HIGH-PRESSURE STEAM GENERATORS AT THE DIEPPEDALLE POWER STATION, FRANCE.

At the Dieppedalle power station of the Electricité de France, steam is provided for two 50-MW turbo-alternators by four "monotube" steam generators built by Sulzer Brothers, Limited, Winterthur, Switzerland. The steam is supplied at 1,200 lb. per square inch and 960 deg. F., and the steam generators are designed to burn either oil or pulverised coal. The turbines, condensers, extraction-steam preheaters and evaporators were supplied by Escher Wyss, Zürich, and th ealternators and other electrical equipment by Ateliers de Construction Oerlikon, Zürich. Sulzer Brothers, to whom we are indebted for the information contained in this article, were also responsible for the planning and supply of the boiler plant, including the feed pumps, the high-pressure pipes and fittings and the pressure tanks.

It was decided in 1946, as part of the scheme for extending France's electric-generating capacity, to erect a new high-pressure steam power station in the vicinity of Rouen. Work was commenced at once, and the station, which is shown in Fig. 1, is now able to take a load of 100,000 kW. The first part of the station, with a capacity of 50,000 kW, was completed in October, 1949, and was followed by a second section with an equal output early in 1951.* The location of the station on the banks of the Seine, as shown in Fig. 2, greatly simplifies fuel transport, ash disposal and cooling-water supply. The selection of a site near the 220-kV interconnecting station of La Vaupaliere was also a very favourable feature for the supply of electricity to the French grid. The station is intended primarily for base-load duties as part of the 220-kV system of the Electricitè de France. It must also be able, in case of need, to feed a separate system and to take over frequency control. The plant must be able to burn coal or oil to ensure optimum economy of power production and adaptability to conditions on the fuel market. Up to the present, the boilers have been operated exclusively on oil fuel.

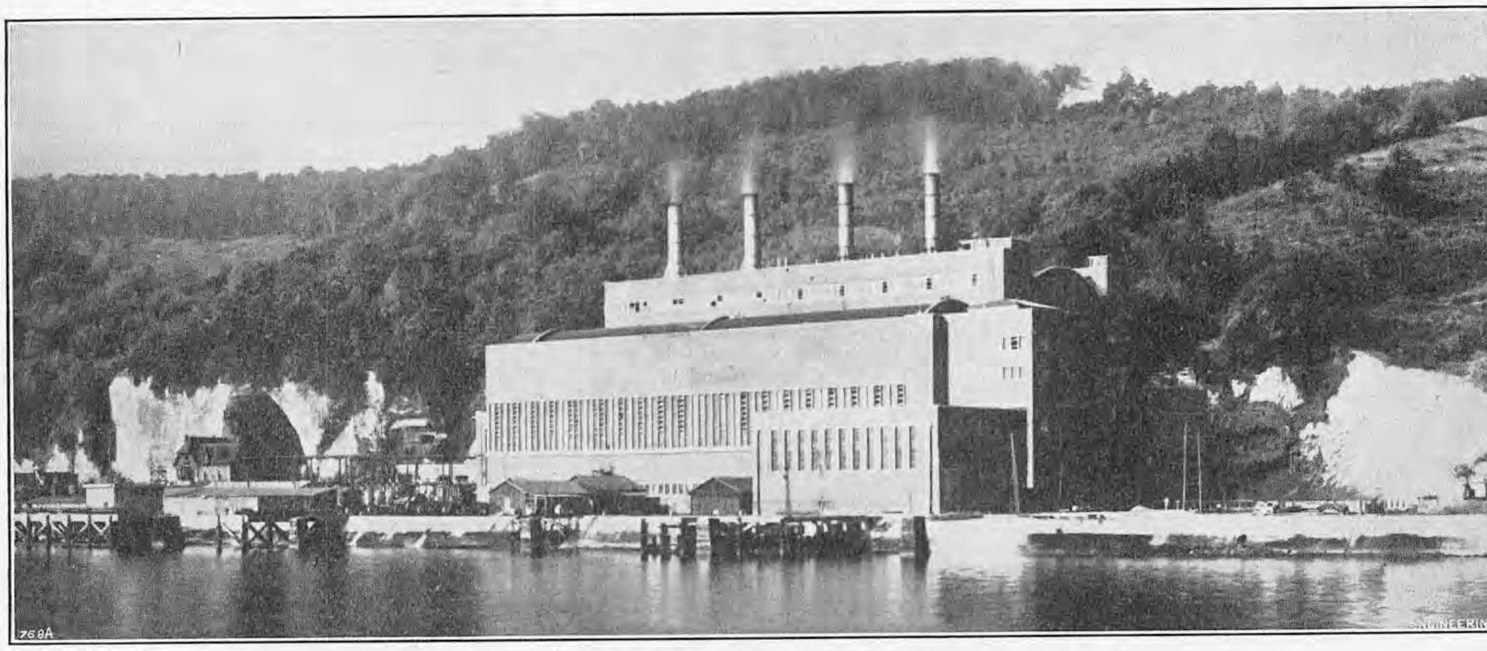


Fig. 1. View of Power Station from River Seine.

Fig. 2. LOCATION OF STATION.

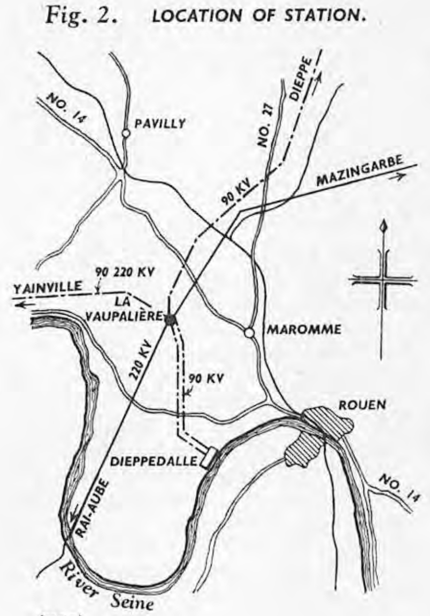
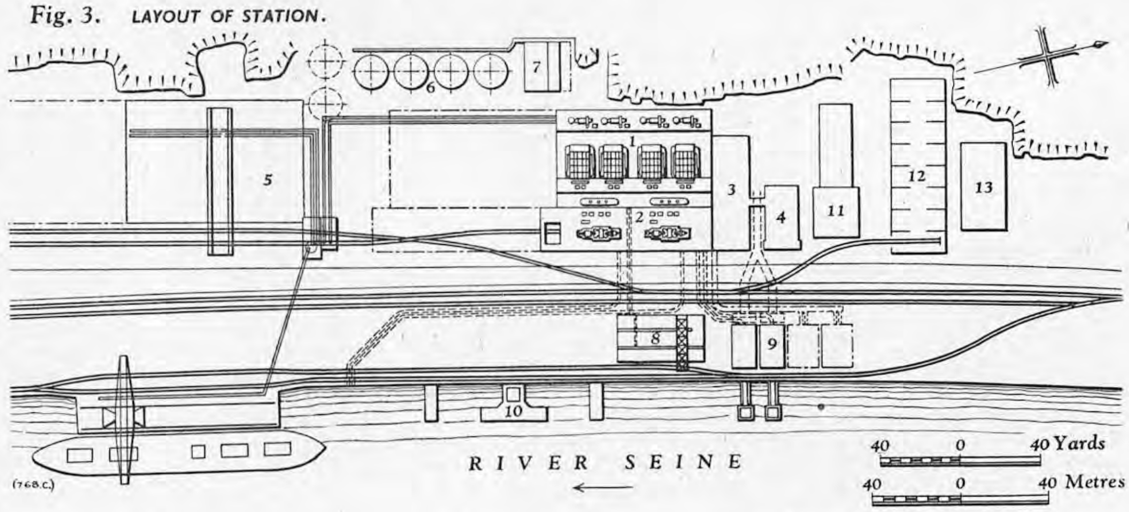


Fig. 3. LAYOUT OF STATION.



1 Boiler-house.
2 Turbine hall.
3 16·5-kV Switchgear.
4 Administration building.
5 Coal-storage yards.
6 Oil tanks.
7 Water-purifying plant.
8 Ash-settling tank.
9 Pumping station.
10 Wharf.
11 Workshops and stores.
12, 13 Switching and distributing station.

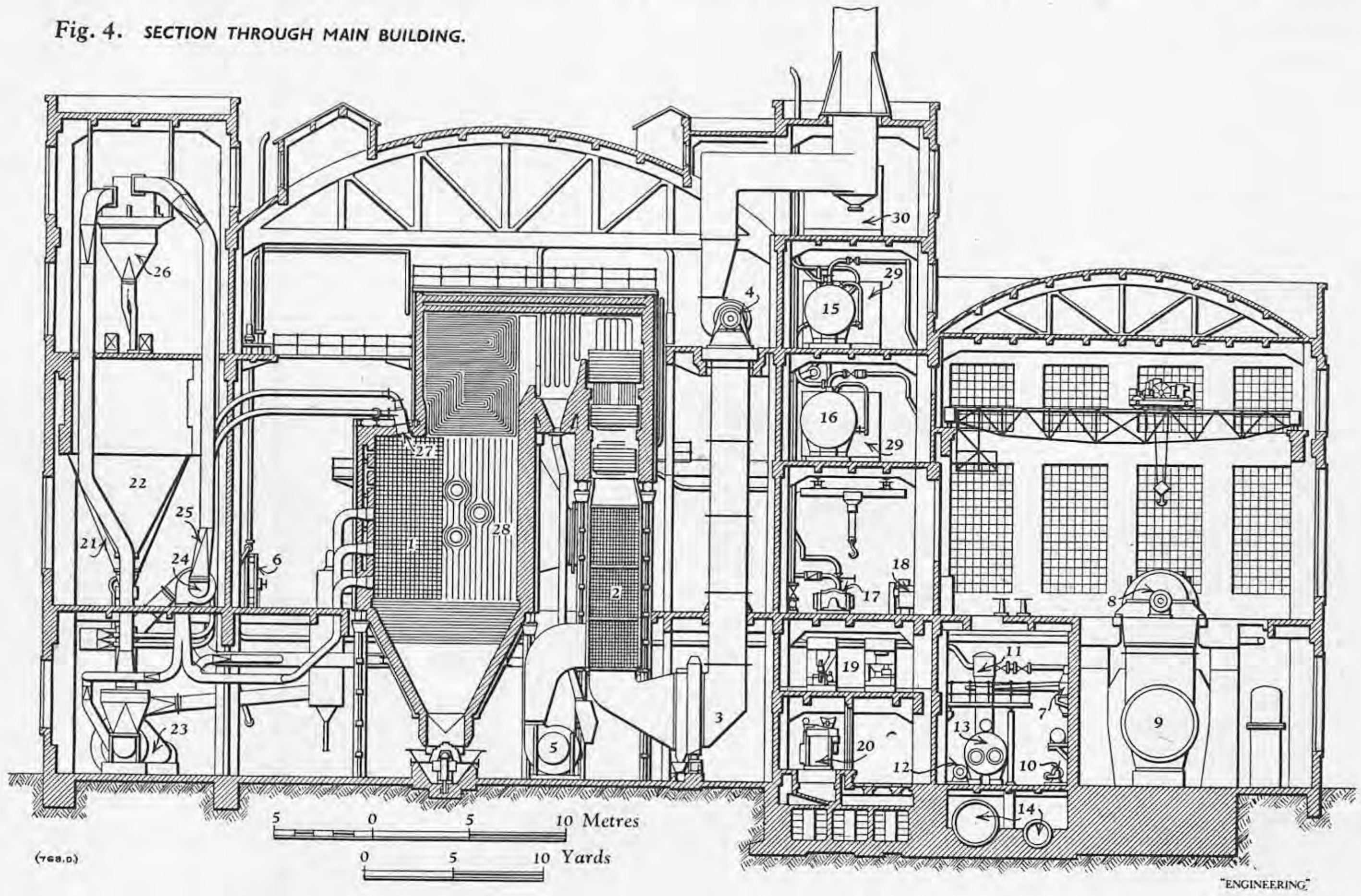
The general layout of the station is shown in Fig. 3. The main building (1) and (2), alongside which space has been left for an extension permitting the output of the plant to be doubled, is flanked on one side by the coal storage yard (5) and on the other by the switchgear and distributing stations (12) and (13). The cooling-water pump-house (9) stands close to the river's edge, with the settling tanks (8) of the ash-disposal plant beside it. To the rear of the space reserved for extension, at the foot of a hill, are the tanks (6), containing fuel oil, and the water-purifying plant (7). The power-station building is of reinforced concrete faced with brick. It consists of the boiler-house (1) and the turbine hall (2), which are connected by a bay housing the auxiliary equipment. The coal bunkers and pulverising mills are located in an adjoining section extending along the back of the station.

A cross-section of the main plant is shown in detail in Fig. 4, on page 386. The four Sulzer monotube steam generators (1), all of the same output, are arranged in line in the boiler-house, where fans (4) and (5) and dust collectors (3) are also situated. The boiler-control instruments are centralised on panels (6), while the main control equipment is also concentrated in central stations in front of each boiler. The turbo-alternator sets (8) are installed parallel to the axis of the building in the spacious turbine hall. The same hall accommodates the condensers (9), which are situated below the turbo-alternators, the various condensate pumps (10) and (12), the extraction steam pre-heaters (11) and the evaporator plant (13). The heavy tanks, such as the starting reservoir (15), the variable-pressure accumulator (16) and the condensate and raw-water tanks (29) and (30) are all situated in the narrow intermediate section of the building. (The functions of the starting reservoir and variable-pressure accumulator are described later, in connection with the system of operation.) The feed pumps (17), together with their switchgear and control equipment (18), are

* See also the following French publications: J. Bellisson, "La centrale de Dieppedalle et son réglage automatique," *Energie*, pages 185 and 217 (1948); J. Bellisson, "La centrale thermique de Dieppedalle," *L'Orientation technique*, page 149 (1950); J. Bellisson, "La centrale électrique de Dieppedalle," *La revue de Rouen*, No. 22 (vol. 3), page 18.

HIGH-PRESSURE STEAM POWER STATION ON THE RIVER SEINE.

Fig. 4. SECTION THROUGH MAIN BUILDING.



1 Sulzer monotube boiler for 175,000-230,000 lb. per hour.
2 Air preheaters.
3 Dust collector.
4 Induced-draught fan.
5 Forced-draught fan.
6 Automatic boiler-control panels.
7 Water separator before turbine.
8 Turbo-alternators of 40-50 MW.
9 Condenser.
10 Condensate pump.
11 Extraction-steam preheater.
12 Medium-lift pump.
13 Evaporator.
14 Cooling-water pipes to condenser.
15 Starting reservoir.
16 Variable-pressure accumulator.
17 Feed pumps.
18 Rheostats of feed-pump motors.
19 Switchgear for auxiliary units.
20 16·5/3 kV transformers for auxiliary drives.
21 Raw-coal bunker.
22 Pulverised-coal bunker.
23 Pulverising mills.
24 } 25 } Fans for mill air and primary air.
26 Pulverised-coal collector.
27 Pulverised-coal burner.
28 Oil burner.
29 Condensate tanks.
30 Raw-water tanks.

installed on a level with the boiler-control station and the floor of the turbine hall. The basement of this part of the building houses the electrical auxiliary equipment; in particular, the transformers for supplying current to the auxiliary machinery. The adjoining bunker section, with the bunkers (21) and (22) for raw and pulverised coal, also accommodates the pulverising mills (23) with their fans (24) and (25) and the coal-dust collector (26).

System of Operation.

The power station has two identical generating sets (shown in Fig. 13, Plate XVIII), which are, however, completely separate. Each pair of steam generators is connected to a 50,000-kW turbine. There are no transverse steam or water connections of any kind between the two sets. As the electrical auxiliaries are also fed from two separate mains, the arrangement gives completely independent operation for the two sets, so that faults cannot be transmitted from one to the other. The method of operation of a complete unit is shown in the diagram, Fig. 5, opposite.

One of the two high-pressure feed pumps (1) supplies the feed water from the starting reservoir (14) to the first economiser (2) and thence, by way of the feed-regulating station (4), to the steam generator. The live steam leaving the latter at 1,200 lb. per square inch and 960 deg. F., flows through the pressure-regulating and steam-outlet valve (12) and the water separator (17) to the turbine (19). After the steam has expanded in the turbine it passes to the condenser (20). The condensate then passes to the condensate pumps (21), which deliver it through the coolers of the steam-jet ejectors (22) and the first three feed-water preheaters (23), (24) and (25) to the medium-pressure pumps (28), whence it is delivered by way of the last two preheaters (26) and (27) to the starting reservoir, which is illustrated in Fig. 12, Plate XVIII. The pressure in this reservoir is normally about 275 lb. per square inch. During starting-up and shutting-down of the boilers, the steam-outlet valve (12) is closed, and the steam from the boiler is led back into the starting reservoir (14) through the by-pass valve (13). Should the pressure in the starting reservoir rise temporarily above a certain fixed limit as a result of this steam supply, the excess steam is automatically discharged into the condenser (20) by the blow-off valve (15). To protect the condenser from excessive steam temperatures, the steam is first expanded in a special apparatus, while it is cooled by the injection of water also taken from the starting reservoir through an automatic valve (16). The condensate is preheated to a normal temperature of 410 deg. F., corresponding to the pressure in the starting reservoir, the heat required for this purpose being taken from the turbine at various stages.

The make-up feed water is prepared in evaporators (31), which are heated with steam from the second tapping point of the turbine. Temporary fluctuations in feed-water requirements are equalised by means of the starting reservoir (14). Two tanks (33), each with a capacity of 3,500 cub. ft., are also available. These each have a steam "cushion" and are used for storing a large reserve of condensate. The steam required for fuel preheating is generated in a heat-exchanger (32), which is normally heated with steam from the first tapping point of the turbine, or in special cases with saturated steam from the starting reservoir. The variable-pressure accumulator (34) is connected to the live-steam pipe through an automatic charging valve (35), and discharges, in case of need, through the automatic valve (36) into the connecting pipe between the high-pressure and low-pressure sides of the turbine. The pressure range of the accumulator is chosen so that the temperature of the accumulator steam is never far removed from the temperature of the superheated steam leaving the high-pressure stage of the turbine. Steam extraction from the accumulator is controlled by the turbine governor (18) and valve (36).

Steam Generators.

The four steam generators are designed for a normal output of 175,000 lb. per hour each, which is approximately their most economical load, and for a maximum continuous output of 230,000 lb. per hour. The general arrangement of these boilers is shown in Fig. 4, and the direction of flow of the steam and water is indicated in Fig. 5. The feed water supplied by the pumps (1) flows through the first economiser nest (2), the feed-regulating station (4) and the additional economiser nests (3) into the evaporator (5) arranged in the furnace. The steam produced here passes through the water separator (7), the contact and radiation superheaters (9) and (11) and finally leaves the boiler through pressure-regulating valves (12) and (13).

The fuel is introduced into the combustion chamber through pulverised-coal burners (27) or oil burners (28) (Fig. 4), being mixed for this purpose with the air delivered by the forced-draught fan (5), which has been preliminarily heated in the air heater (2). The flue gases leaving the furnace pass through the contact superheater, the three economiser nests and the gilled-tube air preheater (2). They are next cleaned in a dust collector (3) and are then delivered into the chimney by the induced-draught fan (4). The combustion chamber (1) had to be designed to burn either non-caking coal, with only 10 to 12 per cent. volatile constituents, or fuel oil. To suit this grade of coal, a combustion chamber with a U-shaped flame path was chosen, as this enables the dimensions of the chamber to be kept within moderate limits in spite of the considerable length of the flame and the thorough combustion. In these circumstances, the front

HIGH-PRESSURE GENERATORS AT DIEPPEDALLE POWER STATION.

SULZER BROTHERS, LIMITED, WINTERTHUR, SWITZERLAND.

(For Description, see Page 385.)

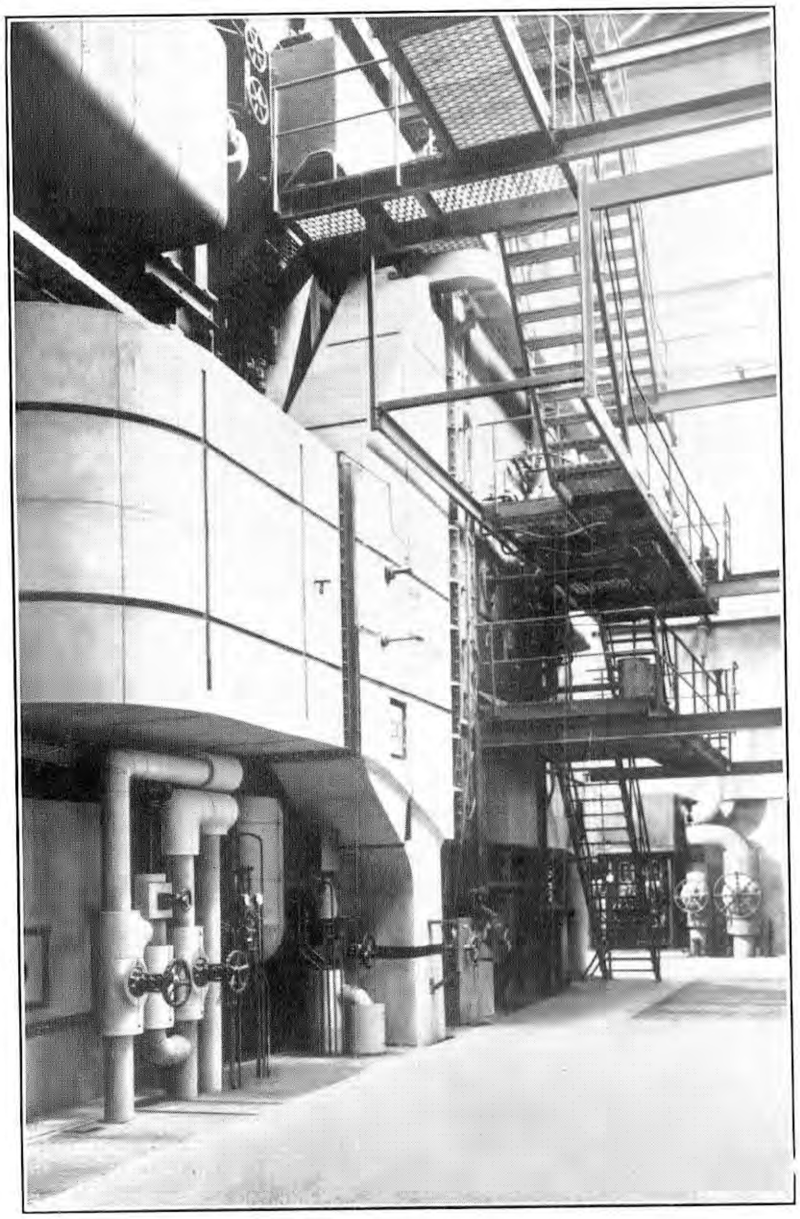


FIG. 6. PART OF STEAM-GENERATOR.

FIG. 7. INTERIOR OF COMBUSTION CHAMBER.

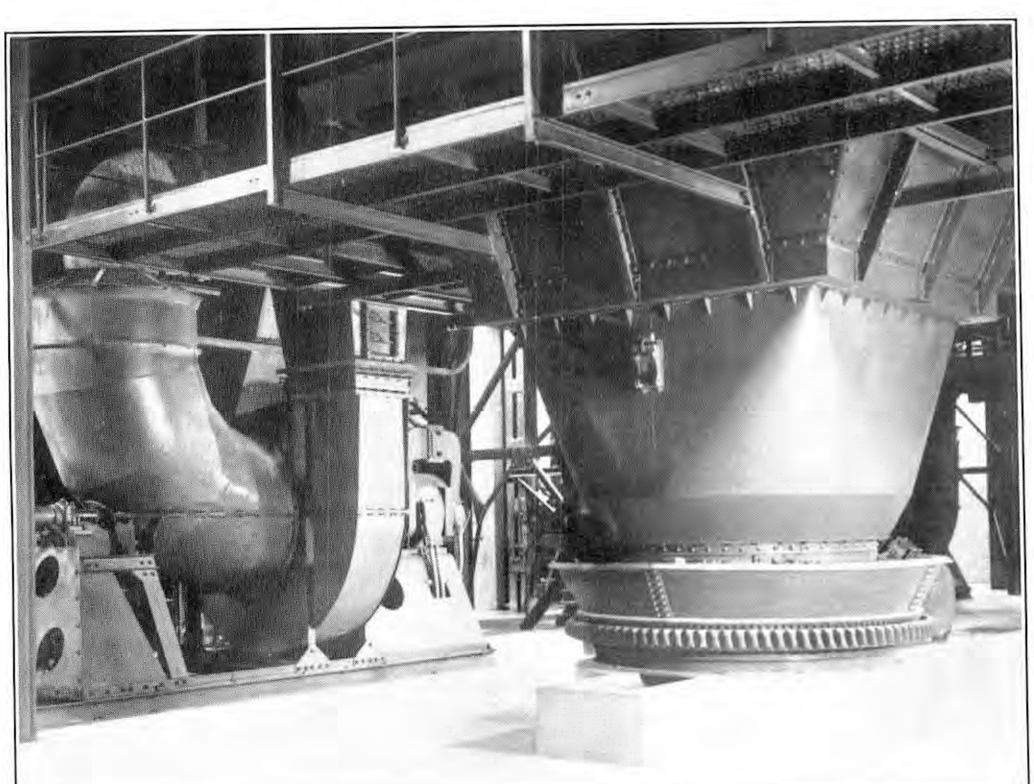


FIG. 8. FORCED-DRAUGHT FAN AND ASH HOPPER.

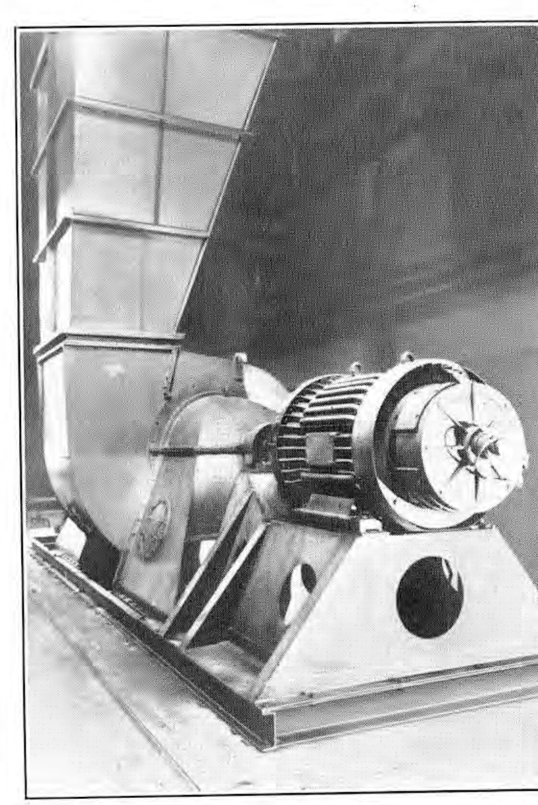


FIG. 9. INDUCED-DRAUGHT FAN.

(To face page 386.)

HIGH-PRESSURE STEAM GENERATORS AT DIEPPEDALLE POWER STATION, FRANCE.

SULZER BROTHERS, LIMITED, WINTERTHUR, SWITZERLAND.

(*For Description, see Page* 385.)

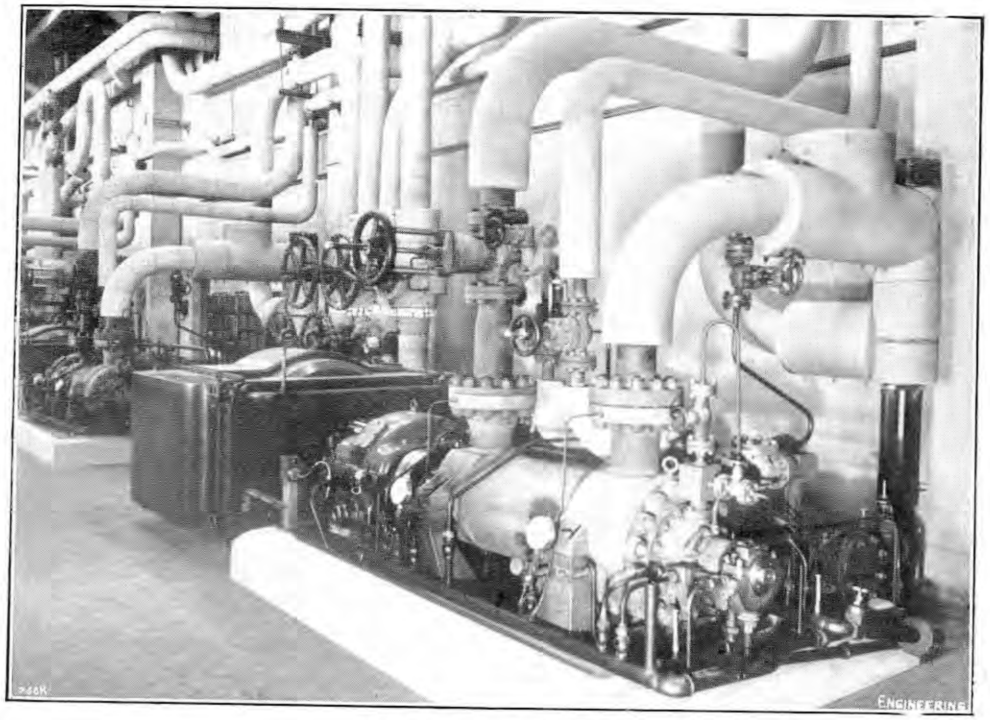


Fig. 10. Feed Pumps.

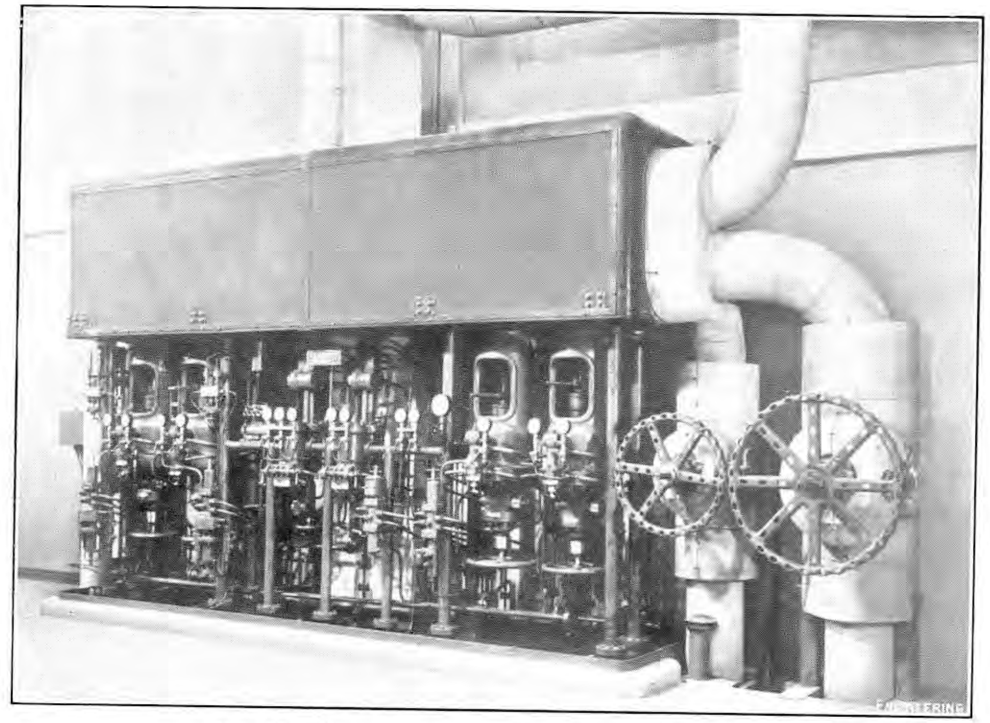


Fig. 11. Regulating Station of Steam Generator.

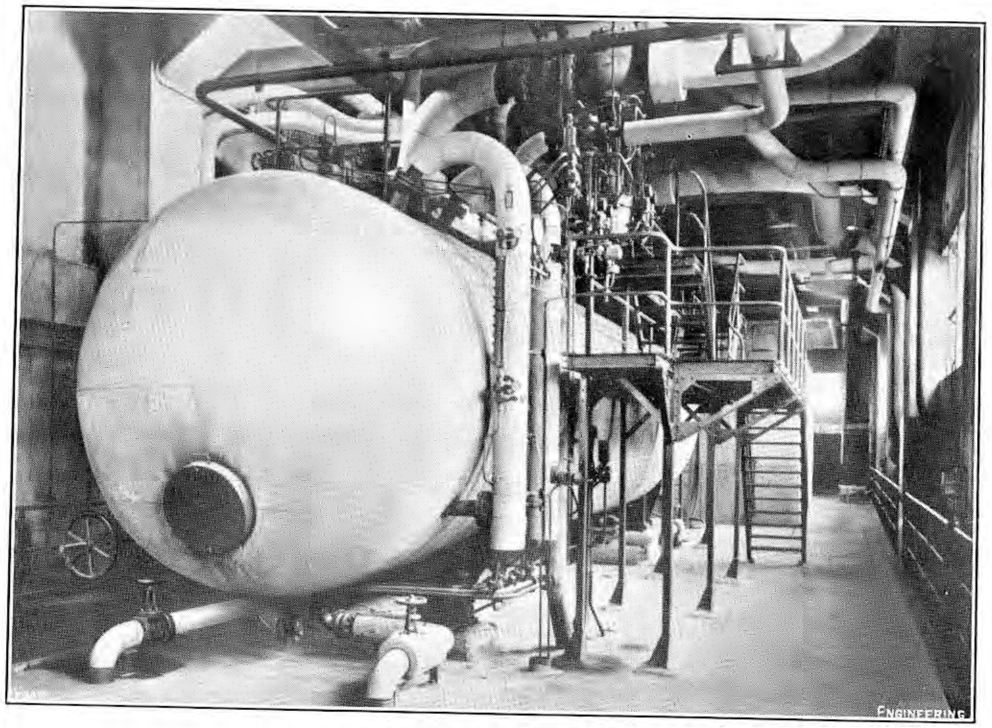


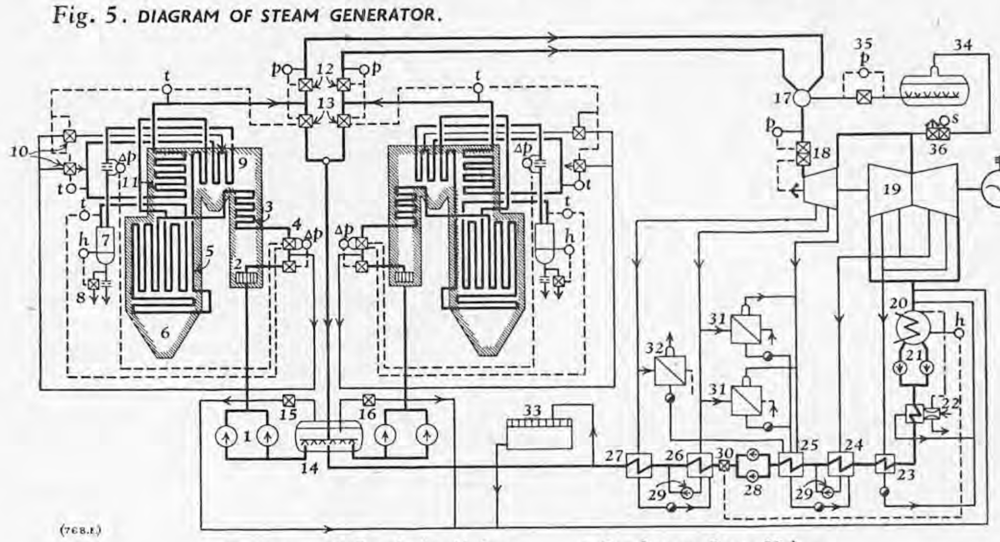
Fig. 12. Starting Reservoir.

Fig. 13. Turbine Hall, with Two 50,000-KW Turbo-Alternators.

(To face page 387.)

HIGH-PRESSURE STEAM POWER STATION.

Fig. 5. DIAGRAM OF STEAM GENERATOR.



⊠ *Automatic Regulating Valves* ⊙ *Condensate Drain Valves*

1 High-pressure feed pumps.
2, 3 Economisers.
4 Feed-water regulating station.
5, 6 Tubular lining of combustion chamber and upper part of ash hopper.
7 Water separator.
8 Automatic blow-down.
9 Contact superheater.
10 Water-injection valves.
11 Radiation superheater.
12 Automatic steam valve.
13 Automatic by-pass valve.
14 Starting reservoir.
15 Steam discharge valve of starting reservoir.
16 Water discharge valve for cooling exhaust steam from valve 15.
17 Water separator of turbine.
18 Quick-acting valve and regulating valves of turbine.
19 Turbo-alternator.
20 Condenser.
21 Condensate pumps.
22 Steam ejector for de-aeration of condenser.
23 Low-pressure preheater No. 1.
24 Low-pressure preheater No. 2.
25 Low-pressure preheater No. 3 and vapour condenser.
26 Medium-pressure preheater No. 4.
27 Medium-pressure preheater No. 5.
28 Medium-lift pumps.
29 Condensate return pumps.
30 Automatic valve for regulating condenser water level.
31 Evaporators and steam washers.
32 Heat exchanger providing heating steam for boiler-oil preheating.
33 Condensate reservoir with steam cushion.
34 Variable-pressure accumulator.
35 Automatic charging valve for accumulator.
36 Automatic discharge valve for accumulator.

wall and part of the lateral walls of the furnace were provided with a refractory brick facing, though the chamber was otherwise lined with heating tubes. This is illustrated in Fig. 4, which also shows the position of the pulverised-coal burners (27) and the oil burners (28). Fig. 7, Plate XVII, is a view of the upper and rear part of the combustion chamber seen from the ash hopper. The outlet of the furnace is visible at the top left, with the extended furnace tubes and the nest of the contact superheater located directly behind them. Part of the radiation superheater can be seen in the top right-hand corner, above the lateral wall with the funnel-shaped openings of the oil burners.

FUELS AND FIRING EQUIPMENT.

The fuel oil is brought up the Seine by tankers and is delivered by a pumping station from the wharf (10) (Fig. 3) to four storage tanks, which have an aggregate capacity of about 350,000 cub. ft. The oil required for current service is conveyed from the store through a filtering installation into the smaller daily service tanks. The oil-firing equipment comprises filters, pumps and pre-heaters, as well as the burners. These auxiliaries are arranged in three independent sets for each turbine unit, one of the sets serving as a standby. The mechanical equipment of the coal-storage yards (5) and the various transport facilities are not yet completed. A wharf to be built on the banks of the Seine will have a crane serving either ships or railway wagons. A conveyor-belt system will transfer the coal from the wharf to the storage yards. From here it will be supplied as required to the hoists and bunkers in the power station by means of a grab and a second conveyor-belt system.

The coal is prepared for firing in a pulverising installation. This comprises drum-type mills in which the raw coal is pulverised and dried before going to the pulverised-coal bunkers, where it is stored ready for burning. It is passed from these to rotary distributors which measure it out to the burners, and deliver it into the combustion chamber with the primary air. All equipment for the pulverised-coal and oil firing system was supplied by the Société Anonyme pour l'Utilisation des Combustibles. The ash is removed from the combustion chamber by means of a revolving grate, in the water-bath of which the clinker is also quenched and granulated. Fig. 8, on Plate XVII, shows the ash hopper of the combustion chamber. The fly ash entrained by the flue gases is separated off in a wet-type collector on the Modave system. The ash deposited on the heating surfaces is removed periodically by a system of soot blowers operated with compressed air and controlled from a central position. In the combustion chamber and superheater these blowers are of retractable design, owing to the high temperatures; the others are fixed. The air preheater is fitted with a device which permits the heating surfaces to be cleaned without dismantling the preheater elements. In view of the relatively high sulphur content of the fuel oil normally used, special steps have been taken to prevent temperature of the air in the preheater from falling below the dew point. For this purpose the cast-iron air preheater is designed to allow of air circulation, part of the preheated air being returned to the suction branch of the forced-draught fan.

CONTROL SYSTEM.

The monotube steam generators are fitted with the Sulzer system of boiler control operated by oil under pressure. The primary duty of the control system is to adjust the quantity of feed water to the temperature of the combustion chamber at all times and to keep the temperature of the live steam constant. The pressure at the boiler outlet is normally regulated by the nozzle control valves (18) (Fig. 5) of the turbine. When the boiler is being started up or shut down, and at times when operation is irregular, valves (12) and (13) of the pressure-control system on the boiler come into action as limiting regulators. The quantity of feed water is regulated primarily by the amount of steam raised. A secondary signal, however, is taken from the steam temperature at a point of low superheating. The maintenance of constant superheating at this point keeps the end of the evaporation zone stationary in the piping system.

The live-steam temperature is regulated by water injection, the injection points being distributed over the piping system in such a way that the temperature of the superheater heating surfaces also remains practically constant. The temperature-regulation system smooths out not only the temperature fluctuations due to load variations but also those caused by a change in the fuel used or by the varying degree of fouling of the heating surfaces. Fig. 11, Plate XVIII, shows the specially-robust pressure, temperature and feed regulating station of one of the monotube steam generators. The furnace is equipped with a Bailey pneumatic control system which keeps the vacuum in the furnace and the air-fuel ratio constant. The control gear of the variable-pressure accumulator (34) (Fig. 5) is combined with the turbine governor (36) and is influenced both by the admission pressure and, when the set is used for frequency-maintenance, by the speed of the turbine. During normal operation the centrifugal governor acts as a speed-limiting regulator.*

AUXILIARY MACHINERY.

The boilers are fed by electrically-driven eight-stage Sulzer centrifugal pumps, illustrated in Fig. 10, Plate XVIII, which were supplied by the Compagnie de Construction Mécanique Procédés Sulzer, Paris. Two pumping sets are allocated to each boiler. Under normal service conditions one pump is used for each boiler, while the other serves as a standby. The feed-water pressure is adapted to the boiler characteristic at various loads by automatic control of the pump speed. The signal for this speed control is taken from the feed-water control system and acts on the resistances in the rotor circuit of the induction motors. The fans were also supplied by Sulzer Brothers. They are constructed of welded-steel components and have split casings to facilitate the removal of the rotors from above. A forced-draught fan is shown in Fig. 8 and an induced-draught fan in Fig. 9, Plate XVII.

FEED-WATER CONDITIONS.

No chemicals are added to the water, which flows in an essentially closed circuit. The properties of the feed water therefore depend mainly on the nature and quantity of the make-up feed and on blow-down. The make-up feed required for covering losses in the high-pressure circuit is taken from the Seine. After being chemically softened in a purifier, it is thermally de-aerated and passed to the evaporators (31), which are heated with extraction steam (Fig. 5). The steam generated by these evaporators is further cleaned in special steam washers, or scrubbers, so as to eliminate any entrained salts and is then condensed in feed-water pre-heater (25), which acts for this purpose as a condenser. The distillate, with a salt content of less than 1 milligram per litre, is added to the feed water by a condensate return pump. The salt is also eliminated from the high-pressure circuit by the continuous blow-down of the monotube boilers. In fact, the water separators (7) of the boilers keep the salt content of the feed water, under stable operating conditions, much lower than that of the make-up feed.† The high-pressure steam is consequently so clean that no deposits appear on the turbine blades even after continuous service periods of more than 7,000 hours.

De-aeration is effected at several points. The make-up water, as already mentioned, is thermally de-aerated. In the circuit itself de-aeration takes place in the condenser. Any residual gases are then expelled in the starting reservoir, in which the water is permanently kept at the boiling point. Such gases are led off with steam employed for the operation of the ejectors. For operating purposes a slightly alkaline reaction of the feed water, with a *p*H-value of about 8·5, is aimed at. This alkalinity is attained without any special measures having to be taken, as a result of the ammonia always present in the raw water. Should it ever happen (up to the present it has not) that the natural but fluctuating ammonia content of the raw water becomes temporarily insufficient, ammonia would be added by artificial means. While Seine water is used for condensing cooling, the glands, bearings, etc., are cooled by a special condensate circulating system in order to preclude the possibility of scale formation.

OPERATING PROCEDURE.

During starting-up, the water is passed by the feed pump in the usual way through the econo-

* A detailed account of the various control systems of the plant appeared in *Energie*, page 217, October, 1948.

† See also *Sulzer Technical Review*, No. 1, 1951: "The Action of the Water Separator in the Sulzer Monotube Steam Generator."

misers, evaporators and superheaters, the normal distribution of steam conditions gradually establishing itself along the path of the water through the tubes. The steam generated is at first condensed in the starting reservoir and in some cases also in the turbine condenser. As soon as the normal steam temperature is approximately attained, the steam valve (12) (Fig. 5), which has so far been automatically closed is opened, and steam can flow to the turbine. The time required for the starting process can be regulated within wide limits and, in particular, can be extended without the safety valves blowing off or the superheaters being endangered, as the superheater tubes of the monotube generator are adequately cooled at all times as a result of the forced circulation, without the use of a special circulating pump. The procedure for shutting-down the steam generator is in principle the same, the sequence of operations being simply reversed.

In normal service a fixed programme is adhered to, the turbine output—which is independent of the frequency—being fixed by the quantity of steam generated in the boilers; in other words, by the performance to which the furnace is adjusted. In general, a given load can be kept practically constant with this system for a number of hours, which permits, among other things, the setting of optimum combustion conditions. Up to the present the variable-pressure accumulator has not been in use during this type of operation. In the exceptional case, when the station supplies an autonomous network and participates in frequency regulation, the output is adapted to the momentary requirements of the network in the usual way by the action of the turbine governor. If, at any time, the steam output should not correspond to requirements, the excess steam goes to the variable-pressure accumulator, which is thus charged, or alternatively the required steam is taken from this accumulator, until the boiler and turbine outputs have been brought into agreement by adjustment of the furnace. The accumulator permits the handling of momentary fluctuations of load up to 10,000 kW. Its capacity is sufficient to cover an extra output of 5,000 kW for at least four minutes, which gives ample time for the adjustment of furnace performance.

The service results and experience so far obtained warrant the assertion that the thermal section of the Dieppedalle power station, and in particular the steam-generating plant, fully satisfies all specified requirements. The measurements so far made show that the boiler efficiency exceeds 92 per cent. at optimum load with oil firing, and the plant efficiency averages about 31 per cent. over a month, calculated on the basis of the net calorific value and after subtraction of the current consumption of the auxiliaries. The part of the station completed in the first stage of erection enabled about 220 million kWh to be generated in 1950.

LITERATURE.

An Introduction to the Theory of Control in Mechanical Engineering.

By R. H. MACMILLAN. Cambridge University Press. Bentley House, 200, Euston-road, London, N.W.1. [Price 30s. net.]

A HISTORICAL note, which Mr. Macmillan has appended to his book, traces the practice and theory of automatic mechanical control back to James Watt and Clerk Maxwell, and is a timely reminder of British achievement in a field of widely recognised importance and rapidly expanding applications. Throughout recent years, indeed, many outstanding developments and much original work have come from this country, the papers of contemporary workers being justly regarded as among the classic contributions to the scientific literature of the subject. In some directions, however, the initiative has lain with America. This is probably the case, for instance, as regards theories of position and process control, for which industrial applications are obvious. More certainly is it true as regards general text-books by authoritative writers, attempting to present comprehensive accounts of control theory for students and technologists.

The publication of Mr. Macmillan's work is therefore something of an event. It is said to be the first English book to explain the principles underlying the action of automatic controls, servo mechanisms and regulators, which it does with a style and competence that make it a notable addition to the literature. Moreover, it is a book of enduring value, notwithstanding the rate at which the subject is developing, because Mr. Macmillan is concerned with fundamental concepts and basic theories, and with the methods and philosophy of control, rather than with specific applications. His treatment is introductory, therefore, in the sense of covering the essential groundwork upon which specific design must always be based, but it is also predominantly mathematical after the opening chapters, which are mainly descriptive, and some engineers and physicists may find their modest mathematical attainments seriously taxed before the more advanced techniques explained by Mr. Macmillan are mastered. It would be wrong, however, to regard mathematical tools as anything but helpful to a proper understanding of control theory, or any difficulty in using them otherwise than as a challenge, since exact analysis is essential to the design of efficient and accurate controllers to fulfil predetermined requirements.

The arrangement of the book, including appendices to explain the use of complex numbers and the Laplace transform method, leads the reader by thoughtfully graduated stages to a rewarding knowledge of most of the control systems that have been thoroughly investigated, and of various graphical procedures (such as the Nyquist diagram) used for studying them. Mr. Macmillan has included a qualitative examination of the characteristic behaviour and effects of human operators in the control linkage, and has dealt instructively with non-linear effects, feed-back, and the criteria for stability and performance in governing, controlling and servo-systems. No attempt has been made to provide numerical data for the immediate needs of technical designers, but the generalised arguments of the text are amplified and consolidated in the reader's understanding by examples at the end of each chapter. They include questions set in recent examinations, exemplifying mechanical control systems in preference to electrical, because the latter type are by far the more numerous in the existing literature.

This clear indication of Mr. Macmillan's intention to make his book especially serviceable to students is not unexpected from a member of the faculty of engineering at Cambridge University. He himself goes so far as to suggest that, by touching upon so many different aspects of applied science, the theory of control can exert a welcome unifying influence, introducing variously specialised engineers to important ideas they might otherwise not meet. It seems likely, nevertheless, that the present tendency for servo and control systems to be themselves a somewhat highly specialised branch of engineering must continue for a long time, exercising the ingenuity of a relatively small proportion of research workers in industry, the Services and the universities. For at least as long a time, this book is likely to be accepted as a standard work by serious students of control systems applied to mechanical engineering.

Tables of the Bessel Functions of the First Kind of Orders Seventy-Nine Through One Hundred and Thirty-Five.

By the Staff of the Computation Laboratory of Harvard University. Harvard University Press, Cambridge 38, Massachusetts, U.S.A.; and GEOFFREY CUMBERLEGE, Oxford University Press, Amen House, Warwick-square, London, E.C.4. [Price 52s. net.]

THE tabulation of the function $J_n(x)$ for all integral values of n from 0 to 100 in the interval $0 < x < 100$ to 18 decimal places for the first four orders and to ten decimal places for the remainder was assigned to the Computation Laboratory of Harvard University at the request of Rear-Admiral A. H. Van Keuren, U.S.N., in November, 1944. The computation has been carried through on the Automatic Sequence-Controlled Calculator presented to the Computation Laboratory in that year by the International Business Machines Corporation. Its publication occupies 12 volumes of the annals of the Computation Laboratory and extends to 7,574 pages. The volume under review not only completes the original contract and brings to a successful conclusion a major project in the systematic tabulation of mathematical functions, but, in fact, goes beyond it. By enlarging the present volume by fewer than 90 pages, it has been possible to extend the ten decimal place tables of $J_n(x)$ through $n = 135$, that is, up to the limit of n for which ten-place entries differ from zero with $x < 100$.

In addition, a table of $J_n(100)$ over the range n 0 (1) 135 to ten places of decimals, together with values of this same function for $n = 0$, 1, 2 and 3 to 18 places of decimals, have been provided to close the interval. A final table gives $J_n(n)$ for all integral values of n from 0 to 100 to 15 decimal places. The main tables list the values of three consecutive orders on each page at intervals of 0·01 in the argument x starting with $J_{79}(x)$, $J_{80}(x)$, $J_{81}(x)$ and finishing with $J_{133}(x)$, $J_{134}(x)$, $J_{135}(x)$. The number of pages occupied by successive sections decreases as the value of x corresponding to the first tabular entry increases from $x = 49 \cdot 61$ for $J_{79}(x)$ to $x = 96 \cdot 7$ for $J_{133}(x)$. Values of $J_n(x)$ to ten decimal places for values of the argument intermediate between those tabulated can be obtained without excessive labour by methods of interpolation described in the introductions to the first and third volumes of this set of Bessel Function Tables.

In his preface, the Director of the Computation Laboratory, Professor Howard H. Aiken, pays tribute to Richard M. Bloch, who was responsible for the coding and supervision during the early stages of the project and to John A. Harr, who succeeded him, as well as to the team of workers who assisted in operating the machine and contributed to the processes involved in transferring the machine output to the final printed pages. That this 12-volume set of Bessel function tables should have been produced within a period of four years is a notable achievement. What makes it even more remarkable is that this particular project was accorded only low priority while at least six other volumes of mathematical tables have been published by the Computation Laboratory within the same period. Moreover, in the light of the experience gained during the course of this tabulation, changes made in the wiring of the Calculator have enabled the efficiency of its operation to be improved. The completion of this monumental undertaking in a manner conforming to the highest standards of accuracy and layout alike makes available values of the Bessel functions of the first kind of all integral orders likely to be needed in practice.

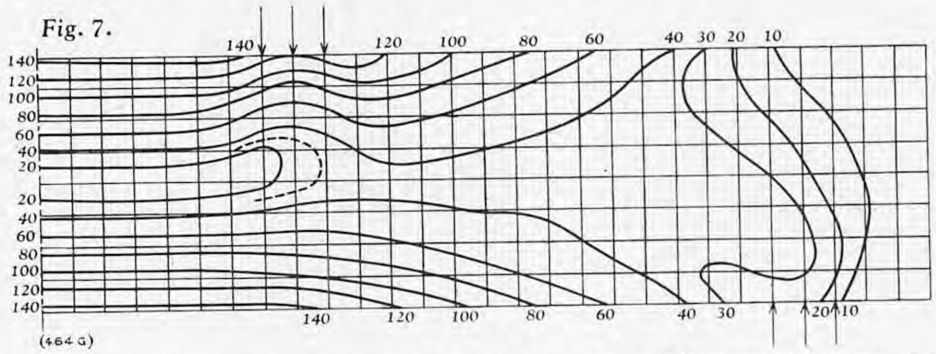
Gas Turbine Theory.

By H. COHEN, M.A. and G. F. C. ROGERS, B.Sc. Longmans, Green and Company, Limited, 6 and 7, Clifford-street, London, W.1. [Price 30s. net.]

THE rapid development of the gas turbine for industrial, as well as for aeronautical, uses makes the time appropriate for the appearance of such a book as this. The authors survey the subject in a general manner, discussing the problems and features of design that are more or less common to all gas turbines, regardless of the duties they are intended to perform. After an introductory chapter describing nine possible arrangements of a gas-turbine plant according to the degree of elaboration that circumstances may justify, the theoretical efficiencies of a number of cycles, from the very simplest to those with various combinations of heat regeneration, inter-cooling and re-heating, are considered in their turn. The Ericsson cycle, interesting only because of its approach to that of the ideal Carnot engine, is mentioned to complete the list. Whatever cycle of operations may be chosen, its successful embodiment in an actual machine requires a knowledge of gas dynamics that is peculiar to this branch of engineering. The supersonic velocities attained by the gases make it necessary to consider shock waves and other phenomena with which the ordinary engineer is likely to be unfamiliar, hence the Mach Number appears frequently in the equations. Furthermore, the kinetic energy of the gases has always to be taken into account in addition to their thermal energy, hence there is introduced the conception of "total head" temperature, which is the temperature that the gases would reach if brought to rest with all their kinetic energy converted into

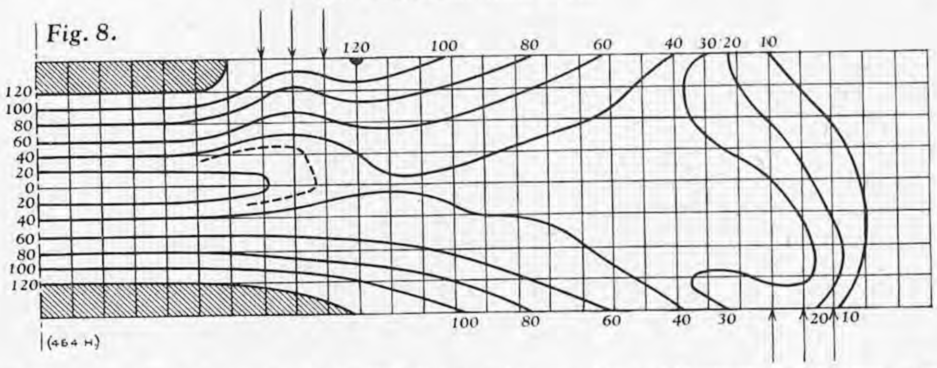
STRESSES IN TRANSVERSELY-LOADED BEAMS.

Fig. 7.



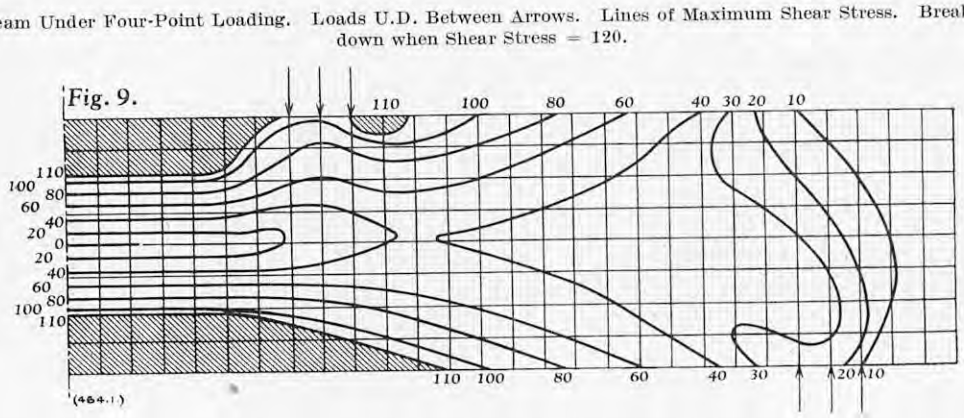
Beam Under Four-Point Loading. Loads U.D. Between Arrows. Lines of Maximum Shear Stress. Breakdown when Shear Stress = 146.

Fig. 8.



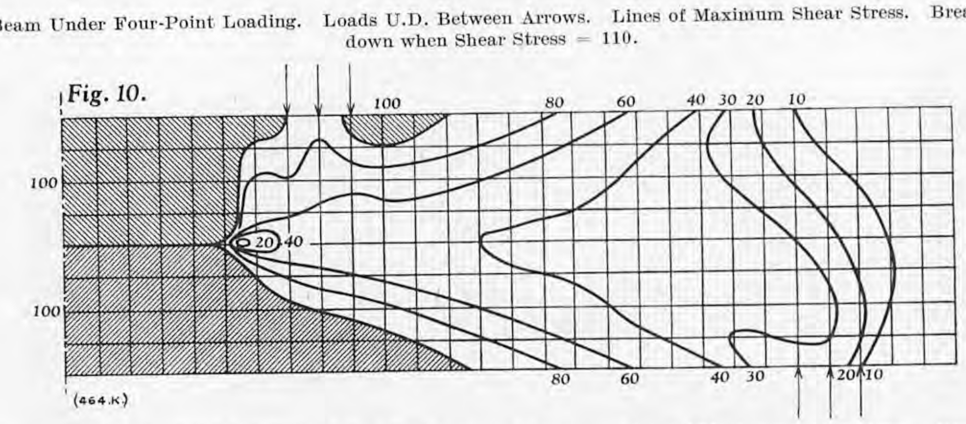
Beam Under Four-Point Loading. Loads U.D. Between Arrows. Lines of Maximum Shear Stress. Breakdown when Shear Stress = 120.

Fig. 9.



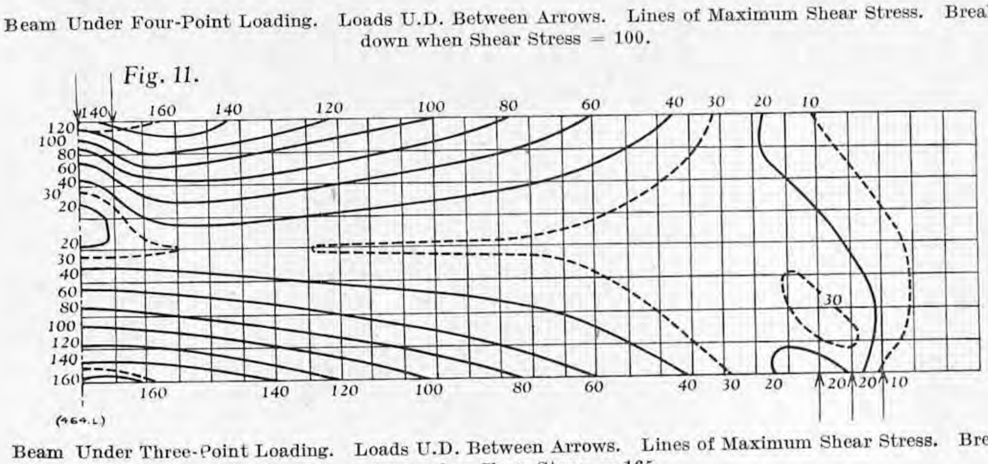
Beam Under Four-Point Loading. Loads U.D. Between Arrows. Lines of Maximum Shear Stress. Breakdown when Shear Stress = 110.

Fig. 10.



Beam Under Four-Point Loading. Loads U.D. Between Arrows. Lines of Maximum Shear Stress. Breakdown when Shear Stress = 100.

Fig. 11.



Beam Under Three-Point Loading. Loads U.D. Between Arrows. Lines of Maximum Shear Stress. Breakdown when Shear Stress = 165.

heat. Corresponding to this temperature there is a similarly fictitious "total head" pressure, and the use of these quantities serves greatly to simplify the calculations. The nature of shock waves, which the authors believe may eventually be turned to good account for the conversion of velocity to pressure in supersonic compressors, is also clearly explained.

The treatment, up to this point, is framed on a theoretical basis. The performances of actual cycles with the inevitable imperfections of their component processes and working gases are next considered. The student is shown how the calculations are made in practice, and will also gather, from the examples given, a fair idea of the efficiencies obtainable. Subsequent chapters deal, respectively, with centrifugal compressors, axial compressors, combustion systems and axial-flow turbines. In explaining the use of non-dimensional functions as co-ordinates for plotting characteristic curves of compressor performances, the derivation of the non-dimensional groups is simplified by allotting to temperature the dimensions of volocity squared. This procedure may be novel to many engineers, but there is no logical objection to it; when it is adopted, the gas constant R, and therefore also the two specific heats, become merely dimensionless numbers. In spite of certain practical advantages possessed by the centrifugal compressor, the axial type originated by Parsons in 1900 for industrial work is thought likely to be preferred for gas-turbine installations where the highest efficiency is required Axial machines may be designed on the free-vortex theory, in which the whirling velocity of the air varies inversely as the radius, or on the principle of constant reaction, which implies a fixed ratio between the temperature rise of the air in the fixed blading and the rise in the moving blading. Both methods are discussed and designs worked out. Though the benefits of vortex blading for compressors are generally accepted, it is suggested that for turbines, where the conditions for efficiency are not so critical, the advantages are hardly sufficient to warrant the present large difference in cost. Combustion systems are treated descriptively, as there is not yet much theory that can be applied to them; and the final chapter deals with the prediction of the performance of simple installations, their torque characteristics, etc. Two subjects of importance to designers, namely, stress calculations and the proportioning of heat exchangers, have been deliberately omitted as it was felt that they had received adequate treatment in other publications. Mechanical details and methods of control have also been passed over as being outside the field of the book. The volume nevertheless covers all that its title implies, and does so in a manner admirably adapted to the needs of a student of the gas turbine. Both of the authors have the advantage of practical experience with the National Gas Turbine Establishment, and evidently write with personal knowledge.

ELASTO-PLASTIC STRESSES IN TRANSVERSELY-LOADED BEAMS.

By JACQUES HEYMAN.

(Concluded from page 361.)

Fig. 7, herewith, shows the contours of maximum shear stress. The central portion of the beam, which is nominally under pure bending, displays such an ideal stress distribution at the centre, but is affected near the point of application of the load. It will be seen that, under this load, the maximum shear stress is lowered due to the presence of two compressive stresses. There is a large area in the centre of the beam where the maximum shear stress lies between 30 and 40. This area is due to the fact that, as the shear stress referred to the rectangular co-ordinates falls away from the centre of the beam, the longitudinal stress increases, producing an almost constant maximum shear stress.

Suppose that the maximum shear stress of 150, corresponding to the normal stress of 200 under the load, is the value at which breakdown of the material occurs; then Fig. 8 will give the stress distribution at first yield of the beam. If the load is increased, plastic zones will be formed. It was found simpler in the present work to investigate the effect of yield on the stress distribution by keeping the load fixed in value, and decreasing the yield stress. For example, if the yield stress is dropped from 150 to 120 units, the load is increased in effect in the ratio 1·25. Fig. 8, on page 389, shows the elasto-plastic stress distribution at this condition; for a quantitative comparison with the elastic solution, the values of shear stress shown in Fig. 8 should be multiplied by 1·25.

The elasto-plastic solution was found in the following way. Since the most highly stressed points in the elastic solution occur on the centre line of the beam at the outside faces, yield will occur first at these two points. It can easily be shown that, since the yield starts from a boundary, the shear and normal stress must be zero, so that, in the as yet undetermined plastic zones, the only stress obtaining is $\widehat{xx} = 120$. Trial plastic boundaries were sketched, and the stress within the boundaries forced to have the constant value 120. The remaining (elastic) portion of the beam was then relaxed to give a solution fitting these boundaries. On examination of the resulting stress pattern, it was found that some of the elastic nodes adjacent to a plastic boundary were subjected, in fact, to a stress greater than 120, while other nodes within the plastic zone could be relaxed to give a maximum shear-stress of less than 120. The trial plastic boundaries were adjusted accordingly, and the process of relaxing the elastic portion repeated. One or two trials were sufficient to complete the solution for any one loading condition. It will be seen that yield is prevented under the load due to the action of the two compressive stresses.

Figs. 9 and 10, on page 389, show the effect of further lowering of yield stress. When this reaches 100 units (1·5 times the load at yield) the centre portion of the beam becomes fully plastic. Since the "shape factor"* of a rectangular section is 1·5, this load is equal to that given by the simple plastic theory.

Figs. 11 to 14, on page 389 and on this page, show analogous solutions obtained for the beam under three-point loading. The value of normal stress under the loading points was taken as 160 in order to give convenient numbers for calculation. The analysis has been carried as far as the collapse load given by the simple theory, assuming the yield stress of 165 recorded in the elastic solution (Fig. 11) to be correct. In fact, the maximum tensile stress is given as 356 by the normal elastic theory, corresponding to a shear breakdown of 178, and this value has been used to calculate the plastic boundaries by the simple theory, shown dotted in Figs. 12 to 15.

According to the simple plastic theory, "collapse" of the beam will occur when the "compressive" and "tensile" plastic zones meet on the neutral axis of the beam; an approximation to the load at this point may be made by noting that the peak of the "compressive" zone occurs at a point distant $3l$ from the centre line, leading to a collapse load of 1·715 times the load at yield, an increase of 14 per cent. above the collapse load given by the simple theory. In fact, experiments on mild-steel beams under three-point loading (Roderick and Phillipps) have given observed collapse loads that are of the order of 10 per cent. in excess of those predicted by simple theory; and this theory accounts satisfactorily for beams under four-point loading. The stress contours and elasto-plastic boundaries shown in the accompanying illustrations have been sketched in by eye.

A difficulty arises when considering conditions inside the yielded portion of the beam. The equation $\nabla^4\phi = 0$ contains the equation of strain compatibility, but the maximum shear-stress criterion of breakdown employed here makes reference only to stresses. It is improbable, therefore, that the strains inside the two-dimensional plastic zones obtained in this article are compatible. If displacements are suffered in the third direction, it would be possible to envisage a compatible system inside the plastic zones. Displacements at the boundary itself, however, may be such that continuity is not satisfied. This problem has received attention from many sources, and a summary of the present position in the mathematical theory of plasticity has been given by W. Prager.*

However, it is felt that the results obtained in this article are of sufficient interest to be presented, since they conflict with no experimental evidence known to the author, and there is at present no exact mathematical theory for dealing with the problem. In addition, the concept of plastic hinges used in the plastic design of structures seems to be supported by the theoretical results obtained here.

In conclusion, Fig. 15, herewith, shows the results of a photo-elastic test conducted by Louis Baes,* agreeing well with the theoretical elastic distributions calculated above.

The preparation of this report forms part of a general investigation into the behaviour of rigid-frame structures which is being carried out at the Cambridge Engineering Laboratory under the direction of Professor J. F. Baker, Head of the Department of Engineering.

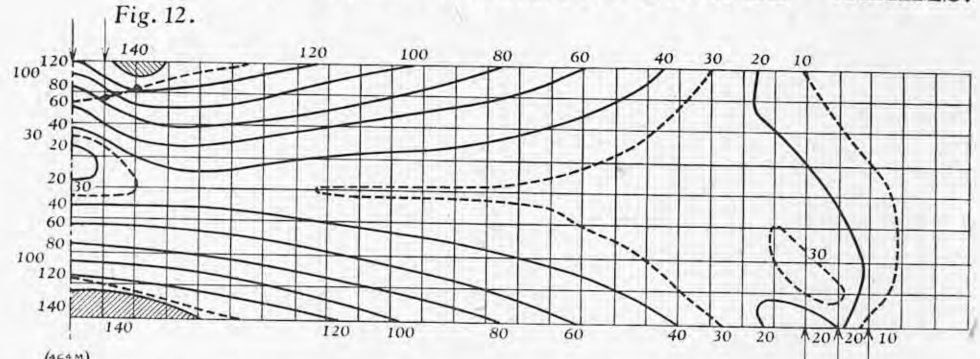
* J. W. Roderick and I. H. Phillipps, *Research: Engineering Structures Supplement*, page 9 (1949).

* *Jl. of App. Mechanics*, vol. 15, page 226 (1948).

* *L'Ossature Métallique*, February 2, 1948.

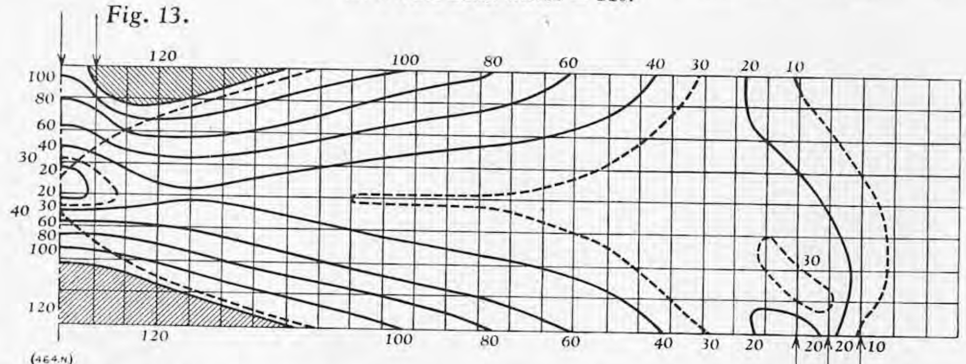
STRESSES IN TRANSVERSELY-LOADED BEAMS.

Fig. 12.



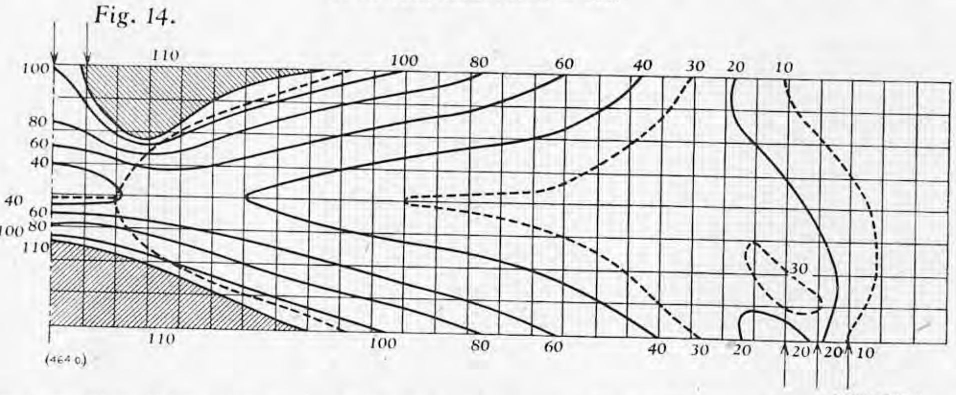
Beam Under Three-Point Loading. Loads U.D. Between Arrows. Lines of Maximum Shear Stress. Breakdown when Shear Stress = 140.

Fig. 13.



Beam Under Three-Point Loading. Loads U.D. Between Arrows. Lines of Maximum Shear Stress. Breakdown when Shear Stress = 120.

Fig. 14.



Beam Under Three-Point Loading. Loads U.D. Between Arrows. Lines of Maximum Shear Stress. Breakdown when Shear Stress = 110.

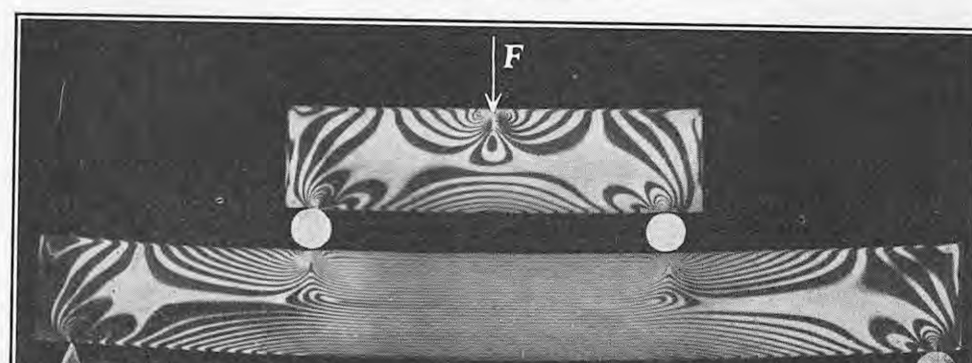


FIG. 15. PHOTO-ELASTIC TEST.

100-MW ALTERNATOR FOR TORONTO.

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

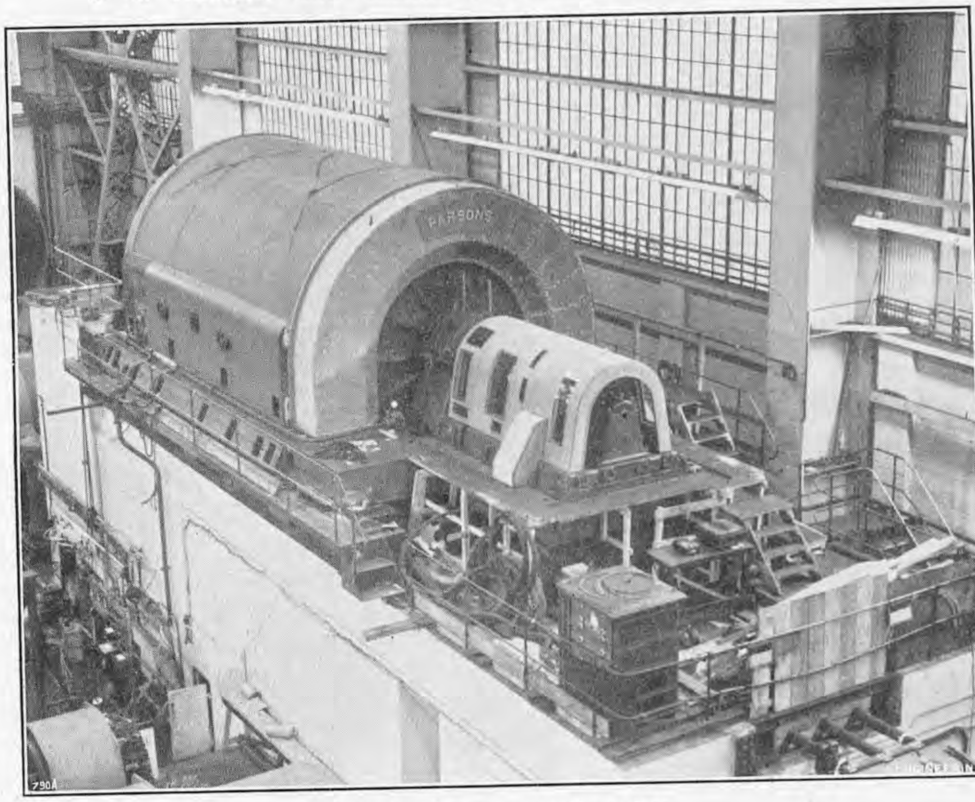


FIG. 9. MACHINE ON TEST BED.

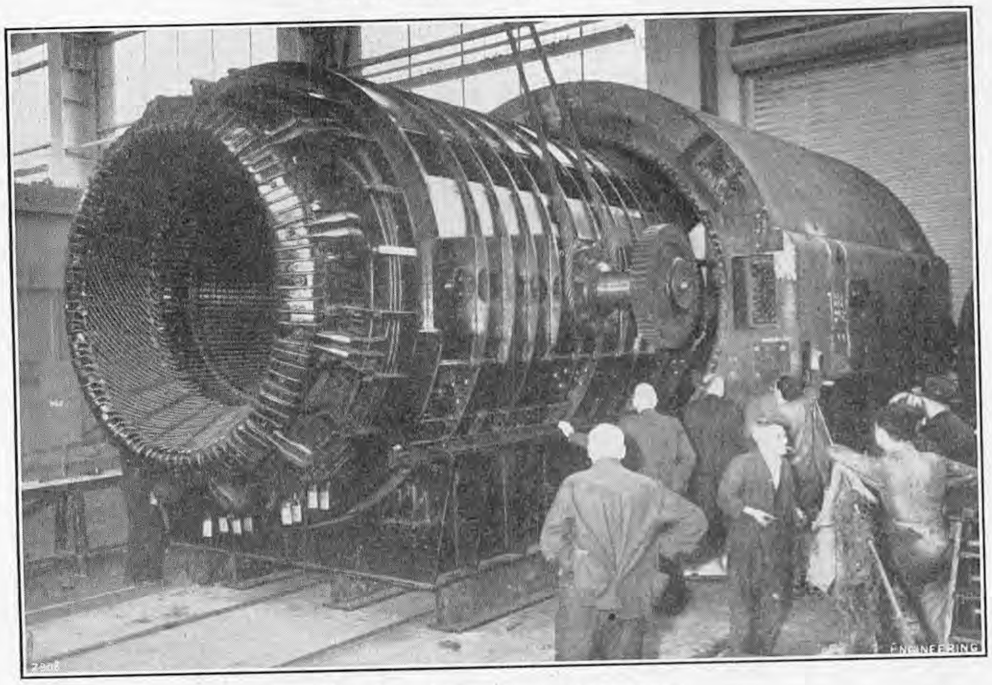


FIG. 10. ASSEMBLING ALTERNATOR.

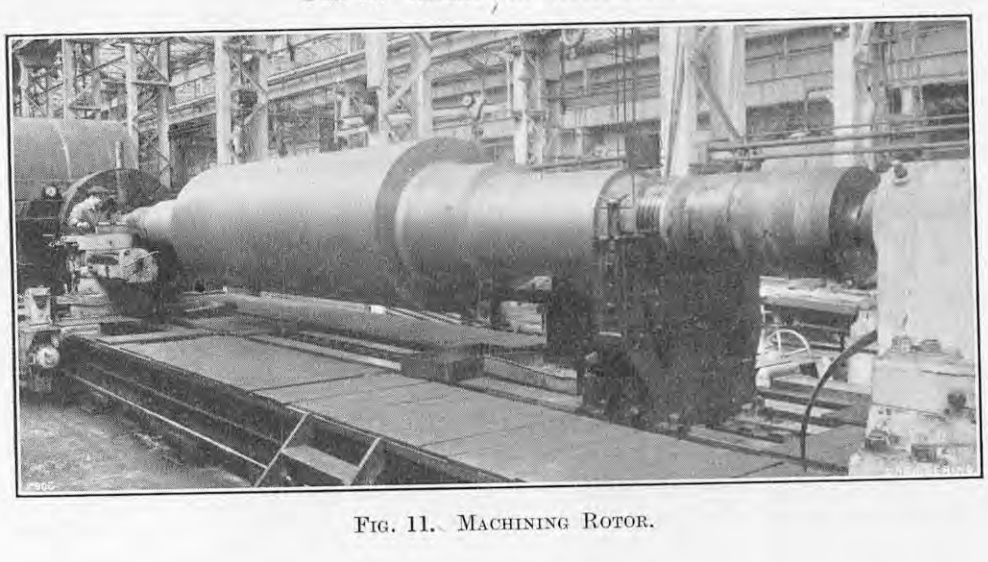


FIG. 11. MACHINING ROTOR.

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

(*Concluded from page* 355.)

THE first alternator, which is of the hydrogen-cooled type, has been designed to provide for a frequency change from 25 to 60 cycles per second, as mentioned in the previous article. It therefore has two ratings. At 25 cycles per second and 1,500 r.p.m., its output is 75 MW (88,235 kVA) at a voltage of 11 kV; and when operating at 60 cycles per second and 1,800 r.p.m., its output will be 90 MW (105,882 kVA) at a voltage of 13·8 kV. As will be appreciated from the foregoing figures, the alternator must be capable of operating as a two-pole generator at 25 cycles and a four-pole generator at 60 cycles. The stator winding has therefore been designed to be two-thirds chorded on the 25-cycle connection, so that when the frequency change-over is effected it can be reconnected to give a four-pole winding, with a coil pitching of 1⅓. While it would have been possible to have arranged the rotor windings so that they could have been reconnected to give a four-pole winding, the machine characteristics at one or other of the conditions would have been unsatisfactory. Two rotors have therefore been provided, one having two poles and operating at 1,500 r.p.m., to give a 25-cycle supply, and the other having four poles and operating at 1,800 r.p.m., to give the 60-cycle supply. A view of the machine on the test bed appears in Fig. 9; Fig. 10 shows it under construction and Fig. 11 shows the rotor being turned.

Owing to transport conditions, the stator had to be manufactured in two parts. The inner part consists of the core, windings and frame and weighs 140 tons, while the outer part comprises the outer casing and gas coolers and weighs 70 tons. The core of the inner stator is built up from laminations of silicon steel, which are insulated on both sides with stoved enamel. These laminations were punched in such a manner that any irregularity in the thickness of the rolled sheets would be distributed evenly round the core, thus eliminating the possibility of slack core plates. The laminations are assembled with overlapped joints, and at regular intervals during construction pressure was applied to consolidate the core, so that when finally pressed and clamped between the two end plates, which are bolted to the stator frame, a tight and homogeneous structure was obtained.

The stator windings are of the basket or diamond coil type, being either short or long pitched, depending upon the condition for which they are connected. In both cases, however, the effective degree of chording is such that the harmonics in the phase-voltage wave are reduced to a minimum. Each conductor is made up of a number of copper strips of small cross-section, alternate strips being insulated with impregnated glass-silk tape. The portion of the conductor which lies in the slot is wrapped in a micanite tube. This was applied by a machine which wrapped on micanite sheet of a length somewhat greater than that of the stator. The micanite sheet consists of mica flakes bonded with a permanently-flexible varnish so that relative expansion between the conductor and the surrounding iron can be accommodated without ill effect. The end winding insulation is also of micanite tape. The stator windings are formed in half coils with electrically-brazed joints at the end winding knuckles. The number of strips forming the stator conductor was chosen so as to enable the eddy-current loss in the conductor to be reduced to a minimum, and the transposition of the strips was carried out when the knuckle joints were made. Thermo-couples are embedded in the stator core and windings in accordance with established practice.

After the stator had been wound and insulated, the end windings were impregnated with varnish under pressure. This process involved lowering the stator in a vertical position into a large impregnating tank, which measured 17 ft. 3 in. internal diameter by 26 ft. deep. Here it was dried out under a vacuum within 2 to 3 mm. of mercury of absolute pressure. The lower set of end windings was then impregnated with varnish under a pressure of 30 lb. per square inch for several hours. After the tank had been drained, the varnish on the lower end windings was then oxidised by the circulation of warm air. The stator was next inverted and a similar cycle of impregnation applied to the other end windings. This process is more effective than the practice of drying out in the usual way under a moderate vacuum and then spraying the windings with varnish.

A view of the inner core being assembled in the outer casing, which is a welded structure fabricated from mild-steel boiler plate, appears in Fig. 10. This outer casing houses the gas coolers, each of which consists of a nest of tubes with water boxes at each end, these boxes being mounted parallel to the axis of the machine's shaft. Explosion-proof steel end shields are fitted to the outer casing and support the shaft seals. These seals, which prevent the leakage of hydrogen from the stator by means of an oil film, are of the thrust type, in which a self-aligning seal ring bears against the side of a collar on the rotor shaft. They have the advantage that the flow of oil and consumption of hydrogen are both small.

The well-known Parsons multiple-path cooling system is employed on the alternator, but in this instance the complete gas circuit is contained within the stator casing and there is no external ductwork. Fans mounted at the ends of the rotor supply the pressure compartments of the casing, from which the coolant passes by various paths in the stator to adjacent exhaust compartments and then to the coolers before being recirculated.

Details of the ancillary equipment required for hydrogen-cooled alternators of this type have already been described in ENGINEERING. It may be mentioned, however, that the oil from the hydrogen side of the seals is conducted to a gas detraining tank before being recirculated; and that automatic devices maintain and record the purity of the gas in the stator casing. This purity is usually between 95 to 96 per cent. Before filling, the casing is "scavenged" with carbon dioxide to displace the air and avoid dangerous mixtures while hydrogen is being admitted.

The two rotors, which weigh 70 and 60 tons, respectively, were machined from single forgings. Each rotor was bored through from end to end, to enable the interior to be examined and test-pieces taken. The rotor windings are formed of silver-bearing copper strip and the coils lie in radial slots which are insulated by micanite troughs. Micanite strip forms the inter-turn insulation, and was fitted as the coil was inserted turn by turn into the slots. The windings are retained in their slots by dovetail keys, and end caps of non-magnetic steel are shrunk on to spigots at each end of the rotor to retain the end turns. A damping winding is provided consisting of copper strips running the whole length of the slots just below the keys.

A detailed and extensive research has been made at Heaton Works into the phenomenon of rotor coil shrinkage. This has shown that the temperature gradient between the individual turns in the rotor slot is a more important factor than the differential expansion of the copper and the iron. As it is impracticable to use thinner insulation between individual turns the aggregate thickness of the insulation between the top and bottom of the slot has been reduced by employing as few turns as possible without unduly increasing the excitation current. The heavier section copper required gives a mechanically strong and robust winding. The superior mechanical properties of hard-drawn silver-bearing copper, such as its high limit of proportionality, creep resistance and increased annealing temperature, have further reduced the possibility of rotor coil contraction to negligible proportions.

The installation of an improved hydraulically-operated rotor trough moulding machine has resulted in an accurately formed component with high mica content and thermal conductivity. This, in conjunction with more accurate machining of the winding slots, has appreciably reduced the temperature difference between the copper and iron and thus the maximum winding temperature. The end windings are rigidly packed with Bakelised asbestos blocks which effectively prevent any residual tendency to shrinkage; and suitable channels are provided in the packings to ensure effective ventilation. A special packing is secured to the end of the rotor body to support the main insulation trough. Experience so far indicates that rotor coil deformation under the most onerous conditions of operation has been effectively prevented.

The exciter is of the open ventilated type and its armature is directly coupled to the rotor by means of a torsion-rod drive. The auxiliary or pilot exciter, which is fitted in accordance with modern practice to give quicker response and better stability characteristics, is built into the main exciter frame.

Special lifting tackle was designed to assist in slinging the stator during transport to site. The set was erected during September and part of October and was commissioned on October 26, 1951, after a drying-out run on short-circuit. For nearly a fortnight the alternator operated at reduced load with air cooling, then hydrogen was admitted and the set has since carried loads in excess of its maximum 25-cycle rating.

The shipment of a machine of this size necessarily involved difficult transport problems, especially due to the alternator stator, the heavier portion of which, when packed on its steel cradle and fitted with sheet steel protection for the core and windings, weighed 150 tons. This weight equals the limiting capacity of the "Titan" floating crane on the Tyne. Shipment had to be arranged from the Tyne direct to a Canadian port (unless lack of facilities compelled routing via New York). The desirable method would have been to use a small vessel—not exceeding 35 ft. beam and 14 ft. draught—which would have been capable of entering the canal system above Montreal and discharging at Toronto. Lack of a suitable crane at Toronto made this impossible; indeed, an examination of all the facilities on the eastern seaboard controlled by the Canadian National Harbours Board showed that no publicly-owned crane of adequate capacity existed. In the circumstances, Messrs. Parsons, guided by earlier experience in the transhipment to lake steamer of small units dispatched to Chicago in 1924, approached Marine Industries, Limited regarding a set of shear-legs located at Sorel, about 60 miles downstream from Montreal, where the Richelieu river enters the St. Lawrence. No makers' capacity data were apparently available, for these legs, but the owners undertook to lift 150 tons in the light of previous experience and the apparent strength of the scantlings. The wharf is connected by rail to the Canadian National Railways who, after examination of the clearances and strength of track and bridges in relation to axle-loadings, accepted the load subject to certain modifications being made. An undertaking was given that a wagon of sufficient capacity would be obtained from United States sources. Clearances were not a major difficulty, in view of the large latitude allowed by the Canadian loading gauge and the absence of platforms and tunnels, although an "out-of-line" haul via St. Lambert and Ayrness was necessary. Rail approaches to the site at Toronto, over a section of track maintained by the Toronto Harbour Commissioners, and laid without ballast on a sandy bed, were far from ideal, and this section also involved a hazardous bridge crossing over the River Don.

In the event, delivery was made without damage, though there were some disquieting moments. It was evident throughout that the various instruments of transportation were only just adequate, and that this, the heaviest piece of machinery imported into Canada, probably represents the present safe maximum. A special train hauled the stator to Toronto. The extreme height above rail was 16 ft. 10 in. and, owing to the high centre of gravity, considerable rolling was experienced. The speed was restricted to 10 m.p.h. and travel was during daylight only. Axle loadings were about 27 tons. Deflection of the wagon frame, which was too long to be ideally suited for a load concentrated over a length of about 14 ft., was considerable.

The stator outer casing weighed 70 tons and measured 21 ft. 2 in. by 17 ft. 6 in. by 16 ft., and was, like the inner core, conveyed by British Road Services to Newcastle Quay for shipment by a Cairn Line vessel. It was discharged by the Montreal floating crane and conveyed by water to Toronto on a wooden scow measuring 100 ft. by 35 ft., as it was too bulky for rail. At Toronto it was necessary to tie up alongside a wharf near the power station, and man-handle the casing ashore, using jacks, long timbers and rollers, as well as monkey winches to exert a pull from the shore. It was rolled on to a Canadian National Railways flat-car, jacked down to the floor and hauled a distance of some 100 yards into the turbine house. The alternator rotor was packed in a case measuring 34 ft. 3 in. long, and shipment was made via London on the s.s. Asia, a vessel with a hatch opening long enough to allow the rotor to be loaded and discharged without tilting. Special permission was obtained for this load to be handled by the Montreal floating crane. The alternator could only be shipped during the open-water season when the St. Lawrence was open. The turbine, which also included some awkward loads, was shipped at an earlier date through St. John, N.B.

AUTOMATIC EXTRUSION PLANT FOR THE ASTON CHAIN AND HOOK COMPANY.

(*Concluded from page* 376.)

IN last week's article on the automatic extrusion press installed at the Erdington works of the Aston Chain and Hook Company it was mentioned that power for operating the press is provided by a Fielding and Platt air-hydraulic accumulator system employing lubricated water. In principle, the accumulator consists of a forged-steel pressure vessel partly filled with water, compressed air at a pressure corresponding to the hydraulic working pressure being admitted to the space above the water. In the plant installed at Erdington, the accumulator comprises one pressure bottle and three air bottles, the air bottles being charged at 3,500 lb. per square inch, the working pressure of the hydraulic circuit. The pressure bottle and three air bottles are illustrated in Fig. 11, on page 400. Air is admitted to the water bottle and, as water is withdrawn for operating the press and ancillary equipment, it expands slightly causing a drop in pressure; a hydraulic pump injects water into the bottle when it has fallen to a predetermined level. Lubricated water, i.e., water containing one per cent. soluble oil, is used; it is pumped into the system from an elevated supply tank by a Fielding and Platt type-H.8 hydraulic pump, the pressure in the bottle, as a consequence, being restored to its original value. It should, perhaps, be emphasised that no air is "consumed" as it merely follows up the water level in the pressure bottle. As already indicated, the maximum working pressure of the system is 3,500 lb. per square inch, and the accumulator is designed to give either a 10 per cent. or 15 per cent. variation of pressure when the useful water capacity has been withdrawn, this percentage variation being obtained by suitable selection of the air-to-water ratio.

It will be appreciated that this system necessitates the incorporation of some means of controlling the water level together with safety devices to prevent either over-filling or drawing off all the water and so permitting the entry of high-pressure air to the water mains. This is accomplished by connecting the bottom of a vertical tube to the water discharge pipe at the base of the bottle, the top of the vertical tube, known as the control tube, being connected to the top of the water bottle. The tube is isolated by suitable valves and it will be realised that, with the isolating valves open, the water level in the tube will be the same as that in the bottle. At predetermined levels in the the control tube are fitted a number of electrodes which, when submerged by the rising water, operate electrical relays. To give a visual indication of the water level, a coloured lamp is installed at the level of each electrode which lights when the electrode is submerged. Six indicating lamps are provided and these are arranged to signal, by a suitable colour code, high water level; maximum working level, i.e., pump by-passing; low level, i.e., the level at which the pump commences

2,000-TON HORIZONTAL EXTRUSION PRESS.

FIELDING AND PLATT, LIMITED, GLOUCESTER.

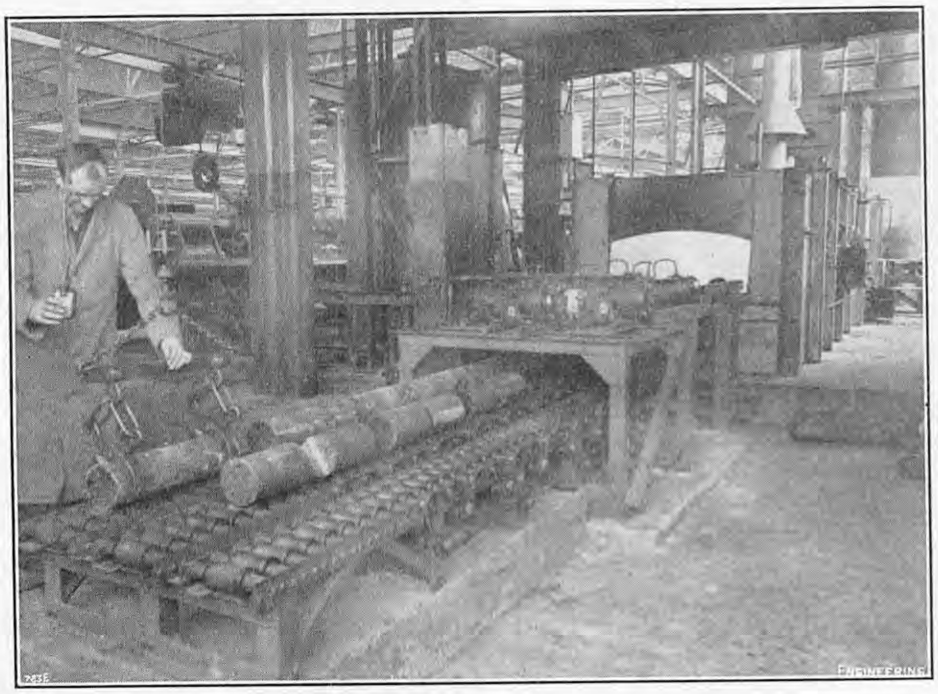


FIG. 5. CONVEYOR FOR LOADING BILLETS INTO FURNACE.

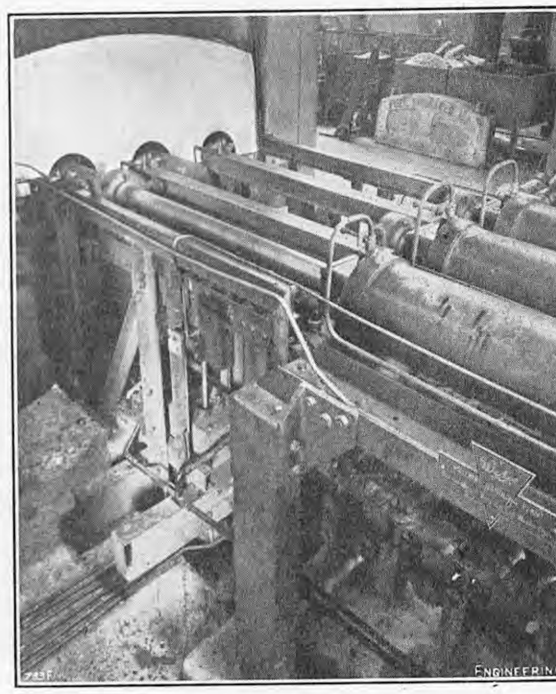


FIG. 6. CHARGING RAMS.

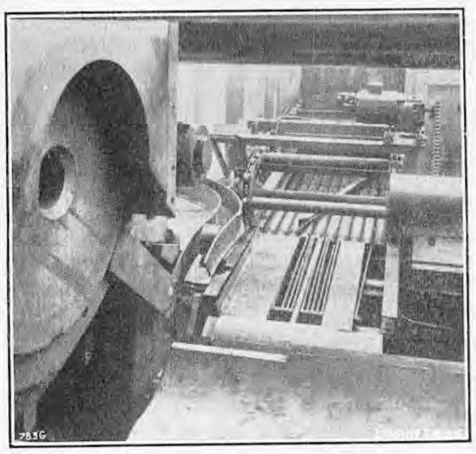


FIG. 7. CONVEYOR FROM FURNACE TO PRESS.

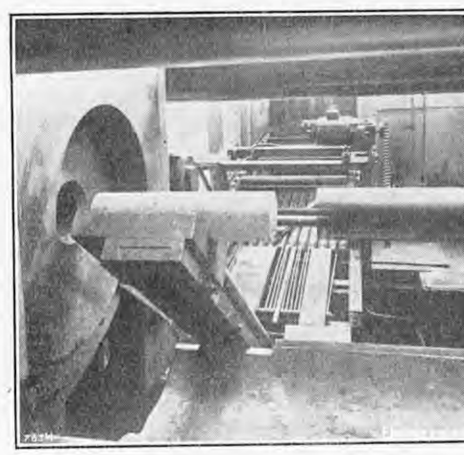


FIG. 8. BILLET READY FOR INSERTION INTO CONTAINER.

to deliver; low-water alarm level, at which an audible alarm sounds; the level at which automatic stop valve comes into operation; and emergency low level. The lamps can be seen in position in Fig. 11, on page 400.

In addition to these electrodes, a double-contact electrical gauge is fitted to the water bottle and arranged so that, if the high level indicated by the top light is exceeded, the high-level contacts of the gauge close due to the extra pressure and shut down the pump. Conversely, if water is drawn off below the emergency low level indicated by the bottom light, the low-level contacts close due to the drop in pressure and shut the automatic stop valve. The delivery from the pump is controlled by a by-pass valve; this, in turn, is actuated by a servo mechanism which opens or closes the valve according to the water level. With this arrangement, the pump operates continuously, circulating the water back to the supply tank while the by-pass valve is open. Compressed air for charging the air bottles is supplied by a Hamworthy three-stage compressor, the delivery pipe from the compressor being connected to a header block adjacent to the air bottles and provided with a check valve, pressure gauge and air charging valves. The Hamworthy compressor is of the two-crank three-stage type with integral coolers. It is designed to deliver 13 cub. ft. of free air per minute at a pressure of 3,500 lb. per square inch when running at 570 r.p.m. and is driven directly by a 15-h.p. electric motor.

As already mentioned, the water bottle is charged by a Fielding type-H8 hydraulic pump designed to use lubricated water as the operating medium. The pump is a horizontal three-ram unit which is driven by a Brush 265-h.p. screen-protected induction motor through double-helical single-reduction gearing and the usual form of flexible couplings. The crankshaft rotates at 200 r.p.m. and the output is 97 gallons per minute, the diameter of the rams being $2\frac{3}{4}$ in. and their stroke 8 in. In general, the construction of the pump is in accordance with the manufacturer's usual practice, the main bedplate consisting of a heavily-ribbed close-grained iron casting provided with bored recesses to accommodate the pump-barrel blocks. Split-type white-metal lined steel-backed main bearings are employed, and the crankshaft, which is machined from a solid forging, is provided with drilled ducts for lubrication of the big ends. The connecting rods are also machined from steel forgings, the big-end bearings being similar in form to the main bearings; the small ends, however, are of the spherical type and work in adjustable bronze bearings in the crossheads. These are of the circular type and work in cast-iron guides retained in their respective positions on a machined platform in the bedplate by studs and nuts. The rams, which are of Nitralloy steel, are ground to a high finish and operate in forged-steel pump barrels, each of which accommodates delivery and suction valves. Forced-feed lubrication is employed for the main bearings, crankpin bearings, crosshead guides and little-end bearings, oil being supplied at a pressure of between 10 lb. and 15 lb. per square inch by a gear-type pump. To ensure that an adequate supply of oil is available at the various bearings when the pump is started, the lubrication system incorporates a priming device, which is also arranged to shut down the pump driving motor should the oil pressure fall to a predetermined minimum value.

To provide a rapid approach of the main and piercing rams before the main high-pressure system is required to complete the extrusion process, a pre-filling tank system is employed. Low-pressure water at approximately 100 lb. per square inch is supplied from the pre-filling tank to the main and piercing cylinders of the press through filling valves, until the resistance of the billet is encountered; high-pressure water is then used to complete the extrusion process. The pre-filling tank is partly filled with water and is then loaded to a pressure of 100 lb. per square inch by compressed air. An unloading valve set to lift at 100 lb. per square inch controls the discharge of excess water exhausted from the press during the return stroke, and it will be appreciated that, with this system, the pressure in the pre-filling tank will fall when the press is operated during its run up by low-pressure water, but will rise again to the normal value of 100 lb. per square inch when the water is exhausted from the press back into the tank. As in the case of the air-hydraulic accumulator, the air in the pre-filling tank is not "consumed" but is compressed and expanded as extrusion proceeds.

Mention has been made already of the high degree of mechanisation adopted for feeding the billets into the press, the billets being handled mechanically from the moment they are placed in the furnace-charging mechanism. The billet-handling installation can be divided, broadly, into two sections, namely, the feed conveyors and associated elevating and charging gear, which feed the billets into the furnace, and the furnace unloading gear, which diverts the heated billets to the press-loading mechanism. Both sections consist of a system of conveyors and pneumatically-operated charging and discharging mechanisms; the conveyors were supplied by the British Wedge Wire Company, Limited, Warrington, and the pneumatic cylinders, etc., by Messrs. Benton and Stone, Limited, Birmingham, 6. The feed conveyors, which are illustrated in Fig. 5, on this page, are situated beside the billet cut-off machines and are fed from the machines by an overhead runway, as shown in the illustration. The conveyors consist of three separate lines of V-roller tracks arranged to feed three corresponding heating lines in the furnace, the first sections of each conveyor line being static, the second section power driven at a relatively slow speed, and the third section power driven but at a considerably faster speed, the fast section carrying the leading billet forward to deposit it on a cradle in which it is elevated to the furnace-loading station. Once the billet reaches the cradle, the conveyors are stopped automatically and, during normal operation, the.e is always a billet in each cradle.

The use of three separate heating lines in the furnace enables three different sizes of billet to be passed through at the same time; though, of course, three lines of billets all the same size can be heated, the actual arrangement used depending on the circumstances. To select a billet from any one line, the operator moves one of three selector valves on the main control desk; this causes the cradle for the line selected to be raised to the furnace charging position by a vertically-disposed pneumatically-operated ram. During its upward stroke, the ram opens a trip valve, which, by working through a relay valve, sets the corresponding horizontally-disposed furnace-charging ram into operation. This ram actually performs two duties, as, in addition to feeding the billet into the furnace, it moves the corresponding line of billets through the furnace, the billet situated at the far end of the line thereby being delivered into the discharge position. The furnace-charging rams, of which there are three, i.e. one to each line of billets, are therefore of a heavy-duty type, having a diameter of 8 in. One of the rams is shown in operation in Fig. 6, on page 393.

To bring the furnace discharge gear into operation, the charging ram opens a second relay valve at the end of its stroke. This supplies air to a pneumatic ram, at the far end of the furnace, which opens a side door located near the press loading section. It will be appreciated that there is a tendency for the billets to stick to one another as they proceed through the furnace, and that if the end billet is pushed sideways before being separated from its neighbour there is a likelihood of the latter billet being pulled at an angle to the main line, a set of conditions that inevitably would lead to jamming of the furnace. To prevent this, the portion of the furnace floor on which the billet ready for discharge rests, known as the withdrawal plate, is moved away from the line of billets in a longitudinal direction before the discharge gear comes into operation, thus effectively separating the billet from its neighbour. This operation takes place during the period in which the furnace side door is opening and at the end of its movement. The withdrawal plate actuates a further relay valve which brings into operation the discharge thruster, a device for removing the heated billets from one side of the furnace. It is operated by a ram having a diameter of 3 in. and a stroke of 4 ft., and is arranged to move across the full width of the furnace, picking up the billet during the course of its travel and depositing it on the discharge conveyor, which is situated at right angles to the furnace and delivers the billet to the press loading station.

The discharge conveyor, which is illustrated in Fig. 7, on page 393, consists of a plate and roller track down which the billets roll, the billets being controlled as they roll down the track by a twin-chain conveyor fitted with cross bars. A spring-loaded gate set diagonally across the track automatically diverts the billet to the loading station and the conveyor is set in motion and stopped by the billets as they enter and leave the feed and discharge sections. When the discharge thruster reaches the end of its stroke, it operates a release valve which causes all pneumatic rams to return to the neutral, or starting, position. As the billet-lifting section of the feed conveyor lowers, however, it trips a switch, which sets in motion the feed conveyors for that particular line of billets so that a fresh billet is deposited in the lifting section or cradle. By this means, a billet is always in position in each cradle, ready for lifting to the furnace-charging station. After each billet reaches the press loading station, it is raised to the centre line of the press by a hydraulic ram, as shown in Fig. 8, the billet subsequently being moved into the container by the main ram. It should be pointed out, however, that this does not form part of the automatic pneumatically-controlled furnace charging and discharging cycle, but is a separate operation under the control of the operator.

The coiling machines for winding the hot extruded rods and sections were built to the design and specification of the Aston Chain and Hook Company. There is a vertical coiler designed to handle rods up to $\frac{3}{4}$ in. diameter and a horizontal coiler for dealing with rectangular and more complex sections. The vertical coiler is situated at the rear of the press near the run-out channel, the hot rods being fed to the coiler pan through a rectangular duct which is hinged so that it can be moved clear of the die-holder when the discard is sheared off. The machine consists of a Kopp 5-h.p. Variator motor coupled to a worm-reduction unit arranged to drive a dished coiling pan, on the base of which is a quadrant. This rotates with the pan, and when extrusion is completed the quadrant is raised by an air cylinder and ram assembly, thus freeing the coil from the pan. The horizontal coiler is situated at the end of the run-out channel as shown in Fig. 12, on page 400. It is operated by an Austin Hopkinson compressed-air motor, the coiling pegs are fitted to a disc integral with the shaft of the motor. The motor is arranged on four slide bars so that, when coiling is completed, it can be withdrawn, together with the coiling disc and pegs, into its housing, the extruded metal, as a consequence, being deposited on the floor for stacking or transporting to the next process. As in the case of the vertical coiling machine, a pneumatically-operated ram is used to withdraw and advance the air motor. Compressed air for this service, and for operating the rams on the billet-handling plant, is supplied at a pressure of 100 lb. per square inch by a Broom and Wade D24 two-cylinder single-stage compressor driven by a 35-h.p. electric motor, a reducing valve being installed in the air line feeding the coiling machines.

FURNACE FOR 2,000-TON EXTRUSION PRESS.

FUEL FURNACES, LIMITED, BIRMINGHAM.

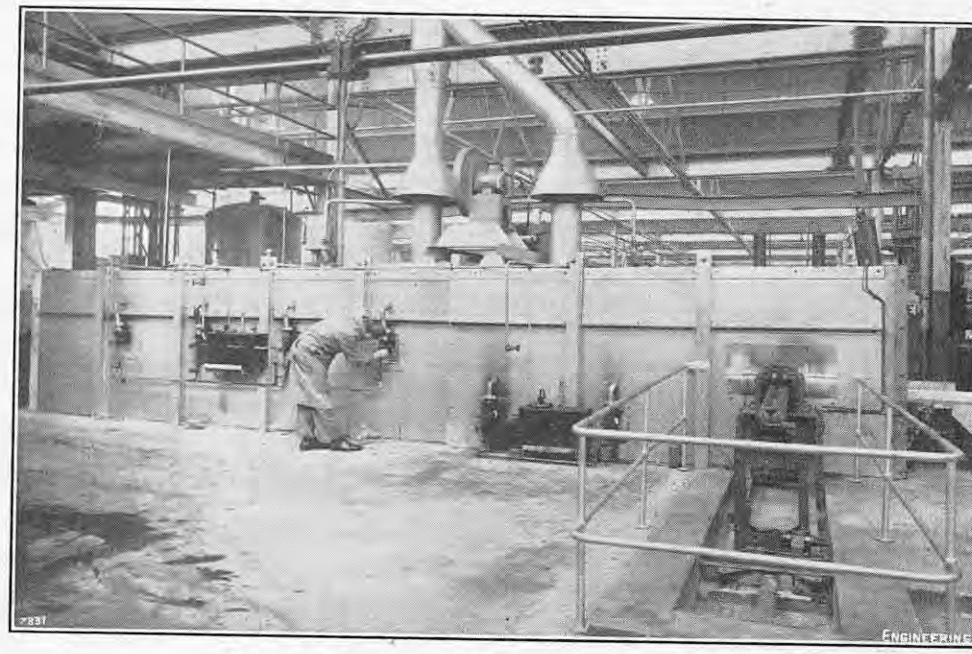


FIG. 9. FURNACE AND BILLET DISCHARGING GEAR.

The billet-heating furnace, which is illustrated in Fig. 9, on this page, was supplied by Fuel Furnaces, Limited, 36, Ashted-row, Birmingham. The hearth for the heating chamber is 3 ft. 6 in. wide, the three grooves along which the billets are moved by the charging rams being lined with nickel-chromium steel. Billets up to 10 in. in diameter are catered for, and the length of hearth, namely, 27 ft., is based on twelve billets each 2 ft. 3 in. long. The output, or discharging, end of the furnace is in the form of an additional chamber; this has a width of 5 ft. 3 in. and a length of 3 ft. 3 in. and contains the withdrawal plate mentioned previously. This is mounted on machined nickel-chromium rollers which move in channels cast from the same alloy and is connected through push rods to two pneumatic rams. These hold the plate firmly against the front edge of the hearth while the billet is moved into position and then withdraw the plate 6 in. to the billet-discharging position.

The furnace is constructed of refractory and insulating materials, the combustion chambers at the output end being lined with silicon carbide. It is fired by twelve small low-pressure oil burners, six at each side, the burners being designed so that the flow of oil is proportional to that of the air. This enables the temperature to be controlled by manipulation of the air valves only and gives the added safeguard that, should the fan stop for any reason, the flow of oil is automatically cut off. The combustion air is pre-heated in waste-gas recuperators and the oil temperature controlled by electric-immersion heaters in the supply tanks within the limits of 150 deg. F. and 170 deg. F. In addition to heating the air, the products of combustion are also used for pre-heating the billets before they reach the high-temperature zones of the furnace. To achieve satisfactory automatic control of temperature, the furnace is divided into two zones each governed by a recorder with a potentiometer control. A third recorder is coupled to a special temperature-measuring device located at the point where the hot billet enters the press, thus enabling the temperature of each billet to be recorded separately; this recorder can also be used for checking the number of billets passed through the machine. An extension from this instrument energises an indicator on the main control desk so that the operator can check the temperature of each billet before passing it into the press. The furnace is rated to heat 5,400 lb. of copper billets per hour to a temperature of 850 deg. C. for the expenditure of $11\frac{1}{2}$ gallons of fuel oil. This rating is based on a thermal efficiency of 42 per cent., but the manufacturers expect this to be exceeded during service.

H.M.S. "VENGEANCE" TO BE LENT TO AUSTRALIA.—The light fleet carrier Vengeance, the Admiralty state, is to be lent to the Royal Australian Navy. An Australian crew is expected to arrive in the United Kingdom about November, 1952, to take the ship over and steam her to Australia, where she will arrive early in 1953. The loan is being made to fill the gap until the light fleet carrier, at present being built in the United Kingdom for the Royal Australian Navy, is completed.

SOME ACTIVITIES OF THE INSTITUTE OF METALS.*

By DR. C. J. SMITHELLS, M.C., F.I.M.

THE Institute of Metals was formed in 1908 and held its first meeting in Birmingham. On December 31, 1908, there were 355 members, and four years later the number had risen to 606. It was not, however, until the Institute was 10 years old (1918) that the membership reached 1,000. To-day it is 3,832.

The comparatively slow growth of the Institute during the early years is of some interest, and was due to two main causes. The first was the very much smaller size of the non-ferrous metals industry in those days, the aluminium industry, for instance, being virtually non-existent, and the much smaller number of metallurgists engaged in the industry. This is reflected by the number of students being trained in metallurgy at the Universities and technical colleges. I have tried to obtain reliable figures, and it appears that in 1910 about 50 students graduated with metallurgy as their principal subject, while in 1951 the figure was 1,009, of whom 236 took University degrees and 773 obtained the Licenciateship of the Institution of Metallurgists, the Higher National Certificate, or the certificate of the City and Guilds of London Institute. The second cause was the character of the industry itself; in 1908 the production of non-ferrous alloys was mainly an art, and science played little part. Coupled with this was a degree of secrecy on the part of manufacturers which to-day seems almost incredible.

There is no doubt that scientific societies like ours, as well as the research associations and development associations, have had a major share in bringing about the more broad-minded attitude now adopted by most of the larger industrial organisations. I think that there is still room for improvement in this respect in some sections of the industry, but co-operation is now much more fashionable than secrecy. Curiously enough, in my experience it is the smaller firms, with the most to gain by co-operation, which tend to remain secretive.

I feel sure that some of us forget how very recent is the science of metals, and how the facts and theories which every student now learns first appeared as original papers in our *Journal* and had to stand the criticism of discussion at our meetings. To emphasise this I should like to quote from some earlier presidential addresses: Sir Gerard Muntz, in 1910, said: "General knowledge of the non-ferrous metals is simply appalling by its absence; it leaves the greater scope for the work of the Institute of Metals." Professor A. K. Huntington, in 1913, remarked: "It must be remembered that metallography for practical purposes has only come into existence within the last fifteen years or so. The difference it has made in understanding what happens to metals and alloys in course of manufacture and in use is incalculable." Engineer Vice-Admiral Sir Henry Oram, in 1914, said: "Methods in brass foundries are often still of the haphazard and rule-of-thumb variety, and close supervision by the chemist or other scientist, which is essential to continuous success, is often wanting. Pyrometers, although more largely used than formerly, are still often unknown, temperature being frequently judged by the eye. One finds generally a lack of scientific precision and knowledge in the melting, mixing and pouring, which, if it existed and were combined with practical experience, would greatly add to the value of an establishment."

Sir George Beilby referred to the almost complete absence in the *Journal* of papers on light alloys, and commented that although the early enthusiasm with which aluminium was welcomed as an industrial metal was largely based on the belief that its combined lightness and strength would enable it to take a place in serious structural and machine work, its mechanical properties were found to have been greatly over-rated, while its resistance to wind and water left much to be desired. I also found, in the first volume of the *Journal*, a statement that no doubt railway companies using steam traction will in due time grasp the advantage to be obtained by using aluminium, thus lightening their train loads and economising generally in their running expenses. Perhaps, in due time, they will!

Even as late as 1928, Dr. W. Rosenhain thought it necessary to devote one half of his Presidential address to giving "something in the nature of an explanation —even a defence—of the equilibrium diagram . . . addressed essentially to the practical man who may perhaps care to know why these things are determined, what they are, and how they can be applied to practical purposes," and the other half to explaining the age-hardening of aluminium alloys.

In the past, the Council has been reluctant to agree to the formation of separate Groups or Divisions within the Institute. In 1944, however, a Metal Physics Committee was appointed to provide a closer link between physicists who are studying metals and academic and industrial metallurgists.

In 1949 another special committee—the Metallurgical Engineering Committee—was formed to promote the study of equipment and instrumentation. It was concerned with the arrangement of the symposia on hot working and cold working, held in 1950 and 1951, and in January of this year it organised a very successful informal discussion in Birmingham on "Tool and Die Materials for the Extrusion of Non-Ferrous Metals and Alloys." The symposium on "Equipment for the Thermal Treatment of Non-Ferrous Metals and Alloys," held during the present meeting, also owes its origin to the Metallurgical Engineering Committee. Hitherto the *Journal* has contained very few papers dealing with the plant and equipment used in the industry, and we hope this important field will now receive the consideration that it deserves.

A sub-committee has recently considered the organisation of future meetings of the Institute with the object of meeting the needs of the widest possible range of members. Its recommendations, which have been approved by the Council, ensure that in the future, at annual general meetings, one whole day will be devoted to a symposium on a subject of interest to production metallurgists and metallurgical engineers, while three half-days will be set aside for the discussion of other papers which have been published in the *Journal*. The suggestion of concurrent sessions on widely differing subjects is being tried again in connection with the present meeting, and both the Metal Physics Committee and the Metallurgical Engineering Committee have been authorised to arrange informal discussions. While, therefore, the presentation and discussion of original papers will still be the main feature of Institute meetings, the needs of the practical man and the specialist should be met by these arrangements.

There has not unnaturally been some criticism from time to time of the duplication in abstracting which results from the publication of their own separate abstracts by each of the three British metallurgical Institutes; the Iron and Steel Institute, the Institute of Metals, and the Institution of Mining and Metallurgy. There is not, perhaps, so much duplication as some people suppose, but the suggestion of issuing one common abstract journal has been made several times on the grounds of economy and convenience.

Quite recently, a meeting of representatives of the three Institutes was held, at our instigation, to consider whether agreement could be reached to publish one comprehensive British abstracts periodical in place of the present three series. Your Council was prepared to go a long way to see this objective reached, but I am sorry to say that the representatives of the other two societies were not prepared to recommend to their Councils the discontinuance of their own separate abstracts, and the Council of one of the Societies has definitely decided to maintain its own separate series. Although with the present high costs of printing, paper, and postage no financial saving would have been effected, the prestige which would result from such a British publication is something that we should keep in mind, in the hope that eventually a solution may be found.

Many of our Presidents have in the past appealed to authors to express themselves in fewer words. Professor Thomas Turner devoted part of his address in 1924 to this subject, and he said that one method of meeting the difficulty was by a more rigid censorship of papers, and by the adoption of a less diffuse style in writing. He reminded members that the ability to express important facts in simple language was an indication of experience and of clearness of thought, and that in many cases the permanent value of a communication varied inversely as the square of its length.

In 1934 Dr. H. Moore made a similar appeal, and our immediate past-President, Professor A. J. Murphy, felt impelled to comment again last year that there were few papers which would not actually be improved in clarity by an hour or two of the author's time being devoted to the removal of superfluous words and phrases. There is still room for some improvement in this respect, although I think this alone will not meet the case. I feel that there should be some method of presenting the results of scientific research in a more condensed form than is now customary, yet without losing anything of value. This in itself is a subject for research, and if the Publication Committee can devise something of this nature it will perform a real service not only to the Institute, but to other publishing societies.

An activity which occupied the attention of the Institute in its early years was the prosecution of metallurgical research. Many of you may have forgotten this, but you must remember that practically all the industrial research laboratories with which we are now familiar were founded 5, 10, or 15 years after the formation of the Institute. It therefore seemed right to our founders that the Institute should be prepared to carry out co-operative research for the industry. Sir Gerard Muntz suggested in 1910 that "A system might be initiated by which any member meeting with some obscure problem, upon which he desired light, might communicate it to the Secretary of the Institute." I don't know what Colonel Guillan's reaction to such a request would be, but I have no doubt that he would be equal to the occasion. And Muntz continued: "Until the Institute is in a position to establish a laboratory and research staff of its own, it must look to its members individually for the necessary help and research in any work which it desires to undertake. It must be some time yet before we are rich enough to think of such an establishment, but there is no harm in dreaming of the days which may be."

The Institute did, in fact, sponsor research into the corrosion of condenser tubes by sea-water, which was at that time a matter of grave concern to the Admiralty. A Corrosion Research Committee was set up in May, 1910, with Dr. G. D. Bengough as the Institute's first (and honorary) investigator. Experimental work was carried out initially at Liverpool University, and was transferred in 1916 to the Royal School of Mines. At its inception the cost was borne by contributions from the Admiralty, the industry, and shipowners. Subsequently, both the Department of Scientific and Industrial Research and the British Electrical and Allied Manufacturers' Association became contributors, and the work was extended to cover light alloys at the request of the Air Ministry. Work of great value, which led eventually to the development of the aluminium-brass condenser tube, was continued by the Institute until 1930, when the research was taken over by the British Non-Ferrous Metals Research Association.

Another matter in which the Institute has played its part is in the practical application of scientific knowledge to industrial processes. Sir George Goodwin in 1920 commented that while he had read and heard a great deal about the advantages that must result from the application of science to industry, a large portion of it had remained for a long time, and still remained, in the abstract and was not really applied. And Dr. Rosenhain, in 1928, said "It is not a bad thing, even for the most scientific worker, to pause at times and consider the nature and possible practical utility of the work on which he is engaged." Sir Henry Fowler in 1932 again laid great stress on this matter and said that one of the great problems of the day was the "marrying up" of research with the practical application of the results obtained.

It was not until about 1948, however, that someone in official circles invented the term "operational research" to cover this activity, which had been constantly in our minds and had long been one of the normal tasks of industrial research teams. The various symposia which we have held in recent years have been a very direct contribution in this field.

There is another metallurgical field, however, which the Institute has deliberately refrained from entering until very recently, namely, that of metal reserves and metal conservation. In 1924 Professor Turner quoted the opinion of Sir Thomas Holland that the whole of the known base-metal supplies of the world would not last for many years at the current rate of consumption, and that a shortage of supply could be expected within the lifetime of persons then living. He added that it was clear that the supply of base metals in future was likely to be restricted to an extent which had not hitherto been contemplated. Of aluminium alone, he said, there appeared to be an unlimited supply. Dr. C. H. Desch returned to the subject in 1938, but added that: "To discuss these questions, tempting as they are, would be to travel far beyond the scope of this Institute."

However, last year, Professor Murphy, realising the increasing importance of this subject, said that it appeared to him that there was a clear opportunity for the Institute to perform a public service by devoting some attention to those aspects of metallurgical science and industry concerned with the resources of metals on which the non-ferrous metallurgical industry is based and with the most efficient utilisation of these resources. Following this suggestion, the Institute organised a general discussion on this subject in October last year, to which contributions were made not only by metallurgists, but also by leading geologists, economists, and representatives of Government departments. While the world situation is creating a serious shortage at the present time, the pessimistic forecasts which have appeared at intervals for the last 50 years would hardly seem justified, at least while so much of the North American Continent remains unexplored.

* Presidential Address delivered before the Institute of Metals on Tuesday, March 25, 1952. Abridged.

INSTITUTION OF MINING AND METALLURGY.—The annual dinner of the Institution of Mining and Metallurgy is to be held in the Goldsmiths' Hall, Foster-lane, London, E.C.2, on Thursday, April 24, at 7 for 7.30 p.m. Applications for tickets, price 45s. each, should be made to the secretary of the Institution, Salisbury House, Finsbury Circus, London, E.C.2, as soon as possible but not later than April 14.

ROLLING LIFT BRIDGE FOR SURREY DOCKS LOCK ENTRANCE.

Fig. 1. BRIDGE LOWERED.

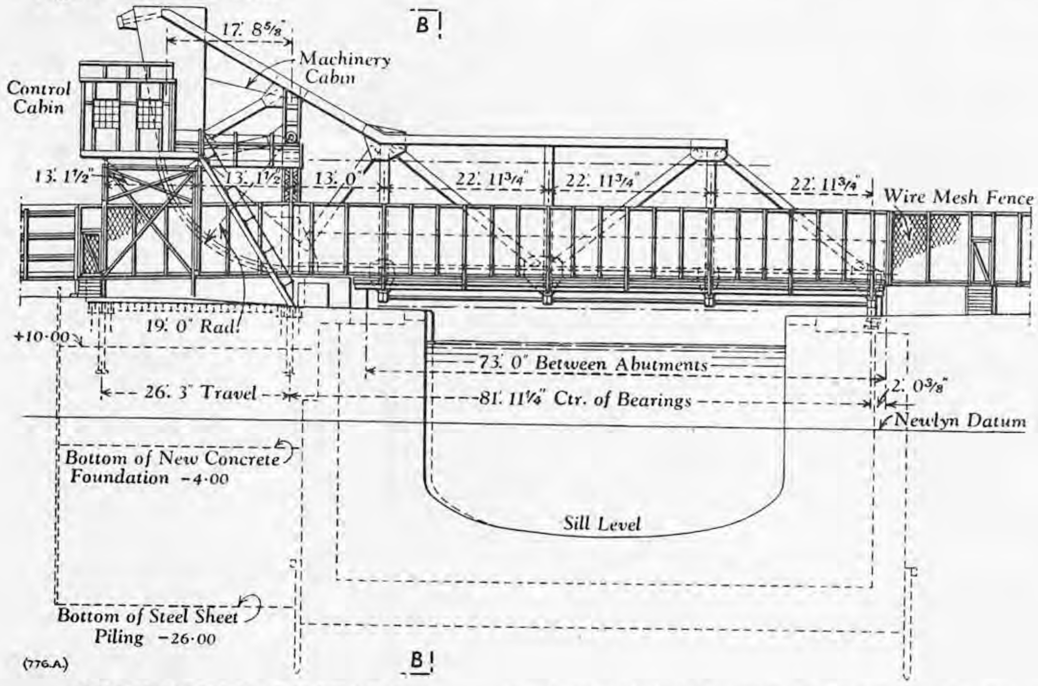
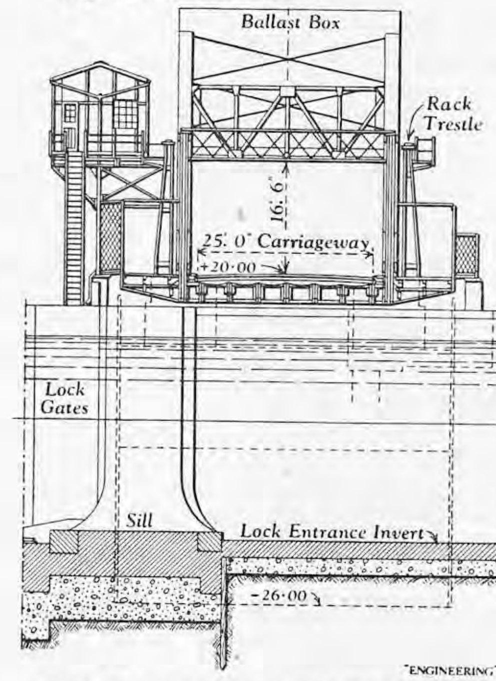


Fig. 2. CROSS SECTION B-B.



HELICOPTER RESEARCH.

METHODS for increasing the forward speeds of helicopters were among the subjects discussed in a paper entitled "Some Recent Helicopter Research Investigations," presented by Mr. William Stewart at a meeting in London of the Helicopter Association, on Friday, March 21. The forward speed of the helicopter, he said, tended to be limited by vibration arising mainly from blade stalling. There were four methods by which this limitation might be overcome. Firstly, a fixed wing could be used in addition to the rotor, allowing the latter to operate at lower thrust and reduced blade incidences. Secondly, a supersonic rotor might be used. Thirdly, a much higher ratio of forward speed to rotor tip speed might be adopted; this gave a considerable region of reversed flow on the retreating side, and the incidence of the retreating blade could be "reversed" to generate lift. The remaining method, which the lecturer discussed in some detail, was to re-distribute the loading over the rotor disc by the use of a second-harmonic pitch control.

The ordinary rotor with flapping hinges and cyclic pitch control, he said, maintained a roughly uniform lift around the disc. As the forward speed increased, the resultant airflow over the retreating blade decreased, and a higher incidence was required. If the loading distribution on the disc could be controlled, the limitation imposed by the retreating blade reaching stalling incidence could be avoided. Second-harmonic pitch control could be introduced, to reduce the loading on the lateral section of the disc and to increase it fore and aft, by a mechanism such as a swash plate rotating at three times the rotor speed, or at the rotor speed in the opposite sense. It would, of course, increase the mechanical complexity of the rotor head. Calculations of the resulting blade motions agreed well with practical results on a Sikorsky rotor-testing tower in which second-harmonic control had been introduced in order to reproduce flight stresses. Forward speed had practically no influence on the blade-flapping motion due to second-harmonic control, so that only a constant phase-angle setting of the control would be necessary. It might be possible to use also a fixed amplitude setting, to avoid the need for additional control by the pilot. This method, Mr. Stewart concluded, could lead to forward-speed increases of the order of 40 to 50 m.p.h.

The paper also described the results of a theoretical investigation on the behaviour of helicopter rotors during transient motions, and wind-tunnel measurements on the motions of an oscillating rotor system.

AWARDS TO INVENTORS.—The National Coal Board are to make cash awards to employees in the industry for technical inventions which can be usefully applied in the Board's mining or ancillary activities (which include carbonisation, briquetting, tar distillation and by-products, brickworks, etc.). Awards panels in the Board's divisions have power to recommend payments of up to 100*l*., and a national tribunal, under independent control, will deal with inventions considered to be worth more than 100*l*. The chairman of the tribunal is Sir Ernest Gowers, and the members are Professor D. M. Newitt, Sir William Stanier, Sir Andrew Bryan, Mr. H. J. Crofts and Mr. R. M. Marson.

ELECTRICITY SUPPLY IN ATHENS.

THE Athens Piraeus Electricity Company, Limited, have celebrated the 25 years of their existence by the issue, in English and Greek, of a well-illustrated booklet recounting the salient facts in the development of the undertaking. Actually, the history of electricity supply in this ancient capital began as early as 1903 when the Compagnie Hellénique d'Electricité erected a 3-MW station at New Phaleron. This concern, however, ran into financial difficulties, and although by 1922 the capacity of the station had been increased to 13 MW this was no longer sufficient to meet the demand.

In 1925, therefore, the Government negotiated an agreement to form the Athens Piraeus Electricity Company, as a result of which the station at New Phaleron was extended by 16 MW and the construction of a modern 45-MW plant was begun at St. George's Bay, Keratsini. The original 110-volt direct-current distribution system was also converted to 220/380 volt alternating current and considerable work was carried out at no cost to the consumer in modernising both factory and domestic installations. Attractive showrooms were opened, and as a result of this technical and commercial enterprise the consumption rose from about 83 million kWh in 1930 to 156 million kWh in 1936, an increase of 188 per cent. Subsequently, the New Phaleron station was modernised by replacing the original reciprocating engines and vertical turbines, and the capacity of the St. George's Bay station was raised to 60 MW. By 1939, the output had reached 234 million kWh and although this naturally fell off considerably during enemy occupation (owing to fuel shortage, which necessitated the conversion of the oil-burning boilers to solid fuel) the plant was not actually damaged until the outbreak of the insurrection of December, 1944. Nevertheless, recovery was not easy and for a time the lack of spare parts led to the use of equipment taken from four obsolescent American auxiliary naval vessels. Later, however, new boilers and Diesel engines were installed, so that by 1948 production had risen to 336 million kWh with a peak load of 57 MW. To meet ever-increasing requirements the capacity of the New Phaleron station was raised to 72 MW by the beginning of 1951, making a total generating capacity in the area of 132 MW, which is twice what it was before the war and 14 times what it was 25 years ago. This is a record of which the company may well be proud.

ELECTRIC POWER CUTS.—In reply to a question by Mr. W. Shepherd in the House of Commons on Monday, March 24, the Minister of Fuel and Power (the Rt. Hon. G. W. Lloyd) said that the number of power cuts had been 16 during the winter of 1949-50 and four in 1951-52.

100-MW TURBO-ALTERNATORS AT THE RICHARD L. HEARN STATION, TORONTO: ERRATUM.—We regret than an error occurs in the first part of the article on "100-MW Turbo-Alternators at the Richard L. Hearn Station, Toronto," which was published in our issue of March 21. At the bottom of the first column on page 355, the sentence "This device is mounted on the governor casing, as shown in Fig. 2, opposite" should read "as shown in Fig. 4, above."

ROLLING LIFT BRIDGE FOR SURREY DOCKS.

THE opening of the new Surrey Lock bridge at Surrey Docks, on Friday, March 7, by Viscount Waverley marked an important improvement in the Surrey Docks area as the new structure replaces an old swing bridge, constructed in 1858, which, having only one roadway 8 ft. 9 in. wide, had long proved a hindrance to traffic. Furthermore, as a result of enemy action, the swing bridge was immobilised during the last war, navigation through the lock entrance, as a consequence, being restricted to barges, while continued deterioration had compelled the Port of London Authority to prohibit the passage of loads over 10 tons. The new bridge, on the other hand, carries a roadway 25 ft. wide, ample for two lines of traffic, and is flanked by two footways, each 7 ft. 6 in. wide. The opportunity was also taken in planning the new bridge to improve the alignment of Rotherhithe-street by eliminating two awkward bends, the necessary land for this purpose having been provided by the Port of London Authority. The re-alignment of the approach road also permitted the new bridge to be built without interfering with the traffic over the old bridge.

The new structure is a single-leaf rolling lift bridge of steel construction, consisting of a front arm which spans the lock entrance and a rear arm forming a balanced quadrant on which the structure rolls when the bridge is raised and lowered. It is illustrated in Figs. 1 and 2, on this page, and in Figs. 3 and 4, opposite, the latter two illustrations showing the bridge in the raised and lowered positions, respectively. The clear width of the lock entrance is 54 ft. and the span of the front arm is 82 ft. between centres of bearings. The radius of the quadrant girders is 19 ft. and the length of travel 26 ft. 3 in. The total weight of the bridge is 720 tons, this figure including 400 tons of counterweight in the ballast box. It is balanced about the centres of the quadrant girders, but, to prevent "chattering" due to the passage of live loads, there is a preponderance of 1 ton at the nose end.

The main foundation of the bridge is of mass concrete, which was placed in position on the west side of the lock entrance, close to the lock wall; to avoid any possibility of the basin being damaged, however, the mass concrete was not grouted to the lock wall until the complete bridge was erected. The concrete was placed inside a cofferdam constructed from sheet-steel piling, and rests on a bed of ballast overlying London clay, the pressure on the ballast being in the neighbourhood of 3 tons per square foot. The general construction of the bridge will be clear from the drawings on this page, from which it will be seen that it is of the built-up open-girder type. The main girders are set at 29 ft. 4½ in. centres and the top and bottom booms are separated by a distance of 18 ft. measured between their centre lines. The bottom booms are spanned by cross girders of the built-up plate type, which are extended outwards to form the supports for the two sidewalks and are arranged to carry the main longitudinals. The quadrant-girder rolling plates and the track plates are made from high-tensile steel 4 in. thick and, to allow for cold-rolling effects, ⅛-in. wide diagonal gaps have been introduced on the rolling and track plates at intervals of 6 ft. 6 in., the angle of the joints on the rolling plate being opposite to that

ROLLING LIFT BRIDGE FOR SURREY DOCKS LOCK ENTRANCE.

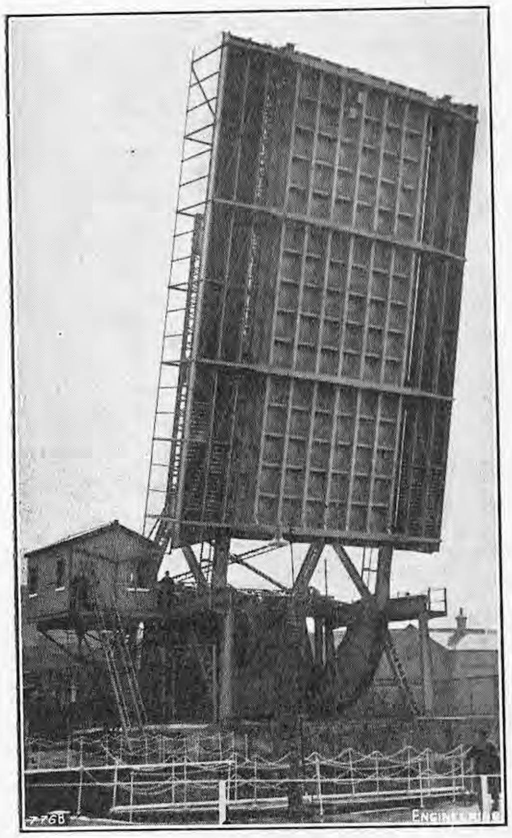


FIG. 3. BRIDGE RAISED ON QUADRANT GIRDERS.

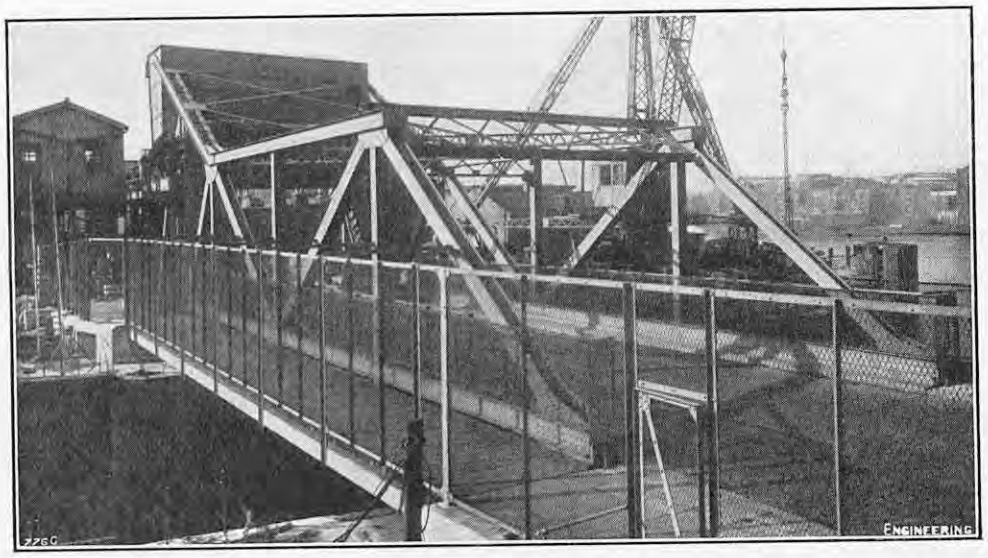


FIG. 4. BRIDGE LOWERED.

of the joints in the track plate. Slots formed in the quadrant-girder rolling plates engage with teeth on the track plates, the teeth being 8 in. long, 5¼ in. wide, and set at a pitch of 2 ft. 2¼ in.

The decking for the road portion of the bridge consists of steel buckle plates filled with concrete, which, in turn, is covered by a layer of asphalt water-proofing. Longitudinal planks, secured to the steelwork by bolts, are laid on top of the asphalt and these are covered by a layer of wood blocks which form the actual road surface. To ensure that the wood blocks remain in position when the bridge is lifted, they are dowelled to each other and secured to the planking by coach screws, there being three such screws to each square yard. The counterweight consists of a steel box filled with 240 tons of concrete and 160 tons of cast iron, pockets being provided in the concrete for the adjusting weights. Ab ut 100 tons of the iron consists of kentledge blocks from an old bridge in the Limehouse area.

The bridge is raised by two electric motors mounted on the moving leaf, each motor being of 50 h.p. These act through a differential unit arranged to drive two trains of reduction gearing, which terminate in the main pinions designed to move along fixed racks supported on trestles situated outside the bridge structure. Straight-spur gearing is used throughout and the overall reduction ratio is 162 to 1, the motors running at 700 r.p.m. A supply of electricity is given on the three-phase system at 430 volts for power and on the single-phase system at 250 volts for lighting, heating and control purposes. Operation is through a master controller situated in the operator's cabin, and all controls are interlocked so that they can only be moved in the correct sequence, a visual indicator in the cabin showing the stages of operation. To raise the bridge, the roadway gates are first closed by hand, a nose-locking bolt withdrawn and the leaf then raised by the main machinery. The locking bolt, which is made from stainless steel, is of square section with sides of 3 in. and is operated by a 1½-h.p. electric motor arranged to drive the bolt, through worm gearing, into a recess formed in the abutment. In fair weather, the bridge can be raised and lowered by one main driving motor in three minutes and with both motors coupled together in 3½ minutes against a wind pressure of 15 lb. per square foot. Auxiliary hand gear is provided for use in the event of a failure in the electricity supply and the brakes are designed to hold the leaf against a wind pressure of 30 lb. per square foot. Two pneumatic buffers are installed at the nose of the bridge; these consist of straightforward piston and cylinder assemblies with the piston rods extruded so that they make contact with the abutment in advance of the main structure, the air escaping from the cylinders through a common adjustable needle valve.

Work on the new bridge was started in April, 1949, and completed in January, 1952, when it was made available for operation by the Port of London Authority, to whom the structure has now been handed over. The bridge was designed and constructed under the direction of Mr. J. Rawlinson, chief engineer of the London County Council, and the main contractors were Sir William Arrol and Company, Limited, 85, Dunn-street, Bridgeton, Glasgow. The civil-engineering work was sub-contracted to Messrs. Paterson and Dickinson, Limited, Westmoreland-road, London, N.W.9, the control gear supplied by the Igranic Electric Company, Limited, Elstow-road, Bedford, and the electrical installation work carried out by Messrs. W. J. Furse and Company (London), Limited, 9, Carteret-street, London, S.W.1. The Bermondsey Metropolitan Borough Council and, of course, the Port of London Authority, also collaborated in the constructi n of the bridge.

The new bridge was handed over officially to the Port of London Authority on Friday, March 7, during an opening ceremony at which Viscount Waverley, chairman of the Port of London Authority, and Mr. J. W. Bowen, chairman of the London County Council, officiated. The total cost of the work was approximately 110,000*l*., this amount being divided between the Ministry of Transport, the Port of London Authority and the London County Council. In addition to easing the flow of road traffic, the new bridge will enable the Surrey Dock entrance to be used by large vessels entering or leaving Surrey docks, thereby reducing congestion of shipping at the other entrance to the Surrey docks, namely, that leading to the Greenland dock at the southern end.

EXPERIENCE WITH THE GAS-TURBINE ALTERNATOR IN THE "AURIS."—According to a statement issued by the Anglo-Saxon Petroleum Company, Limited, St. Helen's-court, London, the tanker Auris has now completed her first trans-Atlantic crossing using the gas turbine alone for propulsion purposes, leaving Plymouth on February 26 and arriving at Curaçao on March 20. Although heavy weather was experienced for several days, at no time was it found necessary to stop the turbine or vary its speed, the turbine working continuously for 23 days. After the pilot was dropped, the Diesel generators which, it will be recalled, provide 75 per cent. of the total propelling power, were shut down and the ship proceeded on the turbine only. In the course of the voyage, the vessel covered 3,897 miles at an average speed of 7·35 knots, and it is understood that throughout the voyage the performance of the turbine was remarkably consistent, a high degree of combustion efficiency having been obtained, with absence of fouling in the principal components. Boiler-grade fuel having a specific gravity of 0·958 and a viscosity of 1,300 seconds Redwood No. 1 at 100 deg. F. was used throughout the trip; the results obtained, therefore, are all the more remarkable. After loading at Curaçao, the Auris is proceeding to South America and then returning to the United Kingdom using the whole of her propelling machinery, which, it will be recalled, consists of three Diesel alternators as well as the turbine alternator, all of which supply a single electric motor arranged to drive the propeller shaft. Details of the gas turbine, which was made by the British Thomson-Houston Company, Limited, Rugby, were given in ENGINEERING, vol. 171, page 209 (1951).

THE INSTITUTION OF NAVAL ARCHITECTS.

THE 1952 Spring Meeting of the Institution of Naval Architects will be held next week on board the Wellington, the headquarters ship of the Honourable Company of Master Mariners, moored at Temple Stairs, Victoria Embankment, London. The opening session will begin at 10.15 a.m. on Wednesday, April 2, when the President, Viscount Runciman of Doxford, will deliver his address, which will be followed by the first of the nine papers, on "Britain's Deep Sea Liner Trade," 1945-51," presented by Mr. Basil Sanderson, M.C. The annual dinner of the Institution will be held on the evening of the same day in the Connaught Rooms, Great Queen-street, W.C.2.

Four papers will be presented and discussed on Thursday, April 3, two at the morning session and two in the afternoon. The sessions will begin at 10.15 a.m. and 2.30 p.m., respectively. The papers to be delivered in the morning are "Merchant Ship Design—A Thought on the Future," by Sir Wilfrid Ayre, and "Changes in Ship Construction Methods, 1850 to 1950," by Mr. Norman M. Hunter. At the afternoon meeting, which will be a joint meeting with the Institute of Marine Engineers, the papers will deal with "The Generation of Gas Bubbles at the Shrinkage Boundaries of Built-up Crankshafts for Diesel Engines," the authors of which are Mr. S. Amari and Mr. E. Ando; and "High-powered Single-Screw Cargo Liners," by Mr. W. H. Dickie.

On the morning of Friday, April 4, at 10.15 a.m., Mr. D. W. Lang, B.Sc., and Mr. W. G. Warren will present a paper on "Structural Strength Investigations on the Destroyer Albuera," which will be followed by one on "The Prediction of Thermal Conditions in H.M. Ships in Tropical Waters," by Mr. J. A. B. Gray, M.A., M.B., and Mr. F. E. Smith. In the afternoon, at 2.30 p.m., Dr. G. Hughes will read a paper on "Frictional Resistance of Smooth Plane Surfaces in Turbulent Flow: New Data and a Survey of Existing Data." The concluding paper of the Spring Meeting, following that of Dr. Hughes, will be by Mr. W. Muckle, M.Sc., and is entitled "The Scantlings of Long Deck-houses Constructed of Aluminium Alloy."

SYMPOSIUM ON SIMPLIFICATION IN STAINLESS-STEEL SPECIFICATIONS.—The Institution of Chemical Engineers, 56, Victoria-street, London, S.W.1, are to hold a meeting on Tuesday, April 1, at the Geological Society, Burlington House, Piccadilly, London, W.1, to discuss "Simplification in Stainless-Steel Specifications." Dr. F. A. Freeth will take the chair at 2.30 p.m., when Mr. J. L. Sweeten will give an introduction to the symposium. After this, Mr. E. Smith will give the "View of the Steelmaker," Mr. M. M. Hallett and Mr. C. Hand the "View of the Foundryman," and Dr. J. W. Jenkin the "View of the Semi-finished Products Maker." After a tea interval, Mr. J. F. Lancaster will give the "View of the Fabricator" at 5.30 p.m., Mr. F. H. Keating and Mr. W. D. Clarke will discuss the "View of the User" and Mr. G. A. Dummett will speak on "Substitute Stainless Steels." A *resumé* of the proceedings will be given from 7.10 to 7.30 p.m. by Dr. E. H. T. Hoblyn. A summary of the remarks to be made by various speakers is obtainable on application to the Institution.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

JAPANESE STEEL ON THE CLYDE.—A consignment of 1,400 tons of steel plates arrived at the Clyde from Yokohama on March 20 for distribution to local consumers. This followed a shipment of 2,000 tons of wire rod which arrived a fortnight previously. The quality of the latter received some favourable comment, the carbon ranging from about 0·08 to 0·15 per cent. A further cargo of about 2,000 tons of rod is expected in the course of the next two weeks.

FLOUR MILLS TO BE BUILT AT LEITH.—Joseph Rank, Ltd., London, were granted a warrant by the Dean of Guild Court, Edinburgh, on March 14, for the erection of flour mills and silos at Leith, which will cost 1,500,000*l*. A portion of the work to be carried out includes the reclamation of 3½ acres of land and the building of two quays. The full scheme will comprise a silo having a capacity of 20,000 tons, flour mills, and a warehouse.

WRECK OF FRENCH WARSHIP "MAILLÉ BRÉZÉ."—Divers have been examining the wreck of the French flotilla leader Maillé Brézé, which blew up off Greenock nearly 12 years ago. There has been talk at various times of raising the vessel, and the present value of scrap, it is considered, might make salvage economic.

BATTERY-DRIVEN RAIL COACHES FOR SCOTTISH RAILWAYS.—An offer, on behalf of the North of Scotland Hydro-Electric Board, to help financially and otherwise in any further experiments that could be made to introduce electric battery-driven coaches on rural railway lines, instead of closing down stations, was made in Glasgow on March 14 by Mr. Thomas Johnston, chairman of the Board. Speaking at the annual dinner of the Scottish section of the Institute of Transport, he made his appeal "to see if, at long last, a real beginning could be made to help to recreate employment and life and vigour in Scottish rural areas."

TRANSPORTING S.S. DUCHESS OF BREADALBANE.—Dismantling was in progress at Loch Awe last week of the British Railways pleasure steamer Duchess of Breadalbane, before she is taken about 20 miles overland from Dalmally to Inveraray. The sections will be towed by tugs from Loch Fyne to Dumbarton for reassembling. The steamer is to go into passenger service between piers on the upper reaches of the Clyde estuary.

COUNCIL OF BRITISH MANUFACTURERS OF PETROLEUM EQUIPMENT.—Members of the Council of British Manufacturers of Petroleum Equipment visited the works of the Motherwell Bridge & Engineering Co. Ltd., and of Newton Victor, Ltd., Motherwell, on March 19. At a luncheon, held between the two visits, it was announced that since its formation soon after the end of the war of 1939-1945 the Council had been able to bring to Great Britain orders which, in recent years, have been valued at about 80,000,000*l*. annually.

COAL EXPORTS.—Scottish coal exports rose last month to 45,345 tons, compared with 40,834 tons in the corresponding month a year ago. The total since the the beginning of the year amounted to 83,166 tons, which contrasted with 77,970 tons in 1951.

BARCALDINE SEAWEED FACTORY.—After having been on full production day and night for several years the seaweed factory of Alginate Industries, Ltd., at Barcaldine, Argyll, has had to restrict production on account of export difficulties. Unfortunately, many employees are to be paid off, and the restrictions will also affect a large number of seaweed gatherers in the Hebrides.

CLEVELAND AND THE NORTHERN COUNTIES.

NORTH-EAST COAST IRON AND STEEL INDUSTRY.—All descriptions of iron and steel are wanted in much larger quantities than are available, and fear is felt that the full tonnage allocations for the second quarter of this year will not be delivered by March 31. Obstacles to an expansion of production at North-East Coast works continue formidable, but, fortunately, the promised imports of steel from the United States are now arriving. This encourages the hope that unloadings will soon expand to an extent which will enable an appreciable increase to be made in deliveries of commodities urgently needed in large quantities for important purposes.

SHORTAGE OF CEMENT IN NORTH-EAST AREA.—As a result of the undertaking of urgent defence work and of considerable activity in the general building trade during the recent mild weather, following upon long spells of frost, a severe shortage of cement has arisen on the North-East Coast area. Delays to ships bringing supplies have further intensified the shortage, but efforts are being made to rectify matters during the next few weeks. It is hoped that it will not be necessary to pay building-trade operatives off while supplies are being replenished.

LANCASHIRE AND SOUTH YORKSHIRE.

THE STEEL OUTLOOK.—Sheffield steel manufacturers support the official view of the British Iron and Steel Federation that steel will continue to be scarce throughout 1952, although supplies are likely to improve in the second half of the year. Mr. W. H. Higginbotham, President of the Sheffield Chamber of Commerce and chairman of Edgar Allen & Co., Ltd., has expressed the view that the industry will be very fortunate if, before the end of the year, it is in a position to fulfil all orders.

WORSENING IN CUTLERY-TRADE POSITION.—Australian import restrictions have led to the dismissal of some Sheffield cutlery employees. Sheffield manufacturers state that, in some cases, business with Australia represented from 70 to 75 per cent. of their export trade and the loss of four-fifths of this trade is a grave matter. It is hoped to divert some of the products to the home market, but it is stated that it is a hopeless task at present to try to sell cutlery to Germany, Japan and the United States. German and Japanese competition has become much keener.

TELEPHONE DEVELOPMENTS.—Plans have been drawn up for a new automatic telephone exchange in Button Lane, Sheffield, to serve the centre of Sheffield and to include a new trunk exchange for Sheffield and district. It will include amplifying equipment for trunk circuits, and terminal equipment for direct dialling by the operator in connection with trunk calls. It will be some years before the new exchange is in operation. In the meantime new automatic equipment is being installed at the existing exchange in West-street and the improvements will be in operation in about three months' time.

A SHORTAGE OF LORRY SPARE PARTS.—Mr. Leonard Matthews, chairman of the South Yorkshire area of the Road Haulage Association, states that there is an acute shortage of motor-vehicle crown wheels and pinions, and axle shafts and cylinder blocks owing to the general shortage of steel. He adds that if more spares are not released soon for the home market there will probably be many commercial vehicles standing idle.

FOREMEN'S CONFERENCES.—Dr. Edwin Gregory, a director and the chief metallurgist of Edgar Allen & Co., Ltd., Sheffield, stated at the annual dinner of the Edgar Allen Foremen's Association that the British Iron and Steel Federation Sheffield area training committee has arranged a series of one-week conferences for foremen to take place during the present year.

THE MIDLANDS.

PERMANENT TRADE EXHIBITION IN BIRMINGHAM.—The National Union of Manufacturers is to lease a building in John Bright-street, Birmingham, for use as a permanent trade exhibition. The scheme was suggested by Mr. F. L. Wraight, of F. L. Wraight & Co., Ltd., makers of hand tools, Halesowen, after a visit to the Engineering Centre at Glasgow. The Birmingham exhibition, which will be housed in a five-storey building, will occupy about 60 per cent. of the total available floor space of 10,000 sq. ft. Part of the accommodation will be used as the Midland area office of the National Union of Manufacturers, who will move from their present premises in Temple-street. Interview rooms and a lecture room will also be provided, and there will be a car park adjacent, with space for about 60 vehicles. Exhibition space will be occupied by members of the National Union of Manufacturers, and trades of all descriptions will be represented. The premises will accommodate several hundred exhibits. If the demand for space is greater than the available capacity, preference will be given to Midland manufacturers; otherwise, exhibitors from all parts of the country will be welcomed. Mr. E. E. Holden, the Midlands secretary of the N.U.M., has stressed the fact that the prime consideration in accepting exhibits will be the quality of the goods displayed. Rents for space will vary according to the size of the exhibit, but no definite rates have yet been established. It is hoped that the building will be ready for opening at the end of the year.

EMPLOYMENT IN THE MIDLANDS.—Mr. W. E. Davis, Midland regional controller of the Ministry of Labour, speaking in Birmingham on March 18, said that nearly 15,000 persons in the Midlands are now under-employed because of shortage of materials or of orders. The causes of short-time working are about equally divided between lack of orders and shortage of materials, principally steel. The total of unemployed in the area, Mr. Davis stated, had risen to 12,584, an increase of 3,400 on the corresponding figure a year ago; but, he pointed out, the total working population of the region is now nearly two millions.

THREATENED CANAL CLOSURE.—The Midland Branch of the Inland Waterways Association is concerned over a threat to close the Staffordshire and Worcestershire Canal. No definite statement has been made by the Docks and Inland Waterways Executive, but the canal in question, which was built under an Act of Parliament of 1766, and created the town of Stourport on the River Severn, has been virtually dis-used since 1948. In that year, the coal traffic which had passed over the canal from the Cannock Chase collieries to the power station at Stourport, ceased. The Staffordshire and Worcestershire canal provides one of two waterway links between Birmingham and Gloucester and the Severn ports. The Waterways Association have pointed out the commercial possibilities of the canal, and suggested a regular cargo service between Birmingham and Gloucester.

PASSENGER TRAIN FIRE.—A Manchester to Bournemouth train caught fire on the London Midland Region main line at Four Ashes, near Wolverhampton, on March 14. The two coaches affected were detached from the train, and the fire was dealt with by the fire brigade from the nearby Ministry of Supply depot at Featherstone, with assistance from the Cannock and Wolverhampton brigades. One coach was completely burnt out, and the other badly damaged. There were no personal injuries.

RURAL SCRAP COLLECTION.—A scrap collection at Pershore, Worcestershire, organised by the local branch of the National Farmers' Union, has been so successful that it has been decided to extend it to the end of March. Over 240 tons of assorted scrap have been collected in the immediate vicinity of Pershore. The items brought in have included farm implements of the last century and several steam traction engines.

STEEL SUPPLIES.—Mr. C. J. S. Whitehouse, assistant secretary of the Engineering Industries Division, Ministry of Supply, speaking at a meeting of the Engineering Industries Association in Birmingham, on March 19, said that the amount of steel available for civil purposes would be the same this year as last. He hoped that supplies might improve later in the year.

SOUTH-WEST ENGLAND AND SOUTH WALES.

PORT TALBOT BAR MILL.—Representatives of the 16 Port Talbot and Margam branches of the Iron and Steel Confederation have met the general secretary of the British Iron and Steel and Kindred Trades Association, Mr. Lincoln Evans, to argue their case against the closing, by the Steel Company of Wales, Ltd., of the 50-year-old Port Talbot bar mill. The men contend that the company are breaking a promise to work the mill for another ten years.

REQUEST FOR STEEL BY FACTORY.—On account of shortage of steel, one of the largest new factories in West Wales has been brought to a standstill. Only four months ago, the owners, the Minnesota Mining and Manufacturing Co., Ltd., completed a plant at Penllergaer for producing a liquid protective compound for motor-car bodies. An urgent request for steel, to make the necessary drums, has been made to the Minister of Supply by Mr. D. R. Grenfell, the M.P. for Gower. In full production, the factory requires 6,000 drums a month.

IMPROVEMENTS AT HIRWAUN COLLIERIES.—The building of two pit-head baths at a cost of 160,000*l*. at the Tower Colliery, Hirwaun, Aberdare, the first to be provided in the Aberdare Valley since nationalisation, is a main stage in the re-organisation and improvement at the colliery which it is planned will be completed by March next year. Workshops and stores will be built at a cost of 18,500*l*. and new offices will cost 4,000*l*.

SUPPLY POSITION AT ROGERSTONE ALUMINIUM WORKS.—A deputation of seven M.P.'s has waited upon the Minister of Supply to urge the immediate reconsideration of the raw-materials supply position in so far as it affects the Northern Aluminium Company's works at Rogerstone, Monmouthshire. In view of the extensions that have been carried out at the works and the part it is playing and will play in the re-armament programme, the deputation has urged an immediate increase in supplies. Mr. Duncan Sandys agreed to re-examine the position.

NEW WORKS TO BE BUILT AT NEATH.—In the course of clearing the site in readiness for a new works for the Baglan Engineering Co. (1919), Ltd., a 195-ft. high stack was felled last week at the old Melyn tin-plate and sheet works, Neath. The stack was built in 1864. The Baglan Engineering Company is a subsidiary of the Briton Ferry Steel Co., Ltd.

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.—Monday, March 31, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. Discussion on "Statistics as Applied to Engineering," opened by Mr. W. A. Carne. *South Midland Centre:* Monday, March 31, 6 p.m., James Watt Memorial Institute, Birmingham. "The Economics of Low-Voltage Electricity Supplies to New Housing Estates," by Mr. F. G. Copland. *District Meetings:* Monday, March 31, 6.30 p.m., Crown and Anchor Hotel, Ipswich. "Domestic Electrical Installations: Some Safety Aspects," by Mr. H. W. Swann. Monday, March 31, 7.30 p.m., Royal Hotel, Norwich. "The Nervous System as a Communication Network," by Dr. J. A. V. Bates. *Measurements Section:* Tuesday, April 1, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. Discussion on "Servo Systems," opened by Professor A. Tustin and Mr. J. F. Coales. *North Midland Centre:* Tuesday, April 1, 6.30 p.m., 1, Whitehall-road, Leeds. "The Sutton Coldfield Television Broadcasting Station," by Mr. P. A. T. Bevan and Mr. H. Page. *North-Western Centre:* Tuesday, April 1, 6.15 p.m., Engineers' Club, Manchester. "Domestic Electrical Installations: Some Safety Aspects," by Mr. H. W. Swann. *Scottish Centre:* Tuesday, April 1, 7 p.m., 39, Elmbank-crescent, Glasgow, C.2. "Inherent Current, Voltage and Speed Control in Dynamo-Electric Machinery," by Mr. J. C. Macfarlane, Dr. J. W. Macfarlane and Mr. W. J. Macfarlane. *Southern Centre:* Wednesday, April 2, 6.30 p.m., Technical College, Brighton. (i) "Inhibited Transformer Oil," by Mr. W. R. Stoker and Mr. C. N. Thompson. (ii) "The Stability of Oil in Transformers," by Mr. P. W. L. Gossling and Mr. L. H. Welch. *Institution:* Thursday, April 3, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. "A Logical Approach to the Problems of Electric Space-Warming," by Mr. D. H. Parry.

ILLUMINATING ENGINEERING SOCIETY.—*Leeds Centre:* Monday, March 31, 7 p.m., Lighting Service Bureau, 24, Aire-street, Leeds, 1. "Light and Sight," by Mr. J. Benson. *Cardiff Centre:* Tuesday, April 1, 5.45 p.m., Offices of South Wales Electricity Board, Cardiff. "Safety and Vision: Industrial Lighting," by Mr. E. W. Murray. *Liverpool Centre:* Tuesday, April 1, 6 p.m., Offices of Merseyside and North Wales Electricity Board, Whitechapel, Liverpool. "New Discharge Lamps: The Extension of the Gas-Arc Condition," by Mr. H. W. Cumming. *Newcastle Centre:* Wednesday, April 2, 6.15 p.m., Minor Durrant Hall, Oxford-street, Newcastle-upon-Tyne, 1. Annual Meeting and Film Display. *Nottingham Centre:* Thursday, April 3, 5.30 p.m., Offices of East Midlands Electricity Board, Smithy-row, Nottingham. "Artificial Lighting for Cinema Studios," by Mr. E. J. G. Beeson.

INSTITUTE OF FUEL.—*Midland Students' Section:* Monday, March 31, 7.30 p.m., The University, Edmund-street, Birmingham. General Discussion Meeting. *Midland Section:* Wednesday, April 2, 6 p.m., Grand Hotel, Colmore-row, Birmingham, 3. Annual Meeting. "Possible Applications of the Heat Pump," by Mr. J. Sumner. *South Wales Section:* Friday, April 4, 6 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "The Seams of the South Wales Coalfield," by Mr. H .F. Adams. *North-Western Section:* Friday, April 4, 7 p.m., County Hotel, Carlisle. "Stokers and Fuel-Handling Equipment for Shell-Type Boilers," by Mr. R. F. W. Guy.

INCORPORATED PLANT ENGINEERS.—*West and East Yorkshire Branch:* Monday, March 31, 7.30 p.m., The University, Leeds. Annual Meeting. *London Branch:* Tuesday, April 1, 7 p.m., Royal Society of Arts, John Adam-street, Adelphi, W.C.2. "General Electrical Installations in Small Factories," by Mr. A. G. Howell. *Peterborough Branch:* Thursday, April 3, 7.30 p.m., Offices of Eastern Gas Board, Church-street, Peterborough. "Modern Dairy Plant," by Mr. C. H. Macquire.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*Bournemouth Branch:* Monday, March 31, 8.15 p.m., Grand Hotel, Firvale-road, Bournemouth. "Applications and Characteristics of Alternating-Current Motors," by Mr. F. T. Bartho. *York Branch:* Wednesday, April 2, 7.30 p.m., Creamery Restaurant, Pavement, York. "Light and Colour," by Mr. J. W. Howell. *South London Branch:* Thursday, April 3, 8 p.m., Café Royal, North End, Croydon. Discussion on "General Installations."

INSTITUTION OF CIVIL ENGINEERS.—*Works Construction Division:* Tuesday, April 1, 5.30 p.m.. Great George-street, S.W.1. "The Construction of the Caisson Forming the Foundation to the Circulating-Water Pump-House for the Uskmouth Generating Station," by Mr. W. Storey Wilson and Mr. F. W. Sully.

INSTITUTION OF CHEMICAL ENGINEERS.—Tuesday, April 1, 5.30 p.m., Geological Society, Burlington House, Piccadilly, W.1. Symposium on "Simplification in Stainless Steel Specification."

INSTITUTION OF SANITARY ENGINEERS.—Tuesday, April 1, 6 p.m., Caxton Hall, Westminster, S.W.1. Brains Trust Meeting on "The Training and Work of the Sanitary Engineer."

INSTITUTION OF STRUCTURAL ENGINEERS.—*Wales and Monmouthshire Branch:* Tuesday, April 1, 6.30 p.m., South Wales Institute of Engineers, Park-place, Cardiff. Various students' papers. *Northern Counties Branch:* Wednesday, April 2, 6.30 p.m., Neville Hall, Newcastle-upon-Tyne. Annual Meeting. "Data in the Drawing Office," by Mr. J. Ross.

INSTITUTE OF PACKAGING.—*Midland Area:* Tuesday, April 1, 6.30 p.m., Imperial Hotel, Birmingham. Annual Meeting. *Southern Area:* Thursday, April 3, 6 p.m., Waldorf Hotel, Aldwych, W.C.2. "An Objective Approach to Packaging," by Mr. J. S. McGill.

INSTITUTION OF WORKS MANAGERS.—*Wolverhampton Branch:* Tuesday, April 1, 7 p.m., Star and Garter Royal Hotel, Wolverhampton. Discussion on "Problems of the Smaller Factory in Relation to Works Management." *Sheffield Branch:* Tuesday, April 1, 7.30 p.m., Grand Hotel, Sheffield. "The Importance of Lubrication to the Works Manager," by Mr. H. O. Bates. *Tees-Side Branch:* Thursday, April 3, 7.30 p.m., Vane Arms Hotel, Stockton. Annual Meeting. *Preston Branch:* Tuesday, April 8, 7 p.m., Starkie House, Starkie-street, Preston. Annual Meeting. Film on "Factory Planning."

INSTITUTION OF PRODUCTION ENGINEERS.—*Reading Section:* Tuesday, April 1, 7.15 p.m., Great Western Hotel, Reading. Discussion on "Diamonds in Industry." *Dundee Section:* Tuesday, April 1, 7.45 p.m., Mathers Hotel, Whitehall-crescent, Dundee. "Productivity and the Machine Tool," by Mr. N. Stubbs. *Nottingham Section:* Wednesday, April 2, 7 p.m., Victoria Station Hotel, Milton-street, Nottingham. "Air-Operated Fixtures," by Mr. C. M. P. Willcox. *Wolverhampton Section:* Wednesday, April 2, 7 p.m., Star and Garter Hotel, Victoria-street, Wolverhampton. "Roller Bearings in Service," by Mr. R. K. Allan. *Southern Section:* Thursday, April 3, 7 p.m., Polygon Hotel, Southampton. "Starting a New Factory," by Mr. A. R. Northover.

INSTITUTION OF NAVAL ARCHITECTS.—Wednesday, April 2, 10.15 a.m.; Thursday, April 3, 10.15 a.m. and 2.30 p.m.; and Friday, April 4, 10.15 a.m. and 2.30 p.m., The "Wellington," Temple Stairs, Victoria-embankment, W.C.2. Spring Meeting.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—Wednesday, April 2, 6 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. Discussion on "Education and Recruitment for the Heating and Ventilating Industry," opened by Mr. N. S. Billington. *East Midlands Branch:* Wednesday, April 2, 6.30 p.m., Victoria Station Hotel, Nottingham. "High-Temperature Industrial Radiant Panels," by Mr. E. B. Tanner.

WOMEN'S ENGINEERING SOCIETY.—Wednesday, April 2, 7 p.m., 35, Grosvenor-place, Westminster, S.W.1. Discussion on "Unusual Occupations."

JUNIOR INSTITUTION OF ENGINEERS.—*Midland Section:* Wednesday, April 2, 7 p.m., James Watt Memorial Institute, Birmingham. "Automatic Feed Presswork-ing," by Mr. C. H. Crawford. *Institution:* Friday, April 4, 6.30 p.m., 39, Victoria-street, S.W.1. Film on "The Argonarc Welding Process," to be introduced by Mr. R. R. Sillifant.

INSTITUTION OF MECHANICAL ENGINEERS.—*Southern Branch:* Wednesday, April 2, 7.30 p.m., Works of Messrs. Transport Equipment (Thornycroft), Limited, Basingstoke. "British Mechanical Road Transport Vehicles, 1851 to 1951," by Mr. John Shearman and Mr. B. B. Winter. *Yorkshire Branch:* Thursday, April 3, 7 p.m., City Hall, York. Chairman's Address on "Mechanical Equipment for Municipal Engineering Projects," by Mr. C. J. Minter. *Institution:* Friday, April 4, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. Meeting in conjunction with the *Industrial Administration and Engineering Production Group.* "Some Considerations Regarding a Factory Maintenance Engineering Department," by Mr. Max Bentham.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—Thursday, April 3, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. Discussion on "Passenger Comfort on Modern Coaching Stock."

BRITISH INSTITUTION OF RADIO ENGINEERS.—*London Section:* Thursday, April 3, 6.30 p.m., London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Discussion on "High-Frequency Broadcasting."

INSTITUTE OF METALS.—*Birmingham Section:* Thursday, April 3, 7 p.m., James Watt Memorial Institute, Birmingham. Annual Meeting. *London Section:* Thursday, April 3, 7 p.m., 4, Grosvenor-gardens, S.W.1. Annual Meeting. Discussion on "Grain Refining."

LEEDS METALLURGICAL SOCIETY.—Thursday, April 3, 7 p.m., Chemistry Department, The University, Leeds. "Metal Spectroscopy," by Mr. E. S. Dreblow.

PERSONAL.

LORD NUFFIELD, G.B.E., F.R.S., PROFESSOR M. L. E. OLIPHANT, F.R.S., and SIR CHARLES BICKERTON BLACKBURN, O.B.E., B.A., M.D., F.R.C.P. (Lond. and Edin.), Chancellor of the University of Sydney, are the recipients of the first honorary degrees to be conferred by the new University of Technology of New South Wales, Australia.

LADY LITHGOW has been appointed chairman of Lithgows Ltd., Port Glasgow. SIR JOHN M. DUNCANSON is continuing to act as deputy chairman and MR. JACKSON MILLAR has been elected a director.

MR. ROBERT MARSHALL, a director of Colvilles Ltd., Glasgow, has been appointed a part-time member of the Iron and Steel Corporation of Great Britain.

MR. A. W. MANSER, B.Sc., A.M.I.Mech.E., M.I.Loco.E., assistant mechanical engineer (works-railways), London Transport Executive, has been appointed chief mechanical engineer (railways) of the Executive.

MR. H. F. SHERBORNE, M.C., M.A.(Oxon.), A.Inst.N.A., M.Inst.Met., who has been a director of the Yorkshire Copper Works, Ltd., Leeds, for 21 years, has now been appointed general manager of the company.

The Minister of Transport announces that MR. A. K. RICHARDS, M.I.C.E., is to be divisional road engineer, Eastern Division, in succession to MR. T. G. NEWCOMEN, M.I.C.E., M.Inst.T., who is retiring on April 30. MR. T. E. HUTTON, B.Sc., A.M.I.C.E., A.M.I.Mun.E., has been made an assistant chief engineer at headquarters. MR. H. S. KEEP, M.C., B.Sc.(Eng.), M.I.C.E., A.C.G.I., is to be divisional road engineer for the South-Eastern Division, in succession to MR. J. ROWLAND HILL, M.I.C.E., A.M.I.Struct.E., M.I.Mun.E., M.R.San.I., who is retiring on May 12. MR. J. S. MCNEIL, B.Sc., A.M.I.C.E., A.M.I.Mun.E., is to be divisional road engineer for the North-Western Division, in succession to MR. A. H. DODD, O.B.E., B.Eng., A.M.I.C.E., who is retiring in October.

DR. P. E. HAMMARLUND, chief design engineer of Asea Electric Ltd. and Fuller Electrical and Manufacturing Co. Ltd., Fulbourne-road, Walthamstow, London, E.17, is leaving on March 31 to take up a senior position with the Asea Company in Sweden. He will be succeeded by MR. A. J. HASELFOOT, who, for the last five years, has been manager of the power department of Asea Electric Ltd.

MR. W. M. B. FURNISS, chairman of the Electric Construction Co. Ltd., Wolverhampton, has been appointed a member of the Midland Regional Board for Industry.

MR. R. G. M. STREET has been appointed chairman of the Transport Users' Consultative Committee for Wales, in succession to LIEUT.-COLONEL H. E. DAVIES, Q.C., who has resigned his appointment. The appointment carries with it membership of the Central Transport Consultative Committee for Great Britain.

MR. H. J. NIXON, who has been with the de Havilland Enterprise since 1934, is joining Alvis Ltd., Holyhead-road, Coventry, as works director, and will take his seat on the board during April.

MR. J. F. H. TYLER, B.Sc.(Eng.), who joined the former Great Western Railway Co. as assistant to the signal and telegraph engineer in 1947, has now been appointed assistant signal and telecommunications engineer, Western Region, British Railways.

MR. R. PATERSON, chief assistant (freight) to the commercial superintendent, London Midland Region of British Railways, has been appointed to the new post of Irish-traffic superintendent of the London Midland, Scottish, and Western Regions. His headquarters will be at Euston and he will take up his full duties on May 1.

MR. F. N. RIDING, sales manager, and MR. C. J. ADY, London manager, have been appointed to the board of Hickson's Timber Impregnation Co. (G.B.) Ltd., a subsidiary company of Hickson & Welch Ltd., Castleford, Yorkshire.

MR. R. T. BYFORD, A.C.I.S., has been appointed secretary of the Tyre Manufacturers' Conference Ltd., and secretary of the Tyre Trade Joint Committee, in succession to the late MR. W. B. STOKES.

MR. W. C. SHELTON has retired from the position of senior sales and technical representative of the Hoyt Metal Co. of Great Britain, Ltd., Putney, London, S.W.15, after 36 years of service.

Richard Sutcliffe Ltd., Universal Works, Horbury Wakefield, Yorkshire, announce that MR. J. S. EXLEY, formerly their publicity manager, has been appointed their Continental representative. MR. V. QUAINTRELL has been appointed chief buyer and MR. P. WOODWARD publicity manager.

Hoover Ltd. announce that MR. G. J. HEMMINGS, hitherto field sales manager (home), has been made Continental sales manager. MR. W. M. TRIBUTE, previously advertising and publicity manager, has been appointed export advertising manager, and MR. H. K. SQUIRES, hitherto assistant to Mr. Tribute, has been made home advertising manager.

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(*For Description, see Page* 392.)

FIG. 10. GENERAL VIEW OF PRESS, SHOWING MAIN AND AUXILIARY CONTROL DESKS.

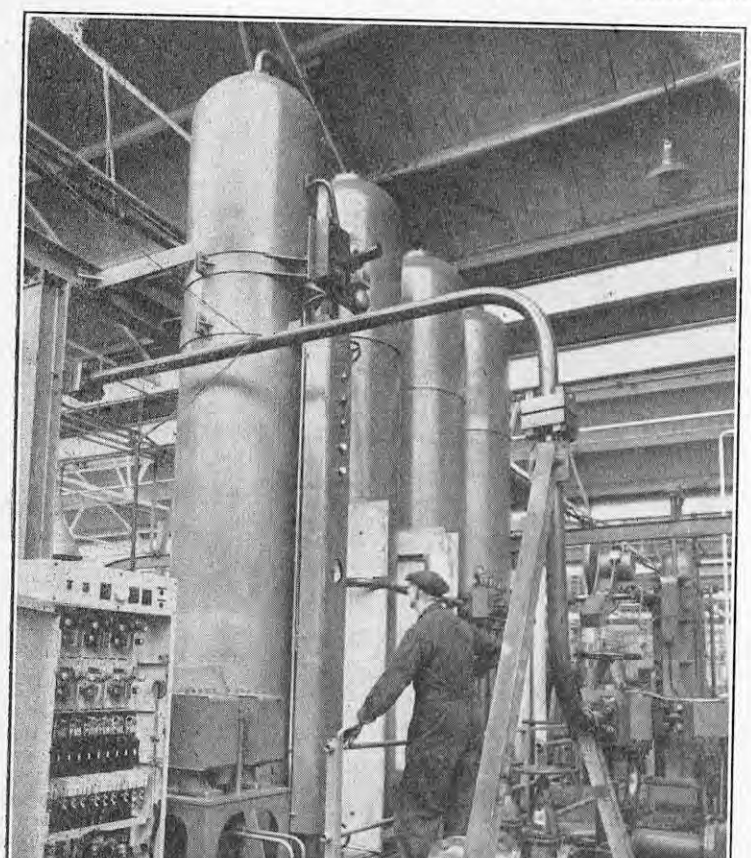

FIG. 11. AIR-HYDRAULIC ACCUMULATORS.

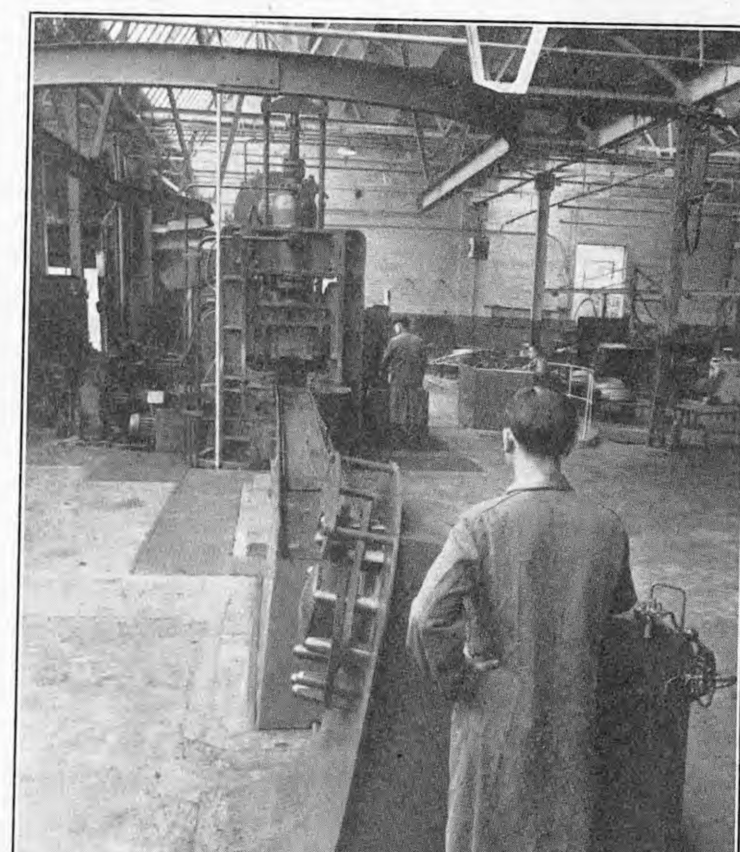

FIG. 12. RUN-OUT END OF PRESS AND COILER.

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ENGINEERING

FRIDAY, MARCH 28, 1952.

VOL. 173. No. 4496.

POTENTIAL ABILITY.

So very many reports, discussions, conferences and papers presented to technical institutions have been concerned with questions of higher and scientific education that it would be wearisome to attempt to compute them. They have ranged over a wide field, but in a broad sense it may be said that most, or all, have led up to the conclusion that the number of students receiving a university, or other form of higher, education should be increased. What may be looked upon as a semi-official expression of opinion was contained in a report on Scientific Man-Power, presented, in 1946, by a committee appointed by the Lord President of the Council. That report stated that before the war British universities were turning out on an average, 2,500 scientists per year and that the "existing capital" of scientists at the end of 1945 was between 45,000 and 60,000. On the basis of estimates obtained from university authorities, it was assumed that by 1955 the output would be 3,500 per year, but as, allowing for wastage, that increase would give a net capital of only 64,000 scientists in 1955, as against an estimated requirement of 90,000, it was decided "that the immediate aim should be to double the present output, giving us roughly 5,000 newly qualified scientists per annum."

Some suggestions for attaining that end were made, of which one to the effect that university grants should be increased has, to some extent, been complied with, but increase in the scientific capital of the country is by no means merely a matter of finance. The fundamental question is whether or not the intellectual potential of Great Britain is capable of supplying 5,000 new able scientific workers every year. This question is not neglected in the report and it is categorically stated that "about 5 per cent. of the whole population show, on test, an intelligence as great as the upper half" of university students, who form only one per cent. of the population. On this reckoning, the reservoir of ability should be amply large enough to supply 5,000 students of the requisite intellectual status per annum, but it would have been more satisfactory if the report had indicated what evidence lay behind the statement that the existence of the 5 per cent. had been revealed "on test."

Large numbers of intelligence tests have been devised and applied to school-children and others. To outsiders, many of these appear very childish, although psychologists contend that they accurately indicate abilities and mental capacities. It would appear, however, that to a great extent the scoring of high marks depends on rapidity of reflex to stimuli and it may fairly be asked if that quality is necessarily an indication of mental capacity. If a boy of ten scores the average marks of those of eleven, he is said to have the mental age of eleven, but it seems at least doubtful if mental alertness at the age of ten is evidence of mental staying-power which will be operative at the age of 30.

Something may, no doubt, be done towards sorting out children at an early age, but judging by the complaints of college and secondary-school authorities about the average quality of the pupils submitted to them, either the sorting process is inefficient or the supply of mentally-gifted students is insufficient. The second is probably the basic reason. In the rough and ready way with which mankind conducts its affairs, it would appear that there is an automatic sorting out of individuals, those of greater mental ability being found in the professions demanding brain power above the average. In the ordinary tests applied to children, the so-called Intelligence Quotient is defined as one hundred times the mental age divided by the actual age. It was pointed out by the late Michael Roberts in *The Estate of Man* that this formula applied to adults results in giving the impression that they became more stupid as they grew older. Accordingly, as an alternative to the Intelligence Quotient, an Index of Brightness has been adopted. In determining this, individuals are compared with the average of their own age groups. It does not seem probable that many tests have been carried out on adults, but Roberts gave a table, compiled from various sources, which indicated that, where 2·5 per cent. of the whole population could be rated as A-plus and 7·5 per cent. as A, corresponding figures for graduate teachers were 33 per cent. and 50 per cent., and for graduate engineers 23 per cent. and 50 per cent. The relation of these figures to those in other types of occupation may be illustrated by quoting civil-service executives at 15 per cent. and 35 per cent., and shorthand typists 9 per cent. and 25 per cent.

It would be wise to accept these figures with considerable reserve; they must be based on very slender evidence, but it may be accepted that scientific workers in positions of any responsibility have an Index of Brightness higher than that of the average of most other workers. Under present methods, or lack of methods, ability does to a considerable extent find its proper place, but the system frequently leads to waste and disappointment. Clearly, in as far as tests, and consideration of the school records of children, enable those of superior ability to be selected for higher education, they should be utilised. This proposition is not only generally accepted, but its application is being carried to extremes and bursaries and scholarships are being presented to students not mentally capable of attaining a high level of accomplishment. No good can come from overloading higher educational institutions with second-rate material.

There can be no question about the desirability of increasing the number of qualified scientific workers in this country. Reports of research organisations, Government departments concerned with scientific services, and many commercial companies frequently refer to the shortage of staff workers of the required calibre. The suggested "capital" of 90,000 was arrived at as a result of enquiries addressed to interested organisations, and there is no reason to suppose that it errs on the high side; the contrary is probable. A report published last year by the Engineering College Research Council of the American Society for Engineering Education stated that there were 20,000 faculty members of American educational institutions qualified to perform research work, and that 12,700 were so engaged. As research in educational institutions is but a small part of the field open to scientific workers, it would appear that, even allowing for a population three times as great, the proportion of trained and competent scientific men is higher in the United States than it is in this country. These American figures refer only to engineers, but the estimate of 90,000 covered scientists generally.

Scientific activities in either the industrial or educational fields are not carried on only by men of the highest attainments; they require many assistants and there is a demand for the second-class material which is being produced as a result of the lavish granting of educational bursaries and scholarships to students who will never attain a first-class standard. Real progress, however, depends on A-plus men. It is not likely that any fully-reliable method of earmarking these at an early age will ever be developed, but fortunately they will usually emerge from the crowd in virtue of their own qualities. Unfortunately, there do not appear to be enough of them, and, in many organisations, staff shortages force first-class men to occupy too much of their time in routine duties which could be performed satisfactorily by men of lower capacity. The dissipation of the energy of first-class minds in second-class activities is not confined to the laboratory and workshop; it extends to the domestic sphere. In view of the present demand for labour in industry, it may appear unreasonable to suggest that the shortage of domestic servants is hampering industrial and scientific advance, but it is none the less true that progress and the interests of the country are dis-served when an A-plus physicist spends his time in occupations which could satisfactorily be performed by a charwoman.

Although much may be done by education and training, it is probably correct to say that A-plus men are born, not made. They may arise in any class and the history of engineering contains the names of eminent men who started life in working-class homes. In general, however, the intellect of this country is supplied by the middle classes, and if progress is desired, that section of the community must be encouraged not impeded. Fortunately, after seven years of budgets which favoured the non-professional class, one has been produced which exhibits some recognition of the fact that the class which produces most of the brains of the country should at least share in any relief which can be granted. Heredity and environment play a part in determining character and for most working-class boys the environment is not favourable to the development of their mental possibilities. This may be unfortunate, but it is so.

NOTES.

New Fellows of The Royal Society.

At their meeting on March 20, the Royal Society elected 25 new Fellows for the year 1952. These include Sir Wallace Alan Akers, C.B.E., F.R.I.C., F.R.S.A., F.C.S., a director of Imperial Chemical Industries, Limited, who has been elected an F.R.S. for his work in the technical direction of the atomic-energy project during the late war and in the building of large research departments and plants for his company. Associate Professor J. F. Dyson, of the theoretical physics department, Floyd Neuman Laboratory of Nuclear Studies, Cornell University, Ithaca, New York, has been honoured for his discoveries in the geometry of numbers and for his contribution to quantum electrodynamics. Professor Harry Jones, B.Sc., Ph.D., who occupies the chair of mathematics at the Imperial College of Science and Technology, London, for his contributions to the theory of the solid state and the detonation processes of solid explosives; Professor A. G. Pugsley, O.B.E., D.Sc. (Eng.) (Lond.), A.M.I.C.E., of the Faculty of Civil Engineering, University of Bristol, for his contribution to the reliability of aircraft structures, the design of which has been much influenced by his researches; Dr. D. MacLeish Smith, M.I.Mech.E., chief engineer, gas-turbine department, Metropolitan-Vickers Electrical Company, Limited, for his contributions to the theory and design of steam and gas turbines and axial-flow air compressors and their applications to aircraft, marine propulsion, the railway locomotive and industrial use; and Mr. E. Wilfred Taylor, C.B.E., F.R.M.S., F.Inst.P., joint managing director of Cooke, Troughton and Simms, Limited, for his contributions to the development of optical instruments used in surveying and phase-contrast microscopy.

The Place of Plastics.

The 42nd annual May Lecture of the Institute of Metals was delivered in London on March 24 by Dr. J. J. P. Staudinger, director of research, British Resin Products, Limited, who chose as his subject "The Place of Plastics in the Order of Matter." The President, Professor A. J. Murphy, who occupied the chair, explained that hitherto, as their name indicated, the May Lectures had always been delivered during the month of May. This year, however, as recommended by the Meetings Sub-Committee, the lecture was being delivered on the evening of the first day of the annual general meeting of the Institute, as it was thought that this would enable a larger number of members from the provinces to attend. In the course of his lecture, Dr. Staudinger said that plastics were not substitutes for other materials, but constituted new materials available to industry. Life without plastics meant life without electronics, radar and television. Plastics could be transparent or opaque, or hard or soft. As malleability, ductility and the ability to be cold-worked were typical properties of metals, it seemed, at first sight, that plastics had not much in common with them. Reflection showed, however, that strength, resilience and impact resistance were properties which were common to both. Moreover, high resistance to shock and to denting were properties possessed by laminated and reinforced plastics and made them suitable for numerous household and other applications. The marked adaptability of plastics for mass production and the ease with which articles could be turned out by modern moulding techniques, coupled with their attractive colour and surface finish, made the new materials more suitable and economical than metals in many cases. Consequently, in a number of fields, the use of plastics was spreading at the expense of metals. All-plastic valves, pickling tanks and other apparatus were now regularly made, while such things as tool handles and door furniture had become popular on account of their low production cost, lightness, hygienic characteristics, and the fact that they were pleasant to the touch. Finally, what might be termed the raw-material availability was a matter of importance. These raw materials included products derived from imported oil, home-produced coal, and vegetable matter such as molasses, cotton waste and seaweed.

The Whitworth Society.

On March 18, the anniversary of the foundation day of the Whitworth Scholarships, the Whitworth Society held its annual dinner, the 27th, at Kettner's Restaurant, Romilly-street, London, W.1. The chair was occupied by the President, Dr. S. F. Dorey, F.R.S. In accordance with custom, two toasts only followed the loyal toast and the silent toast to "The Memory of Our Founder." The first of the two was "Success to the Whitworth Society," proposed by Major-General A. R. Valon and responded to by the President, who himself proposed the second, "Guests and New Scholars." As only Whitworth men are admitted to the dinner, some non-members who were present as guests of members were themselves eligible for membership of the society and it may be hoped that their presence at the enjoyable and successful function may result in them joining. The new Scholars, who were present as guests of the Society, automatically become members without payment of subscription for the first few years of their professional lives. Three of them were present, namely, Mr. M. H. Elphick, who replied to the toast, Mr. D. J. R. Mudge, and Mr. D. J. S. Mudge. These latter gentlemen are twins. We do not know if this is the first time that Whitworth Scholarships have been gained by twins, but various cases are on record of such couples obtaining similar examination results. No Senior Whitworth Scholarship was awarded this year and for that reason no new Senior Scholar was present. Dr. Dorey, in proposing the toast, in accordance with tradition, gave some account of the early days of his career at Chatham Dockyard and in Newcastle. He announced that Sir Henry Guy would be following him in the office of President and would be inducted at the summer meeting, which would probably be held in Southampton. Towards the close of the meeting, Dr. F. T. Barwell asked those present to get in touch with any Whitworth men they knew, who were not members of the Society, and urge them to supply particulars for the Whitworth Register. The letter published in ENGINEERING of November 23, 1951, had produced results, but there were still many Whitworth men for whom particulars were not available. Publication should not be delayed too long while information was collected, as the matter now assembled would tend to become out of date in some cases.

First Jet-Propelled Air Liner Service.

British Overseas Airways Corporation are to open the world's first regular service with jet-propelled air liners on Friday, May 2, when a Comet Series I aircraft will leave London Airport at 14.00 hours G.M.T. for Johannesburg. The first Comet service from South Africa to England will be on Monday, May 5. The Comet Series I air liner, which is constructed by the de Havilland Aircraft Company, is propelled by four de Havilland Ghost turbo-jet engines. It has a take-off weight of 105,000 lb., and carries 36 passengers, in a pressure cabin, at a cruising speed of about 490 m.p.h. over a practical stage distance of 2,140 miles. The operating technique is to climb rapidly to the economical cruising altitude—between 35,000 and 40,000 feet—the climb occupying about 35 minutes. The engines are then adjusted to cruising power and the aircraft climbs slowly throughout the cruising phase, as weight is reduced by the consumption of fuel. The descent normally begins about 200 miles from the destination, at a constant rate of descent of about 1,000 ft. per minute. The actual flying time of the Comet between London Airport and Johannesburg will be 18 hours 40 minutes, and on the return journey 18 hours 55 minutes. The scheduled journey time, with stops at Rome, Beirut (subject to the approval of the Lebanese authorities), Khartoum, Entebbe, and Livingstone, will be 23 hours 40 minutes outward and 23 hours 55 minutes homeward, initially, but ultimately it is expected that these times will be reduced. When the situation in Cairo has settled down, the route will be through Cairo, instead of Beirut, reducing the total distance by 450 miles. During May, there will be one Comet flight a week in each direction on the Johannesburg service, which B.O.A.C. operate in conjunction with South African Airways. who are flying Constellations on the Nile Valley route. At present, B.O.A.C. are operating Handley-Page Hermes 4 aircraft three times a week on the western route to Johannesburg. The Hermes aircraft will be withdrawn progressively as the Comet frequencies are increased. If Comet deliveries take place according to schedule, there will be three Comet services a week by the end of June. Nine Series I Comets, with Ghost engines, have been ordered for the Corporation; later this year, it is intended that they shall go into service between London and Singapore. Five Series 2 Comets, with four Rolls-Royce Avon axial-flow jet engines, are also on order for use on the North Atlantic route in about two years' time.

THE STEEL AND SCRAP POSITION.

The British Iron and Steel Federation found it necessary last week to refute statements attributed in the daily Press to two of their members. Mr. L. C. C. Bell was reported as having said that "the scrap metal collection campaign had been far from a success . . . The campaign was costing about 5*l.* a ton in advertising and personal appeals alone for a very meagre result . . . The Ministry have stood the loss so far; I do not think the industry could afford to stand it." Subsequently, Mr. R. M. Shone, C.B.E., director of the Federation, said that the campaign had cost about 1*s.* or 2*s.* a ton. It was not true that the Ministry had defrayed the cost. The scrap drive had been successful, and 330,000 tons had been collected in a year. It was true that the benefits were slow in developing, but already this year scrap supplies were better than they were last year; the deliveries of home-bought scrap were 75,300 tons a week in the first ten weeks of 1952, compared with 72,900 tons a week in 1951. Moreover, this result had been achieved in spite of higher shipping freight rates, which had had the effect of reducing the number of ships being broken up. In 1951, ships were broken up at the rate of 4,700 tons a week, whereas in 1952 the rate so far was 2,300 tons. Mr. Shone said that he considered the nation would have to continue to make the best possible use of its available scrap. The other statement to which the Federation took exception was one attributed to Mr. L. G. Dover, who was reported as having said that there would be a surplus of steel other than alloy steel later in the year. The Federation believe that, although supplies are likely to improve in the second half of the year, steel will continue to be scarce.

THE MACHINE TOOL TRADES ASSOCIATION.

The annual dinner of the Machine Tool Trades Association, though predominantly a function of the "reunion" type, is a recognised occasion for the ventilation of views upon the many and varied harassments which beset the manufacturer and exporter of machine tools; and it was notable, at the dinner which was held on March 25 at the Dorchester Hotel, London, W.1, how many of the large company which assembled under the chairmanship of the President, Mr. Robert W. Asquith, showed their emphatic agreement with the guest of honour, Sir Frederick Handley Page, C.B.E., when he expressed doubts whether, at the present time, industrialists were obtaining—or demanding—from the universities and other training establishments the right kind of "human machine tools," to staff their design offices and factories. "It is a sad reflection," said Sir Frederick, who was replying to the toast of "The Guests," proposed by the President, "that to-day between 50 and 60 per cent. of our university students are still taking cultural subjects. I think they should be taking subjects that will fit them for use in industry. The age of geographical discovery is a thing of the past, but the great field of experimental science is still there to be explored. Much can be achieved by applied technology in promoting the real industrial progress that concerns every one of us, if our minds and activities are directed towards it." The only other toast, that of "The Machine Tool Trades Association," was proposed by Sir Archibald Rowlands, G.C.B., Permanent Secretary to the Ministry of Supply, and acknowledged by Sir Greville S. Maginness, who drew attention to the forthcoming Machine Tool and Engineering Exhibition, to be held at Olympia, London, from September 17 to October 4.

LETTERS TO THE EDITOR.

PRELIMINARY INVESTIGATION OF HYDRAULIC LOCK.

TO THE EDITOR OF ENGINEERING.

SIR,—I read with great interest the statement by Mr. G. I. Chinn, whose letter was published on page 341 in your issue of March 14, that the machining of a series of finely-pitched grooves in the lands of a valve piston has proved an effective solution in the elimination of hydraulic lock.

Opinion has varied as to the efficacy of grooving, but in cases when it has not been found effective, the use of too large a pitch may have been responsible. The object of grooving is to ensure a more nearly uniform pressure distribution round the piston land, and this should be best accomplished by providing as great a number of closely-spaced grooves as is practicable. As pointed out in my article, the width of the grooves need not be large, and it should be necessary only to ensure that their total cross-sectional area is great compared with the corresponding area of the clearance. The reduction in leakage consequent on the use of small-pitch grooves, to which Mr. Chinn refers, is interesting; it is doubtful, however, whether such grooves give rise to an actual centralising force. It seems likely that, by virtually eliminating any out-of-balance transverse force on the piston, the provision of grooves allows it to remain central in the bore under the usual centring constraints. A positive centralising force, as mentioned previously in my letter published in your issue of February 1, should arise only in the case of a clearance with an effective taper converging in the direction of flow.

Yours faithfully,
D. C. SWEENEY.

Buswell & Sweeney, Limited,
Metro Works,
Bolton-street, Bordesley,
Birmingham, 9.
March 21, 1952.

THE GROWTH OF THE UNIVERSITIES.

TO THE EDITOR OF ENGINEERING.

SIR,—May I encroach on your space to focus attention on a statement in your issue of February 29? In discussing the interim report of the University Grants Committee, it was stated, on page 266, *ante*, that "there may, at times, be a tendency to overlook the fact that the primary function of a university is the same as that of a school, namely, to impart sound instruction. The other benefits which university life confers are incidental." This brings to light a problem which lies at the very heart of the "Technological University" dispute, and which gives rise to much confused thinking: it is not merely that the prime necessity for sound instruction is overlooked, but that many dispute whether it is the primary function at all. Is not the university view more correctly expressed by a member of the staff of one of our most highly respected technological institutions, who told me that he regarded his main function to be the discovery and encouragement of the brilliant student, and, furthermore, that he considered that this represented the tacitly-held view of the majority of the staff?

I consider, sir, that this is a matter of fundamental importance, and if we can get our ideas straight it will help us to decide whether general technological training is to continue to be pursued inside the universities or whether their main function in life is as homes for genius, in which case technology for ordinary folk may better be dealt with by separate institutions.

Yours faithfully,
G. COLE, B.Sc.(Eng.), A.M.I.C.E.

49, Thornbury-road,
Isleworth.
March 24, 1952.

HIGHER TECHNOLOGICAL EDUCATION.

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to Mr. Newhouse's letter in your issue of February 1, there is probably some misunderstanding. I agree fully with Mr. Newhouse's condemnation of the proposed technological university. I plead for a higher technological institute as a part of the University of London. In my view, the Imperial College of Science and Technology is not adequate. Its last annual report, for the year ended July 31, 1951, gives a praiseworthy list of publications and researches; but it also states that the number of full-time men and women students is only 1,565. This is not the total number of full-time students of science and technology in the University of London, as those at University College, King's College, etc., are not included. Even allowing for these, in my view the number should be three or four times greater. For this reason, I believe a higher Institute of Technology, as a part of the University of London, is a necessity, if we are to maintain our position in this country in science and technology in the future.

Yours truly,
C. C. GARRARD.

Devonshire Club,
St. James's, London, S.W.1.
March 24, 1952.

OBITUARY.

SIR JAMES CALLANDER.

WE regret to record the death on March 23, at his home in Newby Bridge, Lancashire, of Sir James Callander, formerly a director of Vickers Limited, and of several of their associated companies, and for many years general manager of their Barrow and Walker works. He was nearly 75 years of age and had been living in retirement for the past five years.

James Callander was a native of Newton Stewart, Wigtownshire, where he was born on April 15, 1877, and where he received his general education at the Ewart High School. He then spent two years at the Glasgow and West of Scotland Technical College before going to Liverpool as a premium apprentice in the engineering works of Fawcett, Preston and Company, where his training extended to all works departments and the drawing office. On completing his pupilage, he was employed for a short time on the engineering staff of the Mersey Docks and Harbour Board, but left them after a few months in order to take up an appointment as draughtsman in the marine engineering department of Vickers, Sons and Company (as the firm's title then was) at Barrow-in-Furness; this was in 1898, only a year after Messrs. Vickers had acquired the shipyard and engine works from the Naval Construction and Armaments Company.

Within five years of going to Barrow, Callander was made assistant chief draughtsman. Eight years later, he became works manager, and eventually general manager at Barrow. He was made a local director, in 1936, of Vickers-Armstrongs Limited, and, in 1940, acting deputy chairman, with supervision of both the Barrow establishment and the Naval Yard at Walker-on-Tyne. He retired from the position of general manager at Barrow on January 31, 1945, but remained on the board of Vickers Limited until March 31, 1947—that is, until within a few days of his 70th birthday, by which time he had been connected with the Vickers organisation for 49 years. During that period, he had been largely responsible for a truly remarkable output of ships (especially warships) and their machinery, a fact which was recognised by the conferment of his knighthood in the King's Birthday Honours in 1941. Sir James was a member of the Institution of Naval Architects, serving on the Council from 1935 to 1949, and representing the Institution for a number of years on the Technical Committee of Lloyd's Register of Shipping. He was also a member of the Institution of Mechanical Engineers and of the Institution of Engineers and Shipbuilders in Scotland.

THE INSTITUTE OF METALS.

THE forty-fourth annual general meeting of the Institute of Metals was opened on the evening of Monday, March 24, in the lecture theatre of the Royal Institution, London, when Dr. J. J. P. Staudinger, director of research, British Resin Products, Limited, Sully, Cardiff, delivered the annual May Lecture. A brief report of the lecture, which dealt with "The Place of Plastics in the Order of Matter," will be found on page 402 of the present issue. On the three subsequent days, March 25, 26 and 27, business and technical sessions were held at the Park Lane Hotel, Piccadilly.

REPORT OF COUNCIL.

On the morning of Tuesday, March 25, the retiring President, Professor A. J. Murphy, occupied the chair, and the first matter to be considered was the report of the Council for the year ended December 31, 1951. This indicated that the members on the active list of the Institute, at the end of 1951, totalled 3,727, compared with 3,579 on December 31, 1950, and 3,506 on December 31, 1949. The Council reported, with regret, the deaths of Professor Emeritus T. Turner, a past-president, Fellow and original member; Mr. Harry Davies, a member of Council; Mr. A. H. Mundey, a former member of Council; and Mr. R. C. Stanley, a Platinum Medallist of the Institute. The deaths of 32 other members, including Mr. J. M. Allan, and Mr. F. W. Dingwall, both original members, and Mr. F. L. Baer, Mr. G. Chelioti, Mr. J. D. Ellis, Mr. A. W. Hothersall, Dr. P. J. M. Leemans, Mr. A. B. Lisle, Mr. G. H. Rogers, and Mr. L. W. T. Webb, had also been notified during 1951. A total of 56 papers and addresses had been published in the Institute's *Journal* during the year, while 855 periodicals were now being regularly searched for the "Metallurgical Abstracts" service. In addition to these, many other periodicals were consulted at irregular intervals. Progress continued to be made with the schemes for National Certificates in Metallurgy and the number of technical colleges holding final examinations for the Ordinary Certificate was now 25, and of those dealing with the Higher Certificate, 16. The Council stated in their report that they felt that they could look back on the year 1951 with considerable satisfaction. For the next seven years their anxieties regarding the Institute's finances had been largely removed by the generous response made by industry to their appeal for support. It was a matter for particular gratification that contributions to the Institute's Industrial Donations Fund has also been received from metallurgical firms in the United States and Switzerland.

HONORARY TREASURER'S REPORT.

The report prepared and presented by the retiring honorary treasurer, Mr. W. A. C. Newman, showed that the income for the financial year, ended June 30 1951, was 27,246*l.* and the expenditure 29,652*l.*, thus giving an excess of expenditure over income for the year of 2,406*l.*, as compared with a deficiency of 1,497*l.* in the previous financial year. The present deficiency had been met by transferring the balance of 1,890*l.* from the War-Time Emergency Fund and a sum of 516*l.* from the new Industrial Donations Fund. Up till June 30, 1951, the gross annual income from the latter fund included 5,028*l.* from annual donations under covenant for not less than 7 years, 2,686*l.* from annual donations to be renewed but not under covenant and 1,612*l.* from other donations.

ELECTION OF OFFICERS.

The officers nominated by the Council at the autumn meeting held in Venice, Italy, on September 17, 1951, were declared to be duly elected for the year 1952-53. They were: as President, Dr. C. J. Smithells, M.C.; as vice-presidents, Mr. G. L. Bailey, C.B.E., and Dr. S. F. Dorey, C.B.E., F.R.S.; as honorary treasurer, Mr. E. H. Jones; and as members of the Council, Dr. N. P. Inglis, Dr. Ivor Jenkins, Dr. A. G. Ramsay, Dr. H. Sutton, Major P. Litherland Teed and Mr. W. J. Thomas. In addition, Mr. Alfred Baer and Mr. N. I. Bond-Williams, who had been appointed during 1951 to fill casual vacancies on the Council, were declared duly re-elected for the year 1952-53. The members were also reminded that, last autumn, the Council had elected Professor F. C. Thompson to serve as senior vice-president for the year 1952-53 and that he would be the Council's nominee for the Presidency in 1953-54. Another announcement made during the morning was to the effect that the autumn meeting of the Institute would be held in Oxford from September 15 to 19.

AWARDS OF MEDALS.

The secretary announced that the Institute of Metals Platinum Medal for 1952 had been awarded to Mr. William Sydney Robinson, until recently President of the Consolidated Zinc Corporation, Limited, in recognition of his outstanding services to the non-ferrous metal industries in developing the Australian zinc-lead industry and the British zinc industry. The W. H. A. Robertson Medal had been awarded to Mr. Cyril Ernest Davies for his paper, "The Cold-Rolling of Non-Ferrous Metals in Sheet and Strip Form," which had been presented to the Institute and printed in the *Journal*. Finally the Rosenhain Medal had been awarded to Professor André Guinier, of the Conservatoire National des Arts et Métiers, Paris, in recognition of his contributions in the field of physical metallurgy, particularly in connection with precipitation phenomena. It was intimated that, unfortunately, Mr. Robinson, who is resident in Australia, had been unable to come to England to receive his medal, but the presentation of the other two awards would take place that day at the end of a luncheon held in the Park Lane Hotel.

INDUCTION OF NEW PRESIDENT.

After a vote of thanks to the retiring officers had been passed, Professor Murphy inducted his successor, Dr. C. J. Smithells into the chair. In doing so Professor Murphy said that Dr. Smithells had been a member of the Institute for 30 years and had occupied many of the offices open to members. He had studied chemistry at the University of Leeds but had later taken up metallurgy as a career. He had held, in turn, a position on the research staff of the General Electric Company, Limited, and the post of general manager to Lodge Plugs, Limited, Rugby; his present appointment was that of director of research of the British Aluminium Company, Limited. In addition to writing a number of papers submitted to the Institute and other learned societies, Dr. Smithells was the author of three books, namely *Tungsten*, *Impurities in Metals*, and *Gases in Metals*. He was also the editor of the *Metals Reference Book* published in 1949. He was at present serving as President of the Institution of Metallurgists.

Dr. Smithells's first duty as President was to call upon Mr. Christopher Smith to propose, and Mr. G. L. Bailey to second, a vote of thanks to the retiring President. This having been carried with acclamation and acknowledged by Professor Murphy, Dr. Smithells delivered his presidential address dealing with some of the activities of the Institute, which will be found in abridged form on page 395 of the present issue. At the conclusion, Dr. L. B. Pfeil, F.R.S., proposed, and Mr. J. S. Walton seconded, a vote of thanks to the President for his address and the meeting adjourned for luncheon.

(*To be continued.*)

GOVERNMENT PUBLICATIONS.—The Department of Scientific and Industrial Research have re-issued Sectional List No. 3 of Government Publications, revised to December 31, 1951. The list gives the titles and prices of those publications of the Department which are still in print or in the press. Copies of the list may be obtained *gratis* from H.M. Stationery Office, Kingsway, London, W.C.2.

TRAVELLING DEMONSTRATIONS OF OPTICAL MEASURING TOOLS.—The Newall Group Sales, Ltd., in conjunction with Optical Measuring Tools, Ltd., Maidenhead, Berkshire, have equipped a van for demonstrating the latest types of gauges and optical measuring instruments for workshop use. The van will tour the country to demonstrate methods of inspection and quality control. Any company wishing to witness a demonstration in their own works should write to the Newall Group Sales, Ltd., Peterborough.

THE PHYSICAL SOCIETY'S EXHIBITION.

THE Physical Society's exhibition of scientific instruments and apparatus, now well-established as one of the most popular annual events in the British scientific calendar, opens at the Imperial College, South Kensington, London, S.W.7, on Thursday, April 3, and will remain open daily with the exception of Sunday, April 6, till the following Tuesday, April 8. This year's exhibition is the thirty-sixth of the series and, as in previous years, the opening ceremony will be performed by the President of the Society, Professor L. F. Bates, F.R.S. Both the main building of the Royal College of Science, in Imperial Institute-road, and the nearby Huxley Building in Exhibition-road, are again being used to house the exhibits, which promise to be even more numerous than last year. The hours of opening are 10 a.m. to 1 p.m. each day, 2 p.m. to 9 p.m. on Thursday, Friday and Monday, and 2 p.m. to 5 p.m. on Saturday and Tuesday. It should be noted, however, that, on Thursday, April 3, entry to the exhibition is restricted to Fellows of the Society and members of the Press until 6 p.m., and that admission to all sessions is by ticket only. Since the exhibition invariably brings many former physics students of Imperial College to London, room G5 in the Huxley Building has once again been reserved for their use as a meeting place.

In accordance with custom, discourses on scientific subjects will be delivered during the Exhibition by persons of standing in the scientific world. This year there will be two speakers, Mr. B. N. Wallis, of Vickers-Armstrongs Limited, who has chosen as his subject "Engineering Supersonic Aerodynamics," and Mr. E. R. Davies, of Kodak Limited, who will speak about "The Physical Basis of Colour Photography." These lectures, each of approximately 45 minutes duration, will be given in the Large Chemistry Lecture Theatre on Friday, April 4, and Monday, April 7, respectively, at 6.45 p.m. in each case. On Saturday, April 5, at 3 p.m., the prizes for craftsmanship and draughtsmanship in the Society's annual competition for apprentices will be awarded in the Large Chemistry Lecture Theatre. As usual, the entries to the competition will be on show during the exhibition.

A comparison of the current list of exhibitors with that of last year shows relatively few changes. A number of names, including those of some well-known firms, have dropped out, but others have arrived to take their place, so that the total number of exhibitors is little altered. In addition to the firms who always supply the greater part of the exhibits, there will be, as in previous years, contributions from Government establishments and research organisations. The universities, this year, will only be represented by Birmingham, but there will be another exhibit by the Science Museum, South Kensington. French scientific exhibits, which were shown last year as a counter gesture for the exhibition of British scientific equipment in Paris, are absent. From the preliminary announcements, there appears to be a tendency among the firms to show fewer pieces of boxed-in production equipment and more apparatus under development in their research departments and not yet beyond the test-rig stage. This is a welcome tendency and should add to the attractiveness of the exhibition.

The British Thomson-Houston Company, Rugby, are confining their exhibit to examples of new equipment developed in their research laboratories and their display, which will include several demonstrations of the applications of the new equipment, promises to be particularly interesting. Last year, it may be recalled, the company showed a model of a moulded germanium crystal diode. Since then, continuous progress has been made in studying the unusual electrical properties of germanium and applying them in the development of new electrical devices. Improved germanium diodes, in which the use of a wire contact is obviated, will be shown. Also on view will be a new design of ophthalmic magnet used for removing ferro-magnetic foreign bodies from the eye. The yoke and poles of the magnet are shaped so that the attractive force on a small particle is a maximum at a distance of 1 in.

PHYSICAL SOCIETY'S EXHIBITION.

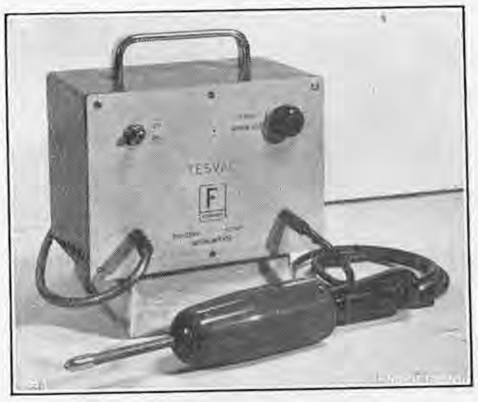


FIG. 1. "TESVAC" HIGH-FREQUENCY POWER UNIT; FERRANTI LIMITED.

FIG. 2. GRAPHITE HEATING ELEMENT FOR HIGH-VACUUM FURNACE; GENERAL ELECTRIC COMPANY, LIMITED.

from the pole tip and, in the case of the type of particle envisaged, the force is likely to be about 24 times the weight of the latter. The magnet weighs 15 lb. and its energisation with direct current requires about 2 kW.

Also among the company's exhibits will be heat-sensitive relays and pyrometers employing lead-sulphide cells. A radiation pyrometer will be on view which can be used to measure equivalent black-body temperatures over the range from 150 deg. to 500 deg. C., correctly to within ± 5 per cent. The area viewed at 15 cm. distance from the lens measures only 5 mm. $\times$ 1 mm., or 10 cm. $\times$ 2 cm. at 150 cm. When temperatures above the upper limit of the range have to be determined, filters and stops, or, alternatively, stops alone, may be employed to limit the intensity and the area viewed. A lead-sulphide cell is used, together with a tuned high-gain amplifier, as a detector of the radiation in a photo-electric flicker photometer. Lead-sulphide cells may also be used directly to actuate relays in response to infra-red light; for example, low-temperature radiant heat, without the interposition of the amplifier which is necessary when photo-emissive cells are employed.

As readers will be aware, great advances have been made in recent years in the development of resinous materials with outstanding electrical properties. The British Thomson-Houston Company's exhibits will include a $\frac{1}{4}$-h.p. squirrel-cage induction motor which will be shown running under water. The windings have been completely sealed against the ingress of water by insulating the stator with a polyester resin, which can be used either for casting or impregnating. In this case, both operations were carried out simultaneously to ensure solid impregnation of the coils with the addition of a resin sheath on the end windings. The rotor is of cast aluminium. This type of insulation has been developed primarily for the stators of motors used in machine tools, which require protection against cutting oils and swarf, but, in addition, the complete absence of voids in the windings, owing to the method of impregnation employed, results in cool running of the motor. The company will also show a high-intensity light source consisting of a xenon discharge lamp, the output of which is increased momentarily to give a flash lasting 0·04 second. This was developed at the request of the Institute of Ophthalmology. New types of glass having unusually high densities, dielectric constants, refractive indices and expansion coefficients, but which are highly transparent to infra-red radiation, will also be shown.

Messrs. Elliott Brothers (London), Limited, Century Works, Lewisham, London, S.E.13, are confining their exhibits to a display of equipment developed in their extensive research laboratories at Boreham Wood. One of the most interesting items on view will be an improved form of automatic dew-point hygrometer. Also likely to attract attention will be digital computing elements, the action of which depends on the phenomenon of magnetostriction. The use of mercury-filled delay-lines in the storage systems of automatic digital computors will be familiar to our readers, some details of their construction and operation having been given previously* in an account of the automatic computing engine at the National Physical Laboratory, Teddington. In the present instance, a delay line will be shown which consists of a narrow nickel tape stretched between two clamps and held between rubber mountings. Two coils of fine insulated wire are wound round the tape, one at each end, and close to the clamps, leaving a free length of about $10\frac{1}{2}$ in. between the coils. The coils take the place of the piezo-electric crystals in mercury-filled delay lines, one acting as transmitter and the other as receiver. A pulse generator is made to supply a rectangular-shaped pulse of current, lasting 1·5 microseconds, to the transmitter coil. Owing to the change in the length of the material of the tape which results from magnetostriction, the current pulse causes a longitudinal compression wave to travel along the tape to the receiver coil. On its arrival there, a voltage is generated in the coil circuit. The time taken by the wave to travel along the tape is about 57 microseconds. During its passage, its waveform is, of course, inevitably distorted, but owing to the dimensions of the tape the distortion is not serious and the pulse may be kept circulating indefinitely in the tape by causing it to generate a fresh copy of itself each time round, as is done in mercury delay lines. A train of pulses sent along the line and spaced at intervals of 3 microseconds may be made to preserve its identity indefinitely. The purpose of the rubber mountings referred to above is, of course, to eliminate reflections from the clamped ends of the tape.

Among the advantages claimed for magnetostriction as compared with mercury delay-lines are their greater simplicity, the fact that they occupy considerably less space, are much lighter, and have smaller insertion losses. There is practically no loss of energy as the wave passes along the tape, most of the loss occurring in the transducing process. Moreover, the output may be taken from any point of the delay line without interfering with the wave in the line. The magnetostrictive delay-line, therefore, is particularly suitable as a rapid-access regenerative store when a large capacity is not essential. The delay-line referred to above will be demonstrated as part of a digital accumulator with associated adding and subtracting circuits. Magnetostrictive delay-lines consisting of flat coils of nickel or nickel-iron wire, wound at the ends with transmitter and receiver coils, consisting of 500 turns of extremely fine insulated wire, will also be on view. The other exhibits of the company include a pulsed signal-generator for testing broad-band networks and a method of measuring the attenuation of radio signals at micro-wave frequencies.

Ferranti Limited, Hollinwood, Lancashire, whose exhibit of an aircraft-aerial radiation-pattern recorder attracted much attention last year, will have what promises to be an interesting range of exhibits, although some of the items listed have been shown previously. Among the new exhibits will be Crater lamps, three-electrode tubes filled with a mixture of mercury and argon the light from which is proportional to the anode current. These lamps can be used for a variety of purposes including the recording of pictures by phototelegraphic methods and the production of sound-tracks on film. Spectral-source lamps of similar construction, which can be obtained with a variety of gaseous fillings, will also be on view. When a spectroscope is available, they have obvious uses in educational establishments as a means of demonstrating the characteristic spectral lines of the different gases or as reference lines.

Cold-cathode gas-filled triode and tetrode valves, the latter known as Neostron valves, will also be demonstrated. The triodes were designed to act as relays in circuits where the mean current does not exceed 5 mA. A fixed potential is applied between the anode and cathode, and the grid has a bias which is insufficient to trigger the tube. An electrical pulse which momentarily raises the grid potential to a value above the critical point is applied when the valve is required to start conducting. The cold-cathode tetrodes were designed as stroboscopic light sources, but may be used for other purposes. The tube is triggered internally by starting a glow-discharge between the control-grid and screen-grid, and the frequency of the flashes can be varied over a wide range by adjustment of the positive bias on the screen and the application of negative pulses to the control-grid. When discharging, the tube can pass a current up to 250 amperes, although the mean current should not exceed 100 mA. An arc-discharge tube, triggered by a high-voltage impulse on an external grid in the form of a clip round the tube, will also be shown. Such lamps are now in fairly common use as sources of high-intensity illumination of short duration and have obvious applications in photography. The breakdown potential between anode and cathode exceeds 2,000 volts, and currents of the order of 500 amperes can be passed at intervals of 0·25 sec., to produce a series of brilliant flashes. Among other items of equipment expected to be on view is a portable source of electrical power of high voltage and frequency, which may be used for a variety of purposes, including the testing of vacua. A circuit similar to the well-known Tesla circuit is employed. At the spark gap, the electrodes are tungsten-tipped and the width of the gap is adjustable. The instrument, which is known as a Tesvac, is illustrated in Fig. 1, herewith.

In accordance with their practice in previous years, the General Electric Company, Limited, Wembley, Middlesex, will be showing equipment developed in their research laboratories and will be demonstrating its mode of operation and its applications. One of the items on view will be a hydrogen replenisher which, as its name implies, is used to make up deficiencies of this gas in any hydrogen-filled device when the deficiency results from ageing in service. Its action may be made automatic. The replenisher consists of an evacuated nickel capsule containing a small quantity of zirconium hydride. When the capsule is heated to a temperature exceeding 400 deg. C., hydrogen, which is evolved from the hydride, is able to diffuse through the walls of the container. When the latter has cooled again, however, the hydrogen is unable to return to the hydride, although it would do so if it were able to, since the gas content of the hydride is less than the saturation value. In the case of a hydrogen-filled thermionic valve, the action may be made automatic by attaching the capsule to the anode. As the pressure in the valve falls during service, the voltage across it rises. This increases the rate of energy dissipation at the anode and raises its temperature, so that the replenisher comes into action. As hydrogen is evolved, however, the pressure in the valve returns to its original value, the temperature at the anode falls, and the evolution of hydrogen ceases.

A demonstration will be given of a method of detecting and recording variations in the diameter of machine-drawn glass tubing. The method adopted is essentially simple, the tubing being

* ENGINEERING, vol. 171, page 7 (1951).

passed continuously between two spring-loaded rollers, mounted vertically on frames which are free to move horizontally. Two similar parallel coils are fixed to one frame and connected into two arms of an electrical bridge, an armature, which moves between the coils, being fitted to the other. Since variations in the diameter of the tubing will cause the armature to move relatively to the coils, an out-of-balance current will be produced in the bridge. In order to increase the sensitivity of the instrument, this current is rectified and amplified by means of a magnetic amplifier the output from which is taken to a recording instrument. It will be noted that only one diameter of each cross-section is measured, so that the instrument does not detect ellipticity in the tubing should this be present. Departures from the circular cross-section could be detected, however, if a second pair of rollers were employed at right angles to the first pair.

The company will also have on view a high-temperature high-vacuum furnace which employs a split-tube graphite heating element, illustrated in Fig. 2, herewith, and holds a cylindrical charge measuring, approximately, 6 cm. in height by 5 cm. in diameter. The furnace is mounted directly under a vacuum pump having a capacity of 300 litres per second. The heat in the furnace is conserved by means of screens which reflect the radiant heat. It is stated that, because of the small thermal capacity of the furnace, a temperature of 2,000 deg. C. can be reached in a few minutes, and that the power required to maintain this temperature is comparatively small.

(*To be continued.*)

WELDED SHIPS.*

STRUCTURAL failures in several welded ships during heavy weather this winter, and, in particular, the almost simultaneous breaking in two last month of two American tankers of the same type off the East Coast of the United States, have raised doubts in some quarters on the reliability of welding as a method of ship construction. Questions naturally arise as to whether the reasons for such failures are known, and whether proper correctives have been found. Records show that these failures have occurred almost entirely among standard welded ships, many hundreds of which were built during the war, mainly in the United States. This immense achievement in production was made possible only by the wholesale and rapid adoption of welding. The end justified the means; these ships admirably fulfilled the purpose for which they were built, and proved a major factor in winning the battle of the Atlantic.

Failures in a few of these ships must be related to the very large number delivered, which included about 2,600 "Liberty" ships and 530 tankers of the type involved in the February casualties. The first major fractures in 1943 sharply focused attention on unforeseen problems of welded shipbuilding. Research was immediately initiated by a special Board set up in the United States for the purpose. Although, in British shipbuilding, welding was at that time being used to a much lesser extent, the significance of these failures was promptly realised, and in June, 1943, the Admiralty Ship Welding Committee was instituted, under the chairmanship of Sir Amos Ayre. Both these bodies have carried out much research, and have throughout maintained close contact and exchange of information. Lloyd's Register have taken a leading part in these and other similar investigations.

Study of these early failures disclosed defects in detail design, to remedy which steps were immediately taken on standard ships still building and in service. These included changes to eliminate notch effects, at which fractures had been found liable to commence, and, in many cases, the fitting of longitudinal riveted connections. Authoritative United States statistical reports state that these measures were effective in greatly reducing the incidence of major fractures. The return since the war to individual rather than standard construction has been marked by a widespread re-organisation of shipyard layout and equipment in many countries for the most efficient use and development of welding. The changeover from riveting, which has naturally taken place at varying rates, depending on local or national conditions, indicates confidence in welded construction.

Since the war, Lloyd's Register have surveyed during building many hundreds of predominantly welded ships, to which the results of earlier experience and of research have been applied, and these ships are giving full satisfaction in service. The current *Rules for Tankers* have been formulated for welded construction, this now being the commonly accepted practice for these ships. In dry-cargo ships, longitudinal framing at the bottom and strength deck is being increasingly adopted, a system which is recommended as conducive to improved efficiency of structure. Safeguards against any tendency to cracking are provided by avoiding in design abrupt discontinuities and notch effects; close attention is given to the standard and control of workmanship, not only in the welding process itself, but in all stages of fabrication and assembly. These requirements are emphasised in the current Rules, and have also been widely disseminated in specially prepared codes of practice. Shipbuilders and surveyors are constantly alert to their application. The steel material involved in the failure of some war-built welded ships, while suitable for riveted construction, was found by subsequent research to be susceptible to brittle failure when stressed in the presence of a notch, particularly at low temperatures. Rule requirements for quality and testing have been introduced which preclude the use of such material, and additional precautions are specified for the thicker plating commonly required, especially in tankers.

Analysis of the Society's records of service behaviour emphasises the importance of judicious distribution of cargo and ballast in minimising longitudinal hull stresses, especially in severe weather. Guidance on this subject has been issued to owners of all ocean-going tankers classed with Lloyd's Register and, at owners' request, suggestions have also been, and are being, made for the most suitable loading of many types of dry-cargo ships.

As an outcome of their investigations, the Admiralty Ship Welding Committee have stated that "Welding as a process for building ships has been entirely vindicated. Given sound design, good workmanship and tough steel, the reliability of welded ships is beyond question." With this conclusion the Society is in complete accord. With proper regard to design, workmanship and material, added to constant vigilance, the Society looks forward confidently to continued advances through the adoption of welding. It is satisfactory to record that, to date, major failures have not occurred in welded ships built since 1945.

* Communication from Lloyd's Register of Shipping, 71, Fenchurch-street, London, E.C.3.

CRANE REPAIR DEPOT.

CRANE REPAIR DEPOT OF BUTTERS BROS. AND COMPANY.

THE new London offices and works of Messrs. Butters Brothers and Company, Limited, are situated at Hillingdon, on a main route out of London, namely, Western-avenue. The full address is the Crane Works, Station Approach, Long-lane, Hillingdon, Middlesex; formerly the works and offices were at Chiswick. At Hillingdon the works can now not only undertake the repair and maintenance of a large fleet of hired plant, principally derrick cranes (hand, steam, and electric), but can also carry out mechanical and structural repairs to cranes built at the company's Glasgow works. The illustration above shows one end of the main shop, which is 128 ft. long by 45 ft. span and is equipped with a 5-ton overhead travelling crane for handling crane assemblies and parts. At the other end of the building there is a machine shop with a small group of machine tools suitable for the jobbing nature of the work performed; they include two centre lathes, a capstan lathe, a radial drill, a shaper, a slotter, a horizontal milling machine, a vertical milling machine, a saw and a press. Nearby on the site there are also a joiners' shop, a paint shop, and an air-compressor house. A large stock of spares will be carried for supplying crane users in the south.

The works is adjacent to the Metropolitan and Piccadilly lines to Uxbridge. Though these electric lines of London Transport are mainly for passenger trains, they are also used by occasional steam freight trains, so incoming and outgoing goods can be transported by rail. A siding is being laid, reaching into the centre of the site, in an area covered by a 10-ton derrick crane with a 120-ft. jib. In another corner of the site, where repaired cranes will be stored, there is an entrance from Western-avenue and a 5-ton derrick crane with a 110-ft. jib.

THE FERTILISER SOCIETY.—A meeting of the Fertiliser Society, 44, Russell-square, London, W.C.1, will be held on Thursday, April 3, at the North British Hotel, Edinburgh, commencing at 2.30 p.m. Mr. J. P. A. Macdonald M.I.Mech.E., will read a paper on "Some Aspects of Mechanical Handling in the Fertiliser Industry."

GRADUATE COURSES IN APPLIED SCIENCES, BIRMINGHAM.—Particulars of graduate courses in mechanical engineering, chemical engineering, and metallurgy have been issued by the registrar, The University, Edgbaston, Birmingham, 15. The courses will be available in the Faculty of Science during the season 1952-53 and will be open to graduates possessing industrial experience. They will last for one year, from October to July. Further details and forms of application may be obtained from the registrar, at the above address.

STUDY COURSES ON INFORMATION WORK.—Aslib are to hold a course of study for those who have recently taken up special-library and information work, from Monday, May 5, to Friday, May 10, at the Friends' House, Euston-road, London, N.W.1. The course will include lectures, discussions, and visits to libraries. Particulars may be obtained from the Director, Aslib, 4, Palace-gate, London, W.8.

STORES AT UNION WORKS, WEMBLEY.

CLASSIFICATION SYSTEM FOR ENGINEERING STORES.

A WIDE range of electrical products, for which a considerable variety of products has to be purchased and stored, is manufactured at the Union Works, Wembley, of the General Electric Company, Limited. In consequence, a relatively large number of types, grades and sizes of materials have been acquired in the course of years, the result being the accumulation of considerable idle and redundant stock. As the supply and control of this material became increasingly difficult, means had to be devised for eliminating unnecessary varieties and for recording, arranging and controlling the essential items. About two years ago, therefore, it was decided to introduce the Brisch system of classification, and it can now be reported that this has been completely successful in eliminating much surplus stock and in bringing about a considerable degree of standardisation.

In addition, the introduction of this system has enabled the arrangement of the stores to be much improved with the result that about 50 per cent. more material can be accommodated in the same areas, and the facilities for handling are better. It has also been possible to use unskilled labour in the stores themselves since the storekeepers' memory and knowledge are no longer such significant factors in dealing with the items. In fact, the employment of the system has enabled the number of items issued to be increased by more than 250 per cent. with one assistant fewer than before. The accompanying illustration shows the stores after the Brisch system was introduced.

The Brisch system of classifying industrial and commercial goods employs a concise, uniform notation, which is descriptive of the goods coded. It is very easily adapted to meet the requirements of the organisation concerned. Nevertheless, the number of digits allocated does not normally exceed seven and anything likely to be used in industry or commerce can be classified under the following ten general headings: 0000, structure, organisation, staff, finance; 1000, raw materials; 2000, bought-out parts; 3000, components; 400, assemblies and sub-assemblies; 500, tools and implements; 6000, production plant; 7000, buildings and services; 8000, by-products, scrap and waste; and 9000, special problems. Each of these main classes can be divided into nine sub-classes, each subclass into nine groups, each group into nine series and each series into 999 sector numbers. For example, in the stores at Wembley the code number 1174–401 would represent bright mild-steel tube, round seamless, of 0·75-in. outer diameter by 10 s.w.g. and 27·5 in. long. The meaning of each digit can be readily understood and, though it is unnecessary to memorise the system, in practice those using it soon learn to appreciate the repetition of fundamental patterns of classification. The system can be applied to any products or materials and in the Union Works is used for rod, tube, sheet, metals and non-metals, as well as for wires of various kinds and for adhesives, and abrasives. It is also being extended to screws, nuts, washers and fasteners in general.

RAILWAY WIDENING AND STATION RECONSTRUCTION AT POTTERS BAR.

IT is announced that approval has been given by the British Transport Commission for an extensive scheme of track widening and station reconstruction at Potters Bar, some $12\frac{1}{2}$ miles north of London on the main line of the Eastern Region, British Railways, to Scotland. At the present time, there is only one down and one up line from Greenwood signal box, 10 miles north of London, to beyond Potters Bar station; and this section includes three tunnels with a total length of 1,830 yards. The result is that freight and slow passenger trains interfere with the running of the expresses, and the widening, by providing two additional tracks, is therefore the first step towards improving the operating efficiency of this most important railway artery.

The widening will provide two additional running lines from near the north portal of Potters Bar tunnel to the north end of Potters Bar station, a distance of about three-quarters of a mile. Potters Bar station will also be reconstructed, with two island platforms serving all four running lines, and will include new buildings at platform level, a new signal box, alterations to the track layout at the north end of the station and new booking and parcels offices at ground level. In addition, the goods yard facilities will be concentrated on the up side of the station, where new offices, a covered bench for loading and unloading, and better shunting facilities will be provided, thus permitting of greater efficiency in handling the traffic which has increased appreciably since 1938. The station approaches will be re-arranged and a car park, lock-up garages, a cycle store, taxi rank and cabmen's shelter will be provided. Finally, it will be necessary to construct a 60-ft. bridge over Darkes-lane. The total cost of the scheme, it is estimated, will be about 400,000*l*.

Prestressed-concrete canopies will be erected above the island platforms, of a type requiring only eight columns to support a length of 260 ft., so that there will be a minimum of obstruction. Both platforms will be connected to the up and down sides of the station by a subway and the existing footbridge will be removed. The buildings will be constructed as far as possible of materials which will require a minimum of maintenance and use a minimum of steel. The existing mechanical signal box at Potters Bar will be removed to make room for the new down line and will be replaced by an all-electric signalling installation controlled from a new box on the up side of the line. The electric point machines and colour-light signals will be operated on the route-setting principle from a control panel on the upper floor of the signal box, thus giving the signalman "finger-tip" control over all train movements within the area. The further widening of the line, by providing two additional lines between Greenwood and a point north of Potters Bar tunnel, a distance of $2\frac{1}{2}$ miles, is being considered; if it is carried out it will necessitate the construction of three new double-line tunnels.

FORTHCOMING EXHIBITIONS AND CONFERENCES.

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

LEONARDO DA VINCI QUINCENTENARY EXHIBITION.—From Thursday, March 6, to about the end of May. In the Diploma Gallery, Royal Academy, Piccadilly, London, W.1. See also page 307, *ante*.

SECOND UNITED STATES INTERNATIONAL TRADE FAIR.—Saturday, March 22, to Sunday, April 6, at the Nay Pier, Chicago. Representative for the United Kingdom and Ireland: Mr. A. P. Wales, 12, St. George-street, London, W.1. (Telephone: MAYfair 4710.)

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

INSTITUTION OF NAVAL ARCHITECTS, ANNUAL MEETING.—Wednesday, Thursday and Friday, April 2, 3 and 4, on the "Wellington," Temple Stairs, Victoria-embankment, W.C.2. Details obtainable from the secretary of the Institution, 10, Upper Belgrave-street, London, S.W.1. (Telephone: SLOane 4622.)

PHYSICAL SOCIETY'S EXHIBITION.—Thursday, April 3, to Tuesday, April 8, at the Imperial College, South Kensington, S.W.7. Information from the secretary of the Society, 1, Lowther-gardens, Prince Consort-road, London, S.W.7. (Telephone: KENsington 0048.) See also page 348, *ante*.

ASLIB AERONAUTICAL GROUP CONFERENCE.—Saturday, April 5, to Monday, April 7, at the College of Aeronautics, Cranfield. Applications to Mr. C. W. Cleverdon, librarian, College of Aeronautics, Cranfield, Bletchley, Buckinghamshire. See also page 246, *ante*.

CONVENTION ON ELECTRICAL CONTACTS.—Monday, April 7, to Wednesday, April 9, at Loughborough College, Loughborough. Organised by the East Midlands Centre of the Institution of Electrical Engineers. Details available from Mr. R. G. L. Ryan, honorary secretary of the Centre, c/o The Brush Electrical Engineering Co., Ltd., Loughborough.

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

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

SYMPOSIUM ON DIAMOND DRILLING.—Monday, Tuesday and Wednesday, April 21, 22 and 23, at Johannesburg. Organised by the Chemical, Metallurgical and Mining Society of South Africa and the Diamond Research Laboratory. Apply to the director of the Laboratory, P.O. Box 916, Johannesburg.

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

LIÉGE INTERNATIONAL FAIR.—Saturday, April 26, to Sunday, May 11, at Liége. Apply to the Fair secretariat, 17, Boulevard d'Avroy, Liége.

TELEVISION CONVENTION.—Monday, April 28, to Saturday, May 3, at Savoy-place, Victoria-embankment, London, W.C.2. Organised by the Radio Section of the Institution of Electrical Engineers. Apply to the secretary of the Institution at the address given above. (Telephone: TEMple Bar 7676.) See also our issue of September 21, 1951, page 371.

INTERNATIONAL FOUNDRY CONGRESS AND SHOW.—Thursday, May 1, to Wednesday, May 7, at Atlantic City, New Jersey, U.S.A. Organised by the American Foundrymen's Society, 616, South Michigan-avenue, Chicago 5, Illinois, U.S.A.

CHEMICAL WORKS SAFETY CONFERENCE.—Friday, May 2, to Sunday, May 4, at the Palace Hotel, Buxton, Derbyshire. Organised by the Association of British Chemical Manufacturers. For further details, apply to the secretary of the Association, 166, Piccadilly, W.1. (Telephone: REGent 4126.)

BRITISH INDUSTRIES FAIR.—Monday, May 5, to Friday, May 16, at Earl's Court, London, S.W.5, and Olympia, London, W.14; and Castle Bromwich, Birmingham. Particulars from the director, British Industries Fair, Board of Trade, Lacon House, Theobald's-road, London, W.C.1. (Telephone: CHAncery 4411); or the general manager, British Industries Fair, 95, New-street, Birmingham, 2. (Telephone: Midland 5021.)

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

INTERNATIONAL ROAD FEDERATION, WORLD MEETING.—Tuesday, May 13, to Friday, May 16, at Washington. Apply to the secretary of the Federation, 550, Washington Building, Washington, D.C., U.S.A.; or to the London office at 18, South-street, W.1.

SWEDISH INDUSTRIES FAIR.—Saturday, May 17, to Sunday, May 25, at Gothenburg. *Agents:* John E. Buck and Co., 47, Brewer-street, London, W.1. (Telephone: GERrard 7576.)

GERMAN EXHIBITION OF CHEMICAL APPARATUS.—Sunday, May 18, to Sunday, May 25, at Frankfurt-on-Main. Organisers: Dechema Deutsche Gesellschaft für Chemisches Apparatewesen E.V., Frankfurt.

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

ELECTRONICS COURSE AT HARWELL.—Monday, May 19, to Friday, May 23. Applications to the Electronics Division, Atomic Energy Research Establishment, Harwell, Didcot, Berkshire. See also page 169, *ante*.

INCORPORATED PLANT ENGINEERS.—Wednesday, Thursday and Friday, May 21, 22 and 23, at the Grand Hotel, Harrogate. Fifth annual conference, on "The Scope of the Works Engineer." Apply to the secretary of the Institution, 48, Drury-lane, Solihull, Birmingham.

INTERNATIONAL HIGH TENSION CONFERENCE.—Wednesday, May 28, to Saturday, June 7, at the Fondation Berthelot, 28, Rue Saint Dominique, Paris. Apply to Mr. R. A. McMahon, secretary, British National Committee, Thorncroft Manor, Dorking-road, Leatherhead, Surrey. (Telephone: Leatherhead 3423.)

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

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

FOURTH INTERNATIONAL MECHANICAL ENGINEERING CONGRESS.—Wednesday, June 4, to Tuesday, June 11, at Stockholm. Subject: "Progress in the Field of Raw Materials Used in the Mechanical Engineering Industry." Further particulars from M. C. de Novar, permanent secretary, Congrès International des Fabrications Mecaniques, 11, Avenue Hoche, Paris, 8e.

FIFTH HYDRAULICS CONFERENCE.—Monday, Tuesday and Wednesday, June 9, 10 and 11, at Iowa City. Apply to the Iowa Institute of Hydraulic Research, State University of Iowa, Iowa City, U.S.A. See also page 341, *ante*.

CONFERENCE ON CIVIL ENGINEERING PROBLEMS IN THE COLONIES.—Monday, June 16, to Friday, June 20, at the Institution of Civil Engineers, Great George-street, Westminster, London, S.W.1. Details obtainable from the secretary of the Institution at the address given. (Telephone: WHItehall 4577.) See also page 339, *ante*.

INDUSTRIAL FINISHING EXPOSITION.—Monday, June 16, to Friday, June 20, at International Amphitheatre, 43rd and Halsted Streets, Chicago, Illinois, U.S.A. Sponsored by the American Electroplaters Society. Further details available from the secretary, Suite 580-84, 35, East Wacker-drive, Chicago, 1.

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

WELDING DESIGN AND ENGINEERING SUMMER SCHOOL.—Wednesday, July 16, to Sunday, July 20; and Sunday, July 20, to Friday, July 25, at Ashorne Hill. Organised by the British Welding Research Association, 29, Park-crescent, London, W.1. (Telephone: LANgham 7485.)

INTERNATIONAL ASSOCIATION FOR BRIDGE AND STRUCTURAL ENGINEERING, FOURTH INTERNATIONAL CONGRESS.—Monday, August 25, to Friday, August 29, at Cambridge. For further information, apply to the secretary of the Association, Swiss Federal Institute of Technology, Zürich, Switzerland.

SYMPOSIUM ON MINERAL DRESSING.—Tuesday and Wednesday, September 23 and 24, at the Imperial College of Science and Technology, Prince Consort-road, South Kensington, London, S.W.7. Organised by the Institution of Mining and Metallurgy, Salisbury House, Finsbury-circus, London, E.C.2. (Telephone: MONarch 2096.) See also our issue of February 15, page 211.

LABOUR NOTES.

ENGINEERING and shipbuilding apprentices in Scotland and the North of England, taking part in an unofficial strike for more money, were condemned for acting unconstitutionally at the annual conference of the youth section of the Amalgamated Engineering Union at Eastbourne on March 20, by Mr. Jack Tanner, the union's President. The strike is in support of an official claim by the A.E.U. for an overall increase of 20*s*. a week for young men engaged in the engineering and shipbuilding industries. About 63,000 men between the ages of 17 and 25 are members of the union's youth section and are affected by the claim, but only a relatively small proportion of them are involved in the strike. Mr. Tanner explained to the 45 delegates at the conference that the claim was presented to the employers' organisation by officials of the union at a joint meeting on February 14, which had been called to discuss the demand, and that the employers' representatives had promised to give an early answer. This, however, had not so far been received.

Mr. Tanner referred to the apprentices in the engineering industry as being among the worst-paid young people in employment at the present time and informed the conference that the union's officials had impressed upon the employers' representatives that there was widespread discontent. He added that the result of the union's application was unlikely to be a more satisfactory one as a result of some of the union's members in various parts of the country taking unofficial action. There was no justification for the apprentices' strike action. Agreements were nearly always compromises reached by mutual consent and it had to be remembered that if members of the union broke an agreement, the employers would be entitled to do the same.

A resolution on the wages of apprentices was replaced, after much discussion, by an amendment asking that the national committee of the A.E.U. should instruct the union's executive council to apply to the Engineering and Allied Employers' National Federation for an all-round increase of 20*s*. a week for all apprentices and youths, in addition to any settlement reached as the result of the claim already pending. This amendment was carried unanimously, but Mr. Tanner ruled out of order a number of attempts to move amendments to the wage resolution, aimed at giving official recognition to the strike. Eventually, an emergency resolution was carried, by 36 votes to eight, in which "applause" was expressed for the "action of the youths in their struggle." The conference is advisory and has no power to decide union policy, but the passing of this resolution is likely to encourage the young men on strike.

Warnings that workpeople could not improve their economic circumstances by taking strike action against the Government were given by Mr. Jack Tanner at the annual conference of the women's section of the Amalgamated Engineering Union, which took place at Eastbourne on March 19. Mr. Tanner, who, besides being President of the union, is also a member of the Trades Union Congress General Council, said that attempts were being made to get workpeople to strike, to ban overtime, to go slow, to repudiate agreements, and generally to weaken and break down the economic life of the country, as a protest against the Government's economic policy. The present position of this country could be likened to that of a ship which had been battered by rough seas for a long time and is still in very rough weather. A large section of the crew might not like the course the ship's captain was taking, but it was no use refusing to fire the boilers. The most likely result of such action would be to wreck the ship completely and put everyone in a far more desperate position.

It had to be remembered, Mr. Tanner continued, that, mainly owing to circumstances beyond everyone's immediate control, the country was not paying its way in the world and industrial strife could easily cause disaster. The situation was very difficult. People might feel angry and anxious to get rid of the present Government, but it was necessary for trade unionists to use their common sense, maintain unity in their ranks, and continue their loyalty to the greater movement of which they formed part. They must prevent the union from being used for political objectives to which it did not subscribe. Turning to the position of women in industry, Mr. Tanner said that no one should expect women to remain content to perform indefinitely work demanding quite high degrees of skill in return for wages less than those paid to labourers.

The delegates to the conference asked the union's executive council to make an immediate application to the employers for a "substantial increase" in pay for all women engaged in the engineering industry. Other demands put forward were for a new wage structure for women engineers, to be graduated according to the skill required, and a minimum wage rate equivalent to that of adult men labourers. The present weekly minimum basic rate for women is 4*l*. 5*s*. against one of 5*l*. 11*s*. for male labourers. The conference represents about 44,000 women members of the union, mainly employed in factories on the rearmament programme and on production for export.

An increase of 8 per cent. on the basic wages of more than 120,000 craftsmen and labourers employed in railway workshops was awarded by the Industrial Court on March 19. This advance in wage rates will be retrospective to September 3 last year and is expected to cost the Railway Executive not less than three million pounds a year. The present minimum rate for a grade 1 fitter of 6*l*. a week will be increased to 6*l*. 9*s*. 6*d*. Basic wages for other workshop staff, which at present range from 5*l*. 2*s*. 6*d*. to 5*l*. 14*s*. 6*d*. a week, will be increased to from 5*l*. 10*s*. 6*d*. to 6*l*. 3*s*. 6*d*. a week. These increases are in accordance with those granted by the Railway Staff National Tribunal a few months ago to other grades of railway employees. They are, however, less than the 11*s*. a week overall increase, which the Confederation of Shipbuilding and Engineering Unions claimed was due to the railway shopmen, in order to bring their wage increases into line with those accorded last autumn to men engaged in other branches of engineering.

According to an announcement by the Treasury on March 19, an agreement has been reached between it and the trade unions concerned whereby engineering craftsmen and labourers employed at Royal Ordnance Factories, Admiralty dockyards, and other Government workshops will receive a second week's holiday with pay each year. This concession will come into force next year and will benefit about half a million persons in Government employment.

The letter on the closed-shop policy of the Durham County Council, recently sent to the Council by the joint committee set up by six professional bodies representing engineering, teaching, medicine, and nursing, was discussed at some length at a meeting of the Council's emergency committee on Monday last. As recorded on page 376, the letter allowed the Council until April 30 to give an undertaking that none of its professional employees should be subject to the policy requiring membership of a professional organisation as a condition of employment in its service, no matter in what manner, direct or indirect, such a condition might be implied. It was stated, after the meeting, that the Council's emergency committee had decided to adopt the suggestion made by the joint committee that representatives of the latter body should go to Durham to discuss the matter further.

The need for persons in executive positions in industry to receive incentives was emphasised in a speech delivered by Major-General Sir Edward Spears, K.B.E., C.B., to the Advertising Association at a luncheon meeting in London on March 19. Sir Edward, who is chairman of the Council of the Institute of Directors, stated that the Chancellor of the Exchequer, Mr. R. A. Butler, had made a worth-while attempt to increase production by the re-introduction of incentives. Unfortunately, however, he had stopped at incentives for wage-earners and had not done anything to give encouragement to directors, managers and professional men generally, in spite of the fact that these people, as a class, did more than any other to promote increased productivity. His bold introduction of incentives was a prerequisite for prosperity.

The battle being waged by the Chancellor for the stabilisation of the pound was immensely difficult and largely psychological. No one could say how far he would be successful in his efforts to persuade other nations that Britain would not permit sterling to decline any further, but if he could demonstrate the country's determination to succeed in this endeavour, and could mobilise its resources, the fight would be won. In recent years, it had seemed natural that wages should keep pace with rises in the cost of living. An immense amount of enlightenment of the wage-earning sections of the community must be undertaken, otherwise difficulties with labour might arise as a result of the reduction in the food subsidies. Any ideas that might exist that more money could be obtained, without additional efforts being made, were quite erroneous. The facts were that funds no longer existed, and that extra costs must be met by increased efforts. If price increases led inevitably to wage demands, inflation would produce worse consequences.

DREDGING CRAFT.

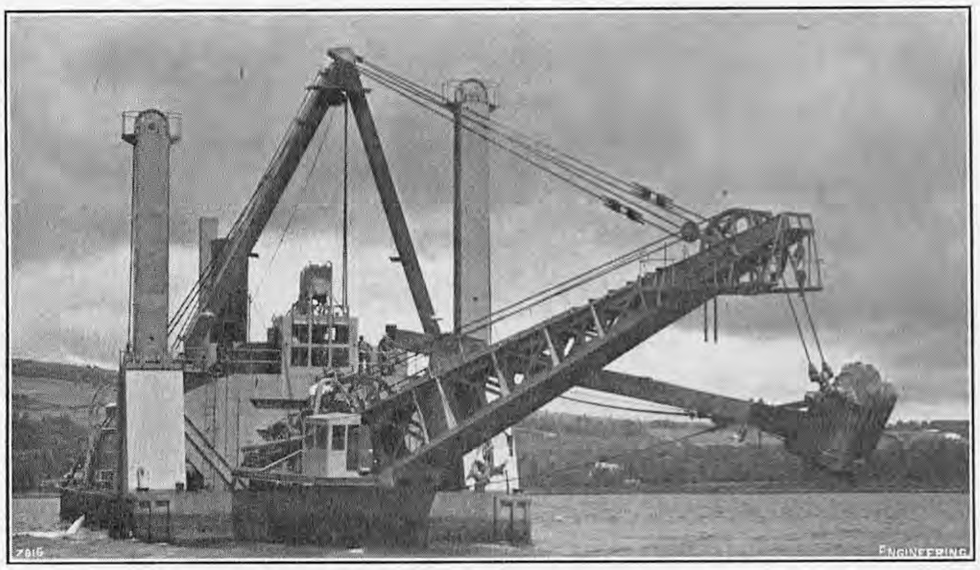


FIG. 7. DIPPER DREDGE "KALA NAG."

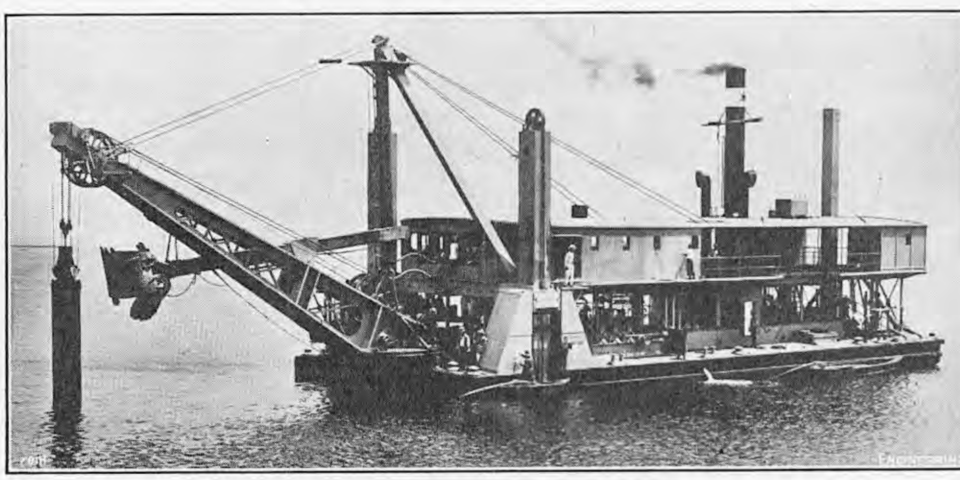


FIG. 8. ROCK DREDGE "CHOSHI."

DREDGING CRAFT.*

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

(*Continued from page* 379.)

THE DIPPER DREDGE.

THE dipper dredge has not sustained favourable interest in this country and the attributes of the type seem to have been neglected. Many dipper dredges were at work in eastern countries until 1939 and were known to have given satisfactory performances under variable service conditions. In the United States, the type is used only for the toughest of dredging duties and is complementary to the suction dredge. There it is recognised as an economic dredging unit of moderate capital cost and low maintenance charges. The salient features of this dredge make it more versatile and capable of dealing with harder material and a wider range of work than other types of dredge.

The steam or Diesel shovel is an efficient means of excavating earthwork; the dipper dredge is the floating steam or Diesel shovel. The single bucket, or dipper, mounted on the end of a pontoon, is arranged to have universal motion within certain angular limits. The boom, carrying the dipper arm and bucket, is seated on a large baseplate strongly attached to the deck, and is suspended from an overhead frame so that it may revolve transversely through an angle of fully 180 deg. The dipper arm and bucket are rigidly mounted together, and the arm is designed to slide through a saddle-block located about the mid-length of the boom and arranged to pivot in the vertical plane. A feed motion to the bucket is operated by the arm. Wire ropes from the barrel of the main hoisting machinery pass through a system of fairleads in the hull and on the boom until they connect directly with the bucket. When hoisting, the bucket describes an arc about the saddle-block as centre; when feeding, the radius of action of the bucket is varied at will, and, when revolving about the vertical axis of the boom base, the bucket may be positioned to dig or deposit anywhere within the designed radius of action by operating the feed to the dipper arm.

The dipper dredge is usually anchored for dredging by three spuds, two forward and one aft, without any external moorings. It has a large degree of mobility and can be manipulated over the dredging area by skilful use of the bucket and the spuds. The dipper bucket works ahead, making successive cycles until the entire face or bank within range is dredged away. The dredge is then advanced, the spuds are reset, and another cut commenced. This type can dig its own flotation through a bank many feet above water level and without danger from the collapse of such a bank. Spoil disposal is effected either by loading into barges alongside or by depositing direct on the river or canal banks. Barge disposal is mostly used for harbour and river dredging, and deposition on the banks in waterways restricted by width. Dipper dredges are generally and preferably arranged as non-propelling craft, as several features peculiar to them render the inclusion of propelling machinery something to be avoided. A very few of these dredges have, however, been equipped with propulsion equipment.

The vessel shown in Fig. 7, herewith, is a steam-operated 11-cub. yd. dipper dredge built recently for service in France and, in particular, to clear the tremendous damage done to the port of Le Havre. In operation, the power is concentrated through the single bucket, which exerts a tremendous digging force at the cutting face. This dredge has set an exceptional standard in its present service. The main particulars are: length between perpendiculars, 130 ft.; breadth, moulded, 50 ft.; depth, moulded, 12 ft.; maximum dredging depth below waterline, 53 ft.; outreach at boom sheaves, 68 ft.; maximum outreach at dump height, 85·5 ft.; dump height, 18 ft.; bucket capacity, 11 cub. yd.

The boom is suspended from the overhead frame by wire ropes and this frame has wire backstays. The boom base is retained in sockets by heavy springs, and the entire arrangement is therefore one of flexibility, with allowance for the boom to rock or roll and thus avoid excessive loads. A separate winch is installed on deck for swinging the boom and is remotely controlled from the operating house. The dipper arm is of laminated construction, with wood filling between steel plates and sections. Again, flexibility is the aim and the flitched beam design has proved successful. The winch, located and operated on the boom, is devoted solely to manipulating the feed of the dipper arm through the saddle-block on the boom, this movement being used on every cycle when dropping to dredging depth, when holding the bucket to the cut, and when thrusting the arm outward to dump the spoil load.

Each forward spud is about 90 ft. in length and weighs 40 tons. A two-barrel independent winch, placed in the hull, is connected by wire rope to each spud and is controlled from the operating house. When the spuds are run down to touch bottom, the hull assumes a condition of free flotation without the weight of the spuds. As the spud winch exerts a downward thrust on the spuds in contact with the bottom, so the hull is raised partly out of the water, and it is in this condition that dredging takes place. In this dredge, the hull lift above free flotation to secure complete stability for dredging varies between 1 ft. 6 in. and 2 ft. 6 in. The utmost care must be maintained lest spud sinkage into the ground or tidal conditions create a variation in spud loading, which would upset the working stability of the craft, and special automatic draught gauges are fitted in the operating house so that a constant record of the amount of hull lift is evident. The after trailing spud is also driven by an independent winch placed on deck and locally controlled. This spud is arranged to swivel in the fore-and-aft plane as the dredge moves ahead to the next cut. It acts as an anchor while the bucket makes the dredge "step ahead." Once the new dredging position is attained the forward spuds are run down, the dredge set, and the after spud raised from the trailing position to the vertical, where it exerts adequate thrust to act as a stabiliser.

The rock dredge is a combination of dipper dredge and rock-breaker. To the features of the dipper dredge is added a rock-breaking attachment, consisting of a rock-cutting chisel operated by the hoisting engine, and an under-water guide, coupled to the boom winch. Dredging and rock-breaking do not take place concurrently, as the same machinery is used for both purposes, but the transfer is accomplished very speedily. This dredge has the advantage that it can break rock under water and then raise it to the surface—an advantage not yet fully exploited. Where a modest volume of rock has to be excavated and large-scale expenditure cannot be warranted, the system offers both efficiency and economy of operation. A typical arrangement of the rock dredge is shown in Fig. 8, herewith.

SUCTION DREDGES.

Dredging equipment common to all suction dredges is the suction pipe and the centrifugal sand pump. The dredging pump is placed as far below water level as possible and it is common practice to dredge to a depth of 55 to 65 ft. below water level, but less common to reach to a depth around 100 ft. As dredging increases in depth, the entrance loss to the suction pipe and the velocity head remain unchanged, but there is an increase in the friction head and in the head required to support the column of mixture, which has a density materially higher than that of water. Additional means must therefore be devised to carry an adequate spoil mixture to the sand pump and this may take the form of a booster pump placed in a compartment in the suction frame. There are three main classes of suction dredge, namely, the sea-going hopper dredge, the river and harbour dredge, and the reclamation dredge.

The sea-going suction hopper dredge is a self-contained dredging unit having a central hopper, with opening doors in the bottom, into which the dredged material is pumped. When the hopper is filled the dredge proceeds to the deposit ground to release the load through the bottom. An alternative arrangement is often included whereby the spoil is pumped from the hopper through an overboard discharge. The hoppers of these dredges in the course of loading spoil are always capped by a large, free water surface which, with a full spoil load, is drained off, but which, with a partial load, usually remains in the hopper. Siphons are sometimes fitted to drain this surplus water overboard. If loaded with a light alluvial silt, the entire hopper content remains in a fluid state. The stability of these vessels is arranged to cope with these circumstances, as well as the possibility of the material leaving the hopper unevenly while dumping in open waters.

These hopper dredges are usually built in one of three forms, the choice being determined by the nature of the ground and the service conditions: to trail the suction pipe on the bottom while propelling ahead at low speed; to thrust the suction pipe into the bottom

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

while moving ahead to anchors; and to rest the suction pipe on the bottom while feeding downward without horizontal movement of the dredge.

In its simplest form the trailing suction dredge is purely a maintenance dredge, lifting spoil from one area, carrying it to and depositing it in another. It works alone on the sea bar at the entrance to the river or navigable channel, or in any waterway having adequate depth and length for manœuvring. Bar dredging is subject to frequent adverse sea and weather conditions and, to accommodate the liveliness of the ship, flexible joints are introduced into the suction pipe. This method of dredging requires no moorings. The suction pipe is lowered to the bottom and, when a favourable mixture of spoil and water is obtained, the mixture is transferred into the hopper. The rate of dredge advance is controlled through the propelling machinery and should be as slow as possible, preferably not in excess of 2 knots. The sand-pump vacuum gauge indicates conditions in the pumping system, and the dredging depth indicator and the suction-pipe hoist rope the disposition of the suction head.

The trailing dredge will pump satisfactorily alluvial silt, soft greasy mud and sandy clay, but the best results will be secured in a free-running sand. To design a trailing, or drag, head has been the sport of many civil and dredging engineers over the years and without doubt the head exerts a dominating influence on dredging results. The shoe type of trailing head has been used successfully in a number of dredges working under widely varying conditions. It is not equipped with a mechanical agitator or hydraulic jets, but may be fitted with teeth. The efficiency of sand pumps ranges from 55 to 70 per cent. The spoil piping in the hull should be as direct as possible. Ground conditions, handling of the dredge, tides and weather all influence the spoil mixture in some way, but if, when pumping into a hopper, an average mixture containing 20 to 30 per cent. of solids is maintained in regular service, the performance can be regarded as satisfactory.

In filling a hopper, a substantial volume of water overflows and in certain circumstances spoil is carried away in the overflow. Many hoppers were allowed to overflow along their entire length, but this method has been superseded by the introduction of weirs and overflow ducts at one end. With the spoil discharges to the hopper remote from the overflow ducts, and the velocity of water restricted to a practical minimum, settlement of the solids in suspension is encouraged to the utmost. With heavy sands the problem of spoil loss from the hopper is not serious, but with light materials the rate of settlement is slow, the carry-over high, and the difficulty of retention a major issue. As a hopper fills with spoil, the intensity of loss increases until there is a point beyond which pumping is futile. One authority, dredging a light alluvial silt, operates a satisfactory procedure. Hopper doors are well maintained and tight so that the hopper may be pumped dry before dredging commences. When the hopper is filled with spoil, no overflow is permitted and the dredge proceeds to dump. This scheme can be made more effective with a large-capacity hopper based on spoil, weighing, say, 30 cub. ft. as against the more usual 20 cub. ft. per ton, but a larger ship is required to meet this condition. Door maintenance costs could be reduced and better sealing retained by the use of hopper valves with rubber landings in place of doors.

A number of different types of trailing dredges are produced: single side pipe, twin side pipe, bow well, centre well and stern well. There is little question that, for straightforward channel maintenance dredging, the twin side-pipe trailer is the superior craft. Adherents of the bow-well and centre-well types may, however, take issue with this statement. Some of the more prominent features applicable to two of the types are noted. Fig. 9, herewith, shows a recent twin side-pipe trailing-suction hopper dredge, designed for river maintenance duties. The leading particulars are: length between perpendiculars, 190 ft.; breadth, moulded, 46 ft.; depth, moulded, 18 ft.; hopper capacity, 875 cub. yd.; dredging depth below waterline, 42 ft.; loaded service speed, 10 knots. The length of this dredge was severely limited, as it is required to dredge frequently within an available length of 600 ft. This restriction permits no loss of time in handling the suction pipes and getting to work. To ensure maximum manœuvrability, twin rudders are fitted behind twin screws. No bottom doors are fitted, the hopper being of the dry type, but a special arrangement of suction passages and control doors is included in the hopper, through which the ship's sand pumps extract the spoil and discharge it ashore.

Two 20-in. bore sand pumps are each driven by a steam engine of 500 indicated horse-power, placed in the pump room just forward of the hopper. Each pump is directly connected to the overside suction pipe, with suitable connections to the hopper suctions, and the discharge pipes lead either to the hopper or overboard on either side. A number of electrically-operated sluice valves are fitted into the spoil piping system. The overside suction pipes are of the rigid

DREDGING CRAFT.

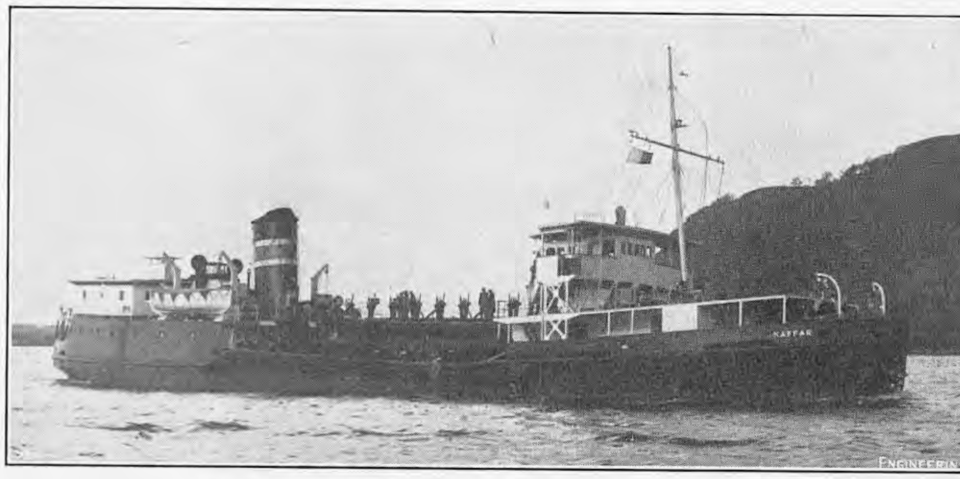


FIG. 9. TRAILING-SUCTION HOPPER DREDGE "HAFFAR."

FIG. 10. STERN-WELL TRAILING CUTTER SUCTION HOPPER DREDGE.

FIG. 11. SINGLE SIDE-PIPE SUCTION HOPPER DREDGE "RIBBLE."

type, intended for use only in calm waters, and are raised and lowered by separate winches, driven by two-speed electric motors equipped with automatic contactor gear which selects the speed best suited to the pipe loading. The dredging controls are located in the wheel-house, which is also the dredge operating house. The telegraphs to the pump room and to the forward and after winches, the push-button controls for all sluice valves in the spoil piping, the sand-pump gauges, and the push-button controls for the suction-pipe winches, are arranged in the wheel-house.

Fig. 10, herewith, shows a twin-screw stern-well trailing-suction hopper dredge, arranged to pump from the bottom and to discharge either to its own hopper, which is fitted with bottom opening doors, or to a hopper barge on one side. The main particulars are: length between perpendiculars, 212 ft.; breadth, moulded, 41 ft.; depth, moulded, 19 ft.; hopper capacity, 1,000 cub. yards; dredging depth below waterline, 55 ft.; loaded service speed, 10 knots. This dredge is primarily designed for trailing work, but is also required to carry out capital dredging, which necessitates the inclusion of equipment for cutter suction dredging. When trailing, difficulty may be encountered in holding the dredge to a course. When the suction frame is on the bottom it acts as an anchor, and, with unfavourable tide and weather conditions, the craft may be awkward to handle even with twin screws and twin rudders.

Between the forward end of the well-way and the after end of the hopper is the engine room, in which are two propelling engines and a pumping engine of 425 indicated horse-power, coupled to a 24-in. bore sand pump. A single compact engine-room arrangement is thus obtained, but the boiler room lies forward of the hopper, which is placed as near mid-length as possible in order to minimise the extent of the changes in trim between light and load conditions. The longitudinal hopper girder carries the actuating gear for the hopper doors. Each of five hydraulic cylinders operates two doors, with the control valve adjacent to each cylinder on the hopper girder. The oil hydraulic system is also used to operate the sluice valves fitted in the spoil piping system. All dredging controls are centralised in the wheel-house. The suction frame has a substantial overhang at the stern, to enable the dredge to cut its own flotation when cutter-dredging. To modify the suction frame for cutter work involves the removal of the trailing head before coupling the cutter head, the shafting, and the drive for this gear. This transfer can be accomplished within a very short time.

In addition, when cutter-dredging, anchors, cables and winches are required for mooring and manœuvring the dredge, which is made to traverse and "step ahead" in precisely the same manner as in multi-bucket dredging, with the difference that the stern of the ship becomes the "dredging bow" and flotation is cut ahead of the stern. On occasion, another method of manœuvring is applied to craft of this type.

Two spuds, fitted forward of the hopper, are arranged in preference to manœuvring by chains only. The dredge is made to swivel about either spud and is traversed across the cut by two side chains. No bow or stern anchor is required and the dredge "steps ahead" to the next cut by manipulation of both spuds. Spuds and their ancillary equipment are advantageous when spoil is delivered overboard to a pipeline or to a barge alongside, but they complicate the self-propelled craft. However, should it be necessary to discharge into the ship's hopper, they are a convenient means whereby dredging can be speedily resumed after dumping.

In the River Mersey, and in the adjacent Ribble, suction dredging has been performed for many years by dredges equipped with side pipes which face forward and are moved forward into the spoil while dredging. This mode of dredging is most successful in coarse free-running sand, favourable to securing and holding a rich pumping mixture, in which difficulties and time loss due to chokage of the suction head are very slight. Thrusting, or forward-feed, suction pipes would not produce satisfactory results if used in a light silt, sludge or clay. Essentially, the material must be obtained easily and flow naturally towards the suction head. This type cuts a trench in the bottom, having a depth dependent upon the penetration into the bottom and a length related to the capacity of the hopper. These trenches are soon levelled out by the influx of sand deposits carried by tidal action.

Fig. 11, opposite, shows a single-screw, single side-pipe suction hopper dredge, the main particulars of which are: length between perpendiculars, 202·5 ft.; breadth, moulded, 40 ft.; depth, moulded, 20·75 ft.; hopper capacity, 1,400 cub. yd.; dredging depth below waterline, 46 ft.; loaded service speed, 8·5 knots. This dredge works to a strict time schedule, dictated by tidal conditions. The vessel proceeds up river on the rising tide, commences dredging fully one hour before, and ceases to pump at high tide. The deep-loaded vessel then proceeds on the ebb tide to the deposit ground in the open waters beyond the entrance to the navigable channel. This cycle is repeated on each tide, but, in favourable weather, sea-bar dredging is also undertaken. When dredging, the vessel works to head and stern anchors, and thrusts or feeds the suction pipe forward. The pipe is lowered gradually into the ground to a maximum penetration around 8 ft. and is slowly advanced at that depth by taking in the head anchor chain, the stern anchor being trailed. Except when dredging, the overside suction pipe is housed inboard along the starboard side of the deck. The lateral and vertical movement of the pipe, swivel joint and sliding saddle is motivated by an oil hydraulic system, controlled from the operating house on the bridge.

The hopper is equipped with six large cylindrical rubber-seated valves, each covering an opening in the hopper bottom. The oil hydraulic system is the medium for operating these valves, which are controlled from the bridge. The hopper valve system offers important advantages in ease and simplicity of maintenance when compared with hopper doors, and in the fact that the dredge can proceed to deposit under very adverse weather conditions. Release of the spoil is, if anything, rendered more easy by a lively ship, but, when hopper doors are fitted, slamming of the doors always occurs in bad weather as the spoil is being dumped; thus, there is a weather condition beyond which it is unwise to empty through bottom doors. This limitation does not arise with hopper valves, which, however, also have disadvantages. There is a loss of hopper capacity due to the large volume of the cylindrical valves, and the area of each opening in the bottom and the slopes of the hopper structure leading to the openings are unsuited to any material which has an adhesive or cohesive quality.

An enclosed pressure-lubricated engine of 425 i.h.p. drives a 24-in. bore sand pump, connected only to the suction pipe and discharging direct to the hopper. This type of vessel has a useful advantage over the trailing dredge in that the propelling machinery does not operate while dredging is in progress. In other dredges of this type only one engine is installed, to drive, through clutches, either the sand pump or the propeller. Economy in fuel consumption is important, and the omission of propelling while dredging offers this feature.

(To be continued.)

RESEARCH POLICY IN THE GAS INDUSTRY.—An agreement on research policy has been reached between the Society of British Gas Industries and the Gas Council. In addition to collaboration with individual member firms of the Society of British Gas Industries, which has been the practice for many years, the agreement provides for a Joint Consultative Committee on Research of the Gas Council and the Society of British Gas Industries, which will be free to discuss any questions of research suggested by either party, and to remit these matters for study and prosecution.

BASIC ENGINEERING STANDARDS.*

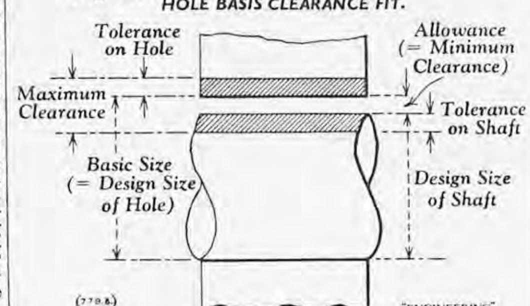
By CAPTAIN G. C. ADAMS, R.N. (ret.), A.M.I.Mech.E.

(Concluded from page 381.)

Limits and Fits.—Engineers have long used, misused, or ignored one or more systems of limits and fits. Confusion is considerable, argument is fierce, and much paper has been covered; but the subject is at last being exposed in its full complexity. This is not the place to argue the merits of this or that compromise, but rather to point out the fundamental principles and the main compromises they entail. To do this in a short space, it is necessary to assume some knowledge of the subject and a reasonable acquaintance with the system of either B.S. 164 or the International Standards Association. The object is to provide a systematic series of fits, so that as few as possible different limits of size will be stated on drawings. This will reduce the number of tools and gauges required. An alternative and/or subsidiary use may be to provide a series of fits which, for varying basic size, provide a similar functional result. These two uses may or may not be compatible.

It is becoming common to hold that the designer should state on the drawing the maximum tolerance which the geometry or function of the design will permit. In principle, this is precisely opposed to the object of using the minimum number of limits of size. There must be a first-class compromise at the outset, and the immense field of engineering will still demand a range of fits which can be achieved only with an adequate "choice" system. Much of the neglect of published systems in the past has been due to their inadequacy for more than a limited purpose. Great attention must be given to simplifying the presentation of any extensive system.

Fig. 2. DIAGRAM OF HOLE BASIS CLEARANCE FIT.



For convenience, a hole-basis clearance fit will be considered, for which the conventional diagram is shown in Fig. 2, herewith. The basic size having been selected, this will be made the maximum metal limit of the hole. This leads to tool economy. The allowance (minimum clearance in a clearance fit) must then be selected and subtracted from the basic size to determine the maximum metal limit of the shaft. This is the design size of the shaft on a unilateral system. The size of the allowance is determined by functional and/or geometric considerations. Its variation with basic size must, therefore, be based on some formula connected with function, or, alternatively, enough allowances must be provided for the designer to be able to select an adequate compromise at any particular diameter. Certain sections of very free fits can conveniently be associated with constant allowances over a considerable range of diameter. The problem is further complicated because there is very little real knowledge of what extremes of fit are functionally satisfactory.

The next step is to allocate tolerances to hole and shaft, within the remaining space permitted by the safe maximum clearance. The magnitude of the tolerance is directly associated with ease of machining. The relative disposal of available tolerance between hole and shaft will depend upon which is the more difficult to machine. This varies with circumstances, and, over certain ranges of diameter, it may be desirable to have duplicate fits, as regards clearances, which alternatively give the larger tolerance to the hole and to the shaft. Account should also be taken of different machining processes; for example, most systems give few fits suitable for milling, slotting, etc. The formula for computing change of tolerance with basic size must therefore be associated with ease of machining. It is fairly certain, however, that it must change at intervals, since normal processes will also change.

It is obvious that we are faced with making big compromises on an inadequate basis of real knowledge. If the standard is to be widely used, it must either be very simple and rudimentary, such as the current recommended procedure in the United States, or sufficiently detailed to cover all reasonable requirements of engineering. It must therefore contain a lucid, simple explanation of principles and a clearly laid out "choice" system. Its main features are likely to be primary concentration on the common ranges of size, perhaps in three separate ranges, such as up to $\frac{3}{8}$ in., $\frac{3}{8}$ in. to 2 in., and 2 in. to 4 in.—more than 80 per cent. of all basic sizes are under 4 in.; recognition of the functional nature of allowance and separation of the choice of allowance as far as possible from that of tolerance; introduction of constant allowance series of fits for certain types of very free fit; adequate selection, with choices, and indication of any particular fits which are known to be suitable for specified purposes over specified ranges of size; and a standardised method of extracting "special" fits from standard series of tolerance and allowance. This may well be a substitute for any choices required outside a fairly limited first-choice series. If so, careful guidance will be needed for avoidance of undue multiplication of fits. It is probably safer to tabulate at least second-choice fits.

The International Standards Association's system goes a long way on this road to perfection, but is capable of much improvement, particularly as regards simple exposition. There is at present no clear conception of the real meaning of a limit of size or of the nature of interchangeability. It is usual to talk of a limit of size as if it were a hard line in a graphical representation of a fit and a clear-cut limit to the size of parts actually made. In fact, it is a more or less hazy zone of size. The first haziness arises from error of measurement. This is nominally small, though in the past the user of "inspection" gauges may have made the zone up to 20 per cent. of the work tolerance outside the limit. A "Standard of Measurement" can clarify this, in principle, though it cannot cater for fortuitous error.

The real haziness is introduced when, as in some modern thought on the subject, account is taken of the statistical chances of mal-assembly. It can be shown easily that tolerances can be increased, and allowance reduced, to a considerable extent without any large risk of mal-assembly outside the true functional clearances, where there is random assembly of large numbers. This is a highly rational argument and extremely logical in relation to large-scale assembly. However, a fit conditioned to this idea would, in principle, be unsuitable for small-batch production or for the provision of strictly interchangeable spares. The designer is thus required to assess, not only the functional fit, but also the level of interchangeability acceptable in the specific conditions of use and production. A similar statistical haziness arises if acceptance inspection is carried out on a basis of sampling by attributes, using limit gauges or the equivalent.

In the manual on *Dimensional Analysis* it is recognised that there is more than one degree of interchangeability. Strict, or universal, interchangeability is dependent on every mating part, whenever or wherever made, lying within certain limits of size fixed in relation to the ultimate standard of length. In principle, no risks of mal-assembly are permissible, but, obviously, many degrees of risk are acceptable and many are regularly taken.

The current trend is to try to talk about "interchangeability" and to ignore the fact that its strict meaning is regularly compromised in practice. If we are to apply the very valuable statistical argument to limits and fits, we must clear the air and recognise the effect on interchangeability. If there are enough fits available, and/or if we are prepared to compromise severely with the principle of giving maximum tolerance, it will be possible for the mass assembler and the batch producer to use different fits for the same functional purpose, if necessary. The batch producer's fit can also be that for large production of articles, in which the need for strict universal interchangeability must be observed.

The biggest difficulty really lies in deciding how much attention must be paid to giving the largest possible tolerance for production. The Service designer takes this very much to heart, since he knows that much of his work will go in time of war to firms whose plant is barely good enough. From a precisely opposite point of view, many well-equipped firms prefer to cut tolerances in favour of a strictly limited tool and gauge programme. It will be noted also that reduction of tolerance leads to increased wear life, and this alone can cause a big diversity of practice. The problem is very complex. Account must be taken of design problems in general, and not merely of those of the designer of high-grade long-lived machinery.

Measurement.—The need for a standard of measurement has been indicated. In principle, it will define the real meaning of the limit of size written on the drawing. The current standards for gauge tolerances go part of the way to do this. There is, however, no agreed convention as to permissible error of measure-

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

ment when other methods of check are used. This standard is not an urgent requirement, but its need is becoming more apparent with increase in precision work.

Surface Texture.—A British standard now exists governing methods of measuring surface texture. This science is as yet too young to permit much standardisation of the use of various grades of surface texture. Much more knowledge is needed of the relations of process, texture, and function. At present, an empirical relation must be established; and the standard exists by which the requirement can then be stated and measured.

Drawing Practice.—This standard consists of definitions of how to express particular requirements on the drawing, so that the same thing written on the drawing always has the same meaning. There must be enough defined methods to express all the requirements that are commonly written down. It must be clearly understood that anything outside this range must be so written and explained that no ambiguity can arise. The need for many forms of statement is not universal, and is often apparent only when the full geometric analysis is taken into account. A very complete system is desirable, however, although it will not always be used in full. Many drawings can, and should, be very simple. It is important that a drawing should be clear and easily read. The more it is covered with notes, etc., the more difficult is quick appreciation of its main provisions. Most of the more complex detailed requirements affect only a limited number of the people who will use the drawing, for example, tool and gauge designers. The use of many kinds of symbol may therefore be highly desirable. They present no difficulty, but rather possess advantages to those who trouble to understand them, and they do not obscure the main provisions of the drawing which are of primary interest to the majority of users.

Standard Forms and Series.—The typical example of this class of standard is that for screw threads. A modern and up-to-date specification is B.S. 1580 for the unified screw thread. The standard defines the basic form, and it also lays down standard series of basic sizes and standard fits, giving all appropriate tolerances and allowances. The basic size for screw threads includes not only the basic diameter, but the appropriate pitch (diameter/pitch series). The table of special threads in B.S. 1580 is a very complete example of the use of choices, which has been systematically worked out from the design aspect of metal available. It gives three choices of diameter. With the first choice of diameter four pitches in two choices are offered, and with the second, three pitches in two choices are offered. The third is intended to use one of these same pitches, and almost certainly would require the finest of them. It may also be noted in the footnote at the end of the table that the third choice of diameters—up to 1½ in.—still awaits the issue of a British standard for linear basic sizes.

The number of diameter/pitch combinations listed in this table looks large. The author checked the number of diameter/pitch combinations in an existing gauge list and, up to a diameter of about 1½ in., found three to five times as many as are given in the whole of the standard and special (1st, 2nd, and 3rd choice) series listed in B.S. 1580 for the same size range. Similar types of standard exist for gears, splines, etc. They are abstract standards in that they represent no concrete article, and they are essential to any economical use of these various forms. They cannot be properly framed without many of the earlier standards mentioned.

Standards of Design.—The term "codes of practice" is sometimes used to cover standards which fall in the class of design standards These standards can lay down very simple guiding rules to govern requirements in any design of the type in question, or they can be detailed. They may even lay down the typical detailed layout of the design and give data from which the appropriate sizes can be completed Their function is to prevent unreasonable multiplication of differences of detail in articles for which fresh designs must frequently be made, but the duties of which do not permit the use of a standard series of articles. An average example* is not very detailed in guidance as to principal dimensions, but it indicates how to dimension a spring in accordance with its function, and recommends tolerances. The tendency of any such standard is to lead to economical design and to consistent requirements in the inspection of articles having a particular type of duty. Each new article tends to be only a detailed variant of a precisely similar design, so that manufacturer and inspector are faced with a straightforward and intelligible problem. Local standards of this type are well recognised in many drawing offices.

The Practical Effect.—If adequate basic standards are provided, the first need, or perhaps effect, is education. Many engineers, for instance, have never opened B.S. 164, *Limits and Fits*; or, if they have opened it, have quickly shut it, for the very good reason that it was of little use in their class of work. Many more have never read it thoroughly; if they had, they would have acquired some information on, though no very deep insight into, the proper use of limits and fits. There is no doubt that these standards must be fairly complex, at least to the extent of giving choices. They cannot be used properly unless there is intelligent appreciation of the intention behind them. Therefore they must contain an adequate, lucid exposition of the subject and a plan simply laid out for use. The prejudice must be finally discarded that a standard must give only information and not instruction; fortunately, it is already weakening. Simplicity is important, but this must not be confused with shortness and must not compromise efficiency. Simplicity in layout and clarity in presentation are of chief importance. Simple numerical values are highly desirable. The basic standards should be an integrated whole, properly explained and based on a rational geometric background.

Nearly all of these standards interlock. Change of one is likely to affect another. It is quite essential that there should be proper co-ordination when they are brought up to date. Once this is done, the way is open to improve the standards for articles. It is a misfortune of standardisation that it is almost compelled to occur too late, since if it starts too soon it may cramp design or deter progress. The result has often been rationalisation instead of standardisation. We have been forced economically to select the least bad, or most commonly used, of a hetereogeneous collection of uncoordinated designs. The complication has arisen more from the details of design, such as sizes and tolerances, than from major differences. It is here that a co-ordinated system of basic standards can help. The details of design will differ far less, the same basic sizes will be used, and so on. Thus can emerge standard articles which are a rational by-product of co-ordinated detailed design.

The real economic value of the basic standards, however, lies in their effect on the non-standard article. There is far more to be saved on the production of the myriads of special design parts than by the standardisation of common articles. In regard to the large industrial organisation this may be an overstatement, but not in regard to engineering as a whole. In large-scale production, tools and gauges are required in considerable numbers, as consumable articles. The fact that for a particular job many are not "standard," or from a restricted range of size, is relatively unimportant. It is in small-scale and batch production that multiplication of sizes becomes most objectionable. Moreover, most big organisations have established local rules, customs, and standards, which lead to a locally efficient approach to production details.

The plea made here is for the generality of users. Whereas the big user may gain little from improved and co-ordinated standards, the smaller user may gain a great deal. In the long run, all parties should obtain much improvement. To the Services, with their widespread sources of production, such standards are most important. For all the local efficiency shown, it is often most startling to observe the very great variation in detail as between similar firms. It is all very well for the big organisation to act intelligently—for its own good. Too many intelligent schemes are already operating, so that it daily becomes harder to co-ordinate for the benefit of the many. The small user cannot set his own standards to any marked extent, and in the aggregate the smaller users form a substantial part of the whole.

The biggest single difficulty in standardisation is to find enough men with the experience and knowledge, who can also give enough time to the work. This is particularly true of the basic standards. These standards are all-embracing and the widest possible outlook must be taken. The present situation is that we have been "putting the cart before the horse" in standardisation. We have concentrated on standardising articles and have largely ignored the standards proper to the design of those articles. Reason demands that we set our house in order before it is too late.

* B.S., 1726-1951. *Guide to the Method of Specifying Helical Compression Springs.* British Standards Institution, 28, Victoria-street, London, S.W.1. [Price 4s.]

ELECTRICITY SUPPLY STATISTICS.—During February, 1952, 5,786 million kWh were generated in power stations under the control of the British Electricity Authority, the North of Scotland Hydro-Electric Board and the Lochaber Power Company, compared with 5,340 million kWh during the corresponding month of 1951, an increase of 8·4 per cent. Of the total, 5,618 million kWh were generated in steam stations. At the end of February, 15,711 MW of generating plant was installed in the British Electricity Authority's stations and 644 MW in the stations of the North of Scotland Hydro-Electric Board, an increase of 7·9 per cent. over the figure of 12 months previously.

31-MeV BETATRON INSTALLATION AT ZÜRICH.

THE issue of the *Brown Boveri Review* dated September-October, 1951, recently distributed by British Brown-Boveri Limited, 75, Victoria-street, Westminster, London, S.W.1, is devoted to a betatron installation constructed in the company's works at Baden, Switzerland, and installed in the University Radiological Institute, attached to the new Cantonal Hospital in Zürich, where it has been in use since April, 1951. The betatron, which is the first to be constructed by the company, accelerates electrons to 31 MeV in a highly-evacuated glass tubular ring located between the poles of a powerful electro-magnet, which is designed, on similar lines to the firm's power transformers, with radial laminations. The high-speed electrons are directed on to a metal target inside the glass ring, thereby producing two beams in opposite directions of ultra-hard X-rays of great penetrating power. The principal use of the Zürich installation is for the treatment of malignant growths by deep therapy, and the equipment is arranged so that the two beams can be used to treat patients simultaneously and independently. It can, however, be employed also for the irradiation of biological specimens, for physical investigations in the production of radioactive isotopes, for the photographic detection of nuclear phenomena, etc. The great penetrating power of the X-rays produced by the betatron renders them particularly suitable for the examination of thick metal parts for the detection of defects such as blowholes, and the Zürich installation has been laid out so that work of this nature can be carried out there. It is stated that iron up to about 50 cm. in thickness can be radiographed with reasonable exposure times and radiographs of small machines such as electric drills, electric fans, etc., reproduced in the *Review*, show the internal details with remarkable sharpness. Articles by different authors deal with the design and construction of the betatron. Other articles are devoted to shielding problems, the betatron as a source of radiation in nuclear physics, the radiographic inspection of metal parts, etc.

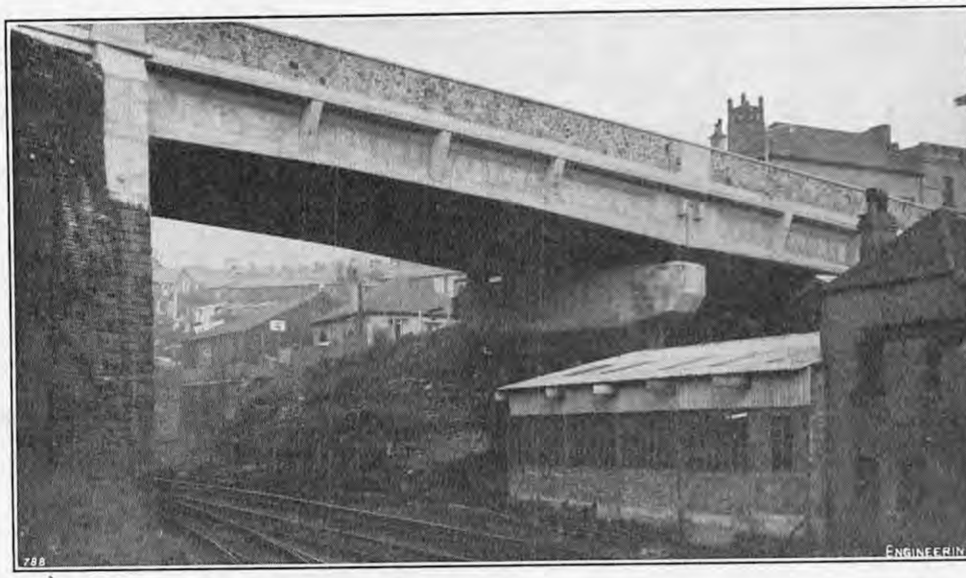
UNATTENDED OPERATION OF THE B.B.C.'s DAVENTRY TRANSMITTER.

THE Third Programme transmitter* of the British Broadcasting Corporation, at Daventry, which came into operation in April, 1951, was designed by Marconi's Wireless Telegraph Company to be suitable for remote control over long distances, and has been working under those conditions for the past two months. It is the first high-power transmitter to be operated in this way. It is capable of an output of 200 kW, but is operated at a maximum of 150 kW to conform with the Copenhagen Plan. It consists of two identical units the outputs of which are combined in a specially-designed circuit; and by pressing a button at the control station the blowers for cooling the valves are started, the filaments are switched on, the main high-tension circuits are closed and the various sections of the two halves of the transmitter are brought into operation in the correct sequence. This series of operations is initiated and controlled by a number of relays, interlocks being provided to ensure that not only are the power supplies and services connected in the right order, but that any fault or failure brings the system to a standstill. When the station is being manually operated, indicator lamps indicate how far the chain of operations has been completed. They also assist to locate faults when the station is being remotely controlled. When all the starting operations have been completed and the transmitter is "on the air," signal lamps are lighted at the remote-control station after about two minutes from depressing the "start" button.

The equipment includes two automatic monitors, one of which continuously controls half the transmitter and automatically shuts it down should a fault occur. In order to prevent complete disconnection owing to a comparatively minor fault, however, the monitor on the faulty unit cuts out a control and thus prevents the healthy section being switched out. At the same time, an alarm circuit is closed. A third automatic monitor checks the transmission from the aerial. An arrangement is incorporated which tests whether the monitor circuits are functioning correctly before the transmitter is shut down. Devices are also included which cut off the high-tension supply when a fault occurs, and then restore it a few seconds later. If the fault persists, the main high tension supply is again interrupted and restored, the transmitter being shut down and an alarm sounded after the third attempt. The monitor is automatically suppressed during these attempts to restore normal conditions, but continues in operation if the break in the programme is due to some other cause.

* See ENGINEERING, vol. 171, page 506 (1951).

PRESTRESSED-CONCRETE ROAD BRIDGE.



PRESTRESSED-CONCRETE ROAD BRIDGE AT ABERTILLERY.

THE new prestressed-concrete Foundry Bridge at Abertillery, Monmouthshire, replaces an old steel bridge built in 1895 to carry the Newport-Brynmawr road over a deep railway cutting. By 1926, the original bridge, which was constructed of steel plate girders, had rusted to such an extent that it was condemned as unsafe and closed to traffic. At the time, the local authority responsible was unable to finance the construction of a new bridge, so, as a temporary measure, the structure was shored up with timber struts and re-opened to limited loads in 1927. It was, however, still quite inadequate for the volume of pedestrian and vehicular traffic which it was required to carry. In 1937, a number of reconstruction schemes were prepared and one chosen which provided for a steel girder bridge carrying a reinforced-concrete deck slab. The advent of war caused the postponement of the scheme, however, and after the war the steel shortage which followed seemed likely to delay the work still further. A design in prestressed concrete was therefore substituted for the steel bridge envisaged, and work was put in hand in July, 1950.

The new bridge is 40 ft. wide, with a carriageway 27 ft. wide and two footpaths each 6 ft. 6 in. wide. Retention of the original pier gives it two unequal spans of 71 ft. 6 in. and 61 ft. 6 in. The prestressed bridge retains many features of the previously accepted steel design; the girders are similar to those originally designed in steel and, as before, five beams in each span carry a reinforced-concrete deck slab. The beams, which are 73 ft. 6 in. and 63 ft. 6 in. long, were cast on the site on a casting bed large enough to accommodate three at a time. In order that the same formwork could be used for all the beams, they were all made to the same dimensions, a section of formwork being simply cut out of the centre to make the shorter beams. Ducts for the straight prestressing cables were formed in the beams with "Ductube" pneumatic tubes; steel tubes were used for the curved cable ducts. The Freyssinet system of prestressing was used, the longer beams being stressed with 24 cables and the shorter with 18. Each cable was made up of 12 wires 0·2 in. in diameter.

The original specification for the concrete was found to be not entirely satisfactory, but after adjustment a mix was produced which gave an average cube strength of 5,171 lb. per square inch at 7 days. The first beam was stressed 22 days after casting and was moved into position 14 days after prestressing. Prestressing was carried out in two stages, partial prestressing being applied on the casting bed and full prestressing after the beams were in position and were carrying the reinforced-concrete decking. While casting was in progress, an investigation of the abutments and central pier was made and necessary improvements carried out. In the course of this work it was found that a culvert which had been thought to lie beside the central pier did, in fact, pass underneath it. The culvert was therefore diverted and the pier underpinned, so that the whole foundation was solidly supported. The abutment foundations also presented unexpected difficulties: at the western abutment it was found that there were layers of clay between the rock strata, and a mass-concrete block was therefore constructed against the rock face to transmit pressure directly to the lower stratum of solid rock. At the eastern end, as there was no satisfactory foundation alongside the existing abutment, pressure piles were used to provide a stable foundation for the new abutment extension and wing walls.

Moving the beams into position was facilitated by the fact that the new bridge was higher than the old one and therefore the existing cross bearers (no longer supported on the steel parapet girder beams, which had been removed, but on the timber strutting) could be left in position and used to carry the prestressed beams during placing. The beams were lifted at each end on to a small trolley, which ran on a railway track laid across the bridge, and were pulled across this track to their approximate position. Each of the five beams was taken across the same track and was moved sideways into its final position by being hung from portal frames erected on the abutment and on the centre pier. After the five beams were in position transverse beams were cast between them. The transverse beams were intended to act solely as stiffeners and were provided with pre-cast ends on the outside of the outer girders. These pre-cast ends housed the anchorages for the two prestressing cables which passed through the stiffeners. After the stiffeners had been prestressed, the formwork for the decking slab was erected and the slab concreted. Movement of the beams across the bridge from the prestressing bed to their approximate position was usually accomplished in less than half an hour. Placing the beams in their final position generally took rather longer but presented no difficulty.

The whole of the work was completed in approximately twelve months—three months less than the original contract time. The consulting engineers were Messrs. Wallace Evans and Partners, Penarth; the general contractors were Sir Robert McAlpine and Sons (South Wales), Limited, Port Talbot; and the prestressing work was the responsibility of Messrs. Vibrated Concrete Construction Company, Limited, 2, Caxton-street, London, S.W.1. The cost of the bridge works was borne jointly by the Monmouth County Council and the Ministry of Transport. Abertillery Urban District Council, to whom Mr. A. Gordon Jones, M.I.Mun.E., is engineer and surveyor, acted as agents for the County Council.

ASLIB FUEL AND POWER GROUP.—At the inaugural meeting of the Aslib Fuel and Power Group of information officers and technical librarians, which was held in London on Wednesday, March 19, a steering committee was elected, comprising representatives of the Ministry of Fuel and Power, the Department of Scientific and Industrial Research, the World Power Conference, the Atomic Energy Research Establishment, and the coal, oil, gas and electrical industries.

COLOUR CHART OF METAL FINISHES.—A colour chart to illustrate treatments of base metals for decorative purposes has been compiled by John Wilkins & Co., Ltd., 231-243, St. John-street, Clerkenwell, London, E.C.1. Actual specimens of 44 metal finishes are included on the chart, and are arranged in groups to show the effects of anodising, enamelling, decorative plating, protective plating, and metal colouring. A variety of colours for aluminium, several shades of silver, and a number of finishes for nickel and gold are given. Examples of hammer and wrinkle enamels are also included in the series. The chart has been combined with a perpetual calendar, for wall use. Firms in London and the home counties may obtain copies free of charge on application to Messrs. Wilkins & Co.

ALUMINIUM AS A SHIPBUILDING MATERIAL.*

By DR. E. C. B. CORLETT, M.A.

IT is now more than half a century since the first all-aluminium craft were built, but the present large-scale marine uses of aluminium do not date back farther than 1930. In the early examples, the materials used were either pure aluminium, with very high corrosion resistance but low mechanical strength, or the Duralumin types of alloy developed by Wilm in 1906 for airship and, later, aeroplane structures, and for which the reverse holds. When the alloys of magnesium with aluminium were introduced, however, it was apparent that they gave promise of wide-spread application at sea, having acceptable strength together with excellent corrosion resistance.

At the outbreak of war, the structural use of aluminium was spreading slowly in shipbuilding, but hostilities, with vast requirements for aluminium alloys for air frames, removed all possibility of marine progress for some time, at any rate for non-military work. So voracious were the aircraft factories that world aluminium extraction, rolling and extrusion capacity proved quite inadequate and the resulting expansion finally overtook and passed the demand that engendered it, leaving substantial capacity available for other uses. Concurrenty, the unit size of plant increased considerably and plates and bars of economic size for shipbuilding became available. Since the war, the use of aluminium in shipbuilding has steadily gained momentum. Both mercantile and naval installations are increasing in size and number.

Those aluminium alloys containing magnesium are commonly regarded as the marine materials, together with those of the magnesium-silicide group. For structural use, a magnesium content of 3 per cent. is the practical lower limit for acceptable strength, while research and experience have given compelling metallurgical reasons for not exceeding $5\frac{1}{2}$ per cent. In, for instance, an alloy containing 7 per cent. magnesium, an inter-metallic compound may precipitate at the grain boundaries and lead to rapid corrosion of the material if stressed. To quote an example, certain Italian naval installations during the war experienced this effect, which rapidly destroyed 7 per cent. magnesium rivets.

The magnesium-silicide group, i.e., those alloys containing small quantities of magnesium and silicon as alloying elements, are easily workable and extrudable metals and are commonly used for bars, but in North America they are in common shipyard use for plate, bars and rivets. Being heat-treatable, their properties are easily controlled, but this is a serious drawback if welded construction is adopted. Continental practice formerly favoured the magnesium-silicide group, for example, under the name of "Anticorodal," but, in common with America, seems to be swinging rapidly to the British type of material, due largely to the impact of the introduction of practical production welding methods.

The original spate of alloys has now subsided considerably and a standard shipbuilding plate has been adopted in this country and may be adopted in a much wider field. This promising state of affairs is due, in no small measure, to the initiative of Lloyd's Register of Shipping, who introduced in 1947 "Tentative Requirements for Quality and Testing of Aluminium Alloys for Shipbuilding Purposes." These requirements, the first in the world, were based on metal falling in the groups described earlier for composition, while the required minimum mechanical properties were based on those of the 5 per cent. magnesium alloy in the annealed or soft condition.

Five per cent. magnesium is a relatively difficult material to roll and in order to avoid the trouble known as "crocodiling," during hot rolling, it may be necessary to cast the rolling blocks with V ends and to limit the overall dimensions. The maximum size of plate is limited and costs are relatively higher than with most of the other materials normally produced. An alloy containing 4 per cent. magnesium and a certain amount of manganese was evolved, and this proved to be a practical and economic material. On one plant, for instance, the maximum plate size for normal production increased from 18 ft. by 6 ft. to 30 ft. by 6 ft. and this length has been exceeded considerably for special production. The mechanical properties of the alloy, when hot-rolled, meet Lloyd's requirements with a handsome margin and the plate has been shown to be readily welded by the latest methods. This plate alloy is now designated NP5/6 under the British Standard general engineering specifications and is, in fact, the standard plate supplied for shipbuilding in this country. Corrosion resistance is very high and, in the absence of bimetallic contacts, the plate is virtually unaffected by sea-water.

* Paper presented to the North-East Coast Institution of Engineers and Shipbuilders, at Newcastle-upon-Tyne, on February 22, 1952. Abridged.

The American plate materials normally used under the alloy name 61S-T6 have mechanical properties comparable with those of NP5/6, but these are obtained by heat treatment. There is a divergence of opinion where riveted constructions are concerned, as the United States and Continental navies have used large quantities of heat-treated material, while the Royal Navy has insisted on non-heat-treatable alloys. If heated in a shipboard fire, the heat-treated, i.e., tempered, materials lose their properties to a much greater degree than do the magnesium-aluminium alloys and this change is irreversible in the case of the former. In view of the prevalence of small fires in action there is much to be said for the British point of view, which has been reinforced by the twin American inventions of argon arc and "Aircomatic" welding.

The magnesium-silicide materials are not suitable for welding unless subsequent heat treatment can be applied, as welds of poor efficiency and of extremely low weld-metal elongation are obtained. In the magnesium alloys, however, welds can be produced virtually equal to the parent metal in strength and elongation and this, of course, applies to NP5/6. It is believed that, as a result of this situation, there is considerable pressure in the United States in favour of a change to the British material in the form of an alloy designated 54S, which is very similar in composition to NP5/6. If such a change be made and Canada follows suit, it is clear that, over the English-speaking world, there will be a virtually standard shipbuilding aluminium-alloy plate and it can be expected that the present Continental predilection for 5 per cent. magnesium is likely to be altered for the same reasons. If this comes about, obtaining materials for repair will be on much the same basis as for steel, with none of the previous confusion of alloy types. The plate position, then, is very satisfactory from most points of view. One desirable target for the future, however, would be the production of 8-ft. wide plate.

Bars do not condense virtues into one material to anything like the same extent. The extrusion process does not, in general, break down grain size as much as does rolling and unless, in the magnesium group, the magnesium is taken to the upper limit and the subsidiary constituents substantially increased, it is difficult to achieve the Lloyd's figures for strength. In practice, it is necessary in most cases to stretch the extrusion to produce cold work, and thus to raise the proof stress. This, in itself, is not always desirable, as it may result in differing proof stresses for the tensile and compressive fibres of the member in bending and thus may affect the position of the neutral axis when a beam is heavily loaded.

The magnesium-silicide group is easily produced, and has excellent properties. The proof stress can be varied within wide limits by varying the heat treatment, although, of course, higher proof stress involves lower elongation. Bars of this composition are rather less easily worked than those in the magnesium group, and where pronounced joggling or bevelling is required, the latter should be specified. The alloy known as HE10-WP is widely used for beams, stiffeners, frames, etc., in normal riveted construction, and is a very satisfactory material for the purpose. In America, the alloy 61S-T6 is closely similar in composition and properties to H10-WP, the chief difference being the addition of a small amount of copper.

Again, welding is threatening to alter the whole position and it is obvious that a new solution will have to be found when production aluminium welding is introduced in British shipyards. From design considerations, it is desirable that the mechanical properties of sectional members be certainly not less than those of their associated plating, and, because the neutral axis of the plating/stiffener combination is always nearer the plate than the extreme fibre of the stiffener, any increased mechanical properties in the stiffener can be used with profit. The aim is a weldable, non-heat-treatable extrusion alloy with both minimum proof stress and ultimate tensile strength, fully annealed, say 20 per cent. above those required by Lloyd's. This is a formidable metallurgical problem.

Three possibilities seem attractive, namely, the use of a material such as NP5/6 combined with the rolling of sections, thereby applying non-discriminatory cold work; new alloy compositions which will give higher strength in the soft condition; and the fabrication of sections from NP5/6 plate on a press brake. Although of limited application, the latter method would offer valuable economies. Annealing in the region of a weld, being close to the neutral axis, would have little effect on the plate/stiffener combination. Corrugated bulkheads and flanged floors are obvious applications of this method. None of these suggestions may be practicable, but if one, or all, were successful, they would offer the possibility of improved all-welded homogeneous aluminium structures. As a further personal opinion, the author feels that this problem is likely to become urgent in the next few years, and the opinion of shipbuilders on the third possibility listed would prove valuable as guidance.

Rivet materials are, to some extent, covered by the earlier remarks, and both the N6 and H10 type alloys are widely used, the former in this country and the latter in America. N6 is a work-hardening alloy and, consequently, either hot or cold, the rivet must be closed with as few and as heavy blows as possible. This places a limitation on pneumatic riveting, which cannot be said to be economical, although quite feasible, above ½ in. diameter for cold driving and ⅝ in. for hot driving. Research on the work required to drive different points has raised the upper limit about 30 per cent. above these figures, but as many of the large rivets as possible should be closed hydraulically.

H10 does not work harden to the same extent as N6, but has a higher proof stress in the fully aged condition —thus requiring more work to produce a given amount of plastic deformation. However, if driven immediately after quenching, the alloy has much the same driveability and strength as N6. The disadvantage is that the rivet ages naturally after quenching, but in American shipyard practice this is overcome by keeping such rivets in ice-cream deep-freeze cabinets and issuing them in paper and aluminium-foil bags which retain the cold and restrain ageing for an hour or so. In the liner United States, some 1,200,000 aluminium rivets were used and this method was adopted throughout.

The hot driving of N6 rivets requires fairly accurate, but simple, temperature control, and this can be achieved by a suitable electric oven. The shear strength produced is about 12 tons per square inch in single shear, comparing with 13 tons per square inch for cold-driven rivets. Where drilling is done on site, a nominal diameter drill, if passed through the plate, will leave sufficient clearance to accommodate the normal tolerance on a cold aluminium rivet. A hot rivet, however, requires approximately the same expansion allowance as does a hot steel rivet of the same diameter. In stressed aluminium structures, much more drilling on site will be required because of the smaller clearances, but, in the opinion of the author, the disadvantages of this are largely compensated by the greater ease of drilling and the possibility of prefabricating more extensively than is common with steel. Aluminium riveting need not be more expensive in labour than steel riveting.

The opinion has been expressed by an eminent shipbuilder that, cost apart, aluminium ship structures will never be really attractive until shipyard production welding of the components is possible. This view is clearly gaining force as good riveters (and they have to be good with large-diameter aluminium rivets) became more scarce, as drawing-office practice and yard layout gravitate towards welded steel construction, and as the cost of steel increases.

The weight of riveted aluminium required to produce the equivalent of a welded steel structure is of the order of 40 to 43 per cent. of the steel weight. The saving in cost of aluminium obtained by welding instead of riveting would be very nearly half the entire first cost of the steel. To this must be added the factor that in many cases the latest aluminium welding techniques are appreciably cheaper than riveting, per foot of join. In chronological order, the processes available are gas welding in its various forms, metallic arc welding, argon arc welding, self-adjusting arc or "Aircomatic" welding, and controlled arc welding (machine-head Aircomatic welding). It is probable that the third, fourth and fifth of these are the only processes at present of real interest to the shipbuilder.

Metallic arc welding is simple and can be used where strength is not important, but the welds are of poor quality, being porous and relatively weak. The oxide of aluminium is heavier than the parent metal, as are many of the suitable fluxes—the reverse of the case with steel—and, consequently, oxide and flux entrapment are an ever-present danger. Most fluxes are corrosive to aluminium, needing great care in final cleaning. Wire brushing of the surface to be welded removes the initial oxide film, but oxidation during the welding period is rapid and no weld is likely to be free from inclusions and porosity.

The solution has been produced in the argon arc process and its later developments, where no flux is used and the arc is struck in an inert atmosphere. The normal argon arc process produces first-class welds in the aluminium/magnesium alloys in the down-hand position. Overhead welding has been difficult hitherto, but recent developments promise to alleviate this difficulty. Aircomatic, or self-adjusting, arc welding is a very efficient production process and is in widespread use in American shipyards. Welding is cheap and simple, even compared with coated electrode work. There seems little doubt that it, or a variant, will become the standard method for joining members in constructional aluminium work.

Heat-treatable material is not very suitable for welding, and perhaps the worst feature is the very low resultant weld-metal elongation. In addition, the tensile properties are poor, although if the welded assembly can be heat-treated, excellent properties can be obtained; this, of course, is impracticable on any ship structures. The British plate material *NP5/6* is, on the other hand, very suitable for welding by the inert-gas methods, and it is a fortunate fact that for this material the best shielding gas is argon. This circumstance is quite fortuitous, but, nevertheless, it is valuable, as helium is not available in this country. The welding of bars calls for the aluminium/magnesium materials, as the weld properties of *HE10-NP5/6* joints seem likely to be very poor. The most obvious solution would be to use rolled *NE5/6* sections or flanged *NP5/6* sections and *NP5/6* plate with welding wire of a similar composition. Such a combination should offer very satisfactory strength, ductility and soundness of weld, and for general shipyard use some such standard practice must be established within the next few years.

The methods normally used for joint preparation are straightforward. For thin material up to and including, say, ¼ in. and perhaps ⅜ in., it is not necessary to V the butts in any way. A backing bar is desirable on the thinner materials and this should be slightly grooved. The bar may be of copper or stainless steel. The only danger in this method of welding is the entrapment of air in the crack between the plates which may produce oxide inclusions. This can be avoided by a satisfactory technique on the part of the operator. For very thick plates of the order of 1 in., double-V butt preparation is required, while single-V butt for the range between ⅜ in. and ⅞ in. thickness is usually regarded as satisfactory. The distortion of welded assemblies must be taken into account, of course, but, although the coefficient of thermal expansion of aluminium is twice as high as that of steel, the actual temperatures in the weld metal and the surrounding structure are much below those in the corresponding steel joint. It is reasonable to assume that the same order of contraction allowance and the same type of sequence as is used in steel welding can be used on a similar assembly in aluminium.

A careful design study should indicate the optimum extent of an aluminium installation. Incorporating aluminium can only be justified if the resulting vessel is a more attractive economic and technical proposition, and it is not immediately obvious in some cases how best this can be achieved. A case in point is that of the liner United States. The use of a smaller quantity of light alloy in this vessel would have produced some of the technical advantages actually obtained but a less favourable overall economic picture. The ship, as built, is smaller than would have been the case with all-steel construction and it can be shown that the extra cost of the structural material is more than offset by the reduction in first cost of the smaller ship and machinery. No expansion joints are used in the 500-ft. long superstructure and the resulting light scantlings allowed a new approach to the whole design problem. Indeed, it is doubtful whether the ship could have been built in its present form without aluminium, having a rigid beam limitation and three-compartment flooding and damaged stability requirements.

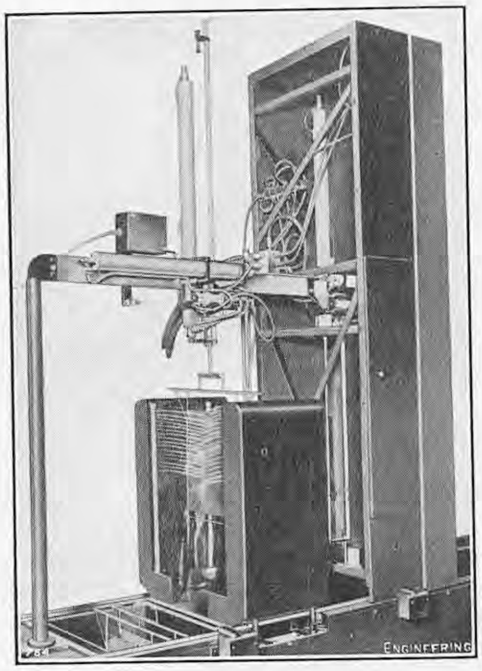
The principal characteristics of the liner United States are: length overall, 990 ft.; beam, extreme, 101·5 ft.; displacement, 50,000 long tons; depth from keel to top of superstructure, 122 ft.; number of decks, 12; number of passengers, 2,000; and number of crew, 1,000. The weight of aluminium in the superstructure is 1,000 tons, and four decks are included. The length of the superstructure is 500 ft., and there are no expansion joints. The weight of aluminium in funnels, boats, masts and davits is 400 tons, and in minor bulkheads, furniture, etc., 600 tons. It is understood that a total weight saving due to the direct and indirect influence of the aluminium of 15 to 20 per cent. of the original displacement is claimed. The direct increase in material first cost due to the use of aluminium is of the order of 400,000*l*., but this is offset by the indirect reduction in hull and machinery costs. These total an estimated 1*l*. to 1·5*l*. million. The interesting conclusion is that the vessel, on British prices, costs materially less than if all-steel construction had been adopted. The fuel saving amounts to 8 to 9 per cent., i.e., about 100,000*l*. per annum.

INSTITUTION OF MECHANICAL ENGINEERS.—The annual meeting of the Benevolent Fund of the Institution of Mechanical Engineers will be held at the Institution on Friday, April 25, at 5 p.m., preceding the general meeting to be held that evening. The committee of the Fund extend an invitation to all members of the Institution to attend the meeting.

THE ASSOCIATION OF BRONZE AND BRASS FOUNDERS.—A luncheon meeting of the London area of the Association of Bronze and Brass Founders, 25, Bennetts-hill, Birmingham, 2, will be held at the Clarendon Restaurant, Hammersmith Broadway, London, W.6, on Thursday, April 3, at 12.15 for 12.30 p.m. A short address will be given by the London Regional Coke Controller.

AUTOMATIC PROCESSING UNIT FOR X-RAY FILMS.

THE equipment shown in the accompanying illustration has been designed by Nucleonic and Radiological Developments, Limited, 22, Marshgate-lane, London, E.15, to ensure the correct processing of medical and industrial X-ray films up to 17 in. by 14 in. It consists of a series of tanks (only partly shown in the illustration), placed end to end, which contain the developing and fixing solutions and the washing water. On each side of the tanks are belts which run the full length of the equipment and the movements of which are synchronised. The cassette containing the exposed film is attached to a hanger, which is provided with a cross arm so that it can be suspended from the belts and projects downwards into the tanks. The film is first drawn gradually through the developing tank until the hanger comes into contact with a micro-switch at its far end. The closing of this switch brings pneumatically-operated lifting and traversing gear into action, so that the hanger is raised in the frame visible in the illustration.



Here it is exposed to a spray and the developing solution is completely washed away. It is then lowered into the fixing tank through which it is drawn by a second pair of conveyor belts, until it comes into contact with another micro-switch. As a result, the hanger is raised by a second set of lifting gear, passed through a light trap and lowered into a washing tank through which it is traversed against a stream of water. In the meantime the two sets of lifting gear have returned automatically to their original position, so that another hanger, with its film, can be dealt with.

The temperature of the developer is usually controlled by a thermostat, which can be arranged to work in conjunction with a refrigerator when the equipment is required for use in the tropics. The compressed air for operating the lifting and lowering gear is obtained from a small self-contained electrically-driven compressor, and a counter is fitted which automatically records the number of films processed daily. The records of counts are used to determine the chemical consistency of the developer which can thus be used for about 12 months without emptying the tank. The developer can also be controlled by using "test strips" of X-ray film. These are exposed to give a step wedge effect and are then compared with a small portion of the film that has been passed through the unit.

SWEDISH LIGHT NAVAL CRAFT.—The Swedish Parliament has approved the expenditure of a sum amounting to 450 million kronor for the building of 46 new light craft for the Swedish Navy. Some 250 million kronor will be spent during the present financial year.

TRUING OF GRINDING WHEELS.—The Industrial Diamond Information Bureau have recently issued a revised edition of their "Bibliography; Truing of Grinding Wheels from 1910 to June 1951." Formerly a leaflet of a few pages, the third edition of the bibliography now takes the form of a 36-page booklet, and includes a name index. Copies may be obtained *gratis* from Industrial Distributors (Sales), Limited, Industrial Diamond Information Bureau, 32-34, Holborn Viaduct, London, E.C.1.

FUEL, HEAT AND POWER AUDITING.*

By L. CLEGG, M.B.E., A.M.I.Chem.E., and J. PRICE WALTERS, T.D., B.Sc.Tech.

THE purpose of this paper is to describe the work of the mobile testing units of the Fuel Efficiency Branch of the Ministry of Fuel and Power over the last three years or so. The title of the paper suggested itself because it most aptly describes what this work has, in fact, become. It has long been realised that in order to achieve optimum fuel efficiency in any factory it is necessary to prepare a complete heat balance showing, on the one side, the total potential energy purchased in the form of fuel or electricity and, on the other side, the quantity of heat and power generated and/or distributed to each department and/or process; or, in other words, to audit the use of fuel, heat and power. This requires accurate measurement which, in turn, necessitates the use of a wide range of instruments such as is rarely found in industrial establishments. Each of the Ministry's mobile testing units and the headquarters organisation supporting it are equipped to do this.

A unit consists of an ex-radar van originally built for the transport of delicate instruments over rough terrain, refitted and equipped with an extensive range of indicating and recording instruments. It will doubtless be of interest to refer here to the design and layout of the unit, particularly as three years' experience in all parts of the country and under a wide variety of operating conditions has not suggested any major modifications. One side of the van is provided with an angle-iron framework on which are mounted aluminium panels carrying the instruments. The panels are constructed in two standard sizes and are drilled so as to be interchangeable. These panels, together with the instruments, may be mounted on special brackets, a number of which are carried for use when the instruments are taken out of the van on to the job. A desk and bookcase are also provided on this side. On the opposite side is a workbench fitted with drawers and cupboards to accommodate small instruments and a comprehensive set of tools for the many minor jobs which necessarily have to be carried out during a survey. Above the workbench provision is made for mounting pressure gauges and certain other instruments. Lighting current is supplied from batteries or the local supply. In addition to the equipment installed in the mobile units, a pool of instruments is held at headquarters from which additional meters, orifice plates, lengths of compensating cable and other equipment can be supplied. Facilities are provided at headquarters for the calibration of instruments, minor repairs and the immediate replacement of instruments returned to headquarters for calibration or repair.

The first essential is a conference with the management to discuss the function of the factory to be investigated, its products, the raw materials used, the physical layout and the processes involved, including space-heating of buildings. The Ministry's fuel engineers, although capable of making heat-balance surveys in any industrial organisation, cannot be expected to have specialised experience of every industrial process they may be called upon to examine. A flow diagram of the process sequence is usually constructed, and the necessary measuring points are discussed and agreed, an examination having previously been made of all the relevant data available on the particular processes. In addition, a diagrammatic arrangement of all the heat and power services is prepared and a note made of any special advice required on particular problems. At a later date another meeting is arranged to discuss the precise date of commencing the survey and the duration of the test on each process or section. At this meeting arrangements are also made for installing orifice plates and, perhaps, design dimensions are given to enable the firm to manufacture the plates themselves (this usually happens where abnormal flow conditions are encountered or where the firm wishes to retain the orifice plates for use later). Some firms operate continuous processes and can shut down sections only for brief periods, or perhaps can put plant out of commission only at week-ends. This calls for careful planning and for close co-operation between all parties concerned.

The heat and power usage is then determined for each section. This may be done either by following the material flow or, more usually, by dealing with heat and power generation and distribution sequence. When a complete survey is made, all types of plant are investigated—the list may include gas producers, furnaces, kilns, driers, vats, evaporators, water-storage systems, refrigeration plant, all types of prime movers, space-heating, air conditioning and electrical installations. Usually, the survey commences with a boiler and power-plant trial, run continuously for a full working week under normal operating conditions or for the period necessary to include all variations of load. In the majority of surveys carried out to date, steam has been the medium for power generation; and process heat supply and the main steam distribution have been measured over the same period as the boiler trial. The steam consumptions of individual items of process plant are usually determined subsequently. An attempt is therefore made to account for every British Thermal Unit in the fuel supplied to the works. All the tests are run under normal operating production conditions. The possibility of improving the thermal efficiency is considered after the initial tests have been completed.

When the survey has been completed, all the observations are analysed and tabulated at headquarters prior to preparation of the report. Existing operation and test results are recorded and supported by relevant drawings and graphs. These may suggest that changes in the method of operation would improve material throughput or uniformity of product, besides giving financial benefits and improved fuel efficiency. In such cases the necessary supporting calculations and diagrams are given. The report normally begins with a summary, giving the main results and observations together with conclusions and recommendations. This is followed by a main report in which the observations, calculations, conclusions and recommendations are given and discussed in more detail. Actual readings in both tabular and graphical forms, flow diagrams, and any other necessary explanatory diagrams (such as Sankey diagrams) are included as appendices. The summary is intended for the management. It shows up the thermal efficiency of the works, the sources of avoidable losses and the scope for economy both in the short term (involving little, if any, capital expenditure) and in the long term, where the capital expenditure involved is shown to be recoverable within a reasonable period of time. The main report is intended for the technical officials of the firm and their consultants. When the report has been submitted, it is usual for the management to arrange a conference to discuss the report with the consultants, the technical officials of the firm and the appropriate Ministry fuel engineers. Where the firms have engaged consultants before the survey takes place, the consultants should preferably be present at the initial conference when the arrangements for the survey are being made.

The Fuel Efficiency Advisory Service of the Ministry is an adjunct, and not an alternative, to the services of a consulting engineer. Its function is to stimulate the interest of all concerned, particularly management, in fuel efficiency, to present the facts and to draw attention to extravagant heat-using processes, sources of avoidable heat loss and the scope for economy. The recommendations may include ways and means of achieving the savings, but the service does not include redesign of plant, design of new plant which may be recommended, preparation of estimates or specific advice on the make of plant or equipment to be installed. The work of the Ministry's fuel engineers should be followed up by prompt and effective action on the part of the management of the firm. The work required may well be within the capacity of the technical staff of the firm, but in some cases it is desirable to call in the services of specialised consultants.

The number of surveys carried out from the inauguration of the service in 1949 to December 31, 1951, was 125. They varied in duration from 4 days to 6 weeks. The savings proved to be attainable varied from 3·6 to 56 per cent., the overall weighted average being 20·8 per cent. In some cases the anticipated savings have actually been achieved or even exceeded by carrying out the recommendations made in the survey reports; but such savings are not always apparent in the fuel-consumption figures because in many cases the effect has been that production has been increased without adding to the fuel consumption of the factory. The types of factories surveyed to date include: chemical manufacture, china clay, rayon, wool and other textiles, cement, paper mills, blankets, diatomaceous earth, tobacco, sheet-metal works, steelworks, building board, cables, domestic appliances, boots and shoes, lace, aircraft, malt extract, motor-car bodies, animal by-products, cellulose film, jointing material, china and pottery, tar-distillers, heavy and light engineering, toys, carpets, glass manufacture, soap, sugar, rubber, tanneries and leather cloth.

This paper would not be complete without an example to show what a survey involves; and, bearing in mind that the Ministry survey reports are confidential documents, the authors have combined in the following example actual surveys in technically allied industries, the figures and other facts quoted being based on those actually observed in practice. The industries selected for illustration are (1) viscose yarn, and (2) film manufacture, because in these industries steam, power, air-conditioning and hot-water supplies are of major importance. They also illustrate the variety of special processes the fuel engineer may be

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* Abstract of a paper presented to the Institute of Fuel at a meeting held in London, on Tuesday, March 18, 1952.

called upon to study before he can plan his survey. [The paper then gave the examples in detail.]

Perhaps the most important result of this work has been to bring home to industrial management an appreciation of the fact that fuel efficiency is essentially a function of management, and that a thoroughly conducted fuel, heat and power audit will pay a substantial dividend. It has also demonstrated the value of instrumentation, and more particularly the importance of ensuring that all instruments are accurately calibrated and well maintained. The fact that a charge is made for the audit service, a charge which someone (usually the managing director) has to agree to pay, may perhaps help to ensure that the report, when submitted, will be given more careful consideration than it might otherwise receive. Having examined it, the managing director is, possibly for the first time, impressed by the economic possibilities of fuel efficiency. In some cases, managements have been so surprised at the cost of steam for certain processes that the survey has stimulated further research and investigation into these processes with the object of reducing the steam consumption, and with beneficial and lucrative results. Had it not been for the surveys, these losses might have continued indefinitely without detection.

Every industrial concern should at reasonable intervals "audit" its fuel and power consumption, i.e., have a heat balance properly prepared for each factory. Each factory should be sufficiently well instrumented to show up the cost of heat and power for each process and its relation to the cost of production. The practice of treating fuel and power as a general work on-cost is liable—indeed, likely—to permit of serious financial losses going on undetected indefinitely. Intelligent "guesstimation" is not a substitute for actual measurement and, if the business does not warrant the full-time appointment of a professionally trained fuel engineer, then the services of a specialist consultant could be retained with advantage. In short, fuel efficiency reduces costs, may well improve productivity and certainly pays dividends; and the first essential step is a thorough fuel, heat and power audit.

ANNUALS AND REFERENCE BOOKS.

The Electrician Blue Book: Electrical Trades Directory, 1952.

Edited by S. G. RATTEE, A.M.I.E.E. Benn Brothers, Limited, 154, Fleet-street, London, E.C.4. [Price 50s., including postage.]

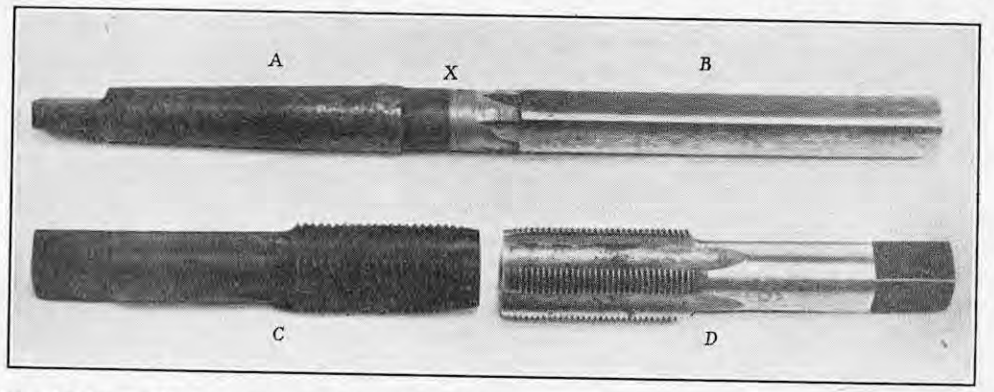
FOLLOWING the practice of the past two years, the 1952 *Blue Book* is divided into 11 sections, covering manufacturers; merchants and patent agents; contractors; wholesalers; consulting and other engineers; electricity supply; transport; institutions; universities and colleges; Government departments; and personal. It is hardly necessary to state that the constant expansion of the electrical industry has made each edition of this book larger than its predecessor, and this year's edition, which is the 70th, is no exception to the rule. In particular, the Trade Names Section has been increased by over 1,000 names, and this, combined with other improvements and careful editing, makes it a work to which those concerned in the industry can refer with confidence.

The Practical Engineer Pocket Book.

Edited by N. P. W. MOORE, B.Sc., A.C.G.I. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 12s. 6d. net.]

A FEW sections of this pocket-book—which has now reached its 64th year of issue—have been modified for the 1952 edition. Those on machining, and welding and cutting, have been rewritten to give more information, including details of modern developments, and that on steam has been extended to give notes on the solution of problems in steam engineering by the use of steam diagrams. The whole book deals primarily with mechanical engineering, as is shown by the chapter headings: general information; pipes, beams, columns, springs, etc.; friction and power transmission; cranes and lifting tackle; pyrometry; metallurgy; steam; steam generation; the steam engine; locomotive practice; steam turbines; condensers; gas and oil engines; gas turbines; air compressors; air and ventilation; hydraulics; machining of materials; modern lubrication; welding and cutting; lighting for workshops; and Unified screw threads. The treatment is necessarily brief, but then the book is not intended to be an encyclopædia of mechanical engineering; rather is it a source of basic information with the advantage that—because it is brief rather than exhaustive—the reader may be drawn to read more than his query necessitated, thereby broadening his knowledge. The illustrations consist mostly of line drawings, though there are some half-tone reproductions, particularly of locomotives. There are also technical dictionaries in German, French and Spanish.

SORTING TUNGSTEN STEEL AND CARBON STEEL.



SORTING TUNGSTEN STEEL FROM CARBON STEEL SCRAP.

IT is important to reclaim worn and broken high-speed steel tools, because of the valuable tungsten they contain. The Ministry of Supply schedule of controlled prices for solid scrap, depending on the alloy content of the steel, gives about one halfpenny per pound for carbon steel to 7s. 6d. per pound for steel of high tungsten content. Many tools are made of carbon-steel shanks and tungsten-steel cutting portions welded together; others are made wholly of one or the other material. It is difficult to distinguish the more from the less valuable scrap material, using cheap testing methods. The simple but effective system described below was proposed by Mr. A. M. Armour of the Research Department of Metropolitan-Vickers Electrical Company, Limited, Manchester, 17, and is used by that company, in conjunction with grinding spark tests, to sort high-speed steel from carbon steel.

It is well known that high chromium-bearing steels are very resistant to rusting. It is not generally realised, however, that the 10 to 30 per cent. tungsten-steel alloys are also to a large extent resistant to rusting. The fact that this resistance is markedly superior to that of carbon steel can be used to distinguish between these two latter alloys. The illustration shows a carbon-steel taper shank A welded to a tungsten-steel reamer B. It also shows a carbon-steel tap C and a high-speed steel tap D. These tools had been lying about the workshop for several weeks, acted on by the normal atmosphere. It is obvious that the parts A and C have suffered much more rusting than parts B and D, and this fact, once pointed out, can be appreciated without any aptitude beyond normal perception. Such a process of rusting is lengthy, but it can be accelerated by cleaning part of the surface with emery wheel or cloth, then wetting this with a strong solution of ammonium chloride (sal-ammoniac) in water, and leaving it in the air while still wet. In about 15 minutes the carbon steel turns golden brown with rust, while the high-speed steel remains more or less free from rust, depending on the alloy. In the illustration the line of material change at the weld X on the parallel portion of the reamer can be seen by the change in the rusting properties overnight after this treatment. With practice in the use of the method, the degree of discrimination among alloys improves. This simple and cheap test has been described to enable all who need to discriminate between high-carbon steel and high-speed steel to use it. Thus the sorting of tool steel scrap will be helped, and the tungsten-bearing material salvaged for future use to the benefit of the country's imports. The reclamation of tungsten from tool tips or from grinding swarf and the like is not such an economic proposition.

TRADE PUBLICATIONS.

Rust Prevention by Coated Papers.—A publication issued by Leonard Stace Ltd., Cheltenham, and entitled "V.P.I. (Vapour Phase Inhibitor) Coated Papers," deals with a modern method of rust prevention developed by the Shell organisation. The paper is used for wrapping up articles made of bare steel or aluminium and it is stated to prevent corrosion when moisture and oxygen are present. The chemical compound in the paper coating vaporises slowly and, it is claimed, forms a completely non-corrosive local atmosphere. When removed from the coated paper, the articles are clean and ready for use.

Stainless Steels.—The third issue of their publication, "Enchiridion," has been published by Messrs. Firth-Vickers Stainless Steels Ltd., Staybrite Works, Sheffield, 9. It contains descriptions of typical applications of the firm's stainless and heat-resisting steels in gas turbines, sinter plants, food-processing equipment and other installations.

BOOKS RECEIVED.

Three Hundred Years on London River. The Hay's Wharf Story, 1651-1951. By AYTOUN ELLIS. The Bodley Head, 28, Little Russell-street, London, W.C.1. [Price 30s. net.]

Synthesis of Electronic Computing and Control Circuits. By the staff of the Computation Laboratory. Harvard University Press, Cambridge 38, Massachusetts, U.S.A. [Price 8 dols.]; and Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4. [Price 52s. net.]

Proceedings of the First United States Conference on Prestressed Concrete. Massachusetts Institute of Technology, August 14 to 16, 1951. The Conference Co-ordinator, Massachusetts Institute of Technology, Cambridge, Massachusetts, U.S.A.

Foundry Work. By EDWIN W. DOE. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 1·75 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 14s. net.]

Finite Deformation of an Elastic Solid. By PROFESSOR FRANCIS D. MURNAGHAN. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 4 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 32s. net.]

Metallurgical Abstracts (General and Non-Ferrous.) Volume 17. 1949-50. Edited by N. B. VAUGHAN. The Institute of Metals, 4, Grosvenor-gardens, London, S.W.1. [Price 60s.]

Locomotive and Train Working in the Latter Part of the Nineteenth Century. By E. L. AHRONS. Volume Two. W. Heffer and Sons, Limited, Cambridge. [Price 18s. net.]

Mathematics. Queen and Servant of Science. By PROFESSOR E. T. BELL. G. Bell and Sons, Limited, York House, Portugal-street, London, W.C.2. [Price 21s. net.]

Department of Scientific and Industrial Research. Report of the Forest Products Research Board, with the Report of the Director of Forest Products Research for the Year 1950. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 3s. net.]

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