1 and 3, 15s. each; vol. 2, 18s.; the other three volumes in preparation].

and legend are treated in due proportion, and though it is now all past history it still survives the ordeal of the printed page.

The heyday of steam locomotive development was undoubtedly at the turn of the century, the time when Mr. Poultney's and Ahrons' writings overlap. From then until the grouping of the railway companies in 1923, the period was notable for the development of larger locomotives and the introduction of long-travel valves and superheating. These two advances in design were the last significant innovations of permanent value, but they took some time to spread and became accepted practice. When grouping took place in 1923, the time was not unpropitious for the first stage in the rationalisation of locomotive design. It is clear, in retrospect, that the cut and thrust of numerous chief mechanical engineers and their designs were no longer so necessary or so fruitful. For the next 25 years—a span that is equivalent roughly to a locomotive "generation"—four C.M.E.'s were occupied with the task of reducing their varied stocks of locomotives and designing new types which would incorporate the best features of the old designs. This drastic rationalisation deprived railway students of much of their material. Indeed, Mr. Poultney's book reflects the change simply by the space devoted to pre-grouping and post-grouping history—the latter occupying less than a third of the book and dealing more particularly with design considerations than with records of locomotive working and performance.

Mr. Poultney is familiar to readers of *ENGINEERING* and other journals as a penetrating commentator on locomotive design. In dealing with recent history he is concerned, like many before him, with questions of proportion, but the differences, as between one locomotive and another, have been so narrowed in the past 30 years that there is not nearly so much scope for entertaining discussion. Thus, as Mr. R. A. Riddles explained in his recent address to the Graduates Section of the Institution of Mechanical Engineers, there were generally no great differences between the performances of the various types when the Railway Executive took over in 1948. The further rationalisation now being implemented is, presumably, the final stage of that process, but it has brought its own problems. Though new locomotives of unconventional design have been effectively banned, Mr. Riddles and his staff are faced with problems that are not so amenable to a purely engineering approach. While locomotive design is being advanced by "painstaking record and comparison, by experiments and trials and continuous assessment of costs," attention is being turned to the economic problems of rolling-stock repairs, on which 61½ million is spent annually. This figure is twice as much as that spent on new building, and the endeavour to reduce it is already affecting the design of locomotives, carriages and wagons. As Mr. Riddles explained, if the cost of engine repairs can be reduced by just over a penny per mile, 2,000,000l. will be saved annually on British Railways.

The pure mechanics and thermodynamics of locomotive design have not by any means reached a stage of near perfection. Nationalisation has introduced the problem of designing locomotives which will burn any coal and work over as much as possible of British Railways. Mr. Riddles also pointed out that consideration must be given to the problem of redistributing steam locomotives whenever, in the future, alternative forms of traction are introduced. The locomotive engineers on British Railways to-day are responsible for forecasting future conditions and reaching decisions of economic significance in a way that was unknown to the worthy chief mechanical engineers before 1914. Locomotive design may leave less scope than formerly for general discussion, but the locomotive designer has a harder task than ever.

SAFETY IN MINES RESEARCH.

THE two main causes of accidents in mines are falls of ground and failure of, or misadventure with, haulage equipment, the latter frequently arising from improper usage. Both of these causes of accidents are to some extent controllable by the men working in the mines, who may themselves be the victims who suffer. The matter is one of care and foresight but, as the Director of the United States Bureau of Mines recently said, "alertness and safety consciousness are attitudes that cannot be legislated, much less enforced." The business of the Safety in Mines Research Establishment does not extend to the control of operations in the mines—that is a matter for the National Coal Board and H.M. Inspector of Mines—but it is certainly concerned with any methods which may tend to reduce the number of accidents arising from inadvertence or carelessness. The latest report* of the Research Establishment is in the main concerned with fire and explosion hazards, mechanical failures and dust control, but some information is given about yielding props and roof bars which has relation to accidents caused by falls of ground.

The report is not concerned with such matters as accidents due to men improperly riding on conveyors but a considerable amount of information is given about investigations into the question of the ignition of conveyor belting. H.M. Chief Inspector of Mines, in his report for the year 1950, referred to the fire hazard from conveyor belting as "alarming." Attention was particularly directed to this matter by the conveyor-belting fire at Creswell Colliery in North Derbyshire, which caused the deaths of 80 men. Fatalities due to conveyor-belting fires are probably not usually attributed to misuse, although inadequate maintenance may in some cases play a part. It is probable that the Creswell fire was started by the frictional heating of trapped torn belting pressing against a delivery roller, and an investigation carried out by the Research Establishment showed that a pad of belting pressed hard against a moving belt passing round the delivery roller was set on fire in a few minutes.

One way of dealing with this matter is the employment of belts of less inflammable type and the report describes the procedure by which samples of various types of belt can be subjected to radiant heat. Some tests have been carried out at the Fire Research Station at Elstree. These did not cover belts of the very low inflammability class which are now available. It was found that rubber belting with a cotton carcass was highly inflammable, but that the inflammability decreased when the belting was worn to such an extent that the carcass was showing in places. Neoprene-covered belting and P.V.C.-covered belting both exhibited low inflammability, and there was little difference between belting with different thicknesses of cover. There was also little difference between rubber beltings with carcasses of cotton or synthetic-fibre fabrics. It was found to be generally true that, while the carcass material controls the ease of ignition, the covering material controls the spread of burning.

For very many years, investigations have been carried on to determine the efficacy of various types of stone dusting in checking the spread of coal-dust explosions; it may almost be said that standard procedures have now been developed. The latest report therefore devotes less space to this subject than has been usual in the past, though a relatively new method of trapping coal dust, which has been used in some thirty German pits, is mentioned. This involves the use of common salt moistened with

water. The dust as it settles is caught in the interstices between the salt granules, which are filled with a saturated solution. As evaporation proceeds the dust is bound in the layer of recrystallised salt in the newly-formed surface. Water lost by evaporation must be replaced by periodic spraying. Some experiments carried out by the Research Establishment showed that the method failed under conditions of high relative humidity of the air and that the frequency of spraying required depended on the speed and humidity of the ventilating air. It is not considered that the rate at which freshly deposited coal dust can be successfully bound by this method has yet been determined.

A considerable amount of space is, however, given in the report to the other important aspect of the mine-dust problem. It has been known for many years that the dust produced in working coal is harmful if breathed in sufficient quantity over long periods. Much work has been done by the Medical Research Council in connection with this matter. The deleterious quality of a mine dust depends on its nature, and it is known that special risks attach to workings in which the surrounding formation is of highly siliceous rock, such as sandstone. Quite apart from mines in which it is known that the dust produced is of a dangerous type, it is desirable in all cases to ascertain the nature of the dust carried by the air, and the report gives information about various developments in sampling methods.

An obvious way of attempting to reduce the pneumoconiosis hazard in mines is to limit the amount of dust produced during coal-cutting operations. Work carried out with rotary-drilling machines has confirmed earlier observations which showed that there is an increase in dust production with increase in the speed of rotation of the drill. If the speed is maintained constant, dust production, within the limits of experimental error, is independent of the rate of feed and pressure. The dust produced per foot of hole drilled is almost inversely proportional to the rate of penetration at a constant speed of rotation. It is therefore highly desirable to use low speeds and high rates of feed requiring high pressure on the drill point. Some tests have been carried out to determine the relative dust-suppression effects of oil-in-water emulsions and plain water in wet drilling. No greater dust suppression was shown by the emulsion, but when the sludge produced was dried, the dust was less readily dispersible in the air if oil had been used with the water.

The report contains information about various metallurgical investigations. There were two breakages of winding ropes during the year 1951. One was caused by faulty winding and the other by localised fatigue at a point where the rope had previously been distorted by a blow, or some similar misuse. The general record of winding ropes, however, is good. Out of more than 3,000 ropes in use, there has been an average of two breaks per annum during the last ten years. There were no cases of breakage in 1949 and 1950. In the case of a flattened-strand rope examined in 1951, looseness of the wires was detected. This state can lead to bending of wire over wire and thus to fatigue. Looseness of the wires can be detected by tapping a rope with a light hammer, and it is suggested that this simple method should be more widely used by colliery-rope examiners. The same procedure is of value in connection with haulage ropes. The small haulage drums sometimes employed demand flexible ropes made up with fragile outer wires. These thin wires require exceptionally good working conditions if they are not to be severed by corrosion pitting or wear. Two ropes of this type broke during the year, one in three months and the other in 6½ months. The corrosion which weakened the outer wires also loosened them on their strand cores. This, also, could have been discovered by tapping with a hammer.

* 30th Annual Report on Safety in Mines Research, 1951. H.M. Stationery Office [Price 2s. 6d. net.]

NOTES.

THE INSTITUTION OF ELECTRICAL ENGINEERS.

THE Council of the Institution of Electrical Engineers have awarded the Faraday Medal for 1953 to Colonel Sir A. Stanley Angwin, K.B.E., D.S.O., M.C., T.D., for his outstanding contributions to the development of telecommunications. Sir Stanley received his technical education at Queen Mary College, and, after a pupilage with Yarrow and Company, then at Poplar, joined the engineering department of the Post Office in 1906. He was instrumental in raising the Lowland Division Telegraph Company from the Post Office staff and was placed in command with the rank of major when the unit was mobilised in 1914 as the 52nd Divisional Signal Company. He served throughout the 1914-18 war in Gallipoli, Egypt, Palestine and France and was awarded both the Distinguished Service Order and the Military Cross. After the war, Sir Stanley joined the Wireless Section of the Post Office Engineering Department and played a leading part in the design and construction of the Leaffield, Cairo and Rugby radio stations and in the inauguration of the trans-Atlantic telephone service. He became Assistant Engineer-in-Chief of the Post Office in 1932; Deputy Engineer-in-Chief in 1935; and Engineer-in-Chief in 1939. He was appointed chairman of the Radio Research Board and of Cable and Wireless, Limited, in 1947 and of the Commonwealth Telecommunications Board in 1951. His period of service with the Post Office saw the introduction and expansion of the short-wave over-sea radio-telephone service and the adoption of the coaxial cable system for trunk-line communication. Sir Stanley was chairman of the Wireless Section of the Institution of Electrical Engineers in 1931-32, became a vice-president in 1939 and was elected President in 1943. It is also announced that Sir Harry Railing has been elected an honorary member of the Institution for his services to electrical engineering, to science and to the Institution. Sir Harry joined the General Electric Company in 1905 and, after being in charge of the test department and laboratories at the Witton works, was successively chief technical adviser to the head of the company in London and in charge at Witton. In 1941, he was appointed joint general manager, subsequently becoming vice-chairman, and chairman and joint managing director. He was President of the Institution in 1944. At present, he is President of the British Electrical and Allied Manufacturers' Association.

EUROPEAN PRODUCTION OF FLAT STEEL MATERIALS.

The secretariat of the United Nations Economic Commission for Europe (E.C.E.) in Geneva have stressed the importance to European economy that full use should be made of the most efficient plants for the manufacture of flat steel products of high quality at low prices. In a preview of a study to be published this spring, the E.C.E. secretariat point out that large increases in the manufacture of flat steel products are being planned in Europe, which is following the United States lead in installing several continuous wide-strip rolling mills, together with cold-rolling and electrolytic-tinning plants. The secretariat's concern is that appropriate policies should be pursued so that a demand proportionate to the present expansion may be developed. The principal consumers of flat steel products are motor-car manufacturing and shipbuilding firms, and industries employing steel strip for making containers, including tins. It is pointed out that, under present plans, the production of the 11 new continuous and semi-continuous strip rolling mills and four Steckel wide-strip mills now going into operation or being installed in Western Europe will be 9.7 million tons in 1956. This figure, it is considered, is below the theoretical annual capacity, based on American productivity, but it is conceded that, for a number of years, there was a serious excess of capacity in the United States and that the same danger may be facing Europe. It is felt that tribute should

be paid to the courage and foresight of those steel companies which recognised that the continuous wide-strip mill could be regarded, in its effect on output and costs, as a lever with which to raise production and consumption, and hence the standard of living, to new levels. Taken altogether, it is concluded, these developments have not only made cheaper production possible, this in turn stimulating demand; they have also brought about a revolution in quality which has been an equally important influence in stimulating industrial growth and the demand for flat products.

THE INSTITUTION OF CIVIL ENGINEERS.

There was much food for thought and many refreshing ideas in the paper on "Corrugated Concrete Shell Roofs," by Mr. J. H. de Warrenne Waller, D.S.O., O.B.E., M.I.C.E., and Mr. A. Clift Aston, B.Sc. (Eng.), presented at the Institution of Civil Engineers on February 10. The subject of the paper was a particular form of arched roof composed of arches springing from ground level, with a corrugated concrete covering of which the pitch is the distance between each individual arch. The inspiration behind this particular form of construction came from the Great Arch of Ctesiphon, near Baghdad; this arch, all that remains of a banqueting hall built some 2,000 years ago, is 112 ft. in height and of 90 ft. span and was constructed with lightly burned bricks of Tigris mud, with pitch and reeds to cement together occasional courses, and check measurements reveal it to be a true linear arch. The designer was Metegenes, and the authors way "Justice demands a tribute to the genius of this long-forgotten builder." The authors chided modern constructors for so greatly neglecting the arch as a means for enclosing space, in favour of the beam and truss (which require the use of steel, either alone or in combination with concrete) when it was possible to cover vast areas by means of an arched structure that virtually required no steel at all. How such structures are built was demonstrated by means of a film. First, the catenary arches are poured and then hessian cloth is stretched over them to give the desired sag between each arch or rib of the structure as a whole. The hessian cloth is then given a coating of cement plaster, trowelled on to a depth of about an inch. When this had set, the result was a self-supporting arch, on which men could walk to lay a wire mesh to be incorporated in a second rendering, which in turn was given a finishing coat. The film also showed a section of roof being experimentally loaded to simulate the positive and negative pressures due to a wind of 120 miles an hour. The maximum deflection measured was 0.4 in. with no signs of cracking, in the 12-ft. length of 60-ft. span under test. Roofs of this type have been built in Spain and East Africa and a few examples also exist in the British Isles, but the authors visualise roofs of this type with spans up to 700 ft. and a rise of 140 ft. and to any desired length. They are claimed to be particularly suitable in climatically unfavourable localities. Another suggestion was to use such a roof to house an "air station"—we use this term to distinguish this idea from the conglomeration of hangars and buildings which answers to the description of airport—in which passengers and staff might enjoy, on the ground, much the same climate as air-liners provide in the air. Such air stations, capable of taking under one roof air-liners, offices, restaurants, waiting rooms and workshops, would be equally desirable in places exposed to extremes of climate.

HEADLIGHTS ON MOTOR VEHICLES.

An investigation that has been in progress for some time at the Road Research Laboratory, Langley, has led to the formulation of some simple recommendations to avoid the bad effects of dazzle from motor-vehicle headlamps. The value of headlamps which are of standard power and are set at the correct angle, both in their normal and dipped positions, was demonstrated recently, using two pairs of headlamps mounted as though on two facing cars about 160 ft. apart. The quality of illumination under different conditions was observed

with the aid of two sets of six boards, painted a dull tone to represent the clothing of pedestrians at night; one set of boards was set up on the near side of the road in relation to each vehicle, the boards being spaced some distance apart from each other. The variables in the demonstration were the power of the headlamps (the normal for a new vehicle, and a typical low power of an old, badly maintained headlight); the angle of aim; and the angle of dipping. Different combinations of these variables for the two sets of headlamps were demonstrated, the criterion of efficiency of seeing during night driving being taken as the number of the dull boards that could be seen by the driver in the face of the glare of the oncoming vehicle. It was apparent from the demonstration that the efficiency of seeing depended not so much on the characteristics of a driver's headlamps as on the relative characteristics of the two sets of mutually approaching headlamps. Thus, if the two sets were of equal power, but one was dipped too much, the driver behind that set was dazzled by the other set, even though the latter were correctly dipped. An angle of dip that was excessive by only two or three degrees made a pronounced difference, and even $\frac{1}{2}$ deg. made an appreciable difference. Similarly, a weak headlamp put a driver at a disadvantage, even though it was correctly aimed and dipped. In the ideal case, when two sets of headlamps are of equal power and are correctly adjusted, the road in front of each driver is well illuminated, even though the oncoming lights are bright. The conclusion reached by the staff of the laboratory are that excessively weak and powerful headlamps should be eliminated; all headlamps should throw a beam of the kind provided by the lamps now being fitted to almost all new cars in this country; the intensity of the meeting beams of these headlamps should fall within certain limits; steps should be taken to secure a high degree of conformity with the standards of aiming and intensity, including easy access to suitable apparatus for adjustment and testing; and new headlamps should have beams giving the same distribution of light. At present, it is important to improve aim and maintenance. Further improvement only seems to be possible through a radical change such as the use of polarised light, but this would lead to a number of difficulties, including the necessity for an instantaneous change-over on all vehicles.

THE INSTITUTION OF HEATING AND VENTILATING ENGINEERS.

The annual dinner of the Institution of Heating and Ventilating Engineers was held at the Savoy Hotel, London, on Wednesday, February 11. Mr. J. R. Kell, M.I.Mech.E., President, in proposing the toast of "Our Guests," prefaced his remarks by saying how much they regretted the absence of the chief guest of the evening, Lt.-Commander the Hon. L. W. Joynson-Hicks, M.P., Parliamentary Secretary to the Minister of Fuel and Power, whose Parliamentary duties prevented him attending. Continuing, he said the Institution was preparing a booklet for the Ministry, dealing with buildings designed for maximum efficiency in the utilisation of heat. The response was made jointly by Sir Wavell Wakefield, M.P., chairman, Parliamentary and Scientific Committee, and Mr. L. G. Vedy, O.B.E., Assistant Secretary to the Ministry of Fuel and Power. Sir Geoffrey Vickers, V.C., member of the National Coal Board and of the Medical Research Council, in proposing the toast of "The Institution," drew attention to the fact that over half a million men were dependent on the art of ventilation in mines. The response was made by Mr. J. W. Cooling, M.Sc.(Tech.), M.I.Mech.E., past-president of the Institution, who remarked that on this occasion two recipients of the Victoria Cross were present: Sir Geoffrey Vickers, V.C., and Mr. Philip Gardner, V.C. member. Mr. Cooling, in his closing remarks, stressed the necessity of research, and said there was disappointment in the Institution not having been called upon to give evidence before the Ridley Committee. They had had to be content, therefore, with preparing a commentary setting forth their views.

LETTERS TO THE EDITOR.

THE G2 4,500-S.H.P. NAVAL GAS-TURBINE.

TO THE EDITOR OF ENGINEERING.

SIR,—When a sectional arrangement of a steam or gas turbine appears in the technical Press, those who practise the art of "turbinology" find it most interesting to scrutinise the detail design. The section of the G2 in your issue of January 30, on Plate II, has a detail of design which, to my eye, looks all wrong. I refer to the position of the resilient disc coupling; in this particular instance, the axial flexibility is eliminated by the central tie, presumably with the object of balancing the turbine thrust against the thrust from the single helical gear without axial flexing. When the coupling is constrained so that it can only bend, it seems that the wrong place to put it is near the centre of the shaft.

The shaft between the power turbine and the gear is being invited to "whirl." The distance between the two roller bearings of the pinion is very short compared with the overhang of the shaft to the resilient coupling. The overhang from the turbine bearing to the coupling is even longer. In my view, a better arrangement would be to have a floating shaft with resilient discs at each end. I am not presuming to suggest the Metropolitan-Vickers Electrical Company are not masters of their craft, but I should like to know why they used this apparently doubtful layout.

Yours faithfully,

R. C. McLEOD.

Leicester,

February 3, 1953.

ENGINEERING EDUCATION IN LONDON AND THE HOME COUNTIES.

TO THE EDITOR OF ENGINEERING.

SIR,—In the article on "Engineering Education in London and the Home Counties," on page 159 of your issue of January 30, the statement is made that I do not consider the Higher National Certificates as a qualification comparable with the diplomas of Continental professional engineers [the article quoted my address on "The Education of Engineers in Some European Countries," which was printed in *ENGINEERING*, vol. 174, pages 70, 116, 165 and 200 (1952)]. While this is certainly my view, it does not give the whole story. A further reason is that, in the investigations I made in order to make a comparison between the numbers of diplomas from the technical high schools and universities in certain European countries, per 100,000 of their populations, with the numbers of engineering degrees, on the same basis, given by British universities, I found that in these countries important additional facilities exist for training men to what we would regard as Higher National Certificate standard. In Federal Germany, for example, in addition to the eight technical high schools, in which *Diplom-Ingenieure* are prepared, there are large numbers of engineering schools, corresponding to our technical schools, in which successful students become *Ingenieure*. As such men were not included in my analysis, a logical comparison was only possible if the numbers gaining Higher National Certificates here were also omitted.

I certainly do not wish to belittle the great national contributions made by holders of Higher National Certificates, and I agree with the writer of the article when he states that many of these men fill responsible engineering posts. But so do many men in European countries who have not passed through a course for a diploma equivalent to a British engineering degree. In my conclusions I urged that we should produce many more men with degrees; but, without investigating the numbers of men with Higher National Certificates prepared annually, I can offer no opinion whether more of these are necessary, as they may well be.

I would repeat one further point: good as these men are, they would, in my opinion, be still better if more attention were paid to their training in fundamental science subjects.

Yours truly,

S. J. DAVIES.

King's College,

University of London,

Strand, London, W.C.2.

February 6, 1953.

OBITUARY.

MR. A. P. GOOD.

THE British engineering industry has lost one of its most colourful personalities by the death, on February 10, of Mr. A. P. Good, deputy chairman of the Brush ABOE group of companies, and chairman of Associated British Engineering, Limited, and of the Heenan and Froude Group. Mr. Good, who was only 46 years of age, had been ill for a long time and was on a visit to South Africa, for reasons of health, when he died.

Alan Paul Good was born at Foxrock, near Dublin, in 1906 and received his general education at Marlborough. He studied law in the University of Oxford and, on graduating, joined the firm of



THE LATE MR. ALAN P. GOOD.

Pennington and Son, solicitors, of Lincoln's Inn, subsequently becoming a partner; but he saw greater opportunities for his organising aptitude in commerce and in 1935, after sundry ventures into building, the steel industry and other trades, he decided to concentrate on engineering. Initially, he applied himself to the rationalisation of industrial Diesel-engine manufacture by acquiring control of a number of companies and so organising their production that each dealt only with a limited range of sizes, while the whole group covered all the sizes in greatest actual or probable demand. The result was the formation of the Brush ABOE Group, which now consists of the Brush Electrical Engineering Company, Limited, and Associated British Oil Engines, Limited, the latter (the "ABOE") comprising Mirreles, Bickerton and Day, Limited, Petters, Limited, J. and H. McLaren, Limited, the National Gas and Oil Engine Company, Limited, and Henry Meadows, Limited. Good controlled the Group by virtue of his position as deputy chairman and managing director of the Brush Electrical Engineering Company, which was the parent company.

While busily reorganising the production of industrial Diesel engines and establishing the Brush ABOE Group as the largest producers in the world of this type of prime mover, Good also turned his attention to other branches of engineering. With Heenan and Froude, Limited, he associated Fielding and Platt, Limited, W. G. Bagnall, Limited, and other old-established firms, and the newly-constituted British Oil Field Equipment Company, to develop British trade in a branch of engineering which previously had been mainly in the hands of American interests. The principles which he had applied with such success to the Diesel-engine industry rapidly bore fruit in these new directions, but by this time Good's health was breaking under the strain of his manifold activities and, by 1950, he found it essential to relinquish his current managerial responsibilities to others. He resigned his managing directorship in October last year, though continuing to take a personal interest in the affairs of his many companies—of which only a few have been mentioned above—but his health continued to deteriorate and his voyage to South Africa came too late to effect any improvement.

Good was in every way a big man—physically, in his breadth of vision, and in the boundless energy with which he applied himself to the realisation of his visions. Many there were who disagreed with his policies because they seemed, at first sight, so daring as to be impracticable; but none would deny his claim to be regarded as one of the foremost figures of this century in the British engineering industry.

MR. W. A. MICHELL.

A FAMILY linked with Cornish engineering in the days of Richard Trevithick and James Watt, and with Cornish mining of even earlier date, lost one of its oldest members on January 25 by the death, at his home in Redruth, of Mr. William Anthony Michell. Mr. Michell, who was born on July 2, 1877, was the youngest son of F. W. Michell, designer of some of the best-known of the Cornish pumping engines, and followed him in the family profession of mining engineering. He received his training at the Redruth School of Mines and remained there as a demonstrator for some time after completing the course. He then went to Australia, where he was manager of the New Bala-Bala copper mines, but returned to Cornwall to join his eldest brother, the late Frank H. Michell, as a partner in the firm of Michell Brothers, at Redruth. There they carried on, as consulting engineers, the practice established by Mr. Michell's great-grandfather, Richard Michell, a contemporary of James Watt, who died in 1836.

As a consultant, Mr. Michell was associated with many of the Cornish tin and other mines, including Wheal Busy, Wheal Florence, the Parka mine, and, more recently, Wheal Kitty, Polhigey and Parc-an-ehy. During the 1914-18 war, he served in the Royal Engineers and, after that war, was for a short time a lecturer at the Camborne School of Mines. For nearly 30 years, also, he was a lecturer in chemistry, assaying and mineralogy in the Redruth evening science school. He was a member (and a member of Council) of the Cornish Institute of Engineers, and an associate of the Institution of Mining and Metallurgy.

In recent years, Mr. Michell devoted a great deal of time to the study of the history of the Cornish type of steam engine, and was an accepted authority on its early development. He was a founder member of the Cornish Engines Preservation Society, and a joint honorary secretary of it, in which capacity he had been engaged, up to the time of his last illness, in preparing for the Society a survey of the engines still remaining in Cornwall. Of the engines that the Society has been able to preserve, two were designed by Mr. Michell's forebears: namely, the 30-in. East Pool engine, built by Holman Brothers, Camborne, in 1887, and designed by his father, F. W. Michell, and the last rotative Cornish beam engine to be made in Cornwall; and the 24-in. Levant whim, designed by his grandfather, Francis Michell, and built by Harvey and Company, of Hayle, in 1840. This is the oldest engine remaining in Cornwall, and it was the desire

100-KW WIND-DRIVEN ELECTRIC GENERATOR.

ENFIELD CABLES, LIMITED, LONDON.

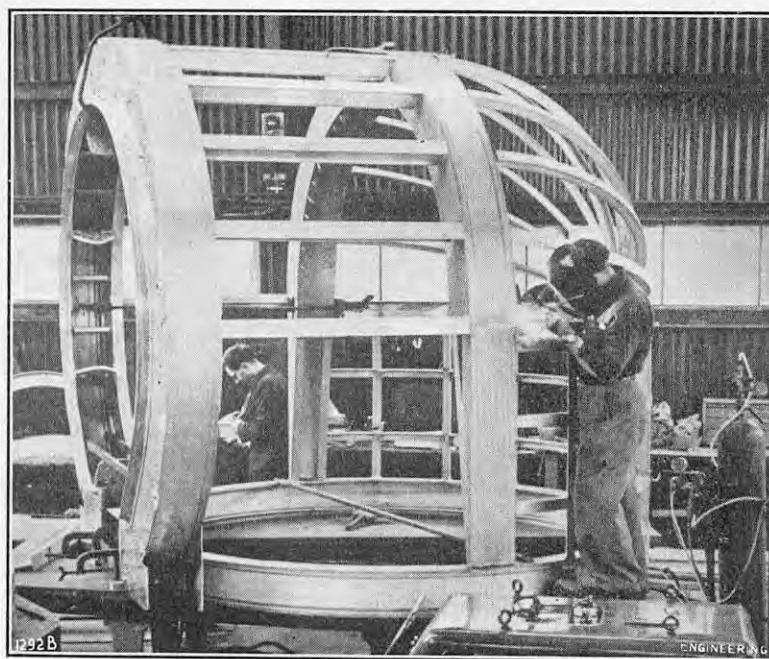
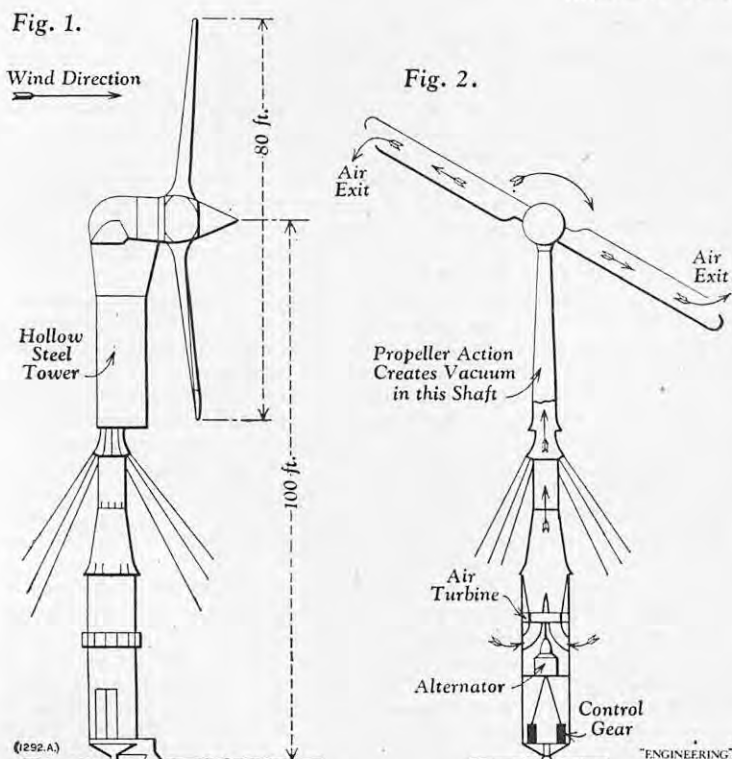


FIG. 3. ALUMINIUM HUB STRUCTURE.

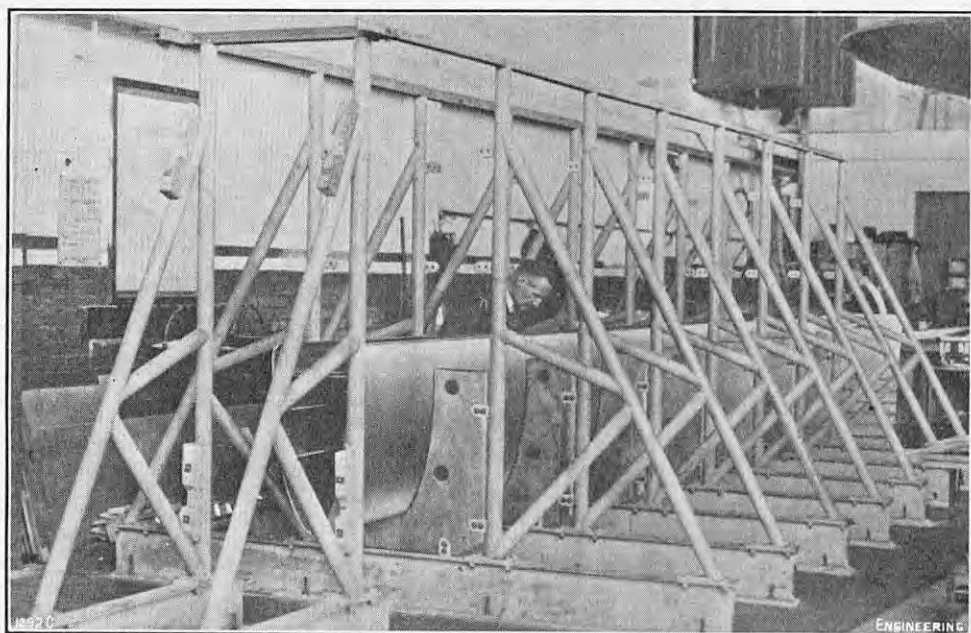


FIG. 4. OUTBOARD SECTION OF PROPELLER.

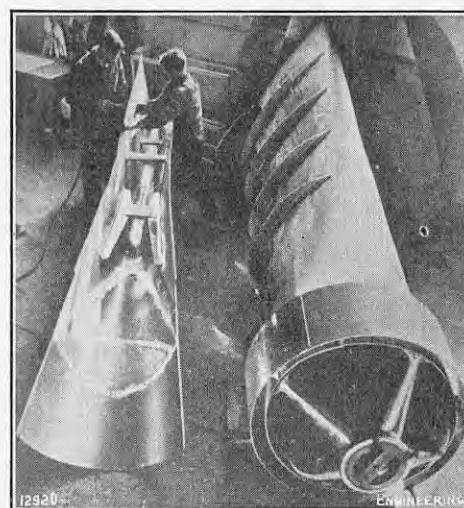


FIG. 5. INBOARD SECTION OF PROPELLER.

to save it from being broken up that led to the formation of the Cornish Engines Preservation Society in 1935. Apart from his activities in collecting facts, photographs, drawings and records of Cornish engines and engineering, Mr. Michell was instrumental in locating and preserving the birthplace of Richard Trevithick, a cottage at Penponds, and in securing, with the aid of the Cornish Institute of Engineers and of the Newcomen Society, of which also he was a member, the erection of a suitable memorial to Trevithick. While always most willing to assist researchers into the history of Cornish engineering, Mr. Michell wrote comparatively little himself, and it is to be hoped that some of his associates and friends will take steps to collect and collate such of his personal reminiscences as they can recall, while the memory of them is still fresh, for his practical knowledge of Cornish engineering as well as his store of inherited anecdote were probably unsurpassed in that field; of which so little now remains that sentimentalists are now seeking funds to preserve the ruined engine-houses in default of the engines themselves.

100-KW WIND-DRIVEN ELECTRIC GENERATOR.

DURING the past few years, considerable attention has been directed to the possibility of utilising the wind as a supplement to more normal methods of generating electricity. In particular, the British Electrical and Allied Industries Research Association have been conducting investigations on the availability of this form of power at certain sites in the Orkney, Hebridean and Channel Islands, as well as in North and North West Ireland and in the west coastal districts of Great Britain. The results of this work have recently been published in Technical Report C/T 108, and provide useful information on the subject. In addition, both the British Electricity Authority and the North of Scotland Hydro-Electric Board have been carrying out researches into the design of the equipment itself, and for this purpose have been using, *inter alia*, a 100-kW plant for which Enfield Cables, Limited, Southampton-row, London, W.C.1, were the principal contractors.

In selecting the system to be employed in this plant, consideration was first given to one in which a propeller drives a generator through gearing. This arrangement, which is largely used in Denmark, has the advantage of simplicity, but possesses the drawback of being subject to mechanical failure. Moreover, it was felt that it would be difficult to apply the lessons learnt from a 100-kW plant of this type to the larger sizes which were likely to be required. It was therefore decided to study the "depression" system which was being tested on a small scale by Andreau in France. As will be seen from Figs. 1 and 2, it is provided with a propeller which runs at the top of a hollow steel tower. The rotation of the propeller produces a pressure difference across a turbine at the base, causing the turbine to rotate. The turbine is directly coupled to an electric generator, but there is no mechanical connection between them and the propeller. Although the efficiency of such a system is lower than that of the orthodox plant, and its cost of development is higher, it was chosen owing to its physical and mechanical advantages, which it was considered would increase in value as the size of the machines grew larger.

As regards construction, the tower foundations are of reinforced concrete with 12 anchors arranged on a pitch circle 96 ft. in diameter. This foundation

carries a 100-ft. tower, which is of stressed steel plate and girder construction and is circular in section, decreasing in diameter from 9 ft. at the base to 3 ft. 6 in. where it enters the hub structure at the top. The upper section, which lies within the zone of the propeller disc, is screened with a light-alloy fairing of aerofoil section, which is attached to and rotates with the hub. The hub structure, of which an illustration is given in Fig. 3, is of fabricated aluminium alloy, and is faired with aluminium sheet and encloses the feathering mechanism and oil-immersed main bearings. It is mounted on roller bearings and rotates about the axis of the tower as the propeller orients into the wind. The tower itself is supported by 12 galvanised steel cables, which are equally spaced and inclined at 50 deg. They were pre-loaded at 6 tons to reduce fatigue.

The propeller, which sweeps a circle 80 ft. in diameter, consists of two blades of aluminium alloy. These blades are hinged for coning and are maintained by torsion springs at a mean coning angle of 5 deg. The pitch is adjusted automatically by a hydraulic system, so that the speed of rotation is maintained constant when the wind velocity is between 30 m.p.h. and 65 m.p.h. Each blade is made in two parts, that in-board being of circular section at the root and changing to aerofoil, as shown in Fig. 5; while the outboard section, which is illustrated in Fig. 4, has a constant chord of 5.75 ft. and terminates at the trailing edge in a port through which the air is extracted by centrifugal force. The propeller operates down wind of the tower at a speed of 95 r.p.m., and its orientation is power-assisted and controlled. This part of the plant was designed by de Havilland Propellers, Limited, Hatfield, Hertfordshire, and was largely constructed in their works, while the tower was built by the Redheugh Iron and Steel Company (1936), Limited, Teams, Gateshead.

The turbine, the position of which at the foot of the hollow tower is indicated in Fig. 2, is of the axial-flow single-stage type, and its 48-in. diameter wheel is carried on a vertical shaft. It has been designed to handle 50,000 cub. ft. of air per minute, which, as already explained, is withdrawn by the propeller. It is coupled direct to a 100-kW synchronous induction alternator of English Electric manufacture, which generates three-phase current at 415 volts and the shaft of which carries an exciter. For operating purposes this generator is started from rest as an induction motor, and when synchronous speed is approached direct-current is supplied to its field, so that it is caused to operate as a synchronous motor running under no-load conditions. Air is then admitted to the turbine, which in turn drives the "motor" in synchronism with the mains system. Control is fully automatic, the equipment installed for this purpose in the base of the tower being connected to the generator by flexible cables of Enfield manufacture. The turbine and generator have a rated speed of 1,000 r.p.m., and the output increases from zero at a wind speed of 17 m.p.h. to 100 kW at 30 m.p.h. Thereafter it remains constant until a wind of 65 m.p.h. is reached, when the plant is automatically shut down.

The plant is shortly to be erected on a site near St. Albans for preliminary trials, or the conclusion of which it will be dismantled and re-erected on the coast.

MILLING SPEED AND FEED READY-RECKONER.—Clarkson (Engineers), Ltd., Nuneaton, Warwickshire, have produced a ready reckoner of pocket size which gives the cutting speed in r.p.m. and the feed rate in feet per minute of end mills and slot drills for five grades of material, assuming a given depth of cut. It is available only on the personal application of foremen, operators, ratifexers, and others concerned.

ENGINEERING PAPERS FOR THE LIVERPOOL MEETING OF THE BRITISH ASSOCIATION.—As is now customary, one of the sessions of Section G (Engineering), at the next meeting of the British Association, which will be held in Liverpool from September 2-9, will be devoted to the reading and discussion of short papers by young engineers and students; about 20 minutes will be allowed for each paper. Those wishing to submit papers for this session are invited to communicate, as soon as possible, with the Recorder of Section G, Professor W. Fisher Cassie, University of Durham, King's College, Newcastle-upon-Tyne, 1.

PROGRESS IN ENGINEERING TRAINING.*

By SIR ARTHUR P. M. FLEMING, C.B.E., D.Eng.

OUR need to develop fully and to utilise effectively all the national assets we possess needs no emphasis. Some of these assets are limited and wasting, but we have one, the quality of our industrial manpower, which lends itself to increasing development and expansion; and of our manpower, the young working group is the most vital section. This is no new point of view, because the education and training of our young people has long been recognised as an essential feature of our industrial economy. This has been particularly true of the engineering industry, but, like all forms of training, engineering education must be adapted to meet the requirements of changing conditions. Often there has been a considerable time lag in effecting the changes that new social and economic conditions demand, and employers as a body have been slow to recognise their obligations to their young personnel; first, to discern their special aptitudes, and then to provide the right kind of organised training to develop these. In the past four or five years, great steps have been made in both national and local schemes of industrial training.

My survey, however, relates solely to the engineering industry, in which both the practical and theoretical aspects of training must receive consideration. Practical training through apprenticeship can be traced back to the Thirteenth Century, when the guilds controlled all the trades and supervised the instruction of the young workers in them. In 1562, the guild system of training was transferred into a national institution by the Statute of Artificers, which was, in effect, a codification of earlier legislation. Under the guild system, not only was practical training given, but also technical knowledge accumulated from experience was imparted and, since apprentices lived under the same roof as their masters, it constituted a system of general education and character training. Various changes in the economic and social life of the country led to the collapse of the guild system, and the Statute of Artificers was repealed in 1814.

One of the chief causes of the decay was the great spate of mechanical inventions that came with the Industrial Revolution. Under the influence of invention, industry became more scientific in its practice, so that the employer, though able to train the young worker in workshop methods, was not able to impart a knowledge of underlying scientific principles. To supply the technical knowledge needed, night classes were started first at Glasgow in 1824, and, subsequently, in London at Brkbeck Institute. These Mechanics' Institutes, as they were called, spread to all the industrial centres of the country. In an address given on the occasion of the opening of the Manchester Mechanics' Institute on March 30, 1825, Benjamin Heywood stated that "The Institution is formed for the purpose of enabling mechanics and artisans, of whatever trade they may be, to become acquainted with such branches of science as are of practical application in the exercise of that trade." In a second address, two years later, he spoke "of striking instances wherein the practical application of principles of science is now promoting individual and national good."

By 1860, there were 750 Mechanics' Institutes. The Great Exhibition of 1851 had an important influence on technical education because it led to the formation of the Science and Arts Department, financed by the Government. In 1879, the City and Guilds of London began their support of technical education from funds provided by the city livery companies. In 1889, the Technical Instruction Act was passed, and, from then on, facilities for part and full-time technical instruction grew apace. The quality of the teaching varied considerably, but certain examination standards were broadly recognised. In 1921, part-time technical education in engineering was established on a national basis by the National Certificate courses.

* Eighth "Manchester Association of Engineers" lecture, delivered in Manchester on February 11, 1953. Abridged.

Though the earliest history of university education in engineering began a century ago, its growth for the first 50 years was slow. This was mainly because of the success of the practical engineer, and the belief that the proper method of becoming an engineer was to be apprenticed to a recognised exponent. From the beginning of the present century, development was steady, though hampered by lack of funds. The rise of the electrical engineering industry, which was based on scientific discovery and grows from the continuous employment of new scientific knowledge, gave the greatest fillip to the technical training of engineering personnel. For a long time, however, the engineering industry was slow to accept the university graduate and looked to part-time technical courses as the proper means of training technical personnel.

On the purely craft side of engineering, a decline in apprenticeship, both indentured and premium, took place at the turn of the century, because the greater subdivision and specialisation of processes, the speeding up of processes by machine tools, and increasing payment by results made it more difficult for journeymen and others to give proper instruction to apprentices. Also, the competition of boy labour led trade unions to impose restrictions on the employment of boys, which, in some cases, caused a reluctance on the part of employers to employ apprentices.

The important factor in all industrial progress is getting and using new knowledge. The opening of this century saw the beginning of a movement to organise the means for the systematic pursuit of new knowledge and its industrial application. Great Britain has been fortunate in her heritage of great scientists such as Newton, Faraday, Clark Maxwell and Rutherford, to mention only a few. Many of their discoveries have, after a lapse of time, found application in some industrial development. An outstanding example is the work of Faraday, on which the whole modern electrical industry is founded. At the beginning of this century, industrialists, in this and other countries, realised the importance of cutting down the time lag between scientific discovery and its ultimate application in industry, and they set up their own research laboratories with this end in view. The Government established the National Physical Laboratory in 1900 and the Department of Scientific and Industrial Research in 1916. Some of the money allocated to this Department was used to help the development and work of the Research Associations as well as to foster research in the universities. All these laboratories created a demand for the employment of graduates and a new demand upon the universities for trained men.

The procedure from a new scientific discovery to its ultimate application in some new material, process or product is through several distinct stages. The discovery itself reveals the explanation of some natural phenomenon. This knowledge may suggest a possible application for the industrial research worker to explore. If the results of the laboratory explorations are hopeful, the development engineer carries the "find" through the next stage by setting up a pilot plant by which to evaluate the industrial and commercial possibilities of the idea. If this is successful, full-scale industrial application will follow.

The large industrial organisations the world over have vast facilities for the pursuit of scientific research, both fundamental and applied, but in Great Britain, where there are large numbers of industrial units too small to support research laboratories, the Government and industry have established Research Associations, which are concerned with the scientific problems of a whole industry. These associations, of which there are now 42, have done invaluable work in the wide field of industries which they represent. Some idea of the growth of the Research Association movement can be gained from a comparison of their expenditure. In 1945-46, there were 26 Research Associations and their expenditure was 11. million, of which just over half was industrially contributed. In 1950-51, the expenditure of the 42 Research Associations was 31. to 41. millions, of which 2.151. millions was contributed by industry. In 1950-51, 300 firms were spending about 241. millions on research.

As electrical engineering has been the branch of

the engineering industry with which I have been most closely associated, I choose this branch for an analysis of its personnel, which will, I hope, give some idea of the present position of their training. The scope of electrical engineering embraces the manufacture of equipment for the generation, transmission, distribution and utilisation of electrical power and for electrical communication, and the installation, operation and maintenance of this equipment. The practice of it is conducted in organisations varying in size and type, from the large manufacturing firms to small groups of two or three individuals engaged in installation and maintenance. Although it is not possible to list all the types of its personnel precisely, certain broad classes can be clearly distinguished.

First, there are the professional engineers, competent to assume personal responsibility for developments, to apply the scientific outlook and method to the initiation, organisation and supervision of technical work, to give authoritative technical advice and to exchange ideas with their fellows for the general furtherance of science and its applications. The conventional training for this group is a full-time course at a university or technical college, leading to a degree, followed by a period of practical works training, generally of two years' duration. The purpose of this practical training is not that the apprentice may become skilled as a workman, but that he may acquire knowledge of the various features of an industrial organisation, its component parts, how it operates, the economic considerations involved, the relationship between management and other workers, and obtain knowledge of how to handle men. During this period of apprenticeship, the trainee "finds himself," in so far as his inherent capacity goes, and he will be led instinctively to make the choice of his future career from among the fields of works management, design, technical salesmanship or research.

In some cases, part of this practical training is obtained before entry to the university. This practice has much to commend it, not the least of its advantages being that it confirms or refutes the wisdom of the choice of career. In other cases, "sandwich" schemes, of alternate periods of college education and workshop experience are favoured, and in others, boys who enter works at the standard of the General or Higher Certificate of Education obtain practical training and technical education concurrently. This is arduous, but, provided the standard of Higher National Certificate in Engineering or an external London B.Sc. is reached, the student will be well on the way towards those qualifications necessary for associate membership of his appropriate professional institution.

The next class is that of the technicians, who carry out approved techniques which are either common knowledge among those who are technically experts in their branch of industry, or specially prescribed by professional electrical engineers. These techniques are not those of the craftsman, though they may involve manual skill; in many cases, they include the skilled use of delicate and complicated instruments, and may also require the intelligent and accurate use of approved methods of calculation. They involve practical experience of some limited branch of engineering, combined with the ability to complete the details of a project.

To become an electrical technician, a person must have received a technical education up to the standard at least of that of the Ordinary National Certificate in Electrical Engineering and, in addition, must have had training and experience in the particular sphere of electrical engineering in which he is to work. At present, the courses of training for electrical technicians are, perhaps, the least satisfactory of all the courses available for engineering personnel. This is because their status is not nearly so well defined, nor the importance of their systematic training so fully appreciated, as is the case with professional electrical engineers or with craftsmen. To produce men with the qualifications required, they must be trained under schemes which include theoretical education in the fundamental principles underlying general electrical technology, and those who belong to a definite branch should also learn the essential principles common to that branch. Only the possession of a knowledge of these two sets of principles can confer the measure of adapta-

bility so essential to the technician's success. To complete the technician's training, the theoretical knowledge should be supplemented by practical training and by experience in the fundamental processes of the engineering workshop, and in those techniques common to all branches of electrical engineering, together with the special techniques of the branch for which he is being trained. For the majority of technicians, instruction beyond the level of the Ordinary National Certificate is needed, which should be more specialised in character than courses for the Higher National Certificates.

So far, the electrical industry has not generally recruited technician apprentices as such. For the most part, the technicians have come from the ranks of craft apprentices who have taken advantage of the opportunities available for technical study by evening courses and part-time day release, or from the student or "school" apprentice ranks who have failed to reach academic professional qualifications. Apprenticeships and more carefully designed courses of technical study are needed. A comprehensive report on the education and training of electrical technicians was prepared by a committee appointed by the Councils of the British Electrical and Allied Manufacturers' Association, the radio industry and the Institution of Electrical Engineers, and published by the Institution of Electrical Engineers in October, 1950.

Craftsmen are those skilled in the carrying out of a range of manual and machine operations, such as tool makers, turners, fitters, blacksmiths, copper-smiths, moulders, pattern makers, instrument makers, etc. The practice of training engineering craftsmen through apprenticeship is ingrained in our national system, and I propose to deal only with those phases of it that are not sufficiently appreciated. In the post-war years, we have seen a movement towards the organisation of apprenticeship on a regional and national basis, with all interested parties, employers, trade unions, and the State taking part. The lads selected for craft training enter the industry at the school-leaving age of 15 + from secondary modern and secondary technical schools. The Education Act of 1944 endeavoured to remedy the existing lack of informed guidance by making the Ministry of Labour and National Service and the Ministry of Education responsible for placing school-leavers and juveniles in suitable jobs. Much experimental work is being done in connection with vocational guidance, and we may look forward to the time when sound vocational guidance will greatly assist the employer's task of trying to determine a boy's fitness for a given trade.

Equally important is the task of initiating a boy in the vast, bewildering and complex organisation of modern industry. This problem of initiation training is met in some works by special initiation courses, during which the new apprentice is shown round the factory, told something of its history and the policy of its management, and given information about general rules and regulations. Under the most progressive apprenticeship schemes, the young craft apprentice, during his first months on probation, will receive practical training in special training workshops under the close supervision of an instructor. This practical training in the workshop school must be supplemented by theoretical craft instruction, and general education, and physical training in the works schools. The practice of day release for educational purposes is growing, and this, supplemented by part-time evening work at local technical schools and colleges, provides the opportunity, for those craft apprentices who have the ability, to take advantage of the existing facilities to obtain a degree of technical knowledge which will ensure their upward mobility and, in some cases, enable them to reach professional status.

Whether the present length of apprenticeship needs revision, having in mind the incidence of National Service and other factors, is a subject to which much consideration has recently been given. What is needed in the training of all types of industrial workers is flexibility, so that efficient workers can be trained in the minimum time, having regard to ability, aptitude and past experience.

Within recent years a good deal of attention has been given to the study of industrial management. As industry has become more and more complex,

the problem of getting efficient and capable management at all levels increases in importance. A vast amount of material has been accumulated on the subject of management and there are many facilities for management education. A White Paper issued by the Ministry of Education on *Education for Management* made recommendations on which some of the existing courses have been framed. The field these courses cover is wide and it is probably too early to judge of their practical suitability. The basic facts and techniques which they aim to teach must be supplemented by practical training in their application and, above all, by experience.

Most of the large engineering firms provide, through their apprenticeship and post-apprenticeship training schemes, opportunities for theoretical and practical training in some of the aspects of management. What is more difficult is to provide the necessary experience to supplement this training, but here again the larger firms have arrangements whereby promising young men having the right personal qualities—and managers are born and not made—in the educational and practical background are moved, under the supervision and guidance of a highly-placed and responsible official, from department to department to ensure that they obtain the breadth of experience necessary to successful management.

So far, this survey has covered those influences in engineering training arising from evolutionary developments in industry, but, apart from these, the effect of the two World Wars has been profound. The need for a vast increase in the production of commodities outside the usual type of engineering products led to mass-production on a large scale and the breaking down into component operations of practices which previously were considered to be the function of the skilled artisan. Large numbers of men and women with no previous experience in machining operations were taught to carry out minor machining work, and facilities for training this semi-skilled type of labour were planned on a large scale.

Apart from this, in both wars an increasing need was felt for highly trained engineers, and also technicians. Not only was this the case in connection with research and development relating to new weapons, but also in the Services, in connection with the use of many new scientific devices. The wars contributed little in the way of entirely new scientific knowledge, but did bring about the application of known science in many new fields, and to that extent stimulated an increasing interest in research and development in the engineering industries.

Consideration must also be given to the effect of commercial developments, particularly those relating to export markets. During the past 50 years, progressive engineering firms have made a practice of attracting young engineering graduates from universities in overseas countries which are backward in manufacturing, so that these young men can acquire practical training in engineering factories in this country. When trained, they return home, some to positions in which they can influence the purchase of goods, plant and equipment, and their natural tendency is to turn to Great Britain for their requirements. The results have shown that men trained in this way become some of our best trade ambassadors, and apart from the actual knowledge they acquire of our engineering manufacture, ties of friendship are formed which further tend to improve the commercial relations between the respective countries.

In a visit I paid recently to nine of the Latin-American countries, I found overwhelming evidence of the need for trained engineers. These countries are in a state of early industrial development, and they need engineering facilities to provide transport, roads, railways, communications and power. The time is, therefore, ripe for attracting young graduates from these countries to England to be trained in our methods, and to obtain knowledge of our products, so that, in this period of development in their home countries, British plant and equipment may be used. This matter of training overseas graduates as part of our export drive should be viewed from the national standpoint. It is not enough to leave the provision of training places to the few large firms.

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.

Sparking Plugs.—A newly-issued revision of B.S. No. 45 aims at providing a common standard for both aircraft and general-purpose sparking plugs. It is intended to supersede both B.S. No. 45 : 1928, covering sparking plugs for motor-car engines and B.S. No. E.9, concerning sparking plugs for aircraft engines and issued in 1931. The provisions of the specification are mainly dimensional and relate to such features of general design as standard reaches and terminals, body hexagon, and the counterbore of the tapped hole, and to the limits and tolerances for the screw thread of the plug and the tapped hole. In assigning tolerances to the threads, and in the standardisation of certain general features of design, full consideration has been given to the desirability of achieving the closest possible measure of interchangeability between British sparking plugs and those made to American aircraft and motor-car specifications. Standardisation has been confined to the 14-mm. sparking plug since it is considered that other sizes are now obsolescent. [Price 4s. postage included.]

Hose Couplings.—A new specification, B.S. No. 1906, covers hose couplings, from $\frac{1}{2}$ in. to $1\frac{1}{2}$ in. nominal size, for air and water. The publication is concerned with three types of couplings, namely, light, medium, and heavy, for use at working pressures not exceeding 150 lb. per square inch. The light series of coupling are of the coned type and are intended primarily for use with paint-spraying equipment and other small appliances. The medium series are of the flat and coned types and are intended primarily for use on light pneumatic tools in the general engineering and allied industries. The heavy series are also of the flat and coned types and are intended primarily for use on the heavy type pneumatic tools such as rock drills and kindred equipment in the mining and quarrying industries and in civil engineering. The specification deals with workmanship, interchangeability and hydraulic testing procedure. Data on materials and on screw threads are also furnished. British Standard Pipe (B.S.P.) Whitworth treads are specified for the light and medium series of couplings and the Unified form of thread for the heavy series. Line drawings of the couplings are given, together with full dimensional particulars. The present publication is complementary to B.S. No. 1782, which covers hose couplings ($1\frac{1}{2}$ in. to 8 in. nominal size) other than fire-hose couplings. [Price 10s., postage included.]

Electrode Boilers.—A new specification, B.S. No. 1894 covers riveted, seamless and welded steel water-heating and steam boilers and cast-iron water-heating boilers. The specification applies to boilers to design temperatures not exceeding 650 deg. F., and is concerned solely with boilers for water heating or for the generation of steam, in which the water is heated by the passage of an alternating electric current. The specification relates to materials, construction and workmanship, scantlings, inspection and testing. Safety valves are dealt with at length and electrical safety devices are also specified. [Price 12s. 6d., postage included.]

THE LAW OF COPYRIGHT.—To illustrate some of the difficulties that may arise in connection with the law of copyright, particularly in its application to the copyright of a technical article, a meeting is to be held at the Institution of Civil Engineers at 5.30 p.m. on Friday, February 20. The narrative of a hypothetical case of infringement of the law of copyright has been prepared, and it will be presented in dramatic form by four people who will take the parts of a research engineer, managing director, editor, and information officer. A member of the legal profession will comment on the case and the meeting will then be open to discussion. The moot is being organised by Aslib, 4, Palace-gate, London, W.8 (telephone No. : WESTern 6321), from whom tickets of admission and copies of the narrative can be obtained.

"EFFLUENT-TREATMENT PLANT FOR TANK FACTORY": ERRATA.—In our issue of November 28, 1952 (vol. 174, page 681), we printed an article with the above title, relating to the (military) tank factory of the General Motors Corporation at Cleveland, Ohio, U.S.A. Our attention has been drawn by Mr. John Kremer, of Cleveland, the contributor to whom we were indebted for this article, to certain errors in the text. The reference to "sodium chloride" in the third and fourth lines of the last paragraph, on page 684, should read "sodium chlorite"; sodium chlorite (NaClO_2) has a strong oxidising action which tends to destroy certain obnoxious constituents of the effluent, but the chloride (NaCl) has no such effect. Later in the same paragraph, the address of Infleco, Inc., who designed the plant, was given as "Tucson" instead of Tucson, Arizona. We regret the errors, and are obliged to Mr. Kremer for the correction.

LABOUR NOTES.

DISPUTES procedure in the engineering industry continues to be the subject of negotiations between the unions catering for the industry and the Engineering and Allied Employers' National Federation. Members of the Transport and General Workers' Union are informed in an article in the February issue of the *Transport and General Workers' Record*, the union's official journal, that further discussions have recently taken place with the engineering employers in an endeavour to obtain the modification of the Agreement for the Avoidance of Disputes, generally referred to as the "York Memorandum." Although this agreement has operated in its present form since 1922, a great many attempts have been made, the *Record* states, to bring it into line with present-day requirements and with the practices existing in other industries.

The unions take the view, it is stated, that the whole of the negotiating procedure in the industry needs to be revised, to enable workpeople to have more adequate facilities for representation at all stages, and this goes beyond the somewhat narrow limits of the 1922 Agreement. The methods of dealing with disputes at local and central conference levels are, in general, considered to be unsatisfactory, because, as they are constituted at the present time, these conferences, in the opinion of the unions, leave the employers in the position of being both judge and jury, which is the negation of joint consultation. The *Record* considers that some of the principles governing Joint Industrial Councils might be applied with advantage to negotiating machinery in the engineering industry. Such a course would benefit both the industry and the workpeople "who have made it the greatest single industry in this country."

Proposals for extending the benefits payable to unemployed persons are being put forward by the Government. Under existing regulations, unemployment benefit is limited to a period of up to 180 days, except for persons who possess rights acquired from contributions under the former unemployment insurance scheme. In their case, there is a possibility of drawing unemployment pay for a further 130 days, according to the contributions paid and the benefits previously received. The Minister of National Insurance, Mr. Osbert Peake, informed the House of Commons on Monday that he had submitted draft regulations to the National Insurance Advisory Committee for making permanent provision for lengthening the period during which unemployment pay could be drawn. The new regulations would apply to all persons entitled to receive unemployment benefit.

The Minister's proposals, which have been put forward in accordance with a section of the 1946 National Insurance Act not previously brought into operation, provide that all contributors, whether insured under the old scheme or not, shall be eligible for benefit during 312 "additional" days, provided that they have been insured under the Act for at least five years. Including the initial 180 days, this arrangement would provide cover for up to 492 days altogether, in respect of any one period of unemployment. The exact number of additional days allowed in each case will depend upon the number of contributions paid in the preceding ten years and on the amount of unemployment benefit drawn during the preceding four years. It is proposed that the new regulations shall come into force on July 5 next.

Operatives in the metal-finishing industry are to receive further wage increases under an award of the Industrial Disputes Tribunal announced on Tuesday last. There will be an extra 2d. an hour for adult male employees, $1\frac{1}{2}$ d. an hour more for adult women, and proportionate increases for juveniles. The Transport and General Workers' Union and the other unions concerned with the industry submitted a claim to the Tribunal on January 28 asking for an increase of 4d. an hour for all adult workpeople, with proportionate additions for juveniles. The award, which will take effect immediately, is in general accordance with

those conceded in a number of other industries during the past twelve months or so.

Insistence on an increase of 15s. a week for all miners employed on a day-wage basis and on the cessation of working voluntary shifts on Saturdays was determined upon by the executive committee of the Scottish area of the National Union of Mine-workers at a meeting in Edinburgh on Monday last. Mr. John Wood, vice-president of the Scottish area, stated after the meeting that a vote taken by the union's branches in Scotland during the preceding week had given clear indications that the men were opposed to the recommendations put forward by delegates at the special national conference held in London on January 27. The conference had proposed that the union's national executive committee should agree to a continuation of Saturday working when the present extended hours' agreement expires on April 30, provided that the National Coal Board agrees on an increase of 6s. a week for all day-wage men.

Progress made in the Scottish area during 1952 in connection with the provision of supplementary pensions for miners and their dependents was reviewed by the area committee at their meeting in Edinburgh. It was reported that, up till December 31, retired Scottish miners not qualified to receive supplementary pensions under the national scheme introduced jointly by the union and the National Coal Board, had been paid a total of over 27,000l. under the Scottish area's own gratuity scheme. On the other hand, retirement pensions and allowances to widows and children in Scotland, paid out under the joint national pension scheme, amounted to nearly 19,250l., up till January 23 last.

Miners in the South Wales area also decided, on Tuesday last, to reject the national conference's decision that an increase of 6s. a week should be sought for the day-wage men. They considered it insufficient and that the union's national executive committee should press for an extra 15s. a week. It was reported, however, that a ballot of miners in the Durham area had resulted in approval of the claim for a 6s.-a-week increase and of the suggestion that, in return, the national committee should agree to the continuation of Saturday working for another year. A similar decision was reached by miners in the union's Midlands area. About 400,000 day-wage men would benefit from the increase.

There was a decline of 78,000 in the total working population of Great Britain during December last. About 60,000 of this number were women and girls, and some 18,000 men and boys. It may be recalled that a similar decline in the country's working population took place during December, 1951. According to statistics issued by the Ministry of Labour and National Service on Wednesday last, persons aged 15 and over who worked for pay or gain, or who registered themselves as available for such employment, numbered 23,295,000 on December 31, 1952, of whom 15,876,000 were men and boys, and 7,419,000 were women and girls. Altogether, there were 22,022,000 persons in civil employment, 872,000 men and women serving in the Armed Forces, 5,000 ex-Service men and women seeking employment, and 396,000 people unemployed. Of those in civil employment, 4,032,000 were engaged in the basic industries, and 8,683,000 in the manufacturing industries. The remainder were engaged in the distributive trades, the building and contracting industries, public administration, and professional services.

The number of persons registered as unemployed on January 12 last was 452,500, of whom 38,700 were only temporarily stopped. This figure was an increase of 53,000 compared with the total on December 8, 1952, and it included 14,800 young persons, mostly boys and girls who had just left school. Of the total number of unemployed on January 12, not more than 177,500 persons had been out of work for longer than eight weeks. Unemployment on that date represented 2.2 per cent. of the estimated total number of employees, compared with 1.9 per cent. in mid-December, 1952, and 1.8 per cent. in mid-January, 1952.

STANDARD CLASS-2 2-6-0 LOCOMOTIVE; BRITISH RAILWAYS.

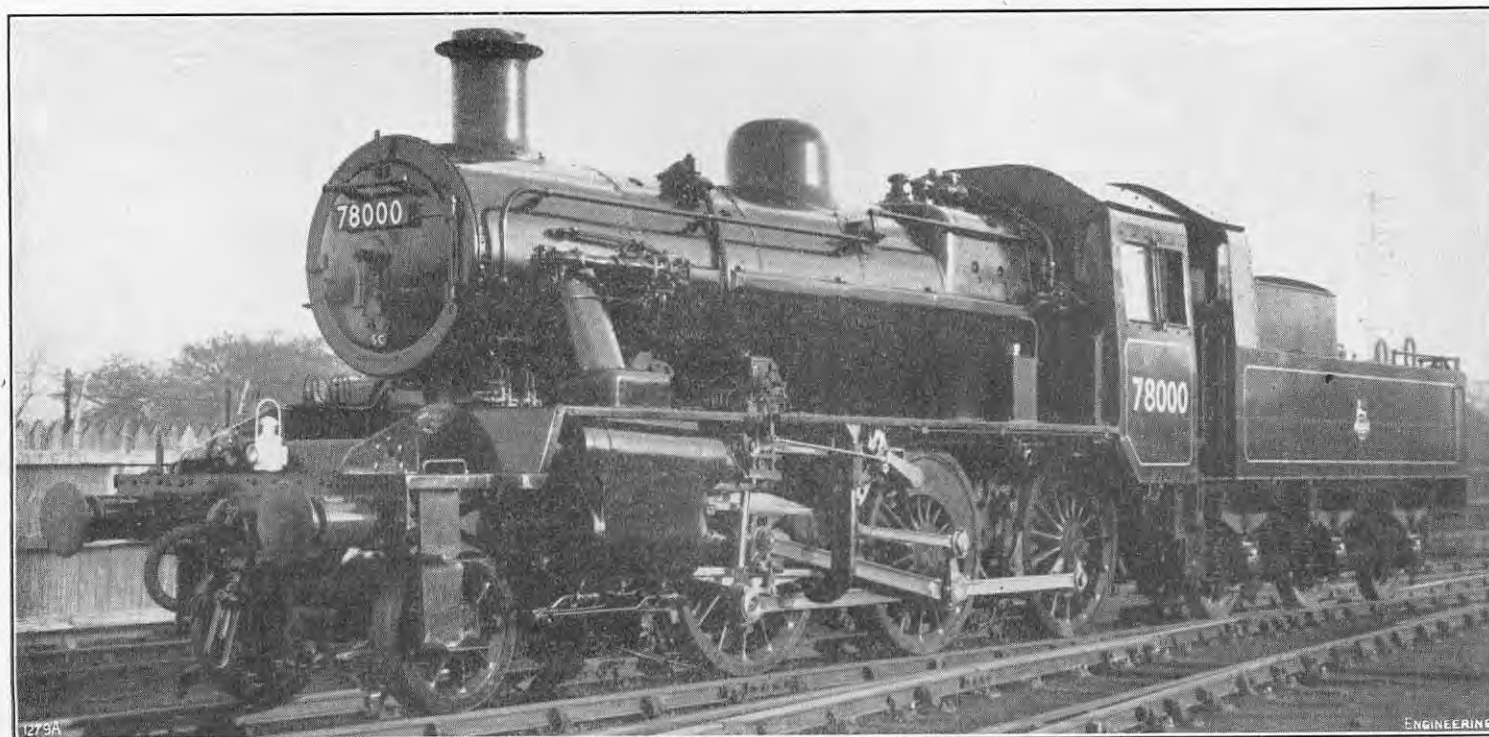
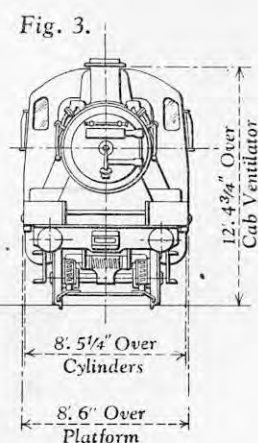
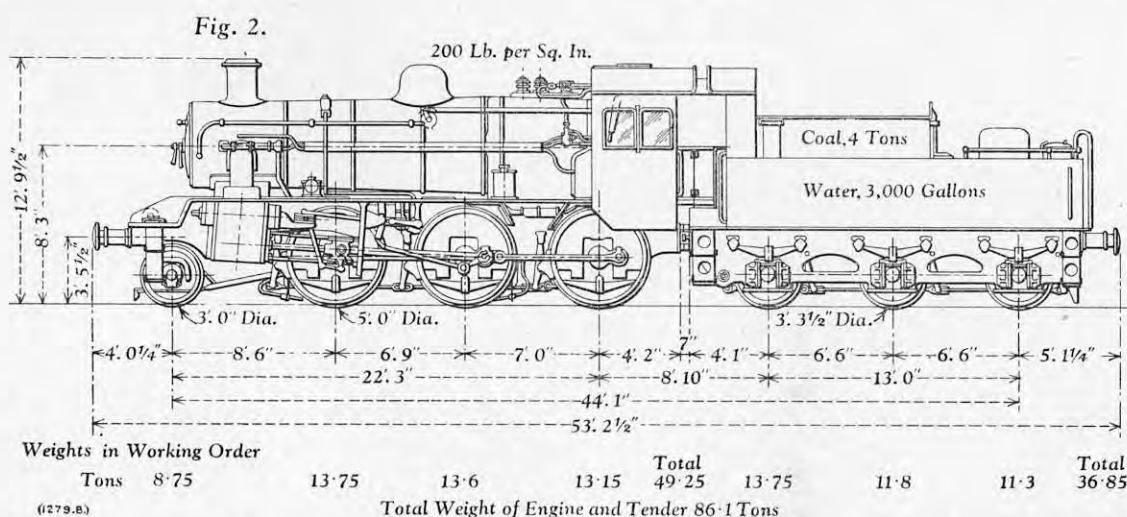


FIG. 1.



"ENGINEERING"

STANDARD CLASS-2 2-6-0 LOCOMOTIVES; BRITISH RAILWAYS.

THE eighth of the 12 standard classes of locomotives which British Railways are designing and building is the smallest tender engine of the range.* Nevertheless, it incorporates the recent developments which have been found successful on the larger engines. These improvements in design, which are primarily for reducing the preparation and "disposal" time at running sheds, include extensive use of grease lubrication, with the nipples grouped for convenience; a rocking grate; a self-emptying ashpan; and a self-cleaning smokebox. All the axleboxes on the engine have plain bearings, but those on the tender have Timken roller-bearings.

The new locomotives, the first of which is shown in Fig. 1, are for mixed-traffic work, especially light passenger trains on main-line and cross-country trains. The boiler pressure is 200 lb. per square inch; there are two outside cylinders, 16½ in. by 24 in.; the

coupled wheels are 5 ft. in diameter; and therefore the tractive effort is 18,513 lb. The engine weighs 49.25 tons in working order and its adhesion factor is 4.9. The axle loads are shown in Fig. 2. The locomotive has been designed and built under the direction of Mr. R. A. Riddles, C.B.E., M.I.Mech.E., member for mechanical and electrical engineering, Railway Executive. The parent office for the designing is Derby, though certain parts were designed at Swindon, Brighton and Doncaster. The first engine, No. 78000, has been completed at the Darlington Works of the Eastern and North Eastern Regions. Ten locomotives are to be built to the present order, and they are to work on the Western Region, where they will fulfil duties similar to those of the existing "2251" and "2301" classes; they can also replace various 0-6-0 classes of similar power.

THE BOILER.

The principal dimensions of the boiler are identical with those of the London Midland 2-6-0 Class 2 locomotive. The heating surfaces are 924 sq. ft. for the tubes, 101 sq. ft. for the firebox, and 134 sq. ft. for the superheater. The total evaporative heating surface is therefore 1,025 sq. ft. The grate area is 17.5 sq. ft. and the free flue area is 2.77 sq. ft. The barrel consists of two carbon-steel rings, the second tapered equally at the top and bottom; the outside diameter is 4 ft. 3 in. at the front and

4 ft. 8 in. at the firebox. The front ring is ½ in. thick and the back ring ¼ in. The smokebox tubeplate, of the drumhead type, carries 12 flue tubes, 5½-in. outside diameter by 7 s.w.g. thick, and 162 small tubes, 1½-in. outside diameter by 12-s.w.g. thick. The length between tubeplates is 10 ft. 10½ in. and the outside diameter of the superheater elements is 1½ in.

The Belpaire firebox is 5 ft. 11 in. in length, outside, and 4 ft. 0⅛ in. wide. The steel wrapper plate is ¼ in. thick and the inner copper wrapper plate is ⅜ in. thick. The throat plate, ⅝ in. thick, and the back-plate, ¼ in. thick, are both vertical. The large dome contains a vertical grid regulator operated from the cab by an external pull rod connected to a transverse shaft which enters the second barrel ring through a stuffing box. All the firebox water-space stays are of Monel metal, fitted with steel nuts inside the firebox, while the roof, longitudinal and transverse stays are of steel. Fibreglass insulation is used to lag the boiler and firebox. There are two separate feeds to the boiler, one from each of two live-steam injectors, situated below the cab on the right-hand side, the water entering the boiler through two clack valves on the first barrel. The water then passes over a tray which deflects it to the sides of the barrel, away from the tubes beneath. The boiler fittings are standard with those of the other British Railways locomotives where this is possible and economical.

* Articles on the first seven standard classes appeared in ENGINEERING as follows: 4-6-2 Class 7, vol. 171, pages 126 and 341 (1951); 4-6-0 Class 5, vol. 171, page 528 (1951); 4-6-0 Class 4, vol. 171, page 752 (1951); 2-6-4 Class 4 tank, vol. 172, page 138 (1951); 4-6-2 Class 6, vol. 173, page 108 (1952); 2-6-2 Class 3 tank, vol. 173, page 698 (1952); and 2-6-0 Class 4, vol. 175, page 12 (1953).

DUST SUPPRESSION ON GRINDING MACHINES.

BRITISH STEEL FOUNDERS' ASSOCIATION, SHEFFIELD.



FIG. 1. DUST-LADEN ATMOSPHERE WITH CONVENTIONAL COWLING.

A manual blow-down valve is fitted for discharging sludge from the front of the firebox.

FRAMES, CYLINDERS AND MOTION.

The carbon-steel main frames are 1-in. plates, on which are mounted hornblocks at the driving-wheel stations and guides at the leading and trailing-wheel stations; the surfaces are fitted with manganese-steel liners and strips welded to a backing plate and finally bolted to the guide. The coupled axleboxes have pressed-in brasses. The wearing surfaces of the plain coupled axleboxes and of the roller-bearing axleboxes on the tender, in contact with the guides, are provided with manganese-steel liners welded to the axleboxes.

Steam distribution to the cylinders is controlled by piston valves of 8-in. nominal diameter, driven by outside Walschaerts gear which provides a valve travel of about 6 in., $1\frac{1}{8}$ -in. steam lap and $\frac{1}{4}$ -in. lead. The valves are lubricated by atomised oil and the pins of the valve gear are grease-lubricated, except for the expansion-link and radius-rod die pins, dies and die paths, which are oil-lubricated. The return-crank rod big-ends have Skefko self-aligning ball bearings. The cylinder drain cocks are steam-operated, thus eliminating shafts and rods. The crossheads are of the two-bar type, with the top bar mechanically lubricated.

The leading pony truck has helical bearing springs, two pairs to each axlebox, each pair acting on either end of a yoke which transmits the load to the axlebox. Double-helical springs are also used for the side control of the truck, and two spring-loaded friction retarders are employed fore and aft of the truck centre to provide additional control of the freedom or side play of the truck. The steam and vacuum-brake equipment is standard, applying steam brakes on the engine and tender and vacuum brakes on the train. The braking force, per cent., is 60.23. The cab is designed to suit the smaller of the British Railways loading gauges and the layout of controls follows very closely the approved arrangement which was demonstrated to motive-power staffs before the larger locomotives were built. The tender has a capacity of 3,000 gallons of water and four tons of coal and is fitted internally for water pick-up apparatus, and can therefore be equipped externally as required. Two combined external water feed-valves and sieves are fitted on each side of the tender for the water feed pipe to each injector. The front plate of the tender is designed to provide good visibility when working the engine tender-first. The minimum radius of curve that the locomotive and tender can negotiate, with a specified gauge widening, is 4 chains. The engine weighs 45.4 tons empty and the tender 19.95 tons.



FIG. 2. DUST-FREE ATMOSPHERE WITH MODIFIED COWLING.

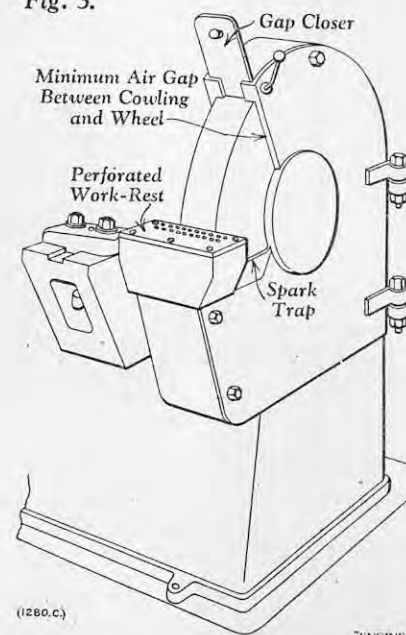
DUST SUPPRESSION ON GRINDING MACHINES.

THE suppression of dust on stand or pedestal grinding machines, such as are used in steel foundries and elsewhere, has formed the subject of an investigation, recently completed, which has led to the development of an improved cowling and work-rest for these machines. The improvements apply with equal effectiveness to machines with wheels that have a high peripheral speed (9,000 ft. per minute) or those with a medium speed (5,400 ft. per minute). Existing cowlings can easily be modified to incorporate the characteristics of the improved cowling, which has been shown to give a marked reduction in the amount of dust escaping into the atmosphere.

The investigation was sponsored by the Committee on Industrial Health of the British Steel Founders' Association, and has been conducted by the Research and Development Division of that Association at their Dust Research Station, established in Sheffield during 1951. Throughout the investigation, the work has been conducted with the co-operation of the Ventilation Committee of the Foundry Trades' Equipment and Supplies Association, who obtained a number of 24-in. pedestal grinding machines of different makes for experimental purposes. As the investigation progressed, it was followed with keen interest by H.M. Inspectorate of Factories, as well as by the trade unions concerned, particularly the Iron, Steel and Metal Dressers' Trade Society.

Preliminary observations carried out at the Dust Research Station were made with Perspex windows fitted into the otherwise standard side covers of the cowlings of the grinding machines; through these windows it was possible to observe, with the assistance of suitable illumination, the flow of the dust-laden air inside the cowling. These observations revealed that the air streams being drawn into cowlings of a conventional pattern prevented the dispersion of the stream of dust-laden air produced by the grinding process, and caused it to cling to, and rotate with, the grinding wheel, instead of being extracted through the exit duct by the fan system. The dust stream adhered to the wheel until it was thrown out of the cowling in front of the operator, where it was deflected directly into the breathing zone of the operator by the work rest and by the work itself. The effect produced on a standard machine is illustrated in Fig. 1 above, which should be compared with Fig. 2, showing the improvement obtained with the modified cowling. The slight glare above the operator's hands in Fig. 2 is caused by the lighting technique employed when taking the photographs; in Fig. 1, the same glare is obscured by the dust itself.

Fig. 3.



By using the extraction system to control the air drawn into the cowling, and by concentrating the effects of extraction on the dust stream alone, it was found possible to reduce substantially the amount of dust-laden air rotating with the wheel and thrown out in front of the operator. Fig. 3 shows how the work-rest has been redesigned for this purpose. Its upper surface is provided with slots or holes which communicate with the extraction duct, so that the dust is drawn off at the point where it is produced. The gap between the casing and the sides of the grinding wheel has been reduced to a minimum and, at the point where the wheel emerges from the cowling immediately in front of the operator's face, the gap is closed by a simple frame in which an adjustable plate is fitted. As the wheel wears, the plate is moved in to close the gap.

No complicated alterations to the grinding machine are involved, so that existing machines can readily be modified; equally, new machines can be designed to incorporate the improvement. A film, recording the detailed stages of this investigation, is to be shown at the annual conference of the Institute of British Foundrymen, to be held at Blackpool from Tuesday, June 16, to Thursday, June 18.

BRITISH ELECTRICAL POWER CONVENTION.—It is announced that the paper on "Electricity and National Prosperity," which is to be read at the fifth British Electrical Power Convention at Torquay on Tuesday, June 9, will be presented by Mr. B. H. Leeson, instead of by Sir Henry Self, and that Mr. E. R. Wilkinson will be the sole author of the paper on "Electricity and Industrial Production," which is down for reading on Wednesday, June 10.

UNIVERSAL COPYRIGHT CONVENTION.—On January 28, the United Nations Educational, Scientific and Cultural Organisation published the Universal Copyright Convention, obtainable from H.M. Stationery Office, Kingsway, London, W.C.2, price 2s. 6d. It supplements the existing Berne Convention for the Protection of Literary and Artistic Works, and provides protection on a wider basis for "authors and other copyright proprietors in literary, scientific and artistic works, including writings, musical, dramatic and cinematographic works, and paintings, engravings and sculpture." One of the provisions of the Convention is the establishment of an Intergovernmental Committee to study problems of international copyright; the Committee to consist initially of 12 representatives, from Argentina, Brazil, France, Germany, India, Italy, Japan, Mexico, Spain, Switzerland, the United Kingdom, and the United States. The Convention will come into operation three months after the deposit of 12 instruments of ratification, acceptance, and accession, among which must be included those of four states which are not members of the Berne Convention.

CAUSTIC CRACKING IN MARINE SCOTCH BOILERS.*

By W. McCLIMONT, B.Sc., A.M.I.Mech.E.

"CAUSTIC cracking" is the term used to describe the intercrystalline fractures which occur occasionally in boiler components under the influence of static stress concentrations and in contact with fairly concentrated solutions of caustic soda (sodium hydroxide, Na OH). On account of the apparently brittle nature of the cracks, this phenomenon is sometimes referred to as "caustic embrittlement," but this is really a misnomer, as tests carried out on specimens taken from the region of the cracks have not shown any appreciable reduction in the ductility of the metal.¹

Dorey² states that a few cases occurred during 1934-37 where the shells of marine cylindrical boilers fitted in vessels classed with Lloyd's Register of Shipping were found to be so seriously cracked that the boilers were unfit for further service and were condemned. Weir³ cites the historic case of the Dutch East-Indian steamship Pahud, while Sellar⁴ states that he has knowledge of about ten Scotch boilers which were found at surveys to be afflicted with caustic cracking in a period of 20 years. Recently failure occurred of a back combustion-chamber plate after about two years' service. Dorey² states that a total of 152 ships have been found in the past 15 years in which the boilers have developed defects indicative of chemical embrittlement; the number of boilers affected was 276.

Schroeder and Berk⁵ have listed the following factors in the production of caustic cracking:—

1. A boiler water which when concentrated will produce intercrystalline cracking; a water containing a caustic alkali will fall into this class and it is generally accepted that sodium hydroxide is the form in which such an alkali is present in boiler water.

2. High stress in the metal; Weir³ and others have found that failure occurs in areas where stressing is non-homogeneous.

3. Very slow leakage or other process taking place in certain areas of the boiler that will allow the formation of a film of concentrated solution.

4. Contact of the film of concentrated solution with the highly-stressed boiler metal.

The simultaneous action of all these factors is considered necessary to cause caustic cracking and it is thus possible to explain the uncertainty of its incidence in boiler operation. Statistical evidence of the value of remedial or preventive measures must be viewed with considerable caution, as due consideration may not have been given to all the complex factors mentioned above.

CAUSTIC ALKALINITY OF FEED WATER.

Sodium hydroxide is formed under certain conditions of boiler-water composition, normally by the hydrolysis of sodium carbonate (soda ash, Na₂CO₃), which is frequently added to boiler feed-water to remove permanent hardness. Schroeder and Berk⁵ found that a concentration of just over 10 per cent. was necessary for the occurrence of failure, but Weir³ found that a failure occurred in a 7.6 per cent. solution. Correlation of the results of different workers is made difficult by the different stresses applied to their specimens, but there is evidence that, above a concentration of the order of 7.5 per cent. to 15 per cent., caustic soda will attack steel in an intercrystalline manner, and that the incidence of failure increases with the degree of concentration. Straub,¹ and Slater and Parr⁸, state that the rate of attack is accelerated with increase in temperature, but Partridge, Kaufman, and Hall,⁹ and also Weir³ found that temperature had no effect. There is no evidence of an increase in the number of failures in service due to increases of operating temperature.

In many opinions, a number of substances act as catalysts, and several workers consider that some of these substances are necessary additions to sodium hydroxide to produce caustic embrittlement. Work is still proceeding to establish the exact mechanism of failure. Information on the various theories can be found in references.^{3-7, 10-12}

* Report No. 79 of the British Shipbuilding Research Association. Abridged.

A great deal of work has also been done in endeavouring to find substances which will inhibit caustic cracking. Straub¹ attached great significance to the maintenance of a high sodium-sulphate/sodium-hydroxide ratio, but later work, particularly that of Straub and Bradbury,¹³ has been inclined to discount the protective value of sodium sulphate. The specification for the control of the sodium-sulphate/sodium-hydroxide ratio included in British Standard 1170:1947 appears, however, to be based on sufficiently substantial evidence to justify continuance of this practice. Considerable success has been achieved on American railways by treatment with sodium nitrate. Laboratory results obtained by Schroeder, Berk, and O'Brien¹⁴ were promising and Berk²⁸ cites examples where treatment has been applied successfully in stationary plants, but Hamer and Colbeck,²⁴ and also Weir³, have expressed doubts about the efficacy of the treatment. The present situation can only be regarded as inconclusive.

Several workers have advanced the claims of certain organic compounds as inhibitors. In particular, Schroeder, Berk, and O'Brien¹⁴ found in laboratory tests that sulphite waste liquor, lignin sulphonate, quebracho, and Philippine cutch are extremely effective in preventing embrittlement, and lignin sulphonate has been used with a measure of success in locomotive boilers in America.¹⁵ Partridge, Kaufman, and Hall,⁹ and Berk²⁸ using the Schroeder embrittlement detector,^{16*} have obtained results showing that tannin is an inhibitor. The other organic substances mentioned above are close relatives of tannin. Weir³ has found that the presence of tannin does not entirely prevent cracking in laboratory tests, but proposes further investigations to clarify this matter.

STRESSES IN BOILER METAL, AND QUALITY OF STEEL.

The steel must be in a stressed condition for damage to occur, and the type of stress applied (tension, bending, or torsion) does not appear to be significant, provided that tension stresses are present in the surface exposed to the caustic liquor. The magnitude of the stresses involved are the subject of some controversy. Parr and Straub¹⁷ considered that caustic embrittlement can only occur when the material is stressed to the yield point, though Straub¹ was able to produce failure at lower stresses. Dorey,² Desch,¹⁸ and Weir³ state that cracking seems always to occur in areas where plastic deformation has occurred. General agreement exists that unhomogeneous stressing greatly increases the susceptibility of steel to caustic cracking; in laboratory tests, the presence of any form of stress-raiser has been most marked. Various forms of bad workmanship will increase the probability of cracking. Faulty alignment of rivet holes, necessitating the use of undue force in lining-up, or the use of excessive riveting pressure are two such forms. All investigators are agreed that failures of this type are caused by static stresses and that alternating stresses are not necessary; in fact, the presence of alternating stresses does not appear to influence the rate of attack to any appreciable extent.^{19, 20, 26}

All steels normally used in boilers are susceptible to caustic cracking to more or less the same extent. German workers held the view for a long time that the quality of steel was primarily responsible for caustic cracking. This belief, however, was shown to be erroneous when cracking occurred in boiler plate known to be of good quality,¹⁸ though there is some evidence²⁵ that aluminium-killed steels are more resistant to cracking, particularly the German "Izett" steels. It should be noted that Colbeck, Smith, and Powell¹² found that poor steel appears to crack much more readily in laboratory tests than good-class steel; Weir³ reports that a

* This apparatus consists of a specimen of rectangular bar form which is clamped firmly to a steel block at one end. By means of a set screw, turning in a threaded hole in the specimen, the other end of the specimen is bent away from the block. In the block a small hole is drilled, connected at one end to the boiler, and at the other end emerges opposite the area of highest stress in the specimen. The detector is so adjusted that a slight leak to the atmosphere occurs past the specimen, thus duplicating the conditions existing in a leaky seam.

fine-grained steel of low carbon content was found to be more resistant to attack than a normal steel of practically the same carbon content, though he also found that a fine-grained steel, slightly enriched in carbon, showed a remarkably improved resistance.

CONCENTRATION OF CAUSTIC FLUID.

As already stated, appreciable damage to steel by sodium hydroxide is only found in laboratory tests when the concentration of the caustic alkali is relatively high, of the order of 10 per cent. or more, a figure considerably in excess of anything possible in the water in a boiler. Straub¹, alone and with Parr¹⁷, put forward explanations to explain this discrepancy, and these are now generally accepted. The usual sites of cracks are seams, such as where butt straps are attached to the shell by rivets. Slight leakage can occur between the plates and the strap and also round the rivets; and, owing to evaporation of water at the surface, a high concentration of dissolved salts, in this case largely sodium hydroxide, will occur. Such an action in a capillary space has been reproduced by Schroeder in the construction of his embrittlement detector.¹⁶ Concentration is possible also in crevices and seams of a boiler, even in the absence of leakage. Variations in steam pressure or in temperature cause a gradual increase in the sodium-hydroxide concentration of the water enclosed in the crevice or seam, due to alternate evaporation of part of this water and replacement by a fresh supply of boiler water. The occurrence of concentration of the foregoing types is confirmed by the fact that, when a cracked boiler is dismantled, strongly alkaline incrustations can usually be found between the plates and round the rivets. Pfeiderer²¹ has shown that the deposition of salts may readily occur in boiler seams, even under not very severe conditions, and it seems doubtful whether riveted seams can be made entirely immune by the most careful manufacture. Alkaline solutions have remarkable powers of seepage.

Some investigators have suggested that the rarity in the past of caustic cracking in marine boilers, compared with land-boiler experience, may be due to the presence of scale on the boiler-metal surfaces at the more vulnerable points, such scale being due to the use of sea water as feed during the early life of the boiler. In this way, a light egg-shell surface was produced on the metal surfaces and may have acted as a protective coating.^{4, 18} It may also have been sufficient to seal most crevices and seams, thereby preventing the concentration of sodium hydroxide. In recent years, the use of sea water in this way has been frowned on and the practice appears to be seldom adopted nowadays. The use of lime to form a light scale is now recommended,²² but no evidence has been found to show how widespread its use may be. There is evidence, however, that it is a practice nowadays to steam boilers *ab initio* with water in a "near-fresh" condition. In such conditions, no protective scale is formed. No evidence can be traced of the effect of these changes in practice on the incidence of caustic cracking.

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(Nos. 3, 12, and 23 in this list include much more comprehensive bibliographies on the subject of caustic cracking than is here attempted. No. 23 includes 427 references.)

¹ "Embrittlement in Boilers," by F. G. Straub. *University of Illinois, Engineering Experiment Station, Bulletin No. 216*, 1930.

² "Note on the Chemical Intercrystalline Fracture of Riveted Joints in Boilers," by S. F. Dorey. *Trans. Inst. N.A.*, vol. 79, page 50 (1937).

³ "Recent Research on Caustic Cracking in Boilers," by C. D. Weir. *Trans. Inst. Engrs. Shipb. Scot.*, vol. 92, page 165 (1948-49).

⁴ Discussion on Reference 3, by G. M. Sellar, page 195.

⁵ Discussion on Reference 13, by W. C. Schroeder and A. A. Berk. *Mech. Eng'g, N.Y.*, vol. 61, page 144 (1939).

⁶ "Caustic Cracking: Stress-Corrosion Tests in Sodium Hydroxide Solutions at Elevated Temperatures," by C. D. Weir. *Proc. I. Mech. E.*, vol. 163, page 18 W.E.P. No. 55 (1950).

⁷ "Action of Solutions of Sodium Silicate and Sodium Hydroxide at 250 deg. C. on Steel under Stress," by W. C. Schroeder and A. A. Berk. *Trans. Amer. Inst. Min. (Metall.) Engrs.*, vol. 120, page 387 (1936).

⁸ "Marine Boiler Deterioration," by I. G. Slater and N. L. Parr. *Proc. I. Mech. E.*, vol. 160, page 341 (1949).

YEAST FACTORY AT DOVERCOURT.



FIG. 1. OFFICE AND PROCESS BLOCKS FROM APPROACH ROAD.

⁹ "Field Data from the Embrittlement Detector," by E. P. Partridge, C. E. Kaufman and R. E. Hall. *Trans. A.S.M.E.*, vol. 64, page 417 (1942).

¹⁰ "Prolonged-Stress Tests on Iron and Steel Specimens Immersed in Hot Sodium Solutions," by C. H. M. Jenkins and F. Adcock. *J. Iron & Steel Inst.*, vol. 58, page 102P (1941).

¹¹ "Inter-crystalline Cracking of Steel in Aqueous Solution," by W. C. Schroeder, A. A. Berk and R. A. O'Brien. *Metals & Alloys*, vol. 8, page 320 (1937).

¹² "Caustic Embrittlement," by E. W. Colbeck, S. H. Smith and L. Powell. *Proc. I.Mech.E.*, vol. 149, page 63 (1943).

¹³ "Boiler-Water Treatment," by F. G. Straub and T. A. Bradbury. *Mech. Eng'g., N.Y.*, vol. 60, page 371 (1938).

¹⁴ "Protecting Steel Against Inter-crystalline Attack in Aqueous Solution," by W. C. Schroeder, A. A. Berk and R. A. O'Brien. *Trans. A.S.M.E.*, vol. 60, page 35 (1938).

¹⁵ "Experience with Inter-crystalline Cracking on Railroads," by R. C. Bardwell and H. M. Laudeman. *Trans. A.S.M.E.*, vol. 64, page 403 (1942).

¹⁶ "Embrittlement Detector," by W. C. Schroeder, A. A. Berk and R. A. O'Brien. *Combustion, N.Y.*, vol. 12, page 19 (1940).

¹⁷ "The Cause and Prevention of Embrittlement of Boiler Plate," by S. W. Parr and F. G. Straub. *University of Illinois, Engineering Experiment Station, Bulletin No. 155* (1926).

¹⁸ "Inter-crystalline Cracking in Boiler Plates, Part I," by C. H. Desch. *J. Iron & Steel Inst.*, vol. 143, page 94P (1941).

¹⁹ "Verformungslose Brüche an Kesselteilen," by W. Rüttmann. *Z.V.D.I.*, vol. 79, page 1561 (1935).

²⁰ "Inter-crystalline Cracking in Boiler Plates, Part V," by H. J. Gough and H. V. Pollard. *J. Iron & Steel Inst.*, vol. 143, page 136P (1941).

²¹ "Dampfkesselschäden," by E. Pfeleiderer. Berlin, 1934, page 185; cited in Reference 3.

²² "The Running and Maintenance of Marine Machinery." Institute of Marine Engineers, 1947.

²³ "Boiler Embrittlement," by C. A. Zapffe. *Trans. A.S.M.E.*, vol. 66, page 81 (1944).

²⁴ "Caustic Embrittlement in Boilers," by P. Hamer and E. W. Colbeck. *Chem. Ind. Rev.*, vol. 63, page 163 (1944).

²⁵ "Inter-crystalline Cracking of Boiler Steel and Its Prevention," by W. C. Schroeder and A. A. Berk. *U.S. Bureau of Mines, Bulletin 443* (1941).

²⁶ "Ursache von Riss-Schäden an Genieteten Kesseltrommeln," by R. Rist. *Z.V.D.I.*, vol. 79, page 812 (1935).

²⁷ Presidential address by S. F. Dorey. *Proc. I.Mech.E., Lond.*, vol. 162, page 368 (1950).

²⁸ "The Prevention of Embrittlement Cracking," by A. A. Berk. Amer. Soc. of Mech. Eng. Annual Meeting, New York, November 26, 1950 to December 1, 1950, Paper No. 50-A-84.

FACILITIES FOR LARGE-SCALE SWITCHGEAR TESTING.
—Speaking in the discussion on the paper on "Current Chopping in High-Voltage Circuit-Breakers," which was read by Mr. A. F. B. Young before the Supply Section of the Institution of Electrical Engineers on Wednesday, January 28 (and of which an account appeared on page 190, *ante*), Mr. D. P. Sayers, said that the British Electricity Authority, were prepared to collaborate with manufacturers by providing facilities for large-scale switchgear testing on the grid.

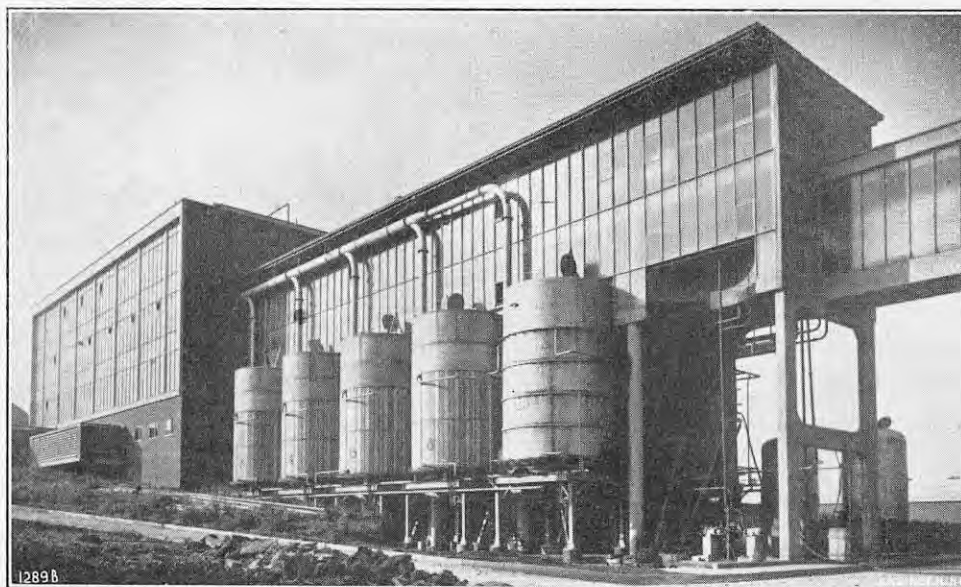


FIG. 2. SOUTH ELEVATION OF PROCESS BLOCK.

YEAST FACTORY AT DOVERCOURT.

A FACTORY building of modern appearance and embodying a number of novel structural features was completed last year for the Standard Yeast Company, Limited, at Dovercourt, near Harwich, Suffolk. The factory is divided into three main blocks: the offices, laboratories and drawing-office block, which runs from north to south, the western elevation of which is shown in the left foreground of Fig. 1, herewith; the main processing block, part of which can also be seen in Fig. 1, but which is also shown in Fig. 2; and the third block, for extraction, storage and dispatch, which also runs from north to south and can be seen in the left background of Fig. 1. The three blocks are linked by two bridges, one spanning between the main process block and the extraction block and shown on the right of Fig. 2, and the other between the process block and the office block.

The purpose of the factory is the direct production of bakers' yeast, using molasses as the fermenting vehicle instead of obtaining the yeast as a by-product from breweries. A refined yeast culture is introduced into the molasses, and under carefully controlled conditions of temperature and dilution the yeast buds and multiplies as the molasses ferment; with the completion of the process the fermented solution is concentrated and the end-product extracted, when it is put into store before being packed ready for dispatch. The

factory has therefore been designed to accommodate all the processes in their natural sequence; thus the reception and off-loading bays, together with the storage tanks for the raw molasses, have been built into the western half of the main process block, and the fermenting tanks, shown in Fig. 2, are in, and below, the eastern half of the same block. The concentrated liquor is then piped across the connecting bridge to the extraction block, where the separation plant is located and where the yeast is stored prior to being packed and dispatched.

The site of the factory is a sloping clay bank which drops away from the level of the approach road towards the estuary of the River Stour, into which the unwanted effluent is discharged on the ebb tide. In order to overcome an otherwise difficult foundation problem, the main process block has been constructed on a cellular raft which has been utilised as the principal storage tanks for the raw molasses. The concrete of the raft was placed outside tanks of thin sheet steel, which were mainly site-welded and which acted as permanent internal shuttering, finally giving protection to the concrete against attack by the molasses. The western half of the process block is 107 ft. long, 45 ft. wide and rises four storeys above ground level to maximum height of 44 ft. The framework and the floor are of reinforced concrete and a red brick has been used for the in-filling to the ground floor on both sides and to the full height of the building on the end elevations. On both side elevations, the three upper storeys have vertical patent glazing,

YEAST FACTORY AT DOVERCOURT.

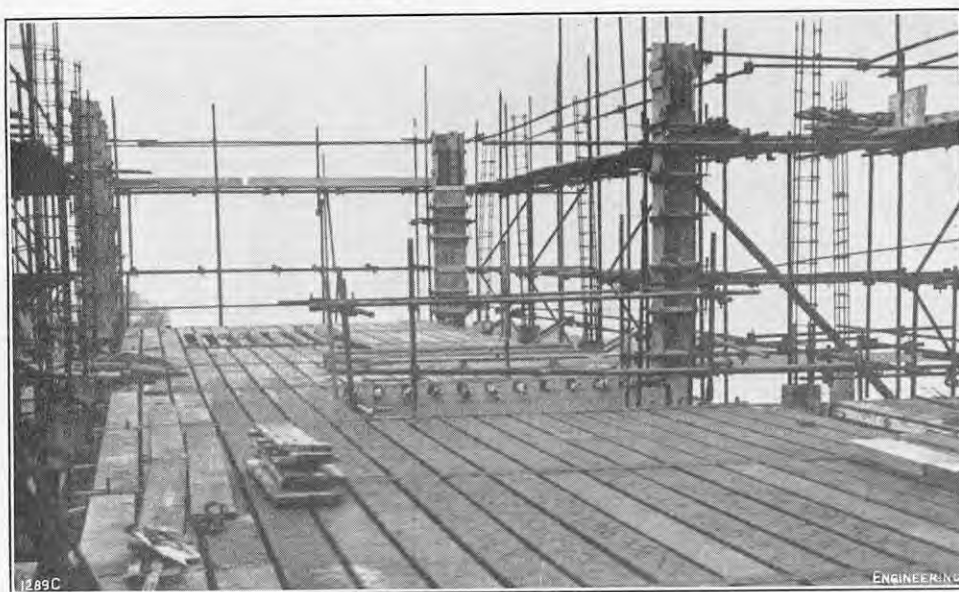
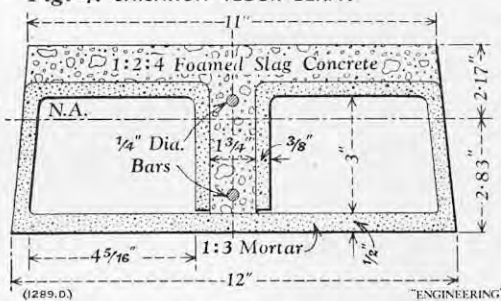


FIG. 3. "SHISHKOFF" FLOOR BEAMS IN POSITION PRIOR TO PRESTRESSING.

Fig. 4. "SHISHKOFF" FLOOR BEAM.



supplied by the British Challenge Company, Limited, Marshgate-lane, Stratford, London, E.15.

The eastern half of the process block, shown in Fig. 2, is 107 ft. long, 26 ft. wide and 50 ft. high above ground level; it is a two-storey structure supported on reinforced-concrete columns. Located below the building, and between the columns, are the insulated stainless-steel fermenting tanks arranged in two parallel rows. These tanks have been built above ground level (which, due to the sloping nature of the site, is on a level with the bottom of the molasses tanks that are under the western half of the block) and access to the top of the fermenting tanks is gained from the lower of the two storeys overhead. The columns supporting the building consist of concrete tubes with a reinforced-concrete filling, the tubes being used as permanent shuttering.

An enclosed reinforced-concrete bridge, with a span of 30 ft. and glazed at the sides, connects the process block with the extraction and dispatch block. The consultants and the building contractors state that a considerable economy was effected by the extensive use of the glazing as a wall covering. The extraction and dispatch block is 200 ft. long, 44 ft. wide and has a maximum height of 40 ft. At the southern end the form of construction adopted is similar to that of the process block, namely, a reinforced-concrete framework with brick in-filling to the ground floor and glazing above that; this section of the building is mostly of three storeys and it has a flat roof. The packing and dispatch departments are housed in the northern half of this block, and a clear floor space, 85 ft. long by 44 ft. wide, with good headroom, has been achieved by the use of a barrel-vault roof. It is claimed by the builders that this roof was among the first of the barrel-vault roofs for which the concrete was vibrated while being placed.

After the yeast has been separated from the concentrated liquor a considerable bulk of effluent remains which has to be disposed of. Two reinforced-concrete tanks, each 30 ft. in diameter, have been therefore built to store the effluent until it can be discharged into the river. Two cast-iron pipes of 9-in. diameter are used to convey the

effluent, under a natural head due to the elevation of the factory site, to a point 1,500 ft. out in the estuary. The line of the discharge pipes is over a deep bed of soft mud, and even at high tide there was not the necessary depth of water to float a boat of sufficient size to convey the lengths of pipe to their final position; the pipe line was therefore laid by using rafts at high tide and wattle hurdles laid on the mud at low tide.

The office and laboratory block is a three-storey building, 100 ft. long by 30 ft. wide; the framework of the building is of reinforced concrete, the floors, roof and staircase of prestressed concrete. The block has a flat roof, brick in-filling on the western elevation and extensive vertical glazing on the eastern side, and the general appearance is in keeping with the two factory blocks.

The floors and roof of this block are all of prestressed concrete and were constructed with proprietary hollow-floor units, known as "Shishkoff" or "Plycrete" units; these units were made on the site, under licence, by the building contractor. The method of making these units was as follows. A fairly dry cement mortar was spread on a strong building paper to a thickness of $\frac{1}{2}$ in. or $\frac{3}{8}$ in., and the paper, together with the cement layer, was then wrapped around two pairs of folding-wedge mandrels. When the mortar had hardened, the mandrels were withdrawn, leaving a hollow box beam of the form shown in Fig. 4, herewith, and having a length of 41 in. and a weight of between 40 lb. and 45 lb. The striking time for the mandrels varied between 12 hours and 22 hours, it being normal practice to withdraw the mandrels at 15 hours and to stack the units immediately in tiers of six. To form a single floor beam, three units were laid end to end with $\frac{1}{2}$ in. gaps that were ultimately filled. Two $\frac{1}{4}$ -in. reinforcing bars were then placed along the central chase; one 10 ft. long, $\frac{3}{8}$ in. from the bottom, and a second 7 ft. long, 1 in. from the top; the unit was then filled with a 1:2:4 foam-slag concrete to form a lightweight floor beam with an effective span of 10 ft. These beams were then placed in position, side by side, spanning between the beams of the framework of the factory, as illustrated in Fig. 3, herewith. The prestressing cables, each comprising a rubber sheath containing two wires of 0.2-in. diameter, were then laid the whole length of the building in the grooves between adjacent units, with an additional cable in every third groove; a 2-in. topping of granite-chip concrete was then laid over the floor beams. When this topping had hardened, the cables were tensioned, using the Freysinnet process.

The engineering consultants were Ove Arup and Partners, 8, Fitzroy-street, London, W.1, and the principal building contractors were Bovis Limited, 1, Stanhope-gate, London, W.1.

WAGONS AND CONTAINERS OF BRITISH RAILWAYS.

In the belief that designers and users of mechanical handling appliances, road motor vehicles, etc., often wish to have information on the principal features and dimensions of railway wagons and containers, the table on page 222, relating to the more important wagons and containers of British Railways, has been prepared with the assistance of the Railway Executive. Seven British Railways' workshops, as well as private wagon builders, are building vehicles to these designs.

The Executive's policy is to replace the old grease-lubricated vehicles taken over from the former railway companies and the private wagon owners by modern wagons with oil-lubricated axle-boxes, and, in certain cases, to increase the capacity of wagons. A few years ago the capacity of mineral wagons had reached a standard of 16 tons, but recent developments among coal, gas and electricity undertakings have justified an increase. It is now considered that the most economical capacity for a coal wagon in this country is 24½ tons, with a loaded weight of 35 tons, this being the maximum load that can be carried on two axles without restrictions on route availability. By adopting a 24½-ton standard, a better ratio of pay load to tare weight will be achieved, enabling train mileage to be reduced for a given quantity of coal. Wagons of even larger capacity are in use on British Railways and on railways abroad, but the new standard types have been developed in relation to the requirements of British trade and industry. For conveying iron ore, the most economic wagon capacity is 25½ tons with bottom-door discharge, or 27 tons without doors, for discharging over the side by wagon-tipping plant. In both cases the total loaded weight is again 35 tons.

With the conditions of trade obtaining in this country, the average load in merchandise wagons rarely exceeds the average tonnage capacity—indeed, the average wagon load is 4 tons—and for this reason the existing standards of 12-ton capacity for covered wagons and 13 tons for open wagons are being retained. Experience shows that cattle wagons cannot be loaded with animals of any kind to a weight in excess of 8 tons, so this is to be the standard in the future. For the steel industry, the requirements are so varied that no standard capacity for steel-carrying wagons can be laid down, and a number of wagons of differing sizes and capacities are, and will be, in the fleet. Fruit and banana vans have been standardised, in consultation with the trade, and they embody the most suitable designs formerly in use. Vans for fresh or frozen meat at present consist of three types; the choice of a standard depends on future trade requirements, as well as on technical and other considerations, and the matter is now being reviewed.

All-steel construction gives an advantage of 12 per cent. in annual costs compared with construction wholly in wood, but, since certain traffics require wooden floors, a proportion of wagons will be so constructed in future. In the past, doors of covered wagons have been either hinged or made to slide; the latter have certain advantages when a wagon is standing alongside a platform, but the former are easier to open. In future, hinged or folding doors will be the normal standard. To eliminate damage to merchandise by rain, the proportion of open wagons fitted with adjustable sheet-supporting bars has been increased, and the number of wagons fitted with special shock-absorbing gear is also being augmented.

The numbers of wagons of different types now operated by British Railways are more than 305,000 open, 141,000 covered, 542,000 mineral (not hopped), 58,600 mineral (hopped), 2,300 special, 13,000 cattle, 43,700 steel-carrying, 4,200 fish, and 14,800 freight brake vans. There are also 24,628 containers. When British Railways took over 1,200,000 wagons on January 1, 1948, there were 480 different types in production. In spite of the many special types still needed for certain kinds of traffic, it is intended eventually to replace these 480 designs by not more than about 150, thus obtaining considerable economies in design and

WAGONS AND CONTAINERS OF BRITISH RAILWAYS.

No.	Type.	Traffic.	Tare Weight.	Capacity	Length Over Headstocks.	Wheel-base.	Minimum Radius of Curve.	Interior Dimensions.			Extreme Height from Rail Level.	Brakes.
								Length.	Width.	Height.		
			Tons. Cwt.	Cub. ft.	Ft. In.	Ft. In.	Chains.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	
1	20-ton freight brake van	—	20 0	—	24 0	16 0	1½	—	—	—	12 2	Vacuum, hand. Compressed air and vacuum.
2	14-ton "Interfrigo" ferry van	Refrigerated	17 10	1,095	30 7½	19 8½	3	25 2½	7 2½	5 8½	12 3½	
3	8-ton banana van	Bananas	8 17	773	17 6	9 0	1	16 8½	7 2½	7 9½	12 2½	Vacuum, hand. Vacuum, hand.
4	12-ton insulated fish van	Fresh fish in boxes with ice	10 18	1,163	21 0	15 0	1½	20 5½	7 9½	7 7½	12 0	
5	12-ton covered ventilated van	General merchandise	7 11	940	17 6	10 0	1	17 4½	7 7½	7 8½	11 8½	Vacuum, hand. Vacuum, hand.
6	8-ton cattle wagon	Cattle	7 13	—	18 6	11 0	1	18 0	7 7½	7 3½	11 5½	
7	22-ton tube wagon	Tubes, pipes, etc.	10 7	—	30 6	17 6	1½	30 1½	7 7½	3 1½	7 2½	Hand. Hand.
8	Experimental pallet van	Palletised goods	7 6	920	17 6	10 0	1	17 4½	7 5½	7 8½	11 10½	
9	24½-ton flat-bottom coal wagon	Minerals	10 2	1,029	21 6	12 0	1½	21 5½	7 11½	6 0½	9 11	Hand. Hand.
10	24½-ton hopper coal wagon	Minerals	9 16	1,029	21 6	12 0	1½	21 5½	7 11½	—	10 6	
11	16-ton mineral wagon	Minerals	7 12	648	16 6	9 0	1	16 5½	7 11½	4 11½	8 9½	Hand.
12	12-ton container wagon	Containers for fast freight trains	6 1	—	17 6	10 0	1	—	—	—	4 2	Vacuum, hand.
13	24-ton covered hopper wagon	Chemicals in bulk	10 13	1,241	21 6	10 6	1	23 0½	8 7	9 7½ (maximum)	12 2½	Hand.
14	13-ton soda-ash wagon	Soda ash	7 2	460	17 6	10 0	1	17 5½	7 11½	3 2½	Body 7 2½ Sheet supporter bar 9 8½	Hand.
15	20-ton bulk-grain wagon	Grain	9 15	1,200	21 6	10 6	1	21 5½	7 8	10 6½	12 4½	Hand.
16	13-ton shock absorbing wagon	Fragile goods	8 11	—	17 6	10 0	1	15 8	7 7½	3 1½	Body 7 3½ Sheet supporter bar 9 11½	Vacuum, hand.
17	13-ton high goods wagon	Potatoes, etc.	7 9	—	17 6	10 0	1	17 1½	7 7½	3 1½	Body 7 2 Sheet supporter bar 9 9½	Vacuum, hand.
18	13-ton high goods wagon (steel body)	General merchandise	7 5	—	17 6	10 0	1	17 5½	7 11½	3 2½	7 2½	Vacuum, hand.
19	42-ton bogie bolster wagon	Long loads, e.g., steel sections, rails	21 19	—	52 0	40 0 (bogie centres)	70 ft.	—	—	—	8 11½	Hand.
20	42-ton plate wagon	Steel plates	18 6	—	52 0	40 0 (bogie centres)	70 ft.	51 10½	8 0	1 0½	5 2½	Hand.
21	25-ton machine wagon	Wheeled, tracked vehicles, etc.	12 18	—	30 0	22 0	2	—	—	—	2 1½ (height of well)	Hand.
22	27-ton iron-ore tippler wagon	Iron ore	7 14	648	16 6	9 0	1	16 5½	7 11½	4 11½	8 9½	Hand.
23	Type BK furniture	Furniture	1 10½	718 (4 tons)	—	—	—	15 8½	6 7½	7 3½	—	—
24	Type A covered small	General merchandise	1 1½	329 (3 tons)	—	—	—	7 3½	6 7½	7 1½	—	—
25	Type L bulk materials	Cement, dolomite, limestone, etc.	0 11½	90 (4 tons)	—	—	—	4 6½	4 6½	4 6½	—	—
26	Type BD covered large	General merchandise	2 0	717 (4 tons)	—	—	—	15 8	6 7½	7 1½	—	—
27	Type BC covered (bicycles)	Bicycles	1 15	78 bicycles	—	—	—	15 8½	6 6½	7 5	—	—
28	Type AX highly insulated	Solid CO ₂ , dry ice	2 0	110 (3 tons)	—	—	—	5 1½	4 0	5 7	—	—
29	Type AF highly insulated	Ice-cream, quick-frozen foods, etc.	1 16	193 (3 tons)	—	—	—	5 10½	5 4½	6 1½	—	—
30	Type FM insulated	Frozen and chilled meat	2 3	600 (4 tons)	—	—	—	14 0½	6 1½	7 1½	—	—
31	Type BM ventilated	Fresh meat	2 3	737 (4 tons)	—	—	—	15 7	6 6½	7 7½	—	—
32	Type C (open)	Earthenware, grates, machinery	0 12	126 (3 tons)	—	—	—	7 3	6 0½	2 10½	—	—
33	Type D (open)	Machinery, castings, pipes, bricks, etc.	1 6	298 (4 tons)	—	—	—	13 9½	6 0½	3 7	—	—
34	Type H (open)	Bricks, slates, firebricks, earthenware, etc.	0 3½	42 (2½ tons)	—	—	—	6 9	3 9	1 9½	—	—

production. So far, 65 types of standard freight wagons have been built on British Railways.

The table is self-explanatory. Some additional information, relating to the sizes of door openings, etc., is given below, the reference numbers corresponding to those in the table. All wagons are four-wheeled vehicles unless otherwise stated below. The internal heights given in the table are normally measured to the highest point, i.e., at the centre of a curved roof. Side doors in wagons are invariably in the centre of the side; in cases where there are two doors per side they are arranged symmetrically.

(1) 20-Ton Freight-Train Brake Van.—Centre spaces of trussed underframe filled with concrete to give additional weight for braking. Clasp-type brakes, four blocks per wheel. Manganese-steel liners fitted to axles and axle-guards to prevent excessive wear.

(2) 14-Ton Interfrigo Ferry Van.—One of a fleet built to British Railways' loading gauge and operated by "Interfrigo"—an international railway-owned company for refrigerated transport, formed by the railway administrations of Western Europe, including British Railways. Floor, walls and roof insulated. Refrigeration is by water ice carried in two bunkers situated at each end of the wagon. Internal air is fed through the ice bunkers and circulated through the interior of the van by eight Flettner ventilators, which rotate when the vehicle

is in motion. Floor provided with wooden gratings. Doors at sides 4 ft. 3 in. wide by 6 ft. 1 in. high.

(3) 8-Ton Banana Van.—Insulated body; steam heating of contents. Hinged side doors with sealing gaskets; opening 5 ft. 0½ in. wide by 6 ft. 5 in. high. Drawgear with Instantan couplings.

(4) 12-Ton Insulated Fish Van.—Wooden floor covered with ½-in. felt and then a layer of asphalt 1½ in. thick at the sides sloping to ¾ in. at the centre. Two water-seal drains in the floor. Sliding doors, with flexible gaskets; opening 4 ft. 2 in. wide by 6 ft. 1½ in. high. Hooks in roof for suspending dry ice in slings. Drawgear with screw couplings.

(5) 12-Ton Covered Ventilated Van.—Body of timber, with steel ends; each end has hooded ventilator. Hinged doors each side; opening 5 ft. 0½ in. wide by 6 ft. 3½ in. high. Drawgear with Instantan couplings. (See ENGINEERING, vol. 172, page 493 (1951), for description and illustrations.)

(6) 8-Ton Cattle Wagon.—Provided with movable partition for dividing wagon, ensuring safety of animals when wagon is only partly loaded. Doors on each side in three parts, two upper parts hinged on stanchions; bottom part forms a ramp when lowered on its hinges. Size of door opening 4 ft. wide by 6 ft. 3½ in. high. Drawgear with screw couplings.

(7) 22-Ton Tube Wagon (Open).—Body of timber

construction with timber-lined steel ends. One door each side, hinged at bottom edge; opening 4 ft. 9 in. wide. Drawgear with three-link couplings.

(8) Experimental Pallet Van.—Experimental van to encourage through-transit of palletised goods by rail. Sliding doors giving exceptionally wide openings—8 ft. 6 in.—by 6 ft. 4½ in. high. Strong floor capable of bearing combined weight of pallet truck (or fork truck) and loaded pallet. Packing shields used between pallet loads when stowing to preserve shape of load in transit, thus facilitating unloading by pallet or fork truck at destination. Special ramps are needed to enable the truck to enter the rail vehicle from platform level, especially when the difference in level exceeds 2 in.

(9) 24½-Ton Flat-Bottom Coal Wagon.—New standard. All-steel welded construction, body plates of low-alloy high-tensile steel to reduce weight and corrosion. One end door and four side doors, two on each side. Each side door in two parts: shallow drop door at top, 3 ft. 8½ in. wide by 1 ft. 11½ in. high; deeper drop door at bottom, 3 ft. 8½ in. wide by 2 ft. 10½ in. high. Body side stanchions designed to present flat faces to beams of wagon tipplers. Drawgear with three-link couplings. There is also an alternative design with riveted frame and body.

(10) 24½-Ton Hopper Coal Wagon.—New British Railways standard hopped mineral wagon. All-

steel welded construction, body plates of low-alloy high-tensile steel to reduce weight and corrosion. Body is hoppers, with two hinged doors which discharge the contents between the rails; doors actuated from either side of wagon. Drawgear with three-link couplings.

(11) *16-Ton Mineral Wagon*.—Underframe and body of welded or riveted construction. Top-hinged door at one end for tippler discharge. Two flap doors on each side, one above the other; top doors, being shallow (10½ in. high by 3 ft. 8½ in. wide), facilitate the bagging of coal; bottom doors 2 ft. 10½ in. high by 4 ft. 0½ in. wide. Drawgear with three-link couplings.

(12) *12-Ton Container Wagon*.—Flat wagon for conveying containers by fast freight train. Hardwood rail, 2½ in. deep, around ends and sides. Container held by four binding chains attached to hooks on curb rail. Chains consist of a hook, 2 ft. 8½ in. of chain, a binding screw for tightening, and a spring-loaded shock absorber. Drawgear with Instantan couplings.

(13) *24-Ton Covered Hopper Wagon*.—Welded-steel body with two hinged doors in roof for loading, to which access is obtained by a cat-walk; size of each opening, 2 ft. 6 in. wide by 7 ft. long. Body is hoppers for discharging between rails through four outlets with sliding doors operated separately by removable handles. To assist discharge of certain chemicals, some vehicles are fitted to take vibrators. Drawgear with three-link couplings.

(14) *13-Ton Soda-Ash Open Wagon*.—All-welded mild-steel body. Flap doors on each side give openings 4 ft. 9 in. wide. Doors when closed are rendered leakproof by rubber seals under pressure of turn-screws. Sheet-supporting bar provided. Drawgear with three-link coupling.

(15) *20-Ton Bulk-Grain Wagon*.—Welded-steel body; two sliding doors in roof for loading, each giving opening 2 ft. 9½ in. wide by 2 ft. 11½ in. long. Hoppers for discharge by gravity between rails through single outlet 1 ft. 3 in. square; sliding door operated by wheel on side of vehicle. Small side door for inspection also provided. Ladder at each end for access to roof doors.

(16) *13-Ton Shock-Absorbing Open Wagon*.—Body free to slide on underframe; its movement controlled by springs on each side, which absorb transit shocks. Body of timber, with ends of pressed steel lined with timber. Flap door on each side, giving opening 4 ft. 11 in. wide. Tubular sheet-supporting bar pivoted on the outside at ends. Drawgear with Instantan couplings.

(17) *13-Ton High Open Goods Wagon*.—Alternative to steel-bodied open wagon, suitable for potatoes and other vegetables likely to be affected by abnormally low temperatures. Body of timber with ends of pressed steel lined with timber. Flap door on each side giving opening 4 ft. 11 in. wide. Tubular sheet-supporting bar pivoted on the outside at ends. Drawgear with Instantan couplings. [The standard 13-ton medium goods wagon and 13-ton low goods wagon were described and illustrated in *ENGINEERING*, vol. 173, page 602 (1952).]

(18) *13-Ton High Open Goods Wagon (Steel Body)*.—Body of all-welded construction, with steel-tube capping along upper edges to prevent damage to sheets. Timber floor. Rings for securing loads are fitted in dished recesses in sides and ends, about two-thirds the way up sides. Door of chequered plate on each side, hinged at bottom, affording foothold during loading and unloading. Doorway 4 ft. 9 in. wide. Drawgear with Instantan couplings.

(19) *42-Ton Bogie Bolster Wagon*.—Two four-wheeled bogies. Trussed underframe with timber floor, boards spaced ½ in. apart for drainage. Sides and ends of steel, 7½ in. above floor. Five fabricated steel and timber bolsters; centre three are fixed, end ones adjustable to suit load. Each bolster has two side stanchions 3 ft. 3 in. high, which can be adjusted to give four varying widths between them from 2 ft. 11 in. to 7 ft. 3 in.

(20) *42-Ton Plate Wagon*.—Two four-wheeled diamond-frame bogies, each of 5 ft. 6 in. wheelbase. Body of timber, with fixed steel ends. Each side in form of two hinged drop doors, running full length of wagon and secured to stanchion at centre of each side; stanchion can be dropped with the doors, leaving side completely open.

(21) *25-Ton Machine Wagon*.—For wheeled or tracked vehicles, agricultural machines, excavators, etc. A well, 2 ft. 1½ in. above rail level and 16 ft. long, permits plant of abnormal height to be carried. The wagon top slopes upward at each end of the well, forming ramps, so that vehicles can be loaded or unloaded from a loading bank on their own wheels. Wooden floor. Three-link couplings.

(22) *27-Ton Iron-Ore Open Tippler Wagon*.—Body of all-welded construction; no doors, flush interior. Four brake blocks per wheel. Drawgear with three-link couplings.

CONTAINERS.

(23) *Type BK Furniture Container (Covered)*.—Fitted with wall battens for securing furniture. Doors at end.

(24) *Type A Covered Small Container*.—Doors at end.

(25) *Type L Bulk-Materials Container*.—Loading hatch at top, operating in minimum headroom. Two large hopper doors underneath, controlled separately by handwheels.

(26) *Type BD Covered Large Container*.—Some of these are equipped with special fittings for conveyance of special traffics, e.g., shelves for bread, hanging bars for clothing, and racks for confectionery.

(27) *Type BC Covered (Bicycle) Container*.—Fitted with wooden racks to hold 78 bicycles, in two tiers.

(28) *Type AX Highly-Insulated Container*.—Insulation maintains temperature of -110 deg. F. Loading hatches in roof.

(29) *Type AF Highly-Insulated Container*.—Rubber-sealed floating floor to reduce heat loss to minimum. Roof hooks for hanging refrigerant. Commodity temperatures of -15 deg. F. can be maintained during 24 hours transit, but normal range is between 5 deg. and 10 deg. F. Some of this type are fitted with eutectic plates which, when precooled at sender's premises, maintain a temperature in container of -6 deg. F. for 24 hours.

(30) *Type FM Insulated Container*.—Hanging facilities for chilled meat: 8 bars, 6 single swivel hooks per bar.

(31) *Type BM Ventilated Container*.—Two ventilators each side and end. Hanging facilities: 11 bars, 7 double hooks per bar.

(32) *Type C Open Container*.—Flap door each end.

(33) *Type D Open Container*.—One end door and two side doors. Some are fitted with rubber cushions for conveying baths.

(34) *Type H Open Container*.—One end door. Convenient for lifting by crane to upper floors of buildings under construction.

LAUNCHES AND TRIAL TRIPS.

M.S. "CLYDEFIELD."—Single-screw oil tanker, built and engined by Harland and Wolff, Ltd., Govan, Glasgow, for Hunting & Son, Ltd., Newcastle-upon-Tyne. Main dimensions: 515 ft. between perpendiculars by 70 ft. by 37 ft. 9 in.; deadweight capacity, about 16,500 tons. Harland-B. and W. six-cylinder two-stroke single-acting oil engine. Trial trip, January 19, 20 and 21.

S.S. "CORMOOR."—Single-screw collier, built by Hall, Russell & Co., Ltd., Aberdeen, for Wm. Cory & Son, Ltd., London, E.C.3. Main dimensions: 320 ft. between perpendiculars by 46 ft. by 22 ft. 4 in. Direct-acting triple-expansion reheat steam engine, developing 1,100 h.p. in service, and two cylindrical forced-draught boilers, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Sunderland. Launch, January 20.

M.S. "IMPERIAL TRANSPORT."—Single-screw oil tanker, built by the Greenock Dockyard Co., Ltd., Greenock, for the Empire Transport Co., Ltd., London, E.C.3. Main dimensions: 512 ft. between perpendiculars by 69 ft. by 38 ft. 6 in. to upper deck; gross tonnage, 11,365; deadweight capacity, 16,550 tons on a mean draught of 29 ft. 10 in. Vickers-Doxford five-cylinder opposed-piston heavy-oil engine, developing 5,500 b.h.p. at 115 r.p.m. in service, constructed by Vickers-Armstrongs Ltd., Barrow-in-Furness; and installed by Rankin and Blackmore, Ltd., Greenock. Speed, 13½ knots. Trial trip, January 27 and 28.

M.S. "BEN LUL."—Single-screw trawler, built and engined by John Lewis & Sons, Ltd., Aberdeen, for Richard Irvin & Sons, Ltd., Aberdeen. Main dimensions: 166 ft. overall by 28 ft. by 15 ft. 3 in. Lewis-Doxford three-cylinder opposed-piston oil engine, developing 750 b.h.p. at 145 r.p.m. Launch, January 29.

NOTES ON NEW BOOKS.

Practical Calculus.

By C. I. PALMER and CLAUDE E. STOUT. Revised second edition. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York, U.S.A. [Price 6.00 dols.]; and the McGraw-Hill Publishing Company, Limited, 95, Farringdon-street, London, E.C.4. [Price 51s. 0d.]

THIS is an introductory manual to the calculus, written for the benefit of engineering students—not mathematicians—and which advances to a standard approaching that of Part I of the degree examination in engineering at the University of London. The subject matter covered is typical of this class of book and includes chapters on limits, derivatives, curves and their equations, maxima and minima, differentiation and integration of trigonometrical, logarithmic and exponential functions, chapters on the various applications to be found in mechanics, and brief mention of expansions into series. In keeping with American practice, the book concludes with an appendix that attempts to summarise all the formulae in the book and to give an exhaustive list of standard cases of differentiation and integration.

Lubricants and Lubrication.

Selected Government Research Reports, Vol. 11. H.M. Stationery Office, York House, Kingsway, London, W.C.2. [Price 35s. net.; by post, 35s. 6d.]

THE 19 research reports which form the basis of this volume—the qualification appears to be appropriate, since each is described as being "based on" some Technical Note or Report—cover a number of miscellaneous investigations which were undertaken at various times under the direction of the Ministries of Supply and Aircraft Production, now combined in the Ministry of Supply. They have been selected and arranged by the Technical Information and Documents Unit of the Department of Scientific and Industrial Research, and range from the lubrication of machinery to that of optical and other instruments. The subjects dealt with include the prevention of aeration in engine lubricating oil, the dilution of oil for use at low temperatures, the lubrication of clockwork mechanisms, the prevention of pivot-rust in air-driven gyroscopic instruments, and the properties of greases for use at temperatures from -65 to 100 deg. C. An associated research, also described, is the application of the moving-plate viscometer to the study of the flow properties of pastes and the sedimentation and caking of particles in suspension. The use of anti-spreading dopes for preventing the spreading of oil from instrument bearings is another subject of interest to specialists, on which information is not generally available elsewhere.

Corrosion Testing Procedures.

By Dr. F. A. CHAMPION. Chapman and Hall, Ltd., 37, Essex-street, Strand, London, W.C.2. [Price 36s. net.]

THE procedures described in this book are intended mainly for investigators concerned with practical problems in the corrosion of metals in service and the production of materials of adequate corrosion resistance for a particular purpose. Much of the information given, however, will also interest persons engaged in fundamental research. The arrangement of the book is logical, the choice and preparation of the metal and corrosive media are dealt with first; then follow data on laboratory, field and service tests. The cleaning of the specimens preparatory to examination is next described and much space is subsequently devoted to the assessment of the effects of corrosion, and the expression and interpretation of results. The long lists of references at the end of each chapter indicate that the author has diligently searched published work and made full use of the information it contains. The style is clear and pleasant to read and the numerous line drawings and half-tone illustrations of apparatus contain many valuable hints on the construction and arrangement of equipment. The author and subject indexes appear to be adequate.

BOOKS RECEIVED.

Parliament of New South Wales. Report of the Department of Local Government for the Period 1st July, 1940, to 30th June, 1951. The Department of Local Government, Sydney, New South Wales, Australia. [Price 8s.]

Higher Industrial Production with Electricity. British Electrical Development Association, 2, Savoy-hill, London, W.C.2. [Price 9s. post free.]

Scale of Charges for Consulting Structural Engineers. The Institution of Structural Engineers, 11, Upper Belgrave-street, London, S.W.1. [Price 1s. 3d.]

Problems in Hydraulics. By R. S. PARADISE. Blackie and Son, Limited, 17, Stanhope-street, Glasgow, C.4. [Price 17s. 6d.]

The High-Speed Internal Combustion Engine. By SIR HARRY R. RICARDO. Fourth edition. Blackie and Son, Limited, 17, Stanhope-street, Glasgow, C.4. [Price 40s.]

A Work Study Glossary. The Institute of Economic Engineering, 28, Victoria-street, London, S.W.1. [Price 2s. 6d.]

Principles of Aerodynamics. By PROFESSOR DANIEL O. DOMMASCH. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 45s. net.]

Solution of Problems in Strength of Materials. By S. A. URRY. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 20s. net.]

Handbuch für Stahlbetonbau. Vol. IV. Part I. Die bodenphysikalischen Grundlagen. Stützmauern. Fifth edition. By DR.-ING. OTTO MUND. Edited by DIPL.-ING. HANS SCHRÖDER. Wilhelm Ernst und Sohn, Hohenzollerndamm 169, Berlin-Wilmersdorf, Germany. [Price 27 D.M. in paper covers, 31 D.M. bound]; and Lange, Maxwell and Springer, Limited, 41-45, Neal-street, London, W.C.2. [Price 47s. 3d. in paper covers, 54s. 3d. bound.]

Ohio State University. Engineering Experiment Station. Bulletin No. 149. Proceedings of the Second Mid-western Conference on Fluid Mechanics, 1952. Held at the Ohio State University, March 17-19. The Director, Engineering Experiment Station, Ohio State University, Columbus, Ohio. [Price 6 dols.]

CONTRACTS.

The PENARTH PONTOON, SLIPWAY AND SLIP REPAIRING CO., LTD., Penarth Docks, Cardiff, have secured a contract from British Railways, Western Region, for work in connection with the annual overhaul of the S.S. St. David.

TAYLOR WOODROW CONSTRUCTION LTD., 10, Park-street, London, W.1, have been awarded a contract for the superstructure of a new nine-storeyed air-traffic control building at London Airport. The work will be carried out under the Air Ministry Works Directorate for the Ministry of Civil Aviation.

MIRPLEES, BICKERTON AND DAY LTD., Stockport, have received an order valued at upwards of 200,000l., in connection with a new power station to be built at Ashford, Kent, by the British Electricity Authority. It is for five 2,000-kW generating sets, each driven by a Mirplees KVSS-12 engine developing 2,900 b.h.p., and capable of running on low-grade fuel oil. The engines will be direct coupled to alternators supplied by the BRUSH ELECTRICAL ENGINEERING CO., LTD., and having an output of 2,500 kVA at 6,600 V and 428 r.p.m.

THE GENERAL ELECTRIC CO., LTD., Magnet House, Kingsway, London, W.C.2, have received the order for the complete lighting installation in the 28,000-ton passenger liner Arcadia, now being built by JOHN BROWN & CO. LTD., Clydebank, for the Peninsular and Oriental Steam Navigation Co. Ltd. Cold and hot cathode fluorescent and tungsten lighting will be employed in the scheme. Plural starting equipment, a 600-line manual and 200-line automatic telephone installation, and a luminous call system are also being supplied.

HEENAN AND FROUDE, LTD., Worcester, have recently dispatched to A. V. Roe, Ltd., Canada, four of their hydraulic dynamometers (DPX 345), for use in the development of gas-turbine aircraft engines. Each machine is fitted with the firm's system of hydraulically-operated remote weighing gear to enable readings of power to be taken inside a sound-proof control cabin some distance from the engines under test.

The steel processing plant required for a new Spanish steelworks, the Empresa Nacional Siderurgica, at Aviles, in the Asturias, is to be supplied by British firms. DAVY AND UNITED ENGINEERING CO., LTD. Sheffield, are to supply all the rolling-mill equipment. That now being built consists of a 42-in. reversing slabbing and blooming mill feeding a three-stand structural mill. The 7,000-h.p. motors for the blooming mill and two 6,700-h.p. motors for the section mill will be supplied by the ENGLISH ELECTRIC CO., LTD.

SURFACE GRINDER.

ARTHUR SCRIVENER, LTD., BIRMINGHAM.

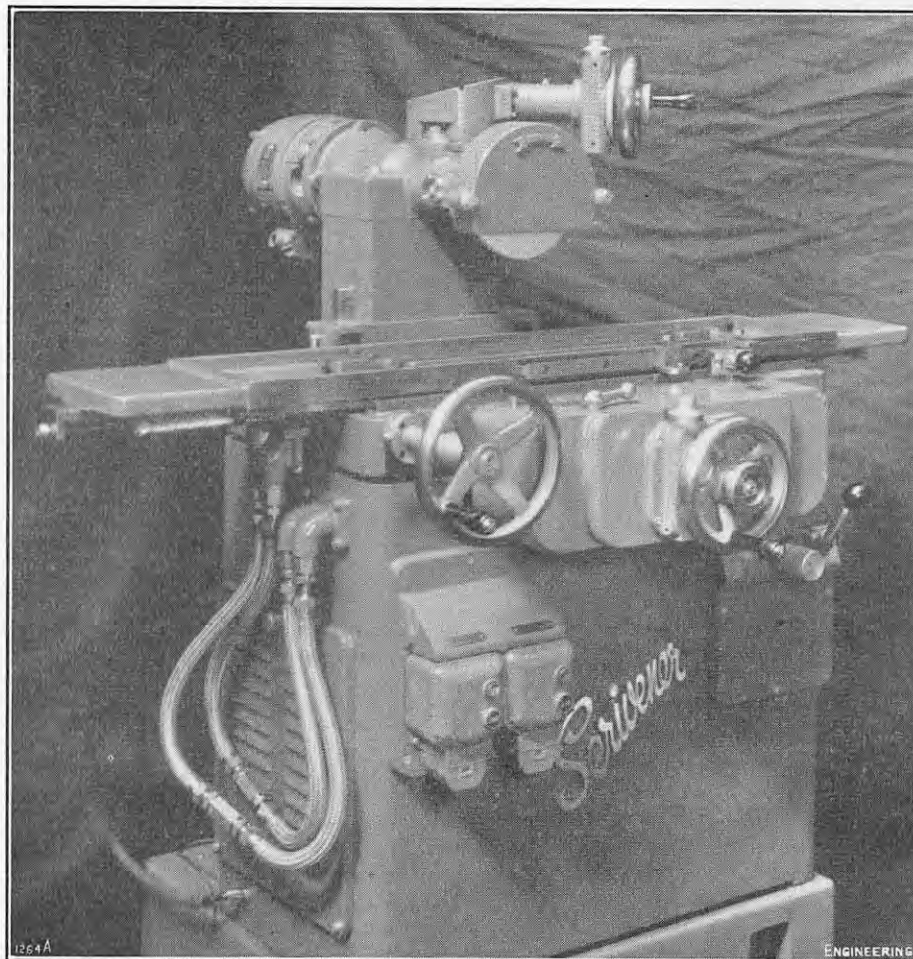


FIG. 1. GENERAL VIEW OF MACHINE.

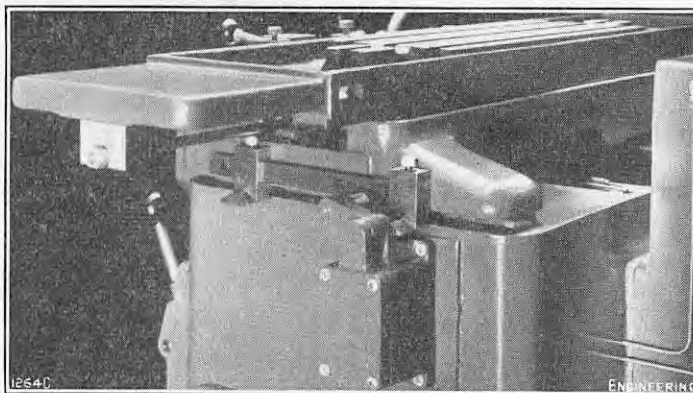
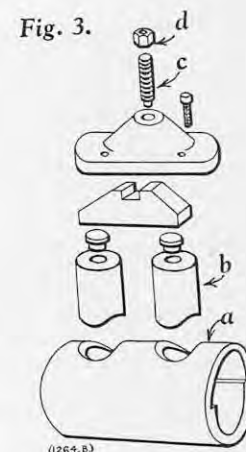


FIG. 2. CROSS-FEED TRIPS FOR SADDLE.



SURFACE GRINDER.

A RECENT addition to the range of surface grinders made by Messrs. Arthur Scrivener, Limited, Tyburn-road, Birmingham, is the "Scrivener No. 1 Super Surface Grinder," illustrated in Figs. 1 and 2, herewith, which has a table measuring 6 in. by 18 in. and a grinding wheel 7 in. in diameter and $\frac{1}{2}$ in. thick, running at 2,800 r.p.m. The height from the top of the table to the wheel is 10 in., the longitudinal travel of the table is 19 in., and the transverse movement of the saddle is 6 $\frac{3}{4}$ in. The machine weighs 30 cwt. and occupies a floor space of 6 ft. by 3 ft. 6 in. It consists of two main castings, the lower of which is the base and carries the hydraulic pump and motor unit, while the upper casting is the bed for the table. The main spindle is of Nitralloy, 1 $\frac{1}{8}$ in. in diameter, mounted in plain bearings and running in an oil bath. Fig. 3 shows one of the two plain bearings; the

shaft bears on the full length of the lower half of *a* and is held by the two top half-bearings *b*. The screw *c* is screwed through the bearing housing to hold the unit in position, and is secured by the lock-nut *d*. The table feed can be operated either by hand or hydraulically, and a valve gear is fitted which ensures a smooth reversal at the end of the travel and a controlled table speed up to a maximum of 66 ft. per minute. The cross feed is manual or automatic, the feed in the latter case being controlled by a single handle giving forward or reverse feeds and disengagement, and also being provided with trips, as shown in Fig. 2. The large handwheel to the left in Fig. 1 is the cross-feed hand control, and is calibrated in 0.001-in. divisions, with a micrometer feed giving directly-read increments of 0.0001 in. The handwheel controlling the up and down adjustment of the grinding wheel gives fine adjustment up to 0.0001 in. Lubrication of the moving faces is by a one-shot lubricator at the rear of the machine.