

ENGINEERING.

THE ABBEY WORKS OF THE STEEL COMPANY OF WALES.

THE main part of the plan for re-organising the South Wales sheet steel and tinplate industries is the construction, at Port Talbot, of the Abbey works of the Steel Company of Wales. The plan included the reconstruction and extension of the blast-furnaces, coke ovens and ore-handling plant at the existing works at Margam; and the erection of the new Abbey works, on an adjacent site, consisting of an 80-in. continuous strip mill, a

The Margam works, exterior views of which are given in Figs. 2, 3 and 4, on page 2, will have three blast-furnaces with an aggregate daily output of 2,700 tons, thus providing sufficient pig iron to feed the melting shop at the Abbey works as well as those at Port Talbot and Margam. The coke for these furnaces is obtained from 144 ovens, which are supplied with local coal and have an output of 15,000 tons per week. This coal is rail-borne, the wagons being shunted on to gravity-operated reception sidings leading to wagon tipplers, from which a new washery is supplied by belt conveyor. The iron

Port Talbot, and is delivered by the same conveyor system to the bunkers at the blast-furnaces. A new Lodge-Cottrell gas-cleaning plant and an additional pig-casting plant have been installed, and the existing open-hearth furnaces are being gradually rebuilt as 80-ton fixed furnaces.

These extensions, for which the main contractors were Sir Robert McAlpine and Sons, London, were carried out without interfering with production. Trial pits were sunk on the sites of the new blast-furnaces, and a ballast strata, capable of taking a load of about 5 tons per square foot, was found at

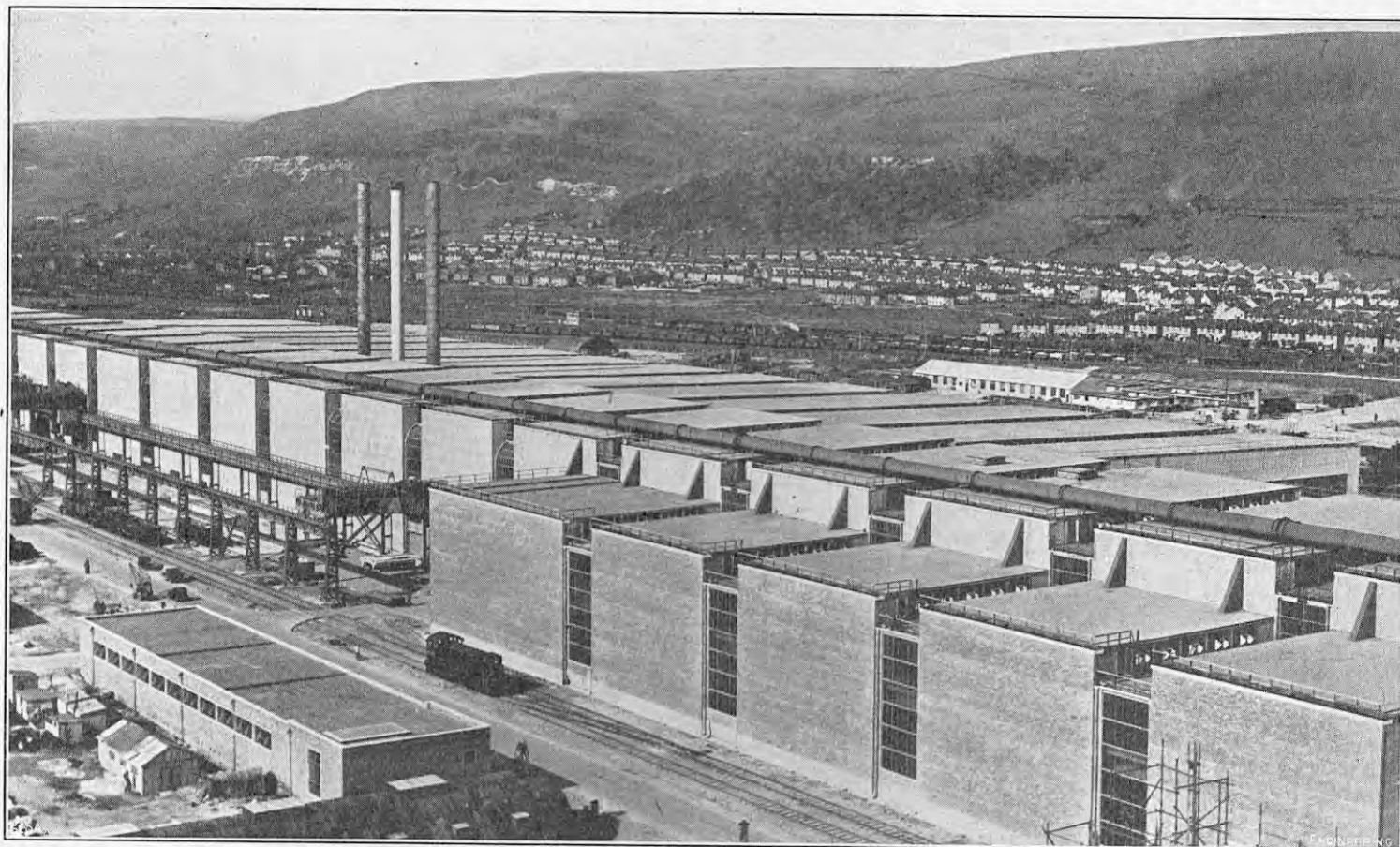


FIG. 1. MAIN BUILDINGS AT ABBEY STEELWORKS.

melting shop and ancillary plant. The Abbey works, when completed, will extend for $4\frac{1}{2}$ miles and will be capable of an annual production of $1\frac{1}{2}$ million tons of ingots. A further integral part of the scheme is the erection of two cold mills—one alongside the new continuous mill and the other at Trostre, near Llanelli, where there will also be a tinplate plant. The consulting engineers for the scheme are Messrs. W. S. Atkins and Partners, 158, Victoria-street, London, S.W.1, the International Construction Company, 56, Kingsway, London, W.C.2, and Messrs. McLellan and Partners, 32, Victoria-street, London, S.W.1. The architects are Sir Percy Thomas and Sons.

ore is obtained either from Oxfordshire by rail (and is also dealt with by tipplers and conveyors) or from overseas. The foreign ore is brought to a 1,350-ft. wharf, which extends the whole length of the stockyard, and is dealt with by three transporter unloaders, with a total maximum capacity of 1,500 tons of ore per hour, which deliver into 100-ton transfer cars. A view of the wharf, showing the transporters, is given in Fig. 3, on page 2. The home ore is taken by the conveyor illustrated in Fig. 4 to hoppers, whence it is collected by 50-ton electrically-operated cars and deposited in bunkers. Limestone is obtained by rail from a completely-mechanised quarry at Cornelly, about 6 miles from

a depth of about 20 ft. A soil-mechanics survey was also carried out at the wharf, where it was considered there was a possible danger of rotational shear slide, owing to the extra load caused by the stocks of ore, and the design of a retaining wall formed by a low-level transfer-car bridge was based on the results. Ground loading tests, which were carried out from the northern to the southern end of the site, showed that, owing to the slope of the gravel strata, it was necessary to pile for foundations in the south and south-western areas.

Both precast, cast *in situ* and bored piles were used, depending on the site conditions. The aggregate employed for making the concrete consisted

of limestone and Holm grit, and was initially dealt with in small mixers as, owing to the congested nature of the site, it was impossible to install a central batching plant. The foundations of the blast furnaces were taken down to the ballast strata and spread to give a maximum loading of $2\frac{1}{2}$ tons per square foot. They were constructed with an inner core of firebrick and *ciment fondu* owing to the heat. As the ground was water-laden, excavation for the foundations of the 1,000-ton furnaces was carried out within a circle of steel sheet piling, 86 ft. in diameter. This piling was supported by a circumferential beam, thus eliminating other forms of strutting and allowing large grabs to be used. Owing to the presence of water and the impossibility of driving sheet piles, the ground was frozen before excavation for the skip pit of this furnace was begun.

The extensions at Margam have necessitated a number of alterations to the works railways and to the adjoining main-line tracks. As a result, five new bridges, with numerous embankments, retaining walls and viaducts, have had to be constructed. In addition, the culvert which carried the Ffrwdwyllt river was diverted and replaced by a new culvert, 1,250 ft. long, the outflow from which into the dock is arranged so that any deposits carried during floods are kept clear of the parts which are dredged.

Operations in connection with the construction of the Abbey works began in 1945, when a complete survey of the levels was made and trial boreholes were sunk. A pre-piling survey was also conducted and test piles were driven and loaded up to 90 tons. Finally, a soil-mechanics test of the peat and clay bed was made to assess the probable ground sinkage under load. In 1947, ten boreholes were sunk to a depth of 70 ft. and reached sand, stone or hard shale. It was found that the peat bed was up to 8 ft. thick, and the earlier conclusion, that the works could be satisfactorily carried on piles between 20 ft. and 50 ft. long, was confirmed. As, however, the unevenness of the load-bearing strata made it impossible to predict the pile length sufficiently accurately to make the use of pre-cast piling economical, it was decided to employ *in situ* piles. In all, 33,700 piles were used by the contractors for this part of the work—the Franki Compressed Pile Company, Limited, 39, Victoria-street, London, S.W.1, and West's Piling and Construction Company, Limited, Aldwych, London.

The level of the whole area occupied by the works was raised 10 to 12 ft. by placing $4\frac{1}{2}$ million cubic yards of filling, consisting either of sand from the dunes or slag from old tips or current production. Pumps, installed on a dredger, which had been launched in a lagoon excavated in the dunes, were used to deliver sand and water to areas enclosed by banks. This water was subsequently drained back into the lagoon (which is now used as a works reservoir) to maintain flotation depth. In another area, the sand was excavated by standard plant and transported by lorries and Euclid loaders. Slag was obtained from old tips by blasting and digging, while that from current production was tipped into a slag pool from which it was dug by a 37 R.B. navvy, after having been well watered.

In order to prevent inroads from the sea, and sand from blowing over the works, low-lying areas of the foreshore are being raised by placing brushwood fences. As these are gradually buried by the sand, further brushwood is being placed on top until a dune of the desired height is obtained, when a fresh dune is begun on the seaward side. The dunes are planted with Marram grass, obtained from adjacent thickly-grown areas and planted to a depth of 9 in. to 10 in. at 2-ft. centres. Subsequently, Corsican and maritime pine trees will be planted and are expected to reach a height of 12 ft. in ten years.

In all about 344,000 cubic yards of concrete with a minimum crushing strength of 2,250 lb. per square inch were used on the site, about half of which was handled by crane in one- and two-cubic yard buckets and the remainder by pumping. Compacting by punning and treading was generally used, vibrators only being employed for concreting in the columns and for special work. The principal contractors for this portion of the work were Messrs. George Wimpey and Company, Limited, London.

EXTENSIONS TO MARGAM STEELWORKS.



FIG. 2. EXTERIOR OF MARGAM WORKS.

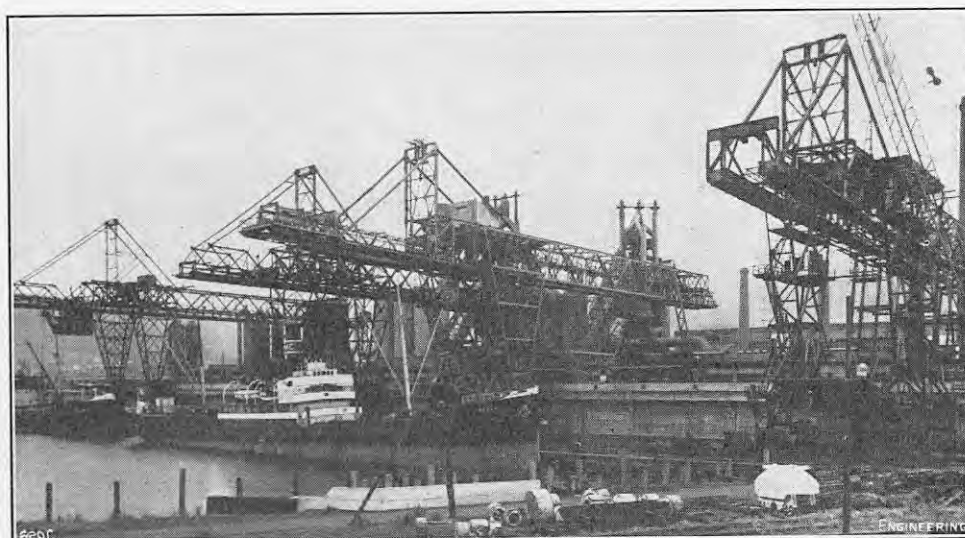


FIG. 3. ORE TRANSPORTERS AT MARGAM WHARF.

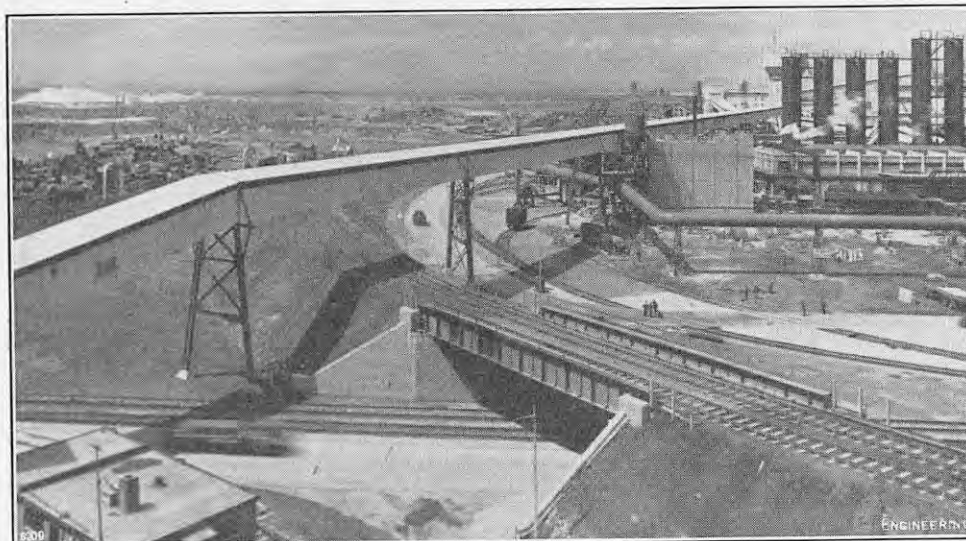


FIG. 4. RAW-MATERIALS CONVEYOR AT MARGAM WORKS.

The main buildings, illustrated in Fig. 1, on page 1, are for the most part rigid-frame structures, some of which, such as the main mill and melting shop, are of open-lattice construction. The bases are generally fully restrained, but a small pin-ended portal is used in the main pump house. No base plates were employed, the columns being bonded to the pile caps so that they are integral with the foundations. All the gantry girders are continuous; the joints which occur over each column cap were welded on site. The gantry rails were also welded to the supporting girders. To reduce maintenance, all the structural steelwork above crane-girder level and the side sheeting rails were grit-blasted and

ABBEY WORKS; STEEL COMPANY OF WALES.

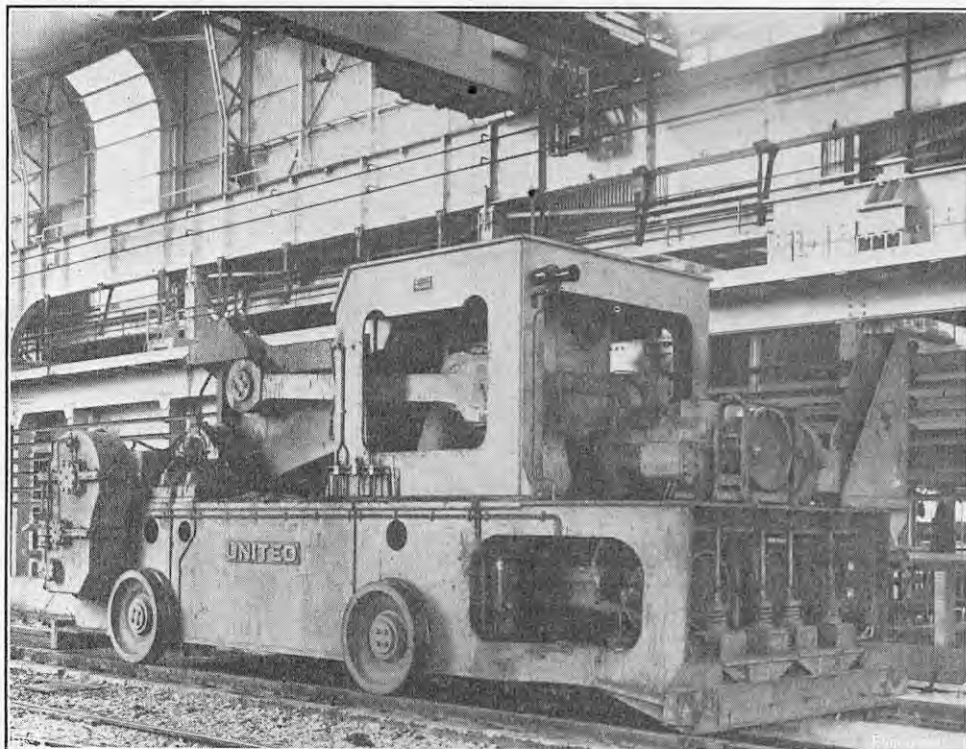


FIG. 5. INGOT BUGGY.

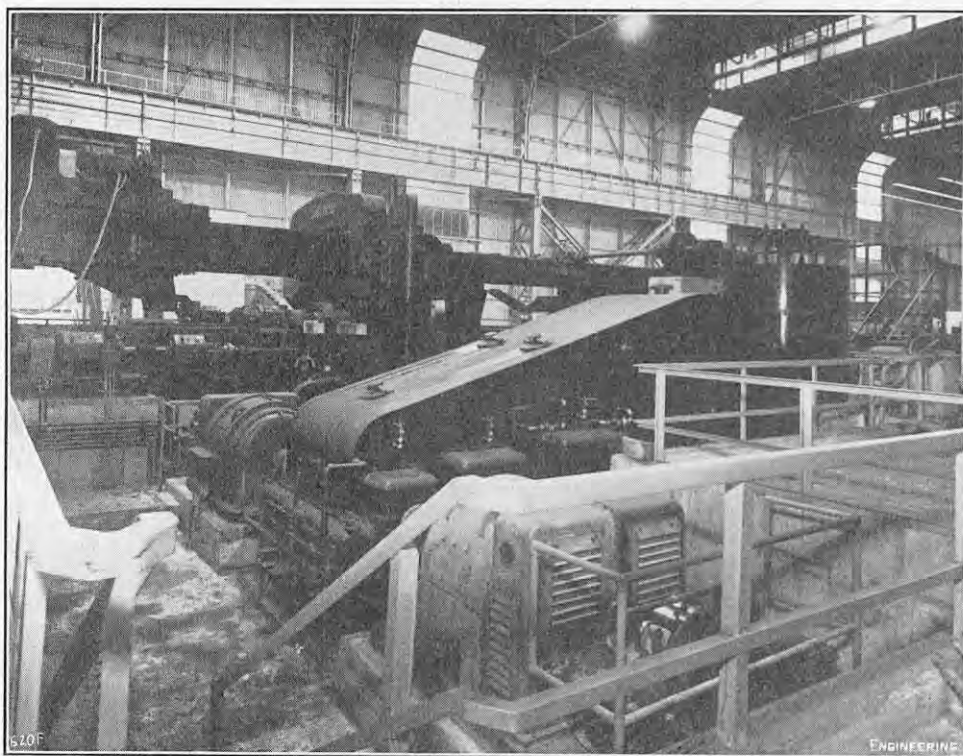


FIG. 6. MAIN DRIVE OF SLAB SHEARS.

sprayed with aluminium to a thickness of 0.004 in., by the wire method, after which one coat of paint was applied. The spraying, which was carried out by Messrs. Metallisation, Limited, was described in *ENGINEERING*, vol. 168, pages 90 and 127 (1949). The remaining steelwork was wire-brushed and given three coats of paint.

The sides of the building consist of 1,206,500 sq. ft. of sheeting and 466,470 sq. ft. of glass, and the roof area is 239,630 sq. yd. The main contractors for the structural steelwork were Messrs. Dorman, Long and Company, Limited, Middlesbrough, and Sir William Arrol and Company, Limited, Glasgow; the steel sheeting was erected by Messrs. Johnson Brothers (Steel Erectors), Limited, 7, Victoria-street, London, S.W.1.

On arrival at the Abbey works, the hot metal from the blast furnaces is poured into one of two

800-ton mixers, which were constructed by Messrs. Head, Wrightson and Company, Limited, Thornaby-on-Tees. These mixers, which are fired by coke-oven gas, are operated electro-mechanically, and are designed so that they return to the normal position should the power fail when they are tilted. They deliver into 75-ton ladles, which stand on transfer cars on weighbridges at stage level, and are hauled into position opposite the furnaces by an electric locomotive. The ladles discharge, in turn, into 200-ton fixed oil-fired furnaces, built by Messrs. Priest Furnaces, Limited, Middlesbrough, with a bath area of 770 sq. ft. and a depth of 31 in. Six of these furnaces are in operation, while another two are under construction. Oil for firing is brought by road from the National Oil Refineries at Llandarcy and is pumped into two storage tanks, each of which has a capacity of 1,000,000 gallons.

The consumption of oil per charge is about 4,000 gallons. Scrap for the furnaces is sorted in the scrap marshalling yard and is then pushed up a ramp in train-loads and loaded into boxes in a filling bay at stage level.

The furnaces are tapped into ladles with a capacity of 200 tons, which were also constructed by Messrs. Head, Wrightson. These ladles are then lifted by one of three 300-ton cranes and their contents poured into ingot moulds with a steel capacity of 20 tons. The 300-ton cranes, which were constructed by Adamson-Alliance Company, Limited, 168, Fenchurch-street, London, E.C.3, are of the four-girder type with a span of 69 ft. 6 in., and, when each is fully loaded, a total weight of 710 tons has to be carried by the structure. This load is taken by 22 welded girders, the longest of which measures 110 ft. by 12 ft. 5 in. by 3 ft. and weighs over 90 tons. The girders forming the bridge of the cranes are of box section and are provided with an end tie bracing. Saddle brackets at the ends of the bridge support cast-steel yokes, on each of which are two bogies with two runners. The bridge is thus mounted on 16 runners, four of which are driven through gearing by two motors placed at the centre. There are two crabs, one of which carries the main hoist and the other auxiliary hoists of 60- and 20-tons capacity, respectively. The frames of these crabs are built up of structural steel sections, the main beams being welded. The hoist on the main crab is of the two-motor double-gear interlocked-drum type, on which each of the intermeshing drums mates with pinions. These pinions are carried on shafts at one end of which worm gearing is mounted. One of these worm gears is right-handed and the other left; and they are arranged so that the meshing worms are in line with each other and at right angles to the drums. They are also connected to each other through a shaft and geared flexible coupling. This arrangement allows simple and accurate adjustment between the two lines of gearing, with the result that although the drum gears intermesh there is no actual contact between the teeth during the normal operation of the crane. A safety feature, in case of mechanical failure, is thus provided.

Each worm is connected to a 200-h.p. mill-type motor, manufactured by the General Electric Company, Limited, Kingsway, London, W.C.2, through a flexible coupling. The two motors are synchronised, so that in case of poor brake adjustment any inequality in the load is shared. They are controlled by equipment supplied by the Igranic Electric Company, Limited, Bedford. Igranic limit switches and electric brakes, including an emergency brake on each hoist motor, are also fitted. The load on the main hoist is carried on 52 falls of rope, which are reeved on two 5 ft. 6 in. diameter barrels. This arrangement incorporates a safety feature which permits one rope or two diagonally-opposite ropes to break without materially altering the position of the beam carrying the ladle.

The moulds are hauled to a stripper bay by 660-h.p. Diesel-electric locomotives, which were constructed by the American Locomotive Company. Here they are stripped by two 200-ton cranes of the screw type, which were also manufactured by the Adamson-Alliance Company. The stripped ingots are then charged into one or other of the 20 bottom-fired soaking pits, which are arranged in pairs. These pits, which were constructed by the Wellman Smith Owen Engineering Corporation, Limited, Wilton-road, London, S.W.1, are capable of heating $1\frac{1}{2}$ million tons of ingots per annum and can each hold a 100-ton charge. They are fired by a mixture of blast-furnace and coke-oven gas having a calorific value of 135 B.Th.U. per cubics foot. This gas enters the bottom of the pit through a single vertical burner, round which the ingots are located. The ingots therefore surround the flame, which gives complete combustion without impinging upon them. The gaseous products travel along and between the axes of the ingots and pass through ports at hearth level to a recuperator and thence to a chimney, of which there is one for each pair of pits. Air is supplied by an electrically-driven fan with an output of 360,000 cub. ft. per hour, and is pre-heated in the recuperators before being led to the burners.

The bottom of each pit is covered with 18 in. of coke breeze and is provided with four cleaning holes

through which the slag and scale are removed by a scraper attached to the ingot crane. Each pit is also provided with a flat cover of refractory material, which is supported on a steel structure. This cover, when it has been lowered into position, seals the pit and prevents air infiltration, thus enabling the internal pressure to be maintained constant. The covers are lifted by two carriages, which run on rails laid at 44 ft. centres (so that they can travel in either direction). When a cover is lifted, the fuel, air and chimney-draught valves are closed automatically and are re-opened when the cover is lowered. This arrangement not only saves fuel, but protects the crane operator and facilitates the handling of the ingots. The temperature and pit pressure are automatically controlled. Coke breeze is conveyed from a main hopper to the soaking pits by an electrically-operated transfer car, and the cinders are discharged into tipping buckets which are hauled to the handling building by an electric-battery truck.

The ingots are taken from the soaking pits to the receiving table by a buggy, which is illustrated in Fig. 5, on page 3. This buggy is equipped with two 100-h.p. G.E.C. mill-type motors for travelling and a 75-h.p. motor for tilting the ingot. It is also equipped with power-operated rollers for rolling the ingot into position and with "electric eyes," which automatically stop it at the ends and indicate its intermediate positions.

Before entering the slabbing-mill stand, the ingot passes on to a scale and turning device which weighs it and turns it through an angle of 180 deg. to ensure that the wide end enters the mill first. The 45-in. slabbing mill, which was constructed by the United Engineering and Foundry Company, Pittsburgh, Pennsylvania, is designed to roll slabs up to 60 in. wide by 10 in. thick from ingots having a maximum weight of 24 tons. The slabs produced for sheet will measure 8 ft. 6 in. by 5 ft. 6 in. by 8 in. thick and those for tinplate 18 ft. by 2 ft. 6 in. by 8½ in. thick. The general appearance of the mill is illustrated in Fig. 7, Plate I, and an indication of its size may be obtained from the fact that each of the two housings in the mill proper weighs 125 tons. It is driven by two motors, each of which is connected through universal spindles to one of the 45-in. rolls. The maximum lift is 68 in. and the screw speed 17.5 ft. per minute. There are no mill pinions, the only mechanical connection between the rolls being through the slab that is being rolled.

The motors, which were constructed by the English Electric Company, Limited, Queen's House, Kingsway, London, W.C.2, and are shown in Fig. 8, Plate I, are together capable of exerting a peak torque of 3,600,000 lb.-ft. at speeds up to 40 r.p.m. At higher speeds, up to 80 r.p.m., the torque falls off, so that the peak rating does not exceed 27,600 h.p. Each motor has two armatures to reduce their diameter and obtain a satisfactory distance between the centres of the top and bottom shafts. This construction also reduces the inertia and thus assists reversal. The complete twin motor is supplied from an Ilgner set, a view of which is given in Fig. 9, Plate II. This set consists of an induction motor, four generators and a flywheel and is controlled by main and auxiliary exciters. The motor is operated by three-phase current at 11 kV and has an output of 6,500 h.p. at a synchronous speed of 500 r.p.m. Each generator is rated at 1,850 kW and supplies direct-current to the mill motors at 0 to 600 volts. The flywheel is of the plate type and has a stored energy capacity of 200,000 h.p. seconds, which, it is estimated, will be sufficient to cover the demand of the mill without the drop in speed exceeding 20 per cent. All the machines are cooled by re-circulated air, there being separate systems for the Ilgner set and the motors. The air which passes over and picks up the dust from the commutators of the direct-current machines is removed by fans and is replaced by air drawn in through electrostatic precipitators. This ventilating plant was constructed by Messrs. Matthews and Yates, Limited, Swinton, Messrs. Heenan and Froude, Limited, Worcester, and the Sturtevant Engineering Company, Limited, London. Pressure lubrication is used on the mill-motor bearings, on the bearing which carries the outer end of the extended spindle over the lower motor and on the flywheel bearings.

The mill is controlled from a foot-operated master

controller, which is installed in an operating pulpit and gives seven speeds between standstill and 40 r.p.m. and a further six speeds between 40 and 80 r.p.m. The controller is connected in the field circuits of two rapid response exciters which, in turn, control the exciters in the generator and motor field circuits. There is a separate control system for dealing with unbalance in the load currents of the upper and lower motors, so that the torque differential between the two is held at a preset value of ± 25 per cent. Differential speed control is also provided and can be adjusted for different roll diameters. In this system the number of relays and contactors required is small, so that the contactor board is only about 7 ft. long.

The two "feed" rollers next to the main rolls on each side of the slabbing mill are driven by a heavy-duty steelworks motor through gearing. These motors are supplied from two variable-voltage generators with rapid-response voltage control and a current control system, as on the main drive. They are operated through contacts on the master controller, so that their speed approximately synchronises with that of the mill. The incoming and outgoing tables, as well as the screw-downs, slab shear and other mill auxiliaries, are driven by G.E.C. mill-type motors. The motors driving these auxiliaries and the ingot buggy, mentioned above, are supplied from the two nine-machine motor-generator sets illustrated in Fig. 10, Plate II. These sets, which were also constructed by the General Electric Company, consist of a 2,000-h.p. 3.3-kV synchronous motor and exciter and seven direct-current generators.

The other auxiliary motors are controlled by contactor gear, which was supplied by the Igran Electric Company, Limited, Bedford, and is mounted on the board which can be seen in Fig. 10. A main isolating switch on each panel is mechanically interlocked with an isolator in the control circuit to enable the panel sequence to be tested with the motor circuit dead, thus facilitating the location of faults and ensuring that the control circuit is opened first and closed last. Each contactor is fitted with mill type magnetic blow-outs and the auxiliary contacts in the electrical interlocking and relay circuits are of "supple" design, thus ensuring lightness of movement and eliminating wipe or abrasive action. These contacts, the majority of which are faced with silver, are mounted in a vertical plane, so that dust does not collect on their surfaces. The rate at which the starting resistance is cut out of circuit is regulated on the Igran condenser time-limit control system, the setting of which can be adjusted to suit the load. To ensure full control during reversal most of the shunt-wound motors driving the auxiliaries are fitted with diverter-resistances which are shunted across the armature in two stages to provide a dynamic braking effect. In most cases this resistance is reduced during the braking period, thus maintaining the retarding torque without excessive current.

The control panels, visible in Fig. 10, Plate II, are each provided with a set of mechanically-interlocked reversing contactors in one pole of the supply, a main contactor which breaks the other pole, and two or three accelerating contactors. These accelerating contactors are fitted with closing and hold-out coils, as well as with a contact for the braking circuit. Main and control isolating switches, overload relays and low-voltage and brake relays are also mounted on the panels. The equipments are controlled from the slabbing-mill pulpit by master controllers, which close or open the contactors in the correct timed sequence.

On leaving the slabbing mill, the slab is taken along rollers a distance of 95 ft. to a separate edger mill, where it is reduced to its final width before entering the shears. This mill is driven by a 800-h.p. 3.3-kV synchronous motor manufactured by the Electric Construction Company, Limited, Wolverhampton. The shears, which are illustrated in Fig. 11, Plate II, are of the down and up-cut type, in which the top block descends upon the material to prevent movement and the bottom block then moves up to the shear. The knife pressure is 3,000,000 lb. and the stroke 19 in. at a speed of 9 r.p.m.; a slab measuring 10 in. by 60 in. can be sheared. The shears are electrically driven by the motors shown in Fig. 6, on page 3, and are fitted with

chutes down which the "crops" pass to an inclined skip hoist, which delivers them to the crop yard and back to the melting shop. The slabs, after being weighed, are pushed on to a transfer skid bank and are thence carried to a high-level table where they travel to two pilers which, in turn, load them on to cars for transfer under the cranes of the slab yards, where they are cooled and dressed. The dressed slabs are then taken on other transfer cars to the inner slab yards for sorting and, finally, through two depilers to the re-heating furnaces.

(To be continued.)

LITERATURE.

Motion and Time Study: Principles and Practice.

By PROFESSOR MARVIN E. MUNDEL, Ph.D. Prentice-Hall, Incorporated, 70, Fifth-avenue, New York, U.S.A. [Price 4 dols.]; and George Allen and Unwin, Limited, 40, Museum-street, London, W.C.1. [Price 40s. net.]

A FULL exposition of the principles of a subject, without the occasional relief provided by concrete examples, can be difficult for a newcomer to follow. He can only read so far before he must be given an example, or his understanding of the abstractions perishes. Clearly, Professor Mundel appreciates that this applies with special force to motion and time study. In the first chapter, which the reader with some knowledge of the subject can omit, he cites a number of cases to show what motion and time study can do, and to give an inkling of the analytical methods employed. Thereafter—apart from the second chapter, on "the human factor," in which he briefly acknowledges the psychological difficulties that may arise in applying motion and time study—he never allows the argument to proceed very far without working out a few cases. This treatment also has the advantage that the reader can "gain experience," so to speak, before he does, in fact, gain experience; by this means, perhaps, the risk of causing those psychological difficulties is lessened. At the end of the book there is also a series of unworked problems for students.

The field that is covered by Professor Mundel's book includes work simplification, work standardisation, work measurement, time study, standards work, motion study and methods research. The first step in solving a motion and time study problem he defines as the determination of the objective in terms of the area of the job to be changed, and the establishment of criteria for evaluating the preferability or success of solutions. This step is itself divided into three parts, the last of which is "the contemplation of the apparently feasible areas of change and the selection of the most feasible area of change." Such abstract wording is indispensable to a proper understanding of the subject; indeed, the author's use of the word "contemplation," shows that, to succeed in motion and time study, it is necessary to become imbued with the principles and then to exercise imagination rather than follow a set of rules. In the next chapter the author proceeds to the compilation of a process chart as a means for analysing the manufacturing or other method. After that comes the use of a chart for portraying the separable steps a person performs when doing a task that requires him to move from place to place; and then, in certain cases, a combined analysis, particularly suitable for paper-work, such as control forms, dispatch sheets, requisitions, etc. The following chapter, on operation charts, is the one likely to be most useful in machine shops and assembly shops, since it deals with "the separable steps of a person's body members when he is performing a job that takes place essentially at one location." In later chapters the author deals with more complex problems, involving several men or machines, and with "micromotion study" (using a cinematograph camera) and analyses based on "therbligs." Time study is likewise treated comprehensively, and in the last chapter the author suggests methods of implementing the results of motion and time studies. A long bibliography, including many references to articles which have appeared in periodicals, is included. Professor Mundel's book should appeal to a considerable number of workers in this field.

THE ABBEY WORKS OF THE STEEL COMPANY OF WALES.

(For Description, see Page 1.)



FIG. 7. SLABBING MILL AT ABBEY WORKS.

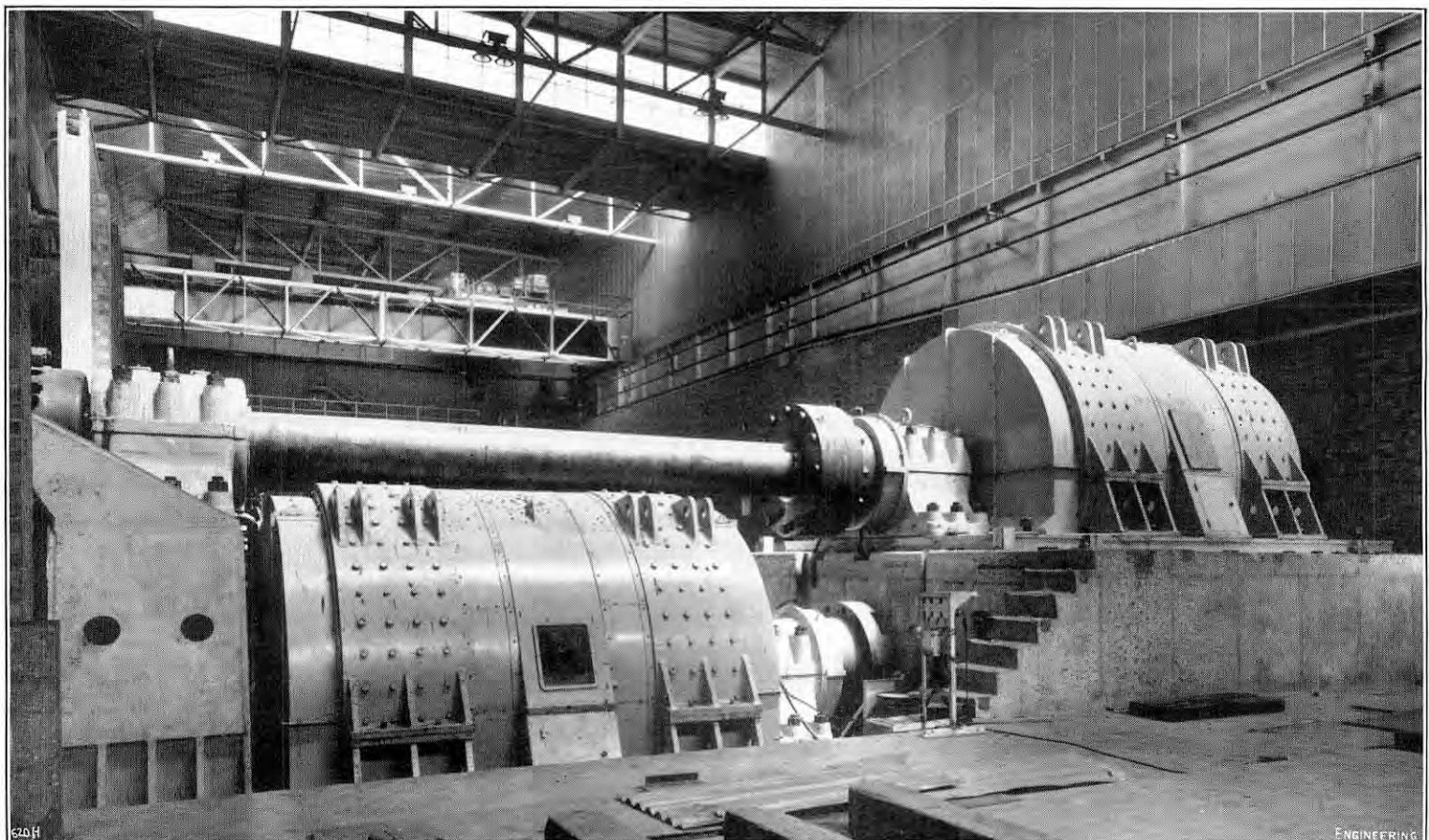


FIG. 8. 27,600-H.P. MOTORS DRIVING SLABBING MILL.

THE ABBEY WORKS OF THE STEEL COMPANY OF WALES.

(For Description, see Page 1.)

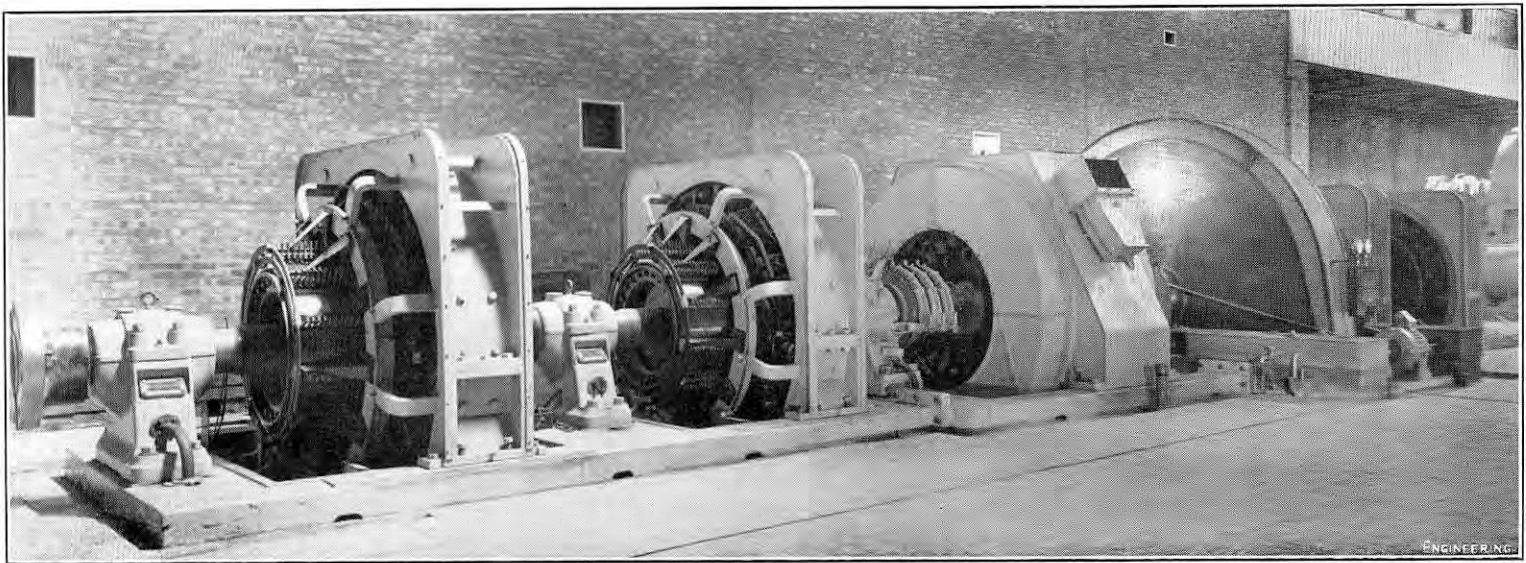


FIG. 9. 6,500-H.P. ILGNER SET FOR SLABBING MILL.

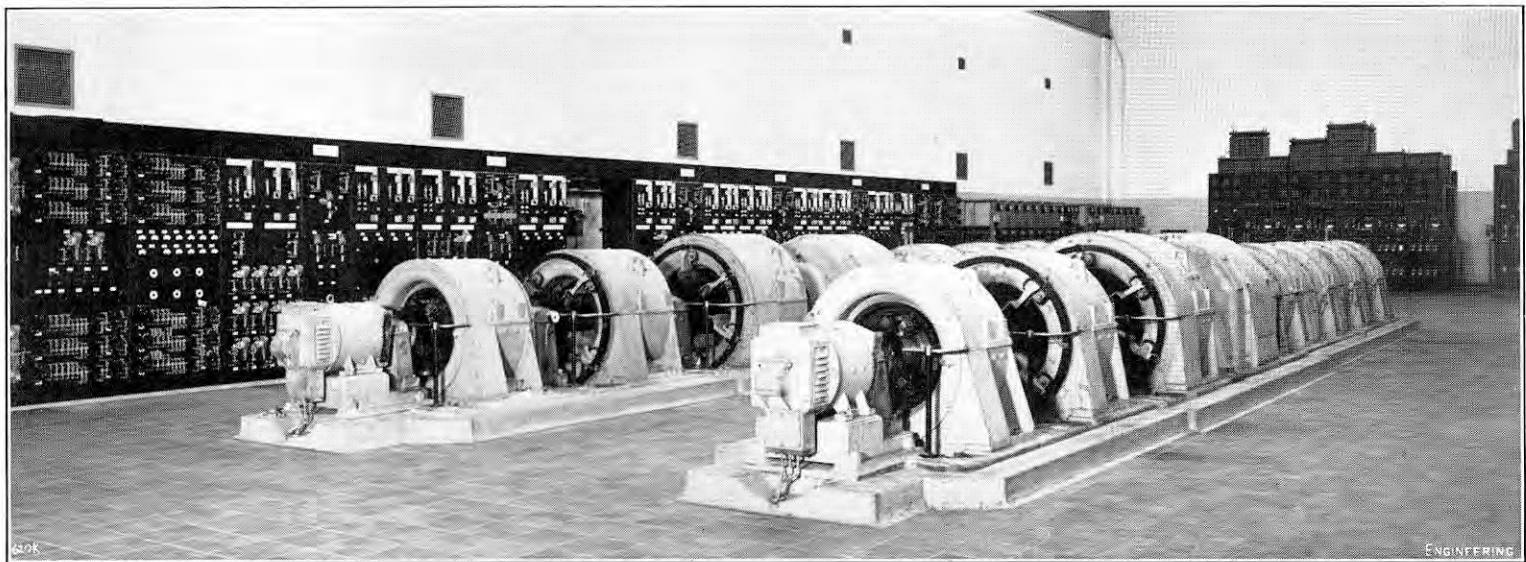


FIG. 10. NINE-MACHINE MOTOR-GENERATOR SETS.



FIG. 11. SLAB SHEARS.

THE ENGINEERING OUTLOOK.

I.—RETROSPECT AND PROSPECT.

THE performance of the engineering industry in 1951 has, in some ways, exceeded expectations. The index of output (see Table I, taken from the *Monthly Digest of Statistics*) rose by 11.5 per cent. during the year ending July, 1951, and the volume of exports in the first nine months of the year was as high as the corresponding period of 1950 (see Table II, taken from the *Report on Overseas Trade*).

TABLE I.—United Kingdom: Interim Index of Industrial Production. (1946 = 100.)

	Engineering, Shipbuilding, and Electrical Goods.	Vehicles.	All Manufacturing Industries.
1947	116	111	109
1948	136	121	123
1949	140	151	132
1950	153	174	146
January ..	140	162	138
February ..	150	170	144
March	158	180	150
April	141	164	139
May	151	182	147
June	165	169	150
July	148	178	139
August	129	144	128
September ..	158	175	149
October ..	162	198	158
November ..	164	196	159
December ..	165	165	144
1951 —			
January ..	151	175	146
February ..	172	174	157
March	158	155	147
April	170	175	158
May	159	173	150
June	173	174	157
July	165	177	147
August	142	140	132

TABLE II.—UNITED KINGDOM: VOLUME OF EXPORTS OF METAL GOODS. (1947 = 100.)

	1950.	1950.				1951.		
		1st Qr.	2nd Qr.	3rd Qr.	4th Qr.	1st Qr.	2nd Qr.	3rd Qr.
Iron and steel	158	147	153	155	175	143	153	130
Non-ferrous metals ..	134	123	122	160	131	125	94	84
Cutlery implements and instruments, etc. ..	128	124	123	128	137	131	152	150
Electrical goods and apparatus	145	142	137	149	154	130	150	153
Machinery	151	155	146	144	158	145	164	162
Vehicles	212	210	219	199	221	208	233	207
Total, all exports	162	157	153	161	175	160	173	165

There were shortages of men and materials at a few key points, and the home civilian market had rather fewer of some less essential goods and perhaps a poorer finish on some more essential goods, but, in general, the impact of re-armament in its first full year of operation upon the engineering industry was surprisingly small. Re-armament, however, is now getting under way, and will make a considerable impact on the industry in 1952. The Ministry of Supply reported in September that 45 to 50 per cent. of their share of orders under the Defence Programme had been placed with the manufacturers concerned, and that the placing of 17 per cent. of the remainder was being negotiated. The Admiralty have also stated recently that the bulk of their major orders have been placed. The total re-armament outlay of 4,700l. millions in the three years 1951 to 1953 will account for 8.8 per cent. of the gross national production, and, of this, 1,700l. millions will be expended on engineering products. Mr. Hugh Gaitskell, M.P., estimated that this represented a load "on the average" of only 20 per cent. on the engineering industry's output over those three years, but, since defence outlay in 1951 was not appreciable, the load on the output of the industry during 1952 and 1953 is likely to average at least 30 per cent.

The metals and engineering industries already employ 3.9 million persons and, even if the necessary manufacturing capacity and materials are available, they are most unlikely to find sufficient skilled and semi-skilled labour both to maintain existing civilian output and carry out the re-armament programme. Production for the home market will doubtless

suffer further cuts, but even supplies of essential capital equipment have already been cut so much as to endanger the ability of companies to maintain output. When originally formulated, it was recognised that the re-armament programme could not be carried through without some drop in engineering exports. It was thought, however, that the total volume of exports could be maintained by increased exports of some consumer goods, notably textiles. Later experience suggests, however, that, in the absence of foreign assistance, it will not be possible to avoid a large adverse trade balance—particularly since it has been decided to start paying back on the American and Canadian loans—unless engineering exports, which, together with metal manufactures, now account for 48 per cent. of total British exports, are maintained.

Re-armament on a world scale has had two important effects on British trade. It raised the price of essential British imports at a time when its own requirements and strategic stockpiling at home brought about an increase in British imports; and it cut the demand for British exports. Re-armament on the scale undertaken by the Atlantic Treaty nations cannot be carried out without some restriction in the spending power of the consumer, even in the wealthiest countries. In the United States and Canada, consumer credit facilities have been severely restricted. The Western European countries have been devoting at least as much of their resources to defence as has Britain. In France, for example, defence is said to account for 9.3 per cent. of the gross national production, compared with 8.8 per cent. in Britain. As a result, sales of consumer goods, including motor cars and textiles, have been falling. The proposed cut of 350l. millions in British imports (principally foodstuffs) announced by the Government in November is not, in itself, likely to bridge the gap in the balance of trade. No one underestimates the pressing need for arms, but, since no nation incapable

of 183,000 tons a week in the corresponding period of 1950. Supplies of ferrous scrap, however, stocks of which at the steel works and foundries amounted to only 305,000 tons in September, 1951, compared with 812,000 tons in September, 1950, continue to dwindle. Imports of scrap from Germany in 1951 were less than a third of the amount imported in 1950. Increases in the price of scrap during the summer failed to increase home supplies, since the increases had largely to be passed on by the merchants to the scrap owner, so that it was no more profitable than before to handle light loose material. It is doubtful if further increases in scrap prices would make it worth while for the merchants to collect and process the scrap (largely "dirty" scrap) which is not already being returned to steel works or iron foundries. Imports of steel from America will help, but they will not make good the deficiencies in home production. In September, the Chancellor of the Exchequer asked the United States Government for assistance in securing 800,000 tons. So far, Britain has been authorised to place orders in the United States for 93,000 tons of ingots, and has been allocated 25,000 tons of finished steel for the first quarter of 1952. Negotiations are still proceeding for the remainder.

In the light of present raw-material supply prospects, the output of steel ingots and castings in the United Kingdom in 1952 is officially estimated at 15.75 to 16 million ingot tons. This will mean a deficiency of supply, compared with demand, of 1.5 million tons if negotiations in Washington are unsuccessful. In reply to a Parliamentary question at the beginning of December, Mr. Duncan Sandys, the Minister of Supply, stated that imports from the United States might possibly cut the shortage from 1½ million to 1 million tons—although this was more of a hope than an estimate.

Steel rationing, which was discontinued as recently as May, 1950 (and even then restrictions on sheet and tinplate remained), is to be re-introduced. The Iron and Steel Distribution Order, 1951 (SI. 1951, No. 2006) which affects both alloy and non-alloy (carbon) steel, will not, however, come into operation until February 4. The Ministry should, therefore, be able to examine the scheme and its complications thoroughly before it actually comes into operation. As it stands, it differs little in detail from the one lately discontinued. The Government are again responsible for assigning priorities, and the engineering industry must once more lose some of its freedom. A "small quantities exemption" clause may help the manufacturer whose production programme is held up through lack of a small but vital quantity of steel.

The shortage of steel-making materials comes when, at long last, there is no longer a shortage of steel-making capacity. Insufficient supplies of sheet steel have seriously hampered the motor-vehicle industry in 1951, when sheet supplies were 15 to 20 per cent. less than in 1950. The Margam Abbey Works of the Steel Company of Wales were, however, opened officially in July, and when they are run-in and fully operational, will have an annual capacity of 100,000 tons of sheet. Provided that the mills can be fed, there should be sheet enough and to spare in 1952. Large users, whether of sheet or other types of steel, may, in fact, suffer least from the shortage. The Ministry of Supply has emphasised that the shortage is a "marginal" one (although it is bound to exceed a million tons in 1951), and while, therefore, inability to obtain a few tons of steel may only inconvenience a large concern, there is a grave danger that small firms, whose total consumption may be only a ton or two per week, may be forced to close down. The success or otherwise of the distribution scheme will depend to a large extent on whether, in practical operation, it is possible to guard against hardship to the small consumer.

The work of the International Materials Conference has eliminated the cut-throat competition in the free world for available supplies of the non-ferrous metals and ferro-alloys. Total requirements by the participating countries of zinc and copper in the fourth quarter of 1951 were about 100,000 metric tons, which represents a deficit of about 15.8 per cent. in the case of copper and 21.4 per cent. in the case of zinc. Supplies of

of supporting itself can defend itself, exports must have first priority.

An appeal to American aid is neither an attractive nor an easy solution, and the request for assistance which has been made so far is for a very limited amount. American impatience with the British attitude towards European Federation and a European army has been growing of late, and acceptance of any large-scale assistance from the United States might well involve Britain in far-reaching political consequences.

The first problem facing British engineering, to consider it in some detail, is the availability of raw materials. In terms of ingot equivalent, the supply of steel to British industry in 1950 averaged 273,000 tons a week. In the first nine months of 1951, it averaged 273,900 tons a week, but this was possible only because exports had dropped from 62,500 tons to 55,000 tons a week; the production of crude steel in the first three quarters of 1951 was only 300,500 tons a week, compared with 310,700 tons in the corresponding period of 1950. In October and November, output averaged 308,000 tons a week, but this was 28,000 tons a week less than in October and November, 1950. The shortage of steel-making materials is so acute that the furnaces are working on a "hand to mouth" basis. A temporary shortage of pig iron, for example, closed ten of the 27 open-hearth furnaces in the West Wales area of Richard Thomas and Baldwins, Limited, at the beginning of December, 1951.

Supplies of iron ore have been improving and the output of pig iron in the first nine months of 1951 was 200 tons more than the average of

these metals should improve in 1952, if only slightly. Efforts are being made to increase production of manganese, nickel, cobalt, tungsten and molybdenum. A report to the Conference by the sub-committee on the utilisation of these five metals forecasts an increase in the production of nickel of 30 per cent. by 1954. Supplies of all the materials with which the Conference is concerned will, however, still be very tight, and they will be available only for essential uses, i.e., defence. Lead, for which no allocation scheme has been announced, is an exception; according to some reports, there should be sufficient to meet all requirements in 1952.

Supplies of fuel and power to the engineering industry in 1952 will be no better than in 1951. The British Electricity Authority, who greatly speeded up their programme during the summer, added 524 MW to the installed capacity in the ten months to October, 1951, but will still be unable to cope with the peak demand. Their attitude to Diesel generation in factories, however, has swung round from discouragement to positive encouragement. To stimulate the production of Diesel generators, the B.E.A., who themselves find Diesel generation uneconomic, have undertaken to buy from manufacturers all large-size units not taken up by British industry or by exporters. Mild weather and higher production have improved the prospect for coal supplies; stocks at the end of November were well over 17 million tons, 2 million tons more than twelve months earlier and just clear of the danger point. Coke supplies, however, are causing some anxiety, particularly to the small foundries. Supplies from the National Coal Board have been maintained, but industrial consumption has risen, largely as a result of increased demand from the blast furnaces; this in turn, is partly due to the high consumption of low-grade home iron ores.

Of the new Ministers who took office in November, none has a more difficult task than Sir Walter Monckton, the Minister of Labour. As he has stated, "something like 400,000 to 500,000 extra workers will be needed when the re-armament programme is in full stride." It may be that it will be possible to find this aggregate number, but that in itself is no easy task without comprehensive direction of labour, which would not be popular, and might be opposed by the unions. Much will depend on the effectiveness of the new credit control methods of the Chancellor of the Exchequer. These, although greatly modified to suit modern conditions, represent merely a return to the old principles of sound finance. In so far as they succeed in checking inflation and in denying credit to less essential industries, labour will automatically be forced into essential employment. The rise in the interest rate can, however, be inconvenient to essential as well as inessential industries, and a restriction of bank lending can cause real hardship—and make exporting industries find it hard to compete—when rising prices of raw materials as well as shortages and production delays are already greatly straining cash resources. It may, however, put an end to the post-war phenomenon of "hidden" unemployment, by preventing some companies from finding sufficient working capital to keep on their books people who are under-employed.

Even assuming that Sir Walter can find an extra half million workers for re-armament and move them to the areas where they are wanted, little will have been achieved if they do not have the requisite skills. Sir Godfrey Ince, the Permanent Secretary to the Ministry of Labour and National Service, has made a special plea for shorter apprenticeships and has thrown out the idea that young men might be trained in two crafts in the time taken for one. Plans are in hand for reviving Ministry of Labour Training Centres, but progress so far has been disappointing. Experience at these centres in war time has shown, however, that adults can be made proficient in semi-skilled and skilled jobs in a remarkably short time, and suggests that apprentice training is at present too protracted. This, however, is of interest only for longer-range planning. For the present, a shortage of skilled men may hold up production at many key points in the re-armament programme. Even in the aircraft

industry, where production depends on jigs to a very large extent, it is not easy to obtain the indispensable minimum of skilled engineers required, and good draughtsmen are notoriously scarce.

The labour shortage in the aircraft industry deserves special mention, for, according to Air Chief Marshal Sir Guy Garrod, 150,000 are needed within the next 18 months. As originally drafted, the plan was to achieve in the year ending March, 1952, a level of production double that of 1950, and in the following year a level four times as great; but if labour is not forthcoming the air re-armament programme will remain "to a large extent on paper." In the past year, some companies have actually been losing employees and between December, 1950, and August, 1951, the whole industry gained only 12,300. Lack of housing and a tradition of insecurity in the aircraft industry, which as late as 1950 was dismissing large numbers of its employees, does not help recruitment, particularly when the present re-armament programme is officially announced to be of short duration.

In the United Kingdom, the Ministry of Supply have succeeded in providing the necessary machine tools on time, and there has been little delay to the

the United States, civilian users of machine tools are even worse off, for the Government have issued an order, effective from February 1, which reserves all machine-tool production for defence and supporting industries. As in the United Kingdom, the production of machine tools is seriously hampered by a shortage of skilled labour, and the new Order will mean that manufacturers of motor vehicles, refrigerators, etc., may be unable to offer a change of models in the coming year.

While British engineering will have to concern itself mainly with supply difficulties in 1952, it can by no means dismiss demand problems as insignificant. Abroad, the market for many products deteriorated during 1951, and in 1952 it may be difficult to maintain British engineering exports, though it is clearly of the utmost importance that they should not fall. Table II indicates that the volume of engineering exports in the third quarter of 1951 was higher than in the third quarter of 1950. With the exception of cutlery, implements, etc., and machinery, they were, however, lower than in the fourth quarter of 1950. The increase in the value of exports as shown in Table III, herewith, taken from the *Report on*

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

	1938.	1949.	1950.	1950.			1951.			Change in Jan.-Sept. 1951, compared with 1950.
				1st Qr.	2nd Qr.	3rd Qr.	1st Qr.	2nd Qr.	3rd Qr.	
Iron and steel, and manufactures thereof	44,556	126,600	156,071	36,956	38,044	38,135	37,342	41,775	38,153	+ 0
Non-ferrous metals, and manufactures thereof .. .	12,339	63,640	76,914	15,915	16,693	23,849	21,214	16,961	15,340	- 7
Cutlery, implements, instruments, etc.	9,028	45,240	50,212	12,252	12,014	12,447	13,324	16,037	16,526	+ 22
Electrical goods and apparatus .. .	13,430	79,080	83,913	20,283	19,907	21,389	20,018	24,247	25,892	+ 11
Machinery	57,868	278,600	319,059	79,963	76,378	76,269	78,945	92,118	93,957	+ 11
Vehicles	44,627	313,300	404,970	100,102	103,458	95,934	105,349	124,873	116,231	+ 14

TABLE IV.—UNITED KINGDOM: EXPORTS OF ENGINEERING PRODUCTS TO SELECTED AREAS. (£1,000: Monthly Averages.)

	1950, January to September.			1951, January to September.		
	Electrical Goods.	Machinery.	Vehicles.	Electrical Goods.	Machinery.	Vehicles.
United States	43	292	696	109	921	1,056
Canada	135	705	2,654	182	1,053	1,376
Other American-account countries .. .	90	564	621	105	644	913
Non-dollar Western Hemisphere countries .. .	418	1,767	2,144	494	1,904	1,505
Sterling members of Commonwealth .. .	2,846	9,303	11,599	2,982	10,941	12,540
Union of South Africa	562	1,953	1,372	710	2,584	1,720
Colonies	924	2,315	3,418	1,132	2,002	4,469
Iraq, Burma and Jordan	95	259	214	111	310	329
Non-sterling O.E.E.C. countries	1,300	5,618	8,440	1,407	6,499	10,354
O.E.E.C. possessions	39	427	456	71	542	676
Irish Republic and Iceland	278	758	814	348	906	963
Eastern Europe	128	1,603	374	165	1,115	663
Total	6,868	25,564	32,802	7,816	29,421	36,564

re-armament programme on that score. In the United States, it has been quite otherwise, and the aircraft production programme is far behind schedule because of a serious shortage of machine tools. Many of those required by the United Kingdom have had to be obtained in the United States, but the Government, who made a prompt assessment of requirements and ordered early, succeeded in obtaining a high priority rating from the United States Government for machines ordered. It was estimated that an extra 35,000 machine tools were required under the Defence Programme, of which about 15,000 to 16,000 could be supplied from home sources, leaving 19,000 to 20,000 to be imported. Of the machine tools to be imported, 7,500 have been ordered in the United States, and these were given a priority ranking equally with American Army orders. Some of those ordered in the autumn of 1950 had been delivered by June, 1951, and deliveries of the remainder will continue until the middle of 1952.

The measures taken to ensure delivery of the home-built machines provide the Government with yet another means of directing the country's economy along the lines they choose. In the early summer it was announced that home machine-tool deliveries to civilian users were to be cut by 35 per cent. over the next year and a half, "the extent of the cut," according to the Minister of Supply, "varying between types of tools and between various sections of the engineering industry." In

Overseas Trade, is largely the result of increased prices. Exports of vehicles in particular have suffered a severe setback; exports of cars in the period January to October, 1951, were 9 per cent. lower in quantity than in the corresponding period of 1950, and exports of wagons and trucks were 47 per cent. lower. The volume of machinery exports over the same period showed an increase of 3 per cent., but some items recorded substantial falls, for example, printing and bookbinding machinery, 12 per cent., and textile machinery, 3 per cent. Exports of other items, like machine tools and boiler-house plant, which fell in both instances by 2 per cent., were lower because of increased allocations to the home market. In some cases, there was a considerable and encouraging increase; exports of refrigerating machinery increased by 26 per cent. and exports of agricultural machinery by 14 per cent. In the vehicle group, exports of agricultural tractors increased by 33 per cent., exports of pedal cycles by 29 per cent., and exports of motor cycles by 27 per cent.

The disappointing level of exports in 1951 was not wholly due to market difficulties, for in the first quarter of the year shipping difficulties seriously hampered the flow of trade. The world shipping fleet is still hardly adequate for all requirements and little has been done to reduce port delays, the elimination of which, according to an estimate of the Organisation for European Economic Co-operation, could increase the carrying capacity of world

shipping by 25 to 30 cent. The prospect of adequate coal supplies this winter, however, means at least that valuable tonnage need not be diverted to bring expensive coal from the United States, and that there should be no major interruptions to the export traffic.

Table IV, opposite, taken from the *Report on Overseas Trade*, shows the distribution of engineering exports by countries. Conditions in the North American markets became much more difficult during the second half of 1951. Exports of metal and engineering products to the United States in the third quarter of 1951 averaged only 2.8L millions a month (2.2L millions in September) compared with 3.4L millions a month in the first half of the year. There was a recovery in October, however, and exports for the ten months to October were at a somewhat higher level than in 1950. British exports of motor cars to the United States for example, though, as with the home-produced American models, they have been hard hit by the restriction of consumer credit, were 6 per cent. higher than in 1950; exports of pedal cycles were 78 per cent. higher.

In Canada, the situation was rather better, except where exports of consumer goods, particularly cars, were concerned. In the first three quarters of 1951, exports of British cars to Canada averaged only 3,000 a month compared with 6,400 in 1950. Exports of machinery, on the other hand, were higher in the third quarter of 1951, averaging 1.3L millions a month compared with 767,000L a month in 1950. Exports of engineering and metal products to other members of the British Commonwealth also increased in 1951. In these countries, however, sales of consumer goods have not been maintained. The Australian Government, for example, had to take strong measures to curb the rising inflation, due partly to the very high prices obtaining for primary products and partly to over-investment in manufacturing industry. As from October, 1951, sales taxes have been imposed upon a variety of goods (20 per cent. on cars) and income tax has been substantially increased. Exports of cars to Australia in January to October, 1951, averaged 8,453 a month, 17 per cent. fewer than the monthly average for 1951, though some of this was caused by the acute shortage of shipping in the first quarter.

Exports of cars are a useful guide to the course of consumer demand in Western Europe. In the ten months to October, 1951, British car exports to Sweden, Belgium and the Netherlands were at an annual rate of 26 per cent., 22 per cent. and 13 per cent. less, respectively, than in 1950. Exports of metals and engineering products to members of the Organisation for European Economic Co-operation averaged only 44.4L millions a month in the third quarter of 1951, which is only slightly greater in value (but less in volume) than in the third quarter of 1950, and certainly much less in both volume and value than the average for the first half of 1951. These countries, moreover, are bound to be influenced in their import policy by the British action in restricting imports, for it is mainly their goods which are affected. Of the total saving in British imports, 100L millions will be found by subjecting to licensing control a wide range of canned foods, fruit and sauces. Some other products, including paper pulp and oils, and some machinery, will also be subject to control, making a further saving of 30L millions.

The restrictions applying so largely to Western Europe are thus essentially discriminatory and come perilously close to infringing the General Agreement on Tariffs and Trade. The post-war transition period, when nations are permitted by agreement a certain amount of freedom in imposing discriminatory restrictions, comes officially to an end in March, 1952, so that Britain will find it hard to justify the new policy at the next session, in June.

A recent report of the United Nations Economic Commission for Europe, *A General Survey of the European Engineering Industry*, draws attention to growing marketing difficulties which were besetting some sections of the European engineering industry in 1950. In their view, this is not due to over-capacity in the industry: the report points out that "it seems doubtful whether the rate of development of the engineering industry, at any rate in Western Europe, has been fast enough." This

appeared true over a year ago and is even more true now with the competing (and conflicting) demands of defence, home investment and exports, particularly—if long-term prosperity of the Western world is the objective—to under-developed regions overseas. Table V, herewith, taken from the

TABLE V.—*European Engineering Production by Countries.*
(Index numbers, 1938 = 100.)

	1948.	1949.	1950.	Planned 1952-53.
Austria*	88	137	178	168
Belgium, Luxembourg	136	132	122	164
Czechoslovakia*	149	162	193	286
Denmark	111	114	127	127
France	115	135	124	176
Western Germany†	34	57	84	86
Hungary	131	183	—	655
Italy	88	98	104	132
Netherlands	122	146	160	161
Poland*	174	216	268	341
Sweden	153	156	159	198
Switzerland	168	—	—	176
United Kingdom*	135	146	162	161
Total of countries listed	97	117	135	149

* Base year is 1937 = 100.

† Base year is 1936 = 100.

United Nations *General Survey of the European Engineering Industry*, shows that the volume of output in Europe, excluding Russia, was 35 per cent. higher than in 1938 and in Britain 62 per cent. higher. In the much shorter period, 1939 to 1947, however, the gross output of the engineering industry in the United States had increased by 78 per cent. The only European country to match this rate of progress was Russia, where, the report states, production increased by 100 per cent. between 1940 and 1950. The failure of the engineering industry in Europe to expand is squarely attributed to bad organisation and low productivity, and not to insufficiency of demand. The case, however, does not seem too well supported: high productivity in the United States is, to a large extent, the result of high wages, of a well-established tradition, and a large market, well drilled into accepting standard products.

In Europe, on the other hand, consideration of the requirements of a large number of widely different markets must be the rule, particularly in the case of the United Kingdom, which accounts for 37 per cent. of the engineering output in Europe outside Russia, and which exports 40 per cent. of its engineering products. It is true that there is scope, in some instances, for greater specialisation in Europe, particularly between countries. The report, for example, points out that undue weight is still being given in all the European countries to the production of the more traditional types of textile machinery, whereas production of more up-to-date types, concentrated in one or two countries, would be more efficient. It also claims that capacity for the production of agricultural machinery, particularly tractors, is now so great all over Europe that there is a danger not only of over-production, but of a failure to produce those types best suited to the needs of agriculture. Though there is a rising tide of economic nationalism, and though, admittedly, the prospect of specialisation as between countries can, perhaps, be exaggerated, further efforts can be expected in that direction, with full American backing.

The principal reason given in support of the plea for increased development in the European engineering industry is "that there are great potential markets in underdeveloped areas"; but the equipment required by these countries is of the type which lends itself least to specialisation. In any case, it is admitted that there is a "marked contrast between the enormous scale of equipment needs in underdeveloped countries overseas and the apparent development of effective demand." The only country with resources sufficient to change potential into effective demand is the United States, and no quick or spectacular results are expected from President Truman's programme. One interesting feature of the report is that it shows clearly how far the expansion in British exports has been possible because of the absence of German competition. British exports at 1948 prices increased by 1,250 million dollars to 2,350 million dollars between 1938 and 1948; total exports of all European countries, on the other hand, increased

by only 1,000 million dollars, and only part of the credit for breaking new ground can be given to the British engineering industry. German exports declined by 873 million dollars to 74 million dollars, so that a large proportion of the increase in British exports can be attributed to this. German competition is now becoming a factor of great importance in the export markets; in the first eight months of 1951, for example, Germany exported motor cars to the value of 42.5L millions, as many as in the whole of 1950.

Japanese competition, generally in cheap goods, is also growing and is a vital factor in those potentially rich undeveloped markets of the United Nations survey. Marketing problems are still of the greatest importance, and it is not easy to agree with the writers of that report that, as shortages increase, preoccupation with the problem of a sufficiency of demand for European engineering products has now largely passed. They are on much stronger ground when they suggest that further international efforts to promote increased productivity and trade are still needed. The new Government in the United Kingdom find themselves in a difficult situation, with little scope for major changes in industrial policy except in the financial field, and it is here that they have the greatest opportunity for increasing productivity. The tightening of credit is a first step in this direction. The next should be a modification of the tax system, for, as the United Nations report points out, "In the longer run there appears to be scope for a comparative examination of taxes and credit policies as they affect the level of production and prices of European engineering products. Particular attention might be given to the examination of taxes which prevent rapid amortisation of plant and equipment or tend to deprive workers of tools."

Government restrictions or policies, at the best, can only influence or modify. At bottom, it is the energy and foresight with which the engineering industry goes about its task which determines success or failure; and, during the next two years, which promise to be as difficult as any in the past, everything that management and workpeople can give will be needed.

INSTITUTION OF ELECTRICAL ENGINEERS—SUMMER MEETING.—The next summer meeting of the Institution of Electrical Engineers will be held in Ireland from Monday, June 30, to Friday, July 4, 1952. Further details will be published in due course.

EXPERIMENTAL OMNIBUS FOR NEW SOUTH WALES.—A new single-deck 'bus with an under-floor engine has been put into service by the New South Wales Department of Road Transport. It is based on a Leyland Royal Tiger chassis and is equipped with a special body which, if successful under test, will form a standard design for a fleet of 100 'buses. The body was designed in collaboration with the Transport Department by the Commonwealth Engineering Company, Limited, Graveville, New South Wales, to carry 43 seated and 27 standing passengers. It is integral with the chassis, the pillars being attached directly to the chassis outriggers and connected to each other by a single longitudinal at each side. The body overhangs the front axle by 7 ft., and the rear axle by 8 ft. 6 in. At each end is a double-folding door, electro-pneumatically operated and controlled by the driver.

PORTABLE BUILDINGS.—A new form of portable building has been introduced by Booth and Co. (England), Ltd., 39, St. James's-street, London, S.W.1. Known as the Uniport Altent, it is made in the shape of a bell-tent, the sides being built up from 18 panels arranged to form a regular polygon, one of which forms the door, and the roof from the same number of triangular-shaped panels. There are three types available, namely, the Senior, the Sixteen and the Outsize, but the design is the same in each case. For the Senior, which has a diameter of 14 ft. 4 in. and a height, measured to the eaves, of 6 ft. 7 in., 13-gauge aluminium is used for the side or wall panels and 14-gauge for the roof panels. As they are made from commercial-grade aluminium, the surfaces are clad with pure aluminium to resist corrosion. The Sixteen is the same size as the Senior, but is of lighter construction. The Outsize has a diameter of 17 ft. 6 in. and is constructed from 22 wall panels. The panels nest into each other when dismantled. The buildings are being marketed by the Unit Construction Co., Ltd., 34, St. James's-street, London, S.W.1.

EXPERIMENTAL PEAT-FIRED GAS TURBINE.

JOHN BROWN AND COMPANY, LIMITED, CLYDEBANK.

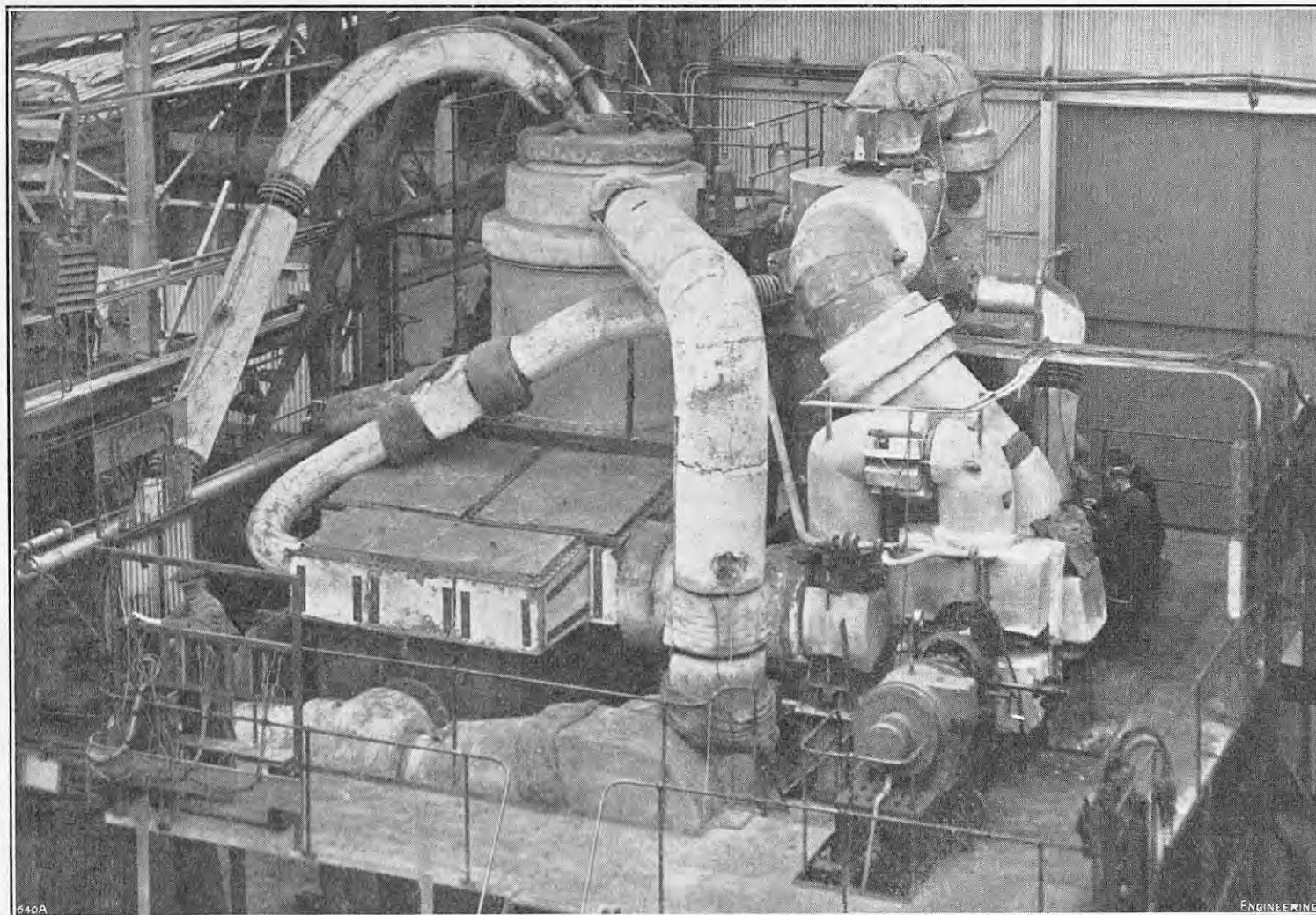


FIG. 1. GENERAL VIEW OF PLANT FROM AIR-HEATER OUTLET SIDE.

EXPERIMENTAL PEAT-FIRED CLOSED-CYCLE GAS TURBINE.

THE closing months of 1951 were marked by an even which will assuredly find a place in the history of gas-turbine development. On November 21, 1951, at the Clydebank works of Messrs. John Brown and Company, Limited, there came into operation the world's first peat-fired gas turbine. It is true that the use of peat as a fuel for the production of power is not new; and that Messrs. John Brown's plant is only an experimental one, employing a closed working-cycle and is, therefore, really a hot-air turbine with a peat-fired air "boiler." Nevertheless, its development is a creditable achievement.

The North of Scotland Hydro-Electric Board were the moving spirits in the new venture. Although the primary task of the Board is to develop the water-power resources of the Scottish Highlands, they are concerned also with other modes of electric power generation and, since their creation by Act of Parliament in 1943, have steadily pursued a policy aimed at restoring the economic prosperity of the Highlands,* for which the new development is fraught with potentially important consequences. In 1947, following a favourable report by their representatives on the closed-cycle gas turbine developed by the Escher Wyss company of Switzerland, the Board placed an order with Messrs. John Brown and Company, Limited, sole licensees of the Swiss company's gas-turbine within the British Empire, for a 12,500-kW closed-cycle gas turbine for the Carolina Port power station, Dundee. The construction of this plant is now well advanced.

Although the air-heater at Dundee is to operate on

heavy fuel-oil, the North of Scotland Hydro-Electric Board, from the start, had in mind the possibility of peat as a fuel. Large tracts of Scotland are thickly covered with peat, a substance which, when dried, has, weight for weight, about $2\frac{1}{2}$ times the bulk and half the calorific value of coal,* and burns readily, leaving a relatively small quantity—5 to 8 per cent.—of soft and comparatively innocuous ash. Accordingly, in 1949, the Board requested Messrs. John Brown and Company to design and construct a peat-fired air-heater suitable for use with their experimental gas turbine which was then in process of conversion to closed-cycle operation. The equipment was ready for test by September, 1950. After certain modifications to the burner and the peat-handling equipment had been made, satisfactory combustion was obtained early in 1951. It was also found possible to dry peat having a 50 per cent. moisture content by means of the waste gases from the combustion chamber, the moisture content being thereby reduced to 30 per cent. or less. After tests which were in progress using an oil-fired air-heater had been completed, in August, 1951, the turbine and its auxiliaries were dismantled and re-erected in the firm's gas-turbine test-house, where the peat-fired air-heater and peat-handling and drying plant were also installed. The plant was complete by the middle of November, 1951, and, as already mentioned, made its first run on its new fuel on November 21. Since then, it has completed some 50 hours of practically trouble-free running.

The gas turbine of the new unit has already been described elsewhere.† A brief recapitulation of its

history, however, may be of interest. It was designed by Messrs. John Brown and Company by the Parsons and Marine Engineering Turbine Research and Development Association (Pametrada) as an open-cycle experimental unit of 500 h.p. The working cycle was straightforward, atmospheric air being drawn into a 21-stage axial compressor having a nominal pressure ratio of 3.5 and exhausted to an oil-fired combustion chamber, the products of combustion from which were discharged to the atmosphere through a turbine driving the compressor and a water brake in tandem. At an early stage, this working cycle, on which the design of the turbine had been based, was modified by the inclusion of a heat-exchanger in which the air supply from the compressor to the combustion chamber was preheated by the gases discharged from the turbine.

The design work referred to above was commissioned in 1945 and the plant was built entirely at Clydebank, where it made its first run under its own power in June, 1948, using light Diesel oil as fuel. Performance tests showed that some modifications to the compressor blading were necessary and that considerable fouling was occurring in the compressor owing to the entrainment of atmospheric dirt which adhered to the blades. Arrangements for filtering the inlet air had, therefore, to be made before endurance trials could be attempted. Even with this modification, however, which inevitably reduced the efficiency of the plant, frequent cleaning of the compressor was found to be necessary. The plant completed over 1,000 hours of running as an open-cycle unit, and during the last 300 of these a heavier grade of fuel oil than Diesel oil was burned. It was found, however, that the ash deposits blocked the blade passages in the turbine and resulted in an additional loss of output.

At an earlier date, Messrs. John Brown and

* ENGINEERING, vol. 166, page 14 (1948).

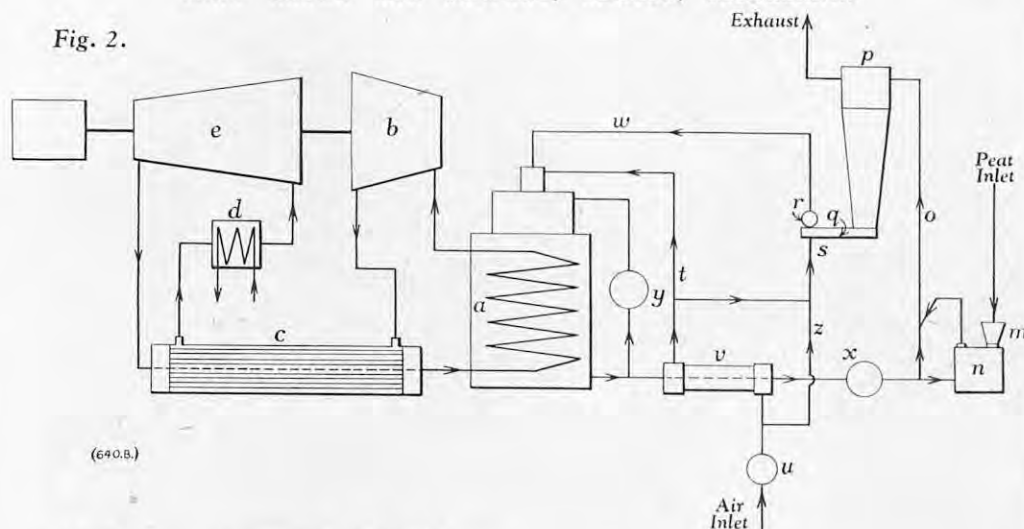
† J. B. Bucher, *Jl. Inst. of Engineers and Shipbuilders in Scotland*, vol. 93, Paper No. 1125 (1950); also *The Oil Engine and Gas Turbine*, vol. 16, March, 1949.

* ENGINEERING, vol. 172, page 313 (1951).

EXPERIMENTAL PEAT-FIRED GAS TURBINE.

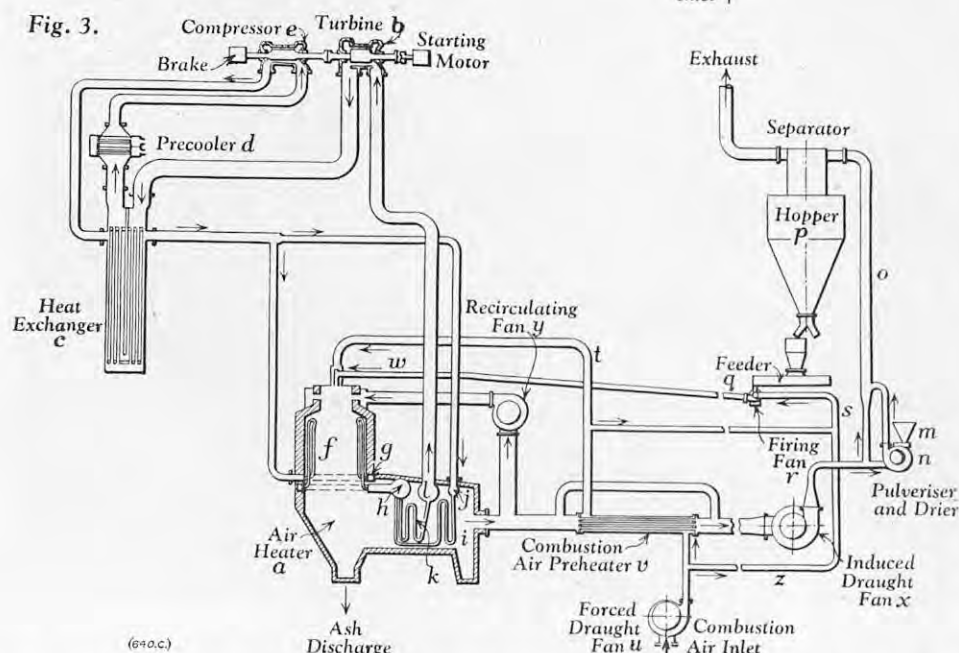
JOHN BROWN AND COMPANY, LIMITED, CLYDEBANK.

Fig. 2.



(640.B.)

Fig. 3.



(640.C.)

Company had reached the conclusion that, for marine propulsion—a potential field of application of the gas turbine in which they were naturally greatly interested—the closed-cycle turbine was likely to prove superior to its rival. By the end of 1948, sufficient experience had been gained from running the experimental set to suggest to the company that their preference for the closed-cycle design was to some extent justified and they decided, therefore, to convert the plant into a closed-cycle unit. An oil-fired air-heater was designed and built to replace the combustion chamber, and an air pre-cooler was installed between the heat exchanger and the compressor. The plant started up as a closed-cycle unit in December, 1949, and, between then and August, 1951, it completed 2,500 hours running on various grades of heavy fuel-oil. Endurance tests presented no difficulty. The output was considerably below the design figure, however, and, as the compressor had been designed to take in air at atmospheric pressure, the plant could not be pressurised to improve its efficiency. The same remark applies to its operation at present with the peat-fired air heater.

The peat-fired plant, as at present erected in Messrs. John Brown's works at Clydebank, is illustrated in Fig. 1, opposite, and Fig. 2, on page 10. The operating cycle is shown diagrammatically in Figs. 2 and 3, above, the latter including some details of the internal arrangement of the air heater. The size of the installation may occasion some surprise, since its output is considerably less than 500 h.p., but it has to be remembered that the installation is an experimental one. It is estimated that, were the complete plant to be designed afresh, a peat-fired unit of 2,000 h.p. could be accommo-

dated within the same space. On referring to either of the schematic layouts of Figs. 2 and 3, it will be seen that the closed cycle of the turbine is on the left and may be considered separately from the rest of the diagram. Air, heated in the combustion chamber *a* enters the turbine *b* at a temperature which, under present operating conditions, is approximately 1,100 deg. F. The corresponding pressure is of the order of 30 lb. per square inch gauge. The air leaves the turbine, at a temperature of about 700 deg. F. and a pressure which is approximately atmospheric, and passes to the heat-exchanger *c*. The latter is mounted vertically, and the hot air entering at the top of the exchanger passes downwards to its base through one half of the tubes and upwards again through the other half before leaving it. The temperature of the air is then approximately 400 deg. F. and undergoes a further considerable reduction in the water-cooled pre-cooler *d* before the air enters the compressor *e*. After compression, the air, now at a temperature of approximately 250 deg. F., returns to the heat-exchanger, where it is warmed by passing over the outside of the tubes containing the air discharged from the turbine before returning to the tubes of the peat-fired air-heater *a*.

A schematic arrangement of the interior of the air-heater is shown in Fig. 3. The heater itself is the partly cylindrical chamber which is the central feature of Figs. 1 and 4. Its steel shell is lined with refractory brick, and, in its upper and cylindrical portion, the heater is furnished with a cylindrical array of tubes *f*, illustrated in the photograph reproduced as Fig. 5, on page 10. The tubes are bent back on themselves so that their centre lines lie on two cylindrical surfaces, one of slightly smaller

diameter than the other, and they terminate in two headers, *g* and *h*, in Fig. 3. As will be seen both from the illustration and the diagram, the inner portions of the U-tubes, which, otherwise, would cause each tube to bend in a radial plane. Part of the air coming from the heat exchanger enters the header *g*, to which the ends of the shorter limbs of the array of U-tubes are connected, and thereby cools the chamber in a region where cooling is particularly desirable. After passing upwards through the inner limbs and downwards again through the outer ring, the air enters the second header *h*.

The remainder of the air coming from the heat-exchanger enters the heating chamber in the rectangular section forming its outlet. At this point, an array of tubes *i*, bent somewhat as shown in Fig. 3, is installed across the exit duct. Some of these tubes are illustrated in Fig. 6, on page 10, the wires which are also visible being thermocouple leads. One end of each tube is connected to the header *h*, already mentioned, and the other is connected to the header *j*, which receives the inlet air. A second array of bent tubes *k* connects the header *h* to the header *l*, which is the exit header. All the heated air is conveyed through the last-mentioned tubes and is then returned to the turbine.

The burner of the heating chamber is illustrated in Fig. 5. It is mounted at the top of the chamber and is of the multi-jet type developed by the Fuel Research Station, East Greenwich. Pipes leading to the burner convey the powdered peat and the primary air, and also a supply of secondary air. A ring of ducts admits a part of the products of combustion which is recirculated in order to control the rate of burning. Also visible in the illustration is the nozzle for starting the burner on oil. The ash resulting from combustion is extracted at the base of the heating chamber. About 30 per cent. of the heat transfer is obtained by radiation in the cylindrical portion of the heating chamber; the remainder is obtained by convection.

The details of the heating cycle will be clear from Figs. 2 and 3. The peat, which has previously been macerated in an appliance known as a "hasher," is fed into the hopper *m*. In this condition, its moisture content is 50 per cent. or less. The plant was designed to operate with peat of 55 per cent. moisture content but, as a result of the comparatively dry autumn in Scotland, the peat at present being supplied to Messrs. John Brown and Company is considerably drier than this. From the hopper, the peat passes to the Atritor *n*, which is a standard type of coal pulveriser manufactured by Messrs. Alfred Herbert and Company, Limited, Coventry. Here, it is reduced almost to a powder between a series of fixed and rotating pins and is borne out on a draught of warm flue-gas coming from the combustion-air preheater. This draught, which has a temperature of about 600 deg. F., serves both to dry the particles of peat and to carry them up through a vertical pipe *o*, known as the drying tube, to a horizontal header joining two hoppers, *p*, in parallel. The first of these is a Multicell type, which collects the coarser particles, and the second a Centrecell type for the fine particles, both being standard products of Messrs. James Howden and Company, Limited, Glasgow. The fuel gases which, by this stage, have been cooled to about 175 deg. F., as a result of driving off the bulk of the moisture from the peat, then pass out to the atmosphere through an exhaust duct in the roof of the building.

The finely-divided and dried peat collecting at the base of the hoppers is fed by means of the Redler chain-feeder *q* to the firing fan *r*, the fuel intake being at a venturi in the pipe *s* which conveys the primary air. The secondary air passes through a separate pipe *t*, and both supplies, which enter the system from the atmosphere at the forced-draught fan *u*, are heated in the preheater *v* by means of the gaseous products of combustion to a temperature of some 750 deg. F. After entrainment of the fuel at the firing fan, the fuel and primary air are conveyed through the pipe *w* to the burner, the peat at this point having a moisture-content of just under 10 per cent. After combustion has taken

EXPERIMENTAL PEAT-FIRED GAS TURBINE.

JOHN BROWN AND COMPANY, LIMITED, CLYDEBANK.

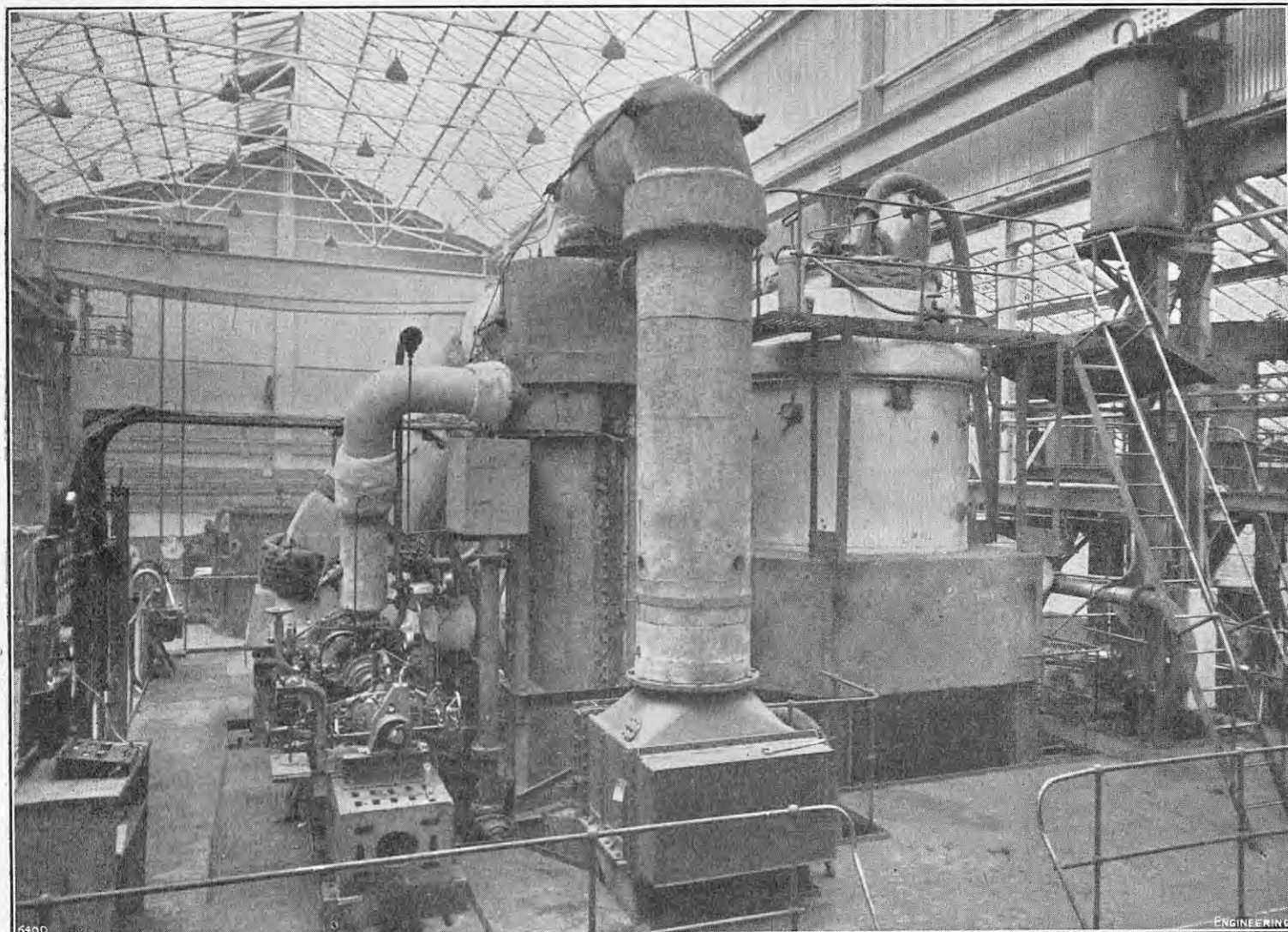


FIG. 4. GENERAL VIEW OF PLANT; PRE-COOLER IN FOREGROUND.

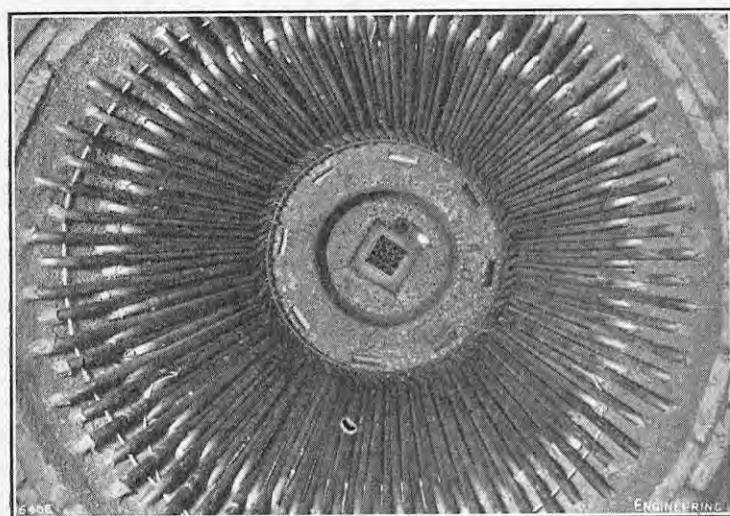


FIG. 5. CYLINDRICAL PORTION OF AIR HEATER; SHOWING BURNER.

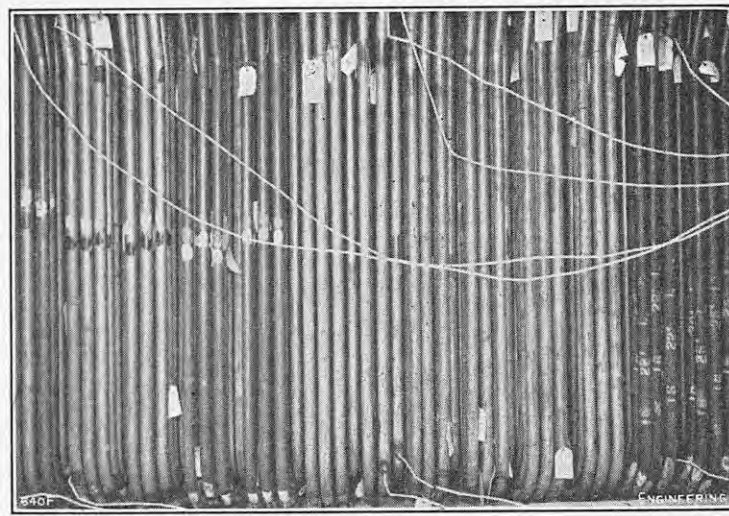


FIG. 6. NEST OF TUBES IN OUTLET OF AIR HEATER.

place at approximately atmospheric pressure, the hot gases, consisting mainly of carbon dioxide, pass down through the cylindrical portion of the heating chamber, turn through a right angle into the rectangular portion, pass through the nest of tubes, illustrated in Fig. 6, and leave the chamber at a temperature of about 1,200 deg. F., and at a pressure slightly below atmospheric, owing to the action of the induced-draught fan *x*. They then pass through the tubes of the combustion-air preheater, as already described, except that a portion of the gases, amounting to 50 per cent., approxi-

mately, is returned to the combustion chamber through the re-circulating fan *y* and its associated pipe-line, and serves to control the rate and temperature of combustion. The pipe *z* is a by-pass by which the temperature and quantity of the primary air may be controlled. It is normally closed.

As already mentioned, the burner is started on oil, and the turbine and compressor by means of an electric motor. The available output power is absorbed in a water-brake. It will be appreciated that the temperatures and pressures in the cycle

depend on the operating conditions, and the values which have been quoted are merely typical. The shaft speed is approximately 6,000 r.p.m. The plant was designed to consume 1,200 lb. per hour of peat having a 55 per cent. moisture content. The weight of air passing through the turbine at full load is approximately 9.3 lb. per second.

Most of the main parts of the installation are visible in Figs. 1 and 4. In Fig. 1, the turbine starting motor is on the right, with the ducting which brings the hot air from the heating chamber to the turbine behind it. The exit ducting leading

from the turbine to the top of the heat exchanger is immediately behind that and, beyond, is the pipe which leads from the compressor exit to the heat exchanger. In the background, is the duct which conveys the turbine gases from the heat exchanger to the precooler, which is seen in the centre foreground of Fig. 4. The vertical pipe to the left of the starting motor in Fig. 1, is the duct which conveys the recirculated portion of products of combustion back to the top of the heating chamber. Behind this pipe, the long inclined branching pipe conveys the air from the heat exchanger to its two entry points into the heating chamber. The pipes leading to the top of the heating chamber are those which carry the primary air and fuel, and the secondary air, the former pipe being unlagged. In the centre foreground of Fig. 1, the pipe leading to the combustion-air preheater is partially visible. The compressor and water brake are seen on the left, in Fig. 4, and, beyond the platform on the extreme right, part of the fuel hoppers. The chain feeder for the fuel, and the various fans are below the platform and are not visible in the illustrations.

The gas turbine is about to begin a series of extended trials to establish the reliability of the peat-fired heating chamber and to obtain precise figures for the thermal exchange. There seems little doubt, on its present showing, that it will come through its trials satisfactorily but, even in that event, it would be idle to assume that the way is open to the employment of peat-fired gas turbines on a grand scale for power generation. The major task, that of obtaining the requisite supplies of fuel economically, has still to be overcome. The North of Scotland Hydro-Electric Board have always been fully conscious of this aspect of the problem and at an early stage brought the matter to the attention of the Secretary of State for Scotland. The investigation of the means to be employed to win the peat is one which is outside the Board's province and primarily concerns the Department of Agriculture for Scotland. The action taken by the then Secretary of State was the appointment, in 1949, of a Scottish Peat Committee, on which all the interested parties were represented. The terms of reference of this committee, which is at present under the chairmanship of Sir Edward Appleton, Principal of Edinburgh University, are three-fold, namely, to advise upon a survey of Scottish peat deposits; to advise upon a programme of research into peat-burning gas turbines; and, lastly, to advise upon the commercial exploitation of Scottish peat deposits generally. The programme of research is financed by the Development Commission, which has provided 130,000*l.* for the purpose in the past two years.

The committee, which has been at work for fully two years, is to submit an interim report to the Secretary of State for Scotland in the near future. Under its direction, the Department of Agriculture have completed surveys of the Flanders Moss in Stirlingshire and Perthshire, and the Altnabreac Moss in Caithness. The Department is now in process of surveying the extensive Badenloch area of Sutherland. It appears that some 2,700 square miles of Scotland are covered by peat deposits more than two feet deep, and that nearly one-third of the deposits are at a reasonably low height above sea-level and have an average depth of about ten feet. This area could provide 350,000,000 tons of dried peat, which is the equivalent of the total coal production of Scotland over ten years. Moreover, were it possible to remove the peat, a considerable area of land suitable for agriculture or forestry would be uncovered. An example of what can be done in this way on a small scale is to be found in Perthshire and resulted from a remarkable experiment begun in 1766 by a certain Lord Kames, who succeeded in removing the peat from a considerable area of his estate and floating it down to the river Forth, thereby uncovering an extensive tract of arable land which supported numerous settlers and is still under cultivation. An account of the work of Kames and his successors has been given by Cadell.*

The methods employed by Kames, however, which

involved manual cutting of the peat, are not suitable for large-scale production, indeed, cutting and stacking by hand, as practised at present in the Highlands, is a seasonal occupation and, apart from being uneconomic, would be unsuitable for ensuring the continuous supplies necessary for power stations. Mechanised cutting and transportation must be adopted, and appropriate means for doing this are being studied. Machine cutting of peat is at present practised in Germany and Eire.* A second problem is that of drying the peat. In its natural state, peat is 90 per cent. by weight water. By natural drying in sun and wind, the water content can be reduced to 30 per cent., but the process is a lengthy one. About two-thirds of the water can be removed by pressure, but the product is then still nearly 70 per cent. water, and the remaining water, being combined with the solid matter colloiddally, can only be removed by heat or chemical action. Peat pressing has been developed in Germany, and the Ministry of Fuel and Power are providing presses which will be tested by the Department of Agriculture for Scotland, at Gardrum Moss, near Falkirk. A description of such presses has recently been given by Dr. H. Roxbee Cox.†

If satisfactory methods of cutting, drying and transporting peat can be devised, and if large peat-fired gas turbines prove to be practicable, the final stage of the development will probably involve the erection of power stations in the neighbourhood of extensive peat mosses capable of supplying their fuel requirements for a period of the order of 20 years. Such stations might operate continuously, or intermittently during peak-load periods. Examples of large peat-fired power stations already in operation are to be found at Portarlinton, Eire‡ (25 MW) and Wiesmoor, Germany (15 MW). Four thousand acres of land have already been cleared at Wiesmoor and are now under cultivation, and the waste heat from the power station heats a large area of greenhouses which produce annually 2,500,000 cucumbers and 2,000 tons of melons, tomatoes, raspberries and strawberries. These may not be among Britain's prime needs, but the German example at least shows what can be accomplished.

The alternative possibility in the case of peat-fired gas-turbines, namely, that of open-cycle working, is being investigated on behalf of the Ministry of Fuel and Power by Messrs. Ruston and Hornsby, Limited, Lincoln. Further details of the proposals have been given elsewhere.§

RUBERY, OWEN AND COMPANY, LIMITED.—The history and present activities of the Owen group of companies, of which Rubery, Owen and Company, Limited, Darlaston, is the principal, are recorded in "An Industrial Commonwealth," a book which the firm have published recently. The group consists of 28 companies whose products include structural steelwork, motor-car frames and wheels, pressed-steel parts, bolts and nuts, steel office furniture, front and rear automobile axles, pressed-steel pulleys, cutting and other tools, machine tools, fork-lift trucks, etc. The business has grown from a partnership formed in 1893 between J. T. Rubery and A. E. Owen; the two sons of A. E. Owen, who died in 1929—A. G. B. and E. W. B. Owen—now manage the business, which also has a branch firm in Australia.

IMITATION NICKEL-PLATE FINISHING PROCESS.—The recent Government orders restricting the use of nickel for plating purposes have given added interest to alternative methods of coating metals. Fortunately, important advances have been made recently in the development of such alternatives, a good example being furnished by the Nicklit finish, a treatment developed by Metal Processes, Limited, Kingsbury-road, Erdington, Birmingham, 24, which, it is claimed, gives an effective imitation of nickel plating on brass and copper articles. According to the manufacturers, the process changes the surface of the metal but leaves no deposit and does not affect the overall dimensions; fine limits, therefore, can be maintained. The Nicklit finish is obtained by straightforward immersion of the parts in a chemical bath, no electrical apparatus of any kind being required, and steel articles can be treated provided they are first plated with copper or brass.

* ENGINEERING, vol. 171, page 389 (1951).

† H. Roxbee Cox, "Some Fuel and Power Projects," 38th Thomas Hawksley Lecture, I.Mech.E. (1951), ENGINEERING, vol. 172, page 824 (1951).

‡ ENGINEERING, vol. 171, page 389 (1951).

§ H. Roxbee Cox, *loc. cit.*

SUPPRESSION OF EXPLOSIONS IN TANKS.

THERE are many industries in which inflammable materials, which can form explosive mixtures of combustible vapours, dusts or mists with air, have to be handled. The storage of fuel in tanks with an air space above it, the evolution of methane or firedamp at the working face in a coal mine, the machining of plastics and magnesium alloys, and food-processing plants, are examples that come readily to mind. An interesting approach to the suppression of explosions in such circumstances has developed from research into the mechanism of explosions of mixtures of air and petroleum vapours, during which it was found to be possible to extinguish an explosion in a confined space provided that the extinguishing medium was applied in the initial stages of the explosion before the pressure had risen greatly.

Up to the present the development of explosion suppression has been mainly concentrated on equipment for protecting the fuel tanks of military aircraft which may be exposed to the dangers of incendiary bullets. With the general adoption of kerosene fuel, this hazard has been intensified, because explosive mixtures of kerosene vapour and air can exist, under the pressures prevailing at high altitude, over a wider range of temperatures than an explosive petrol-air mixture. The equipment, which is made by the Gravier Manufacturing Company, Limited, Poyle Mill Works, Colnbrook, Buckinghamshire, is completely automatic in operation; it is light in weight and requires little servicing.

We had the opportunity recently of seeing a film, produced by the Royal Aircraft Establishment, of an impressive demonstration of explosion-suppression equipment in action. Pairs of fuel tanks, identical except that one was equipped with explosion suppressors and the other was not, were exposed to incendiary-bullet gun-fire. The tests were carried out with a petrol-kerosene mixture producing an explosive vapour-air mixture. In every case, a violent explosion occurred in the unprotected tank, causing the tank to burst and the fuel to flare up. In the protected tanks, although the initiation of an explosion was revealed by a slight rising of the tank under pressure and a puff of smoke, the suppression equipment was effective in extinguishing the explosion before the pressure had risen sufficiently to burst the tank walls.

The possibility of suppressing explosions of inflammable vapour mixtures was first demonstrated by two research chemists, Mr. W. G. Glendinning and Mr. A. M. MacLennan, of the Royal Aircraft Establishment.* In carrying out investigations on the pressures developed by petrol-air and kerosene-mist explosions, they observed that, after 10 milliseconds, the pressure had risen to less than 1.5 lb. per square inch. Preliminary experiments were carried out successfully in a 5-gallon laboratory vessel with a kerosene-spray/air mixture, to see whether an explosion could be arrested before it had developed fully. The vessel contained a metal bellows which, under a rise of pressure of $\frac{1}{2}$ lb. per square inch, closed a switch setting off a detonator immersed in a glass container filled with carbon tetrachloride. The mixture was ignited by an electric spark. As the pressure in the vessel rose and the detonator fired, the glass container broke and dispersed the extinguishing liquid. Oscillograph records showed that, with the suppressor in action, a maximum pressure rise of only $1\frac{1}{2}$ lb. per square inch was experienced.

Fig. 1, on page 12, shows the results of further investigations on normal and suppressed explosions of hexane/air mixtures in a transparent spherical vessel; the hexane/air mixture explodes much more rapidly than either a petrol/air or kerosene/air mixture. High-speed oscillograph measurements of the pressures developed are plotted against time for unsuppressed and suppressed explosions. In the unsuppressed explosion, the pressure had risen to nearly 5 lb. per square inch after 15 milliseconds, and continued to rise to more than 90 lb. per square inch after 45 milliseconds, whereas the maximum pressure recorded in the suppressed explosion was less than 3 lb. per square inch. The detonator operated 10 milliseconds after the explosion had started. Within 15 milliseconds the explosion was extinguished.

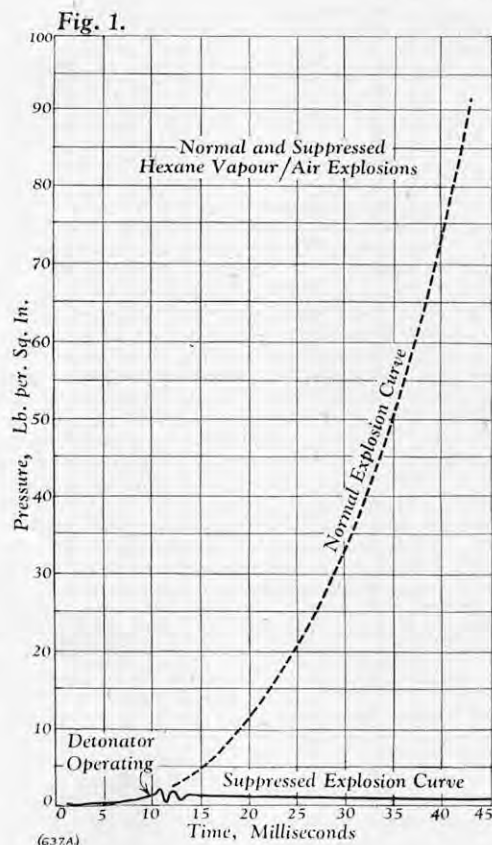
In 1949, the Gravier Manufacturing Company, Limited, undertook further development of explosion-suppression equipment, which was patented under British Patent No. 643,188. The two units, the detector and the suppressant distributor cup, are secured to the walls of the fuel tanks in suitable positions. Figs. 2 and 3, on page 12, show the Gravier repeating explosion detector, which is arranged to close the contacts of the suppressor circuit only when the rate of pressure rise exceeds a predetermined value, ranging between 50 lb. and 300 lb. per square inch per minute,

* Suppression of Fuel-Air Explosions," by W. G. Glendinning and A. M. MacLennan, *Quarterly of the National Fire Protection Association*, vol. 45, No. 1, July, 1951.

* H. M. Cadell, *The Story of the Forth*, James Maclehose and Sons, Glasgow (1913).

SUPPRESSION OF EXPLOSIONS IN TANKS.

THE GRAVINER MANUFACTURING COMPANY, LIMITED, COLNBROOK.



according to the application. By this means the "triggering" of the detector by pressure changes caused by rapid descents in altitude, by impact loads during servicing, or by pressure-fuelling, is eliminated, since the speed of propagation of explosion pressure is much greater than that of other sources of pressure waves. The detector consists of two spring diaphragms in a housing sealed by a film against the entry of liquid. Between the diaphragms is an air space. Small carefully-calibrated orifices in each diaphragm provide communication between the enclosed air space and the surrounding atmosphere, so that there is a balance of pressure on the diaphragms unless the pressure of the atmosphere increases suddenly in an explosion. In that case, the diaphragms will deflect, closing a pair of electrical contacts, when the pressure has attained a value sufficient to overcome their spring force; they are usually set to operate at about $\frac{1}{2}$ lb. per square inch. When pressure balance is re-established, the spring diaphragms return to their normal position and open the contacts of the suppressor circuit.

A cross-sectional diagram of the Gravier distributor cup, which is filled with suppressant fluid, is shown in Fig. 4. It consists of a sturdy base casting, which also forms the detonator housing, and a frangible hemisphere which is sufficiently tough to withstand the impact of the detonation of an adjacent distributor cup in a multiple-shot system. When the detonator is set off, the distributor cup breaks into fairly large pieces, which cannot clog the fuel filters, and the suppressant fluid is sprayed in a blanketing cloud at a speed of about 300 ft. per second, much higher than the initial speed of advance of a hydrocarbon flame front, which is of the order of 5 ft. per second. Special high-speed explosive detonators are essential since the action of the suppressant must be accomplished within the shortest possible time; with the Gravier equipment, the suppressant is distributed within 5 milliseconds of ignition, and the maximum pressure developed does not exceed 3 lb. per square inch. By suitably selecting the detonator location and the shape of the distributor cup, it is possible to protect vessels of widely varying shape. The high-speed detonators scatter the fluid in the distributor cups in the form of hemispheres, the effective radius of which depends upon the size and contents of the cups. Various detonators are available which enable cups of 100 c.c. capacity to extinguish effectively within a radius of 12 in. to 15 in., 225 c.c. cups within a radius of 15 in. to 18 in., and 535 c.c. cups within a radius of 24 in. to 30 in.

In the United States, suppressor cups are being tried out for extinguishing fires in aircraft-engine compartments. The following is an extract from a progress

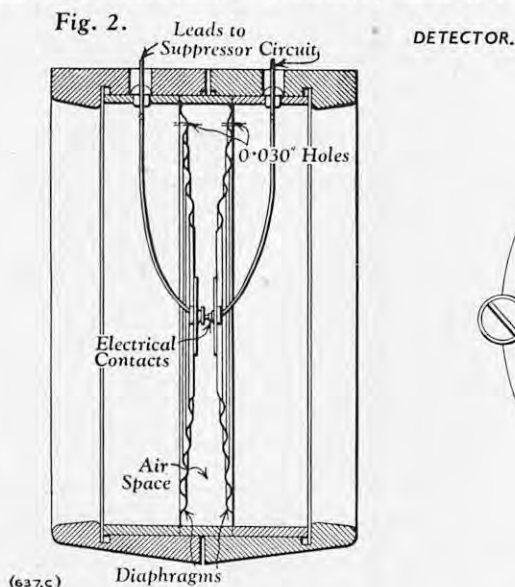
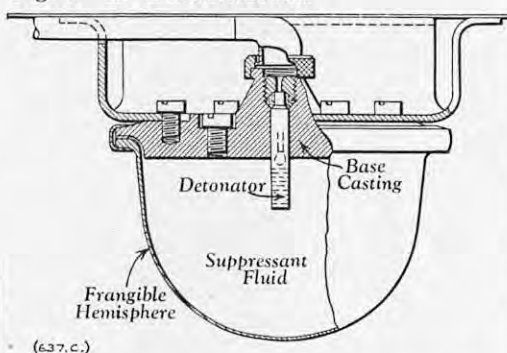


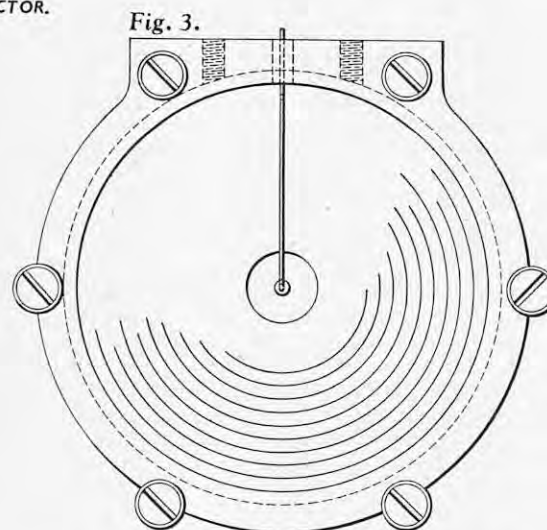
Fig. 4. 225 C.C. DISTRIBUTOR.



report issued in February, 1951, of the aircraft fire prevention programme of the Civil Aeronautics Administration, carried out at the Technical Development and Evaluation Center, Indianapolis, Indiana, U.S.A. "Fire tests conducted in the No. 3 engine compressor compartment have indicated that considerable advantage can be gained by utilising high rates of extinguishing agent discharge, even at the expense of duration of discharge. High discharge rates have been found to be very effective in extinguishing fires and appear to eliminate the need for careful distribution of agent by perforated plumbing. In the light of this information, we propose to conduct tests in the near future to determine the practicability of utilising frangible extinguishing agent containers and explosives to obtain very high discharge rates. Such containers could conceivably be located in a fire zone and would eliminate the use of plumbing and high-pressure cylinders." Further progress reports issued in May indicated that the fire-extinguishing properties of the distributor cups compare favourably with conventional systems, with a considerable saving in weight. Photographic records are taken to determine the size and shape of the distributor pattern and the approximate rate of discharge that can be expected.

It has been determined that, for every gallon of tank space, 10 c.c. of suppressant fluid are sufficient to give protection against explosion when the tanks are under atmospheric pressure; the amount of fluid required is proportional to the pressure. It will thus be seen that the weight of the equipment can be kept very low; the detector weighs 10 oz., and a distributor cup of 225 c.c. capacity, filled with carbon tetrachloride, weighs 1 lb. 2 oz. For fuel tanks, the fluid selected for suppressing the explosion should be miscible with the fuel and must not interfere with combustion in the engine. From this point of view, carbon tetrachloride is a suitable fluid; it extinguishes the explosion partly by altering the fuel-air ratio and rendering the mixture inert, and partly by cooling. For applications where the adulteration of the fuel is not important, water is highly effective and is lighter than carbon tetrachloride; its action is mainly by cooling. In experiments on hexane-air explosions, hexane has been successfully used as a suppressant, causing the mixture to become too rich to support combustion.

In America, development work on the Gravier system is carried out under licence by Messrs. Simmonds



Aerocessories, Limited. They have recently carried out tests on interconnected fuel tanks.* When an explosion occurs in one of the tanks, and no protection is provided, the explosion is likely to spread to the adjacent tank. If suppressant distributors are fitted in each tank, and an explosion occurs in one tank, it has been found that sometimes the firing of the distributor in that tank may trigger the detector in an adjacent interconnected tank; it is therefore suggested that the response pressure of the detector in each interconnected tank should be adjusted individually. As already mentioned, the possible need for providing for the suppression of more than one explosion has been foreseen; the distributor cups are designed to withstand the impact of bursting cups, and the detector mechanism is repeating. In a multiple-shot system a sequence relay would be provided so that only one distributor cup at a time would be fired when the detector circuit closed.

Although little practical work has been carried out so far on other applications of explosion-suppression equipment, and it would appear that considerable development would be required for its application in large spaces, the inventors have in mind the possibilities of its use in dust-extraction ducts and in coal mines.

SPEECH AMPLIFICATION SYSTEM IN ST. PAUL'S CATHEDRAL.

BUILDERS of great cathedrals in bygone days were certainly not deterred by acoustical considerations. Most great buildings of the kind are too vast for speech from one point to be audible everywhere throughout their interiors at one time and, indeed, their resonance is such that speech even when audible is unintelligible, except comparatively near its source. It may well have been for such reasons that, in the past, services intended for large congregations were often mainly musical, and that it became common practice to hold separate services simultaneously in different parts of the same building.

St. Paul's Cathedral, London, is no exception to this rule, and for 250 years, its acoustical properties have presented a formidable problem for preachers and congregation. During the past 20 years, various schemes of speech reinforcement have been tried out in the building, none of which has been wholly successful. Direct amplification of speech from the pulpit, situated under the periphery of the dome, does not overcome the echo which is particularly bad at this point owing to the long reverberation time. The latter has been determined at 12 seconds in the empty cathedral, compared with 4 seconds in the Royal Albert Hall, $2\frac{1}{2}$ seconds in the Royal Festival Hall, and 1 second in the London Coliseum, under similar conditions. The difficulties are overcome, to some extent, in the present sound-amplification system by the use of a large array of loudspeakers concealed beneath the chairs and directed downwards towards the floor, but, in order to reduce the energy ultimately reflected from the roof and walls, most of the low-frequency components of the sound are suppressed, with the result that speech,

* "Report of Explosion Suppression Development," by Jack Isreeli. Society of Automotive Engineers Preprint, October, 1951.

SPEECH AMPLIFICATION IN ST. PAUL'S CATHEDRAL.

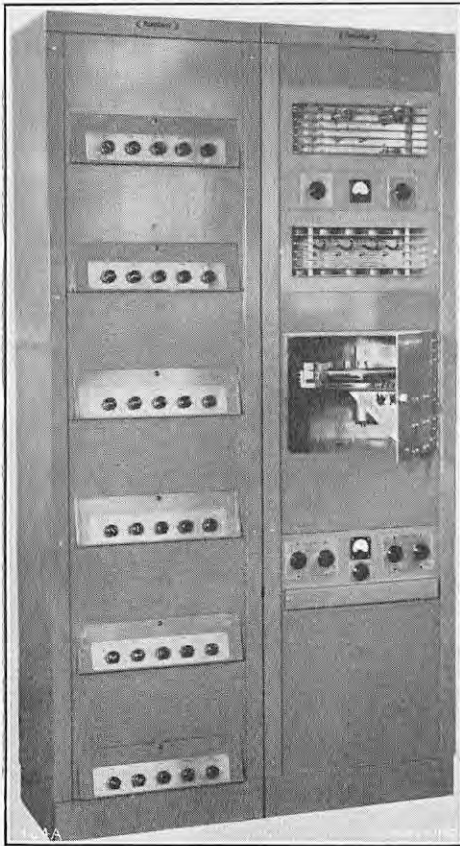


FIG. 1. AMPLIFICATION AND DELAY EQUIPMENT.

though audible and intelligible, has a thin and somewhat rasping character which not only becomes quickly irritating to a listener, but requires a major effort of concentration on listening, instead of leaving the listener free to concentrate on the spoken words.

As a result, however, of experiments undertaken by the Building Research Station of the Department of Scientific and Industrial Research, with the collaboration of Pamphonic Reproducers, Limited, Westmoreland-road, London, N.W.9, a system of speech amplification and distribution has been developed which is a considerable improvement on the existing one, installed some three years ago, and has favourably impressed the Dean and Chapter, although it has not yet been tried out in the presence of a large congregation or been accepted officially. The success of the system depends on a combination of scientific principles of acoustics and techniques made possible by magnetic-tape recording. The natural qualities of the voice are largely preserved and the echoes are reduced considerably by directional reinforcement of the sound without excessive reduction of the frequency range. Furthermore, although there are a number of centres of projection, a listener has the impression that the sound is coming wholly from the pulpit, owing to the use of a delay system.

The main projection unit is a vertical column of loudspeakers mounted beside the pulpit. There are eleven 10-in. speakers spaced along the whole length of the centre line of the baffle board, and nine 3-in. speakers in a row to one side, but accommodated entirely on the centre panel. The small loudspeakers project the high frequencies and the large ones the lower frequencies, the demarcation frequency being approximately 1,400 cycles per second. Owing to the close spacing of the loudspeakers, each row approximates to a finite line source of sound and the projected energy, therefore, is concentrated mainly in a wide-angle wedge with its edge vertical and along the line of loudspeakers, and its width equal to the length of the line. There is, of course, some lateral spreading above and below, owing to the sources being of finite length, but the proportion of energy lost in this way is not great and the amount reflected as echoes from the roof is greatly reduced.

The main column of loudspeakers at the pulpit is supplemented by ten assemblies mounted on the pillars in the nave and connected in pairs. The same principle is employed, but there are seven loudspeakers of each size in each of the units. The baffles are mounted some distance above the congregation and are, therefore, inclined downwards slightly. For the benefit of those who may visit the cathedral and see the installation, it should be emphasised that the present arrangement



FIG. 2. TURNTABLE MECHANISM OF DELAY EQUIPMENT.

is experimental and does not represent a finished design. A microphone is at present installed in the pulpit and it is intended that there shall also be microphones at other points within the cathedral.

The amplifiers and delay equipment are housed in the crypt, and are illustrated in Figs. 1 and 2, herewith. As regards the latter, it may be mentioned that if the amplified speech were projected from all the loudspeakers simultaneously, the sound heard by a person sitting in the nave would appear to reach him from the nearest projection unit, that is one of those installed on the pillars. This is because, as a result of what is known as the Haas effect, a person determines the direction of a source of sound very largely by the slight difference in the arrival times of the wave trains at the two ears. The relative intensities at the ears, of course, also play a part, especially when the source is close at hand. If a listener at the east end of the nave were, say, 20 ft. from one of the loudspeaker columns in the nave and 130 ft. from the main column beside the pulpit then, with simultaneous projection from these sources, the sound from the nearer source would reach him approximately one-tenth of a second before that from the other, and the sound, therefore, would appear to be coming from the loudspeaker in the nave. If, however, by means of a delay system, the sound emitted by the loudspeaker in the nave were delayed rather more than 0.1 second, the sound from the unit beside the pulpit would reach the listener first and he would think that all the sound was coming directly from the pulpit. This was recently strikingly demonstrated in St. Paul's, where the amplification system was demonstrated both with and without the artificial delay. With the delay in operation, the illusion that all the sound was coming from the pulpit was maintained over the whole area normally occupied by the congregation, resulting in a great gain in realism.

Fig. 1 shows the racks containing the electrical equipment. There are six amplifiers of standard design mounted on the left. One of these is for direct amplification of the input signal and supplies the main column of loudspeakers; the others amplify the delayed inputs and supply the five pairs of units on the pillars of the nave. Each amplifier is equipped with a volume control and separate controls for base and treble. The racks on the right contain a mixer unit for inputs from different microphones, the delay unit and the power pack. The principal part of the delay unit is shown in greater detail in Fig. 2. It consists essentially of a motor-driven turntable, similar to that used in a gramophone but having a tape of magnetic material mounted round its periphery. The tape is used to record the speech, and the recording is done by means of a recording-head mounted on the baseboard close to the periphery of the turntable so that the tape passes between the pole pieces. Five similar heads are stationed at intervals round the periphery to pick up the signal after it has been recorded, and a sixth head, which contains both a permanent magnet and an electromagnet, erases the record from the tape before

it reaches the recording head again. Most of the erasing is done by the permanent magnet, the electromagnet, which is supplied with current at an ultrasonic frequency, serving merely to clean off any remaining "mush." In the illustration, the recording head is in the foreground, on the left, and the erasing head is towards the rear. The positions of the five pick-up heads, also in the foreground, can be varied to give the requisite delays for the five pairs of loudspeaker units in the nave. The equipment operates entirely on power from the supply mains.

Pamphonic Reproducers, Limited, who have provided most of the equipment and have been entirely responsible for the design of the delay equipment, are carrying out tests of similar equipment at Harringay Arena, London. Preliminary experiments were also made earlier by the firm at Wembley Stadium, the work having been in charge of Mr. Paul Taylor. The arrangement of loudspeakers to suit the architectural acoustics of St. Paul's was devised after tests by the Building Research Station, which were directed by Mr. P. H. Parkin, B.Sc., A.M.I.E.E. The installation is still partly experimental and a final appraisal of its effectiveness can be made only when the conditions are those for which it was designed, namely, with a large congregation in the cathedral. Nevertheless, a good indication of its performance has been obtained already. Until the equipment is used at services, however, it will not be known whether the sound is quite loud enough. The permissible amplification is limited by the feed back of the amplified sound into the microphone which, if too great, would cause instability in the form of "howling." To assist matters, a directional microphone, having a polar diagram of cardioid form, is employed in the pulpit, but the present limitation could be avoided completely by moving the main loudspeaker column farther away from the pulpit. Such a course, however, would result in some loss of realism, as the sound would no longer appear to come from the pulpit but rather from the column. Other methods of overcoming the difficulty are being investigated.

THE LATE DR. ERIC SEDDON.—We note with regret the death of Dr. Eric Seddon, at the early age of 45, at King's College Hospital, London, on December 27. Dr. Seddon, who was well known in the glass industry for his research activities, was a Yorkshireman by birth. He was educated at Batley Grammar School and at the University of Leeds, where he graduated B.Sc., subsequently obtaining the Ph.D. degree. From 1930 until 1938, he was at the University of Sheffield, first as research physicist, then as assistant lecturer, and finally as lecturer in the Department of Glass Technology, under Professor W. E. S. Turner, O.B.E., D.Sc., F.R.S. Dr. Seddon was appointed director of research to the United Glass Bottle Manufacturers, Ltd., at Charlton, London, S.E.7, in 1939, and had continued to serve in this capacity. He was a Fellow of the Institute of Physics and a vice-president of the Society of Glass Technology.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

STEELWORKS NEW YEAR HOLIDAYS.—Scottish steelworks and re-rolling concerns, in general, closed down on Saturday morning, December 29, and resumption notices were issued, in most cases, for a restart on Monday, January 7. During the week, fairly extensive repairs and overhauls to furnaces, machinery, and plant are being undertaken. If it were not for the raw-material shortage, the outlook for 1952 would be bright, since all the steel-consuming industries have heavy order books.

SHIPBUILDING ACTIVITY.—Scottish shipyards launched 119 ships aggregating 502,198 tons gross during 1951, representing decreases of six ships and 10,014 tons compared with 1950. Marine engineering shops produced propelling machinery totalling 450,074 h.p., or 82,100 h.p. less than in 1950. The shipyards enter 1952 with about 2,500,000 tons gross under construction, or to be built; about 2,000,000 tons of this is on the Clyde and 500,000 tons on the East Coast. Clyde orders announced during 1951 totalled nearly 1,250,000 tons gross.

COAL AND COLLIERIES.—Scottish miners produced about 250,000 tons more coal in 1951 than in the preceding year, the estimated output being 23,550,000 tons against 23,293,000 tons. The improvement reflected an expansion in production at small drift mines, their outputs in 1951 being 1,680,000 tons compared with 1,300,000 tons in 1950. Thirty-four of these mines were in operation as part of a short-term policy to replace output from collieries approaching exhaustion, to increase overall production, and to keep man-power effectively employed until the long-term major new sinkings in hand reach maturity. At one period during the year it appeared that the increase in output would fall far short of consumers' requirements, but the unusually mild weather from September onwards transformed the situation. Industrial users, in particular, enter the new year with good stocks, engineering firms having some 40 per cent. more in reserve than at this time in 1951.

TRADE POSITION OF SCOTLAND.—A warning that Scotland had still to feel the main impact of the rearmament programme was given by Lord Bilsland at the annual general meeting of the Scottish Council (Development and Industry) held in Edinburgh on December 14. Re-elected president, Lord Bilsland said that employment had been maintained until the present time by drawing on stocks of raw materials, but these had declined. Figures showed a considerable reduction in consumer demand, especially in the clothing and textile trades. On the other hand, order books in the heavy industries were very full. Negotiations were proceeding with a number of large firms in the United Kingdom and in North America, who were considering production in Scotland. Almost all of these were engaged in precision engineering, electronics, chemicals, or similar industries.

THE LATE DR. H. F. STOCKDALE, F.R.S.E.—Dr. Herbert Fitton Stockdale, who was Director of the Royal Technical College, Glasgow, from 1903 until his retirement in 1933, died on December 28, at his home in Helensburgh, Dunbartonshire, at the age of 84. A Yorkshireman by birth, Dr. Stockdale had both business and administrative experience when he was appointed secretary and treasurer of the College in 1899, at the age of 31. Much of the labour connected with the raising of funds and the arrangement of the present College building fell upon him. Dr. Stockdale's personality was reflected in the harmonious working of the numerous departments of the College. His mastery of detail was often the subject of comment in educational circles. In recognition of his services the degree of Doctor of Laws of Glasgow University was conferred upon him in 1919. He was also a Fellow of the Royal Society of Edinburgh.

CLEVELAND AND THE NORTHERN COUNTIES.

NORTH-EAST COAST GAS GRID.—A gas-grid system for the whole of the North-East Coast area is being put in hand by the National Coal Board in collaboration with the Northern Gas Board. Gas supplies from coke-ovens belonging to the National Coal Board and private owners and from gasworks of the Northern Gas Board will be linked together, and the aim is to concentrate production in the most economical centres between the north bank of the Tees and Blyth, in Northumberland. New coking plants are to be erected at Lambton and Fishburn, Co. Durham, and a new gasworks is being built at Howden-on-Tyne, Northumber-

land. The scheme is being carried out in stages, and it is anticipated that, after the first five-year period ending in 1956, gas production in the area will have risen from 122,000,000 cub. ft. to 150,000,000 cub. ft. per day.

M.S. "PORT AUCKLAND" DOCKS AT NEWCASTLE QUAY.—What is stated to be the largest ship ever to have sailed so far up the River Tyne for cargo loading, the 12,000-ton twin-screw motorship Port Auckland, docked at Newcastle Quay on December 23. She is a vessel of the Port Line Limited, London, and was built in 1949 by R. and W. Hawthorn, Leslie & Co., Ltd. She sails for New Zealand after taking on cargo.

LANCASHIRE AND SOUTH YORKSHIRE.

FREEDOM FROM POWER CUTS.—Sheffield has enjoyed a remarkable immunity from power cuts since the load-spreading scheme was started in September. The major factor has been the working of the staggered hours system in industry. It may be necessary to make power cuts in the New Year when there will be in operation the radio system of giving warning of impending cuts. Posters have appeared in public-service vehicles in Sheffield and Rotherham urging the necessity to exercise economy in the use of electricity at peak periods.

STEEL COMPETITION.—Sheffield manufacturers continue to carry on a considerable export business in spite of the rearmament demands. Germany is helped in competing by having no rearmament work to do, and, in some overseas markets, is taking business which formerly was given to Sheffield. Both Germany and Japan are outbidding Sheffield in South Africa and Ireland in the matter of edge tools, and in New York wood-boring bits from Japan are being offered at a little over one-half the price of comparable British tools. The quality of the Japanese product is said to be poor.

LADLE LININGS FOR FINLAND.—A consignment of refractory linings for steel ladles for Finland was given priority by British Railways to enable it to be put on board a vessel large enough to break through winter ice to Finland. The consignment was of 280 tons in 26 wagons and another 300 tons will follow in February. The order was the first of its kind to be received in this country from Finland, and was placed with the ganister firm, Chambers Bros., Stoke-street, Attercliffe, Sheffield, 9.

EMERGENCY FUEL.—In Sheffield and Rotherham, retail coal merchants have been delivering 14-lb. bags of patent fuel to householders who otherwise would have been without fuel. The Ministry of Fuel and Power has resumed the production of "Ovoid" briquettes, which have been a welcome addition to supplies of fuel, to augment house-coal allowances.

THE LATE MR. R. C. WADE.—We regret to learn from British Insulated Callender's Construction Co., Ltd., that Mr. Robert Capel Wade, B.Sc., A.M.I.E.E., their engineer in charge of the installation of the overhead equipment on the Manchester-Sheffield railway electrification scheme, died suddenly on December 20. Mr. Wade was born on August 10, 1905, and was educated at Rossall School and Birmingham University. Subsequently, he joined the former B.I. Cables Company in 1928 as an engineer in the Contract Department. Between 1928 and 1937 he had a varied experience on cable and overhead line contracts and, from 1937 to 1939, was assistant engineer in Warsaw for the electrification of the Polish State Railways. On his return from Poland, he worked as assistant to Mr. H. B. Davies on the Liverpool Street-Shenfield electrification. During the war he took charge of the company's airfield contracts, with headquarters at St. Neots, and, when the Manchester-Sheffield electrification was recommenced after the war, he was appointed resident engineer in charge of that work.

THE MIDLANDS.

ERECTING CABLE BY HELICOPTER.—A power cable crossing a thickly wooded valley on the Malvern Hills, Worcestershire, is to be placed in position with the aid of a helicopter. The normal method of laying the cable along the ground and then drawing it taut between poles at each side of the valley would have involved the destruction of many of the trees. The Midland Electricity Board are therefore to use the helicopter to take a light rope across the valley. A heavier rope will then be drawn across, and this in turn will be used to haul the cable into position. When it is in place, the cable will be about 100 ft. above the bottom of the valley. Mr. R. Mallet, sub-area manager for Worcester and district for the Board, saw helicopters being used for cable laying in the United States, and decided that the present operation could be effected similarly. The work will be

started during the first week in January if the weather is suitable.

DEFENCE ORDERS IN THE MIDLANDS.—Mr. S. A. Davis, regional controller for the Ministry of Supply in the Midlands, said at a Press conference on December 17 that more than 10,000 defence contracts had been placed in the area during 1951. Although, he said, this was more than double the quantity of orders placed in 1950, it would be further augmented in 1952.

THE STAFFORDSHIRE IRON AND STEEL INSTITUTE.—The Staffordshire Iron and Steel Institute, the oldest organisation of its kind in the world, is extending the activities of its associates' section: it is intended to provide lectures of a type specially suitable for the younger members. A meeting was held at Wednesbury on December 18 to discuss the re-organisation of the associates' section.

FERGUSON TRACTORS.—The Standard Motor Co., Ltd., Coventry, dispatched 72,899 Ferguson tractors in 1951. This is claimed to be the biggest output of a single model of tractor from any factory in Europe, and is 37.5 per cent. above the 1950 figure. Tractors now out-number motor-cars produced by the Standard Company.

BANBURY RAILWAY STATION.—Reports that work was to start early this year on the rebuilding of Banbury railway station (Western Region) have been denied by British Railways. Plans were drawn up in 1939 for the complete rebuilding of the station, but were shelved because of the war. British Railways state that a certain amount of temporary work is intended at Banbury in 1952, but that approval has not yet been received from the Ministry of Housing and Local Government.

IMPROVEMENTS AT BEECH TREE COLLIERY.—Pithead baths, built at a cost of 19,590/., have been opened at Beech Tree colliery, near Cradley, Staffordshire. Beech Tree is one of the few collieries still working the celebrated Thick Coal of South Staffordshire. It is to be mechanised in 1952, when electric winding gear will also be installed.

SOUTH-WEST ENGLAND AND SOUTH WALES.

DOWLAIS FACTORY TO CHANGE HANDS.—It has been announced that the Birmingham Small Arms Co. Ltd. intends to take over the factory of Harrison, McGregor and Guest Ltd., manufacturers of farming implements, at Dowlais, Merthyr, on February 1. At present the factory employs 180 persons. An official of the B.S.A. Co., who visited Merthyr recently, said that there was a possibility of the factory being extended.

CARDIFF'S HIGHEST BUILDING.—A medical training centre, to be built at Cardiff and to have between six and twelve storeys, will be the highest building in that city. The governors of the United Cardiff Hospitals' Board, who have been given a progress report, have been told that the Ministry of Health had suggested that the planning of the new teaching centre should be such as to permit the building to proceed in stages. The Board has been told by its working committee that the site available would not carry a hospital and school of the size contemplated, if low buildings were planned.

ALLEGED GO-SLOW TACTICS AT COLLIERY.—Area headquarters of the National Coal Board have decided to withdraw County Court proceedings against six Rhondda miners alleged to have adopted go-slow tactics. The proceedings resulted in a threat of a strike in the coalfield, and the hearing was adjourned until January 17. A deputation from the Fernhill Lodge of the National Union of Mineworkers met the area general manager and appealed to him successfully to withdraw the claims for damages for breach of contracts in view of the improved results at the colliery during recent weeks.

RAILWAY WORK NEAR WESTBURY.—The track beds of several sections of railway line between Westbury (Heywood-road Junction) and Patney & Chirton have recently been "blanketed," and an obsolete bridge over the Western Region main line near Westbury has been demolished by explosives. For the blanketing work, the line was almost completely closed for four weeks, during which the track bed was excavated 2 ft. 6 in. below sleeper level, and a layer of stone dust placed, followed by a layer of graded ballast. The bridge, a three-span brick arch structure, was prepared for demolition by first removing all brickwork except the arch rings and piers, using concrete breakers. Imperial Chemical Industries, Ltd., supplied the explosives and supervised the placing and blowing. A ring main of Cordtex was connected to 85 lb. of Polar ammon gelnite. The blow was entirely satisfactory, the piers being cut off cleanly at their bases and the outer arches at their springings.

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 MECHANICAL ENGINEERS.—*North-Eastern Branch*: Monday, January 7, 6 p.m., Neville Hall, Westgate-road, Newcastle-upon-Tyne. Annual Meeting. "The Measurement and Interpretation of Machinery Noise, with Special Reference to Oil Engines," by Mr. C. H. Bradbury. *South Wales Branch*: Tuesday, January 8, 6 p.m., South Wales Institute of Engineers, Park-place, Cardiff. Thomas Hawksley Lecture on "Some Fuel and Power Projects," by Dr. H. Roxbee Cox. *Scottish Branch*: Thursday, January 10, 7.30 p.m., Royal Technical College, Glasgow. "Steel Castings and the Engineer," by Mr. J. F. B. Jackson. **AUTOMOBILE DIVISION.**—Tuesday, January 8, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Steering and Stability of Single-Track Vehicles," by Mr. R. A. Wilson-Jones.

INSTITUTION OF ELECTRICAL ENGINEERS.—*South Midland Centre*: Monday, January 7, 6 p.m., James Watt Memorial Institute, Birmingham. "Protection of Electrical Power Systems: A Critical Review of Present-Day Practice and Recent Progress," by Mr. H. Leyburn and Mr. C. H. W. Lackey. *Mersey and North Wales Centre*: Monday, January 7, 6.30 p.m., Royal Institution, Colquitt-street, Liverpool. Joint Meeting with LIVERPOOL ENGINEERING SOCIETY. "Modern Developments in Electric Welding," by Dr. H. G. Taylor. *Measurements and Radio Sections*: Tuesday, January 8, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. (i) "Two Electronic Resistance or Conductance Meters," by Dr. L. B. Turner. (ii) "A Bridge for the Measurement of the Dielectric Constants of Gases," by Mr. W. F. Lovering and Mr. L. Wiltshire. *North-Western Centre*: Tuesday, January 8, 6.15 p.m., Engineers' Club, Manchester. "Electricity in Newspaper Printing," by Mr. A. T. Robertson. *North Midland Centre*: Tuesday, January 8, 6.30 p.m., Hotel Metropole, Leeds. (i) "Crystal Diodes," by Mr. R. W. Douglas and Dr. E. G. James. (ii) "Crystal Triodes," by Mr. T. R. Scott. *Southern Centre*: Wednesday, January 9, 6.30 p.m., Polygon Hotel, Southampton. "Domestic Electrical Installations: Some Safety Aspects," by Mr. H. W. Swann. *Scottish Centre*: Wednesday, January 9, 7 p.m., Heriot-Watt College, Edinburgh. "Transient Theory of Synchronous Generators Connected to Power Systems," by Mr. B. Adkins. *Institution*: Thursday, January 10, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. "Electricity in Newspaper Printing," by Mr. A. T. Robertson.

INSTITUTION OF PRODUCTION ENGINEERS.—*Halifax Section*: Monday, January 7, 7.15 p.m., George Hotel, Huddersfield. "Steam Turbine Manufacture," by Mr. A. C. Annis. *Dundee Section*: Tuesday, January 8, 7.45 p.m., Mathers Hotel, Whitehall-crescent, Dundee. "Production Engineering in Textiles," by Mr. G. A. D. Coghlan. *Preston Section*: Wednesday, January 9, 7.15 p.m., Bull and Royal Hotel, Church-street, Preston. "Manufacture of Steels," by Mr. C. C. Hodgson. *Birmingham Section*: Thursday, January 10, 6.30 p.m., Imperial Hotel, Birmingham. "Industrial Management and the Accountant," by Mr. A. B. Waring. *London Section*: Thursday, January 10, 7 p.m., Royal Empire Society, Northumberland-avenue, W.C.2. "Building a Locomotive," by Colonel G. Rigby. *Southern Section*: Thursday, January 10, 7 p.m., Polygon Hotel, Southampton. "Electronics as an Aid to Production," by Mr. J. L. Gray. *Rochester Section*: Thursday, January 10, 7.30 p.m., Sun Hotel, Chatham. "Induction Hardening," by Dr. R. H. Barfield.

JUNIOR INSTITUTION OF ENGINEERS.—*North-Western Section*: Monday, January 7, 7.30 p.m., 16, St. Mary's Parsonage, Manchester. Chairman's Address, by Mr. A. Eaton. *Institution*: Friday, January 11, 6.30 p.m., 39, Victoria-street, Westminster, S.W.1. "Aircraft Hydraulics," by Mr. E. H. Bowers.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Sheffield Branch*: Monday, January 7, 7.30 p.m., College of Technology, Pond-street, Sheffield. "Synthetic Resins as Foundry Sand Binders," by Mr. P. G. Pentz. *Burnley Section*: Tuesday, January 8, 7.30 p.m., Grammar School, Blackburn-road, Accrington. "Phosphor Bronze," by Mr. E. Jackson. *Lincolnshire Branch*: Thursday, January 10, 7.15 p.m., Technical College, Lincoln. "Production of Turbine Castings," by Mr. N. Charlton. *Middlesbrough Branch*: Friday, January 11, 7.30 p.m., at Messrs. Head, Wrightson and Co., Ltd., Teesdale Iron Works, Thornaby-on-Tees. "Process Planning in the Steel Foundry Industry," by Mr. S. L. Finch. *Lancashire Branch*: Saturday, January 12, 3 p.m., Engineers' Club, Manchester. "Examples of Loam Moulding: Ferrous and Non-Ferrous," by Mr. E. Clipson. *West Riding of Yorkshire Branch*: Saturday, January 12, 6.30 p.m., Technical College, Bradford. "A System of Castings Defects," by Mr. G. W. Nicholls and Mr. D. T. Kershaw.

INSTITUTE OF MARINE ENGINEERS.—Tuesday, January 8, 5.30 p.m., 85, The Minorities, E.C.3. "Diesel Hydraulic Propulsion," by Mr. F. J. Mayor.

INSTITUTION OF CHEMICAL ENGINEERS.—Tuesday, January 8, 5.30 p.m., Geological Society, Burlington House, Piccadilly, W.1. "Froth Flotation Kinetics," by Mr. William Gibb.

ILLUMINATING ENGINEERING SOCIETY.—Tuesday, January 8, 6 p.m., Royal Society of Arts, John Adam-street, W.C.2. "Control of Light in a Lighthouse Lens," by Dr. W. M. Hampton. *Edinburgh Section*: Wednesday, January 9, 7 p.m., 357, High-street, Edinburgh. "Measurement of Light in the Eighteenth Century," by Mr. H. Buckley. *Glasgow Centre*: Thursday, January 10, 6.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. "The Development of the Tungsten Lamp," by Mr. B. P. Dudding.

INSTITUTION OF WORKS MANAGERS.—*Merseyside Branch*: Tuesday, January 8, 6.30 p.m., Adelphi Hotel, Liverpool. "Management Practice in the United States," by Mr. E. Packer. *Birmingham Branch*: Tuesday, January 8, 7 p.m., Grand Hotel, Birmingham. "Production Economy," by Mr. T. A. Yapp. *Preston Branch*: Tuesday, January 8, 7 p.m., Starkie House, Starkie-street, Preston. "The Use of Gas in Industry," by Mr. J. Ward.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—*North-East Coast Branch*: Tuesday, January 8, 6.30 p.m., Neville Hall, Westgate-road, Newcastle-upon-Tyne. "School Heating," by Dr. J. C. Weston. *Institution*: Wednesday, January 9, 6 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "Fibrous Filters for Fine-Particle Filtration," by Dr. D. J. Thomas.

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—*Western Group*: Tuesday, January 8, 7.30 p.m., Grand Hotel, Bristol. "The Servicing of Brakes," by Mr. J. W. Kinchin. *East Midlands Centre*: Wednesday, January 9, 7.30 p.m., Mechanics Institute, Nottingham. "Use of Aluminium for Road-Vehicle Bodies," by Mr. R. Esmonde. *South Wales Group*: Friday, January 11, 7 p.m., South Wales Institute of Engineers, Park-place, Cardiff. Informal Meeting.

INCORPORATED PLANT ENGINEERS.—*Edinburgh Branch*: Tuesday, January 8, 7 p.m., 25, Charlotte-square, Edinburgh. "Organisation of Scientific Research in Great Britain," by Dr. H. Buckley. *East Lancashire Branch*: Tuesday, January 8, 7.15 p.m., Engineers' Club, Manchester. "Secondary Air and Its Application," by Mr. H. Hetherington. *East Midlands Branch*: Wednesday, January 9, 7 p.m., Welbeck Hotel, Nottingham. "Building a Passenger Liner," by Mr. J. Melville. *Kent Branch*: Thursday, January 10, 7 p.m., Queen's Head Hotel, Maidstone. "Automatic Combustion Control as Applicable to Industrial-Type Boilers," by Mr. S. J. Clifton. *Newcastle-upon-Tyne Branch*: Thursday, January 10, 7.30 p.m., Roadway House, Oxford-street, Newcastle-upon-Tyne. "Fuel-Injection Equipment," by Mr. W. H. Simpson.

INSTITUTION OF ENGINEERING INSPECTION.—*South Western Branch*: Tuesday, January 8, 7.30 p.m., Tramways Hall, Bristington. "Limits and Fits," by Mr. A. Conway. *Leeds Branch*: Wednesday, January 9, 7.30 p.m., Golden Lion Hotel, Lower Briggate, Leeds. Film Evening.

NEWCOMEN SOCIETY.—Wednesday, January 9, 5.30 p.m., Iron and Steel Institute, 4, Grosvenor-gardens, Westminster, S.W.1. "Early Refining of Pig Iron in England," by Dr. H. R. Schubert.

INSTITUTE OF PETROLEUM.—Wednesday, January 9, 5.30 p.m., Manson House, 26, Portland-place, W.1. "Some Aspects of Field Operations in Kuwait," by Mr. E. Boaden and Mr. E. C. Masterson.

BRITISH INSTITUTION OF RADIO ENGINEERS.—*North-Eastern Section*: Wednesday, January 9, 6 p.m., Neville Hall, Westgate-road, Newcastle-upon-Tyne. "Test Gear Design," by Mr. A. W. Wray. *London Section*: Wednesday, January 9, 6.30 p.m., London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. "Crystal Triodes," by Dr. E. G. James and Mr. G. M. Wells.

INSTITUTION OF STRUCTURAL ENGINEERS.—*Northern Counties Branch*: Wednesday, January 9, 6.30 p.m., Cleveland Scientific and Technical Institution, Corporation-road, Middlesbrough. "Reconstruction of Hondon-on-Tyne Gas Works," by Mr. W. R. Garrett.

INSTITUTE OF FUEL.—*North-Western Section*: Thursday, January 10, 2.30 p.m., Radiant House, Bold-street, Liverpool. "Progress in Domestic Heating Research," by Dr. A. C. Monkhouse.

INSTITUTION OF CIVIL ENGINEERS.—*Midlands Association*: Thursday, January 10, 6 p.m., James Watt Memorial Institute, Birmingham. "Sewage Purification," by Mr. David M. Watson.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, January 11, 6.15 p.m., Mining Institute, Neville Hall, Newcastle-upon-Tyne. "Fueling at Sea," by Mr. I. McD. Black.

PERSONAL.

SIR ERIC MIEVILLE, G.C.I.E., K.C.V.O., C.S.I., C.M.G., has been elected a director and chairman of Dewrance & Co., Ltd., in succession to Mr. HAROLD FORBES-WHITE, following the latter's resignation.

SIR EDWARD WILSHAW, K.C.M.G., had conferred upon him the honorary degree of LL.D., at a ceremony held on December 14 at the University of Birmingham.

SIR ALEXANDER AIKMAN, C.I.E., who has been chairman of Powers-Samas Accounting Machines Ltd. since 1945, has relinquished that position. His successor from January 1 is COLONEL A. T. MAXWELL, T.D., a director of Vickers Ltd.

PROFESSOR I. C. F. STATHAM, M.Eng.(Sheffield), M.Inst.Min.E., F.G.S., who was to have retired from the Chair of Mining of the University of Sheffield in September, 1952, has agreed to accept the invitation of the University Council to continue as Professor of Mining for a further two years from that date.

MR. ANDREW SPROT, who has been secretary of the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne, for the past 20 years, retires to-morrow, January 5, on his 65th birthday after 50 years of service with the company. His successor is Mr. F. G. APPLETON, at present assistant secretary.

MR. W. D. KENNEDY has joined the Bristol Aeroplane Co. of Canada Ltd., as general manager of Bristol Aeroplane Engines (Western) Ltd., at Vancouver, British Columbia.

MR. P. BUTLER, B.Sc., M.I.E.E., and **MR. W. B. LAING, A.H.-W.C., M.I.E.E.,** have been appointed joint general managers of Bruce Peebles & Co., Ltd., Edinburgh, 5, with responsibility to the managing director.

MR. H. F. FARMER, superintendent, control gear factory, British Thomson-Houston Co. Ltd., Rugby, on January 1, 1952, relinquished this position which he had held for 21 years, to join the works manager's department, Rugby, for special duties. He has been succeeded by Mr. P. J. DAWTON, who has been assistant superintendent under Mr. Farmer since October, 1940.

MR. DAVID HIGGS, B.Sc., son of Mr. WALTER F. HIGGS, M.I.E.E., chairman of Higgs Motors Ltd., Witton, Birmingham, 6, has been elected a director of the company.

MR. J. D. BLACK, engineer superintendent, pilot vessel service, Corporation of Trinity House, retired on December 31 and has been succeeded by Mr. A. R. MURRISON.

MR. J. STANLEIGH TURNER has been re-elected President of the Coal Utilisation Joint Council, the members of which have decided to revert to the pre-war title of Coal Utilisation Council. **SIR JOHN CHARRINGTON** has been re-elected vice-president of the Council.

MR. WALTER HART retired from the managing directorship of Kerry's (Great Britain) Limited on December 31, but will retain his seat on the board. **MR. W. NORMAN HART,** who has been a director since 1946 and assistant managing director since January, 1948, has been appointed managing director.

MRS. DORCAS E. CROFT has succeeded her late husband, **MR. STANLEY CROFT,** as chairman and managing director of Stancroft Ltd., 48, Lancaster-street, Birmingham, 4.

MR. W. P. JAMES, O.B.E., has been made Ministry of Transport licensing authority for the West Midlands Traffic Area, in succession to Mr. R. STUART PILCHER, C.B.E., F.R.S.E., M.Inst.T., who retires under the age limit on January 29.

MR. S. G. DEAVES, Mr. P. H. GIBBS and Mr. A. E. HUGHES have been appointed sales managers for various products of the British Tyre and Rubber Company Ltd., Herga House, Vincent-square, London, S.W.1. **MR. FRASER BRYANT** is to be sales manager at the firm's London depot, 6, Star-road, West Kensington, W.14.

MR. W. T. W. BALLANTYNE, formerly representative of the Society of British Aircraft Constructors in South America, has joined Armstrong Siddeley Motors Ltd., to act as liaison officer with the increasing number of firms now using that firm's aero engines.

LIVESEY and HENDERSON are removing from 14, South-place to National House, 12-18, Moorgate, London, E.C.2, as from Monday, January 7. Telephone: MONarch 2173-2171 and telegraphic address, "Livesey, London," remain unaltered.

DEWRANCE and Co. LTD. announce that their Birmingham office has been transferred to 630, Coventry-road, Small Heath, Birmingham, 20. (Telephone: Victoria 1478.) **MR. R. W. OGDEN** is the company's manager for this area.

VICKERS LTD., Vickers House, Broadway, Westminster, London, S.W.1, inform us that an error occurred in their announcement in connection with the African representation of Vickers-Armstrongs Ltd., reproduced in our "Personal" column at the foot of page 783 of our issue of December 21, 1951. **MR. D. W. STANLEY,** who will be chairman of Vickers-Armstrongs South Africa (Pty.) Ltd., was incorrectly given the title of chairman and managing director.

PROGRESS AT ERROCHTY HYDRO-ELECTRIC POWER STATION.

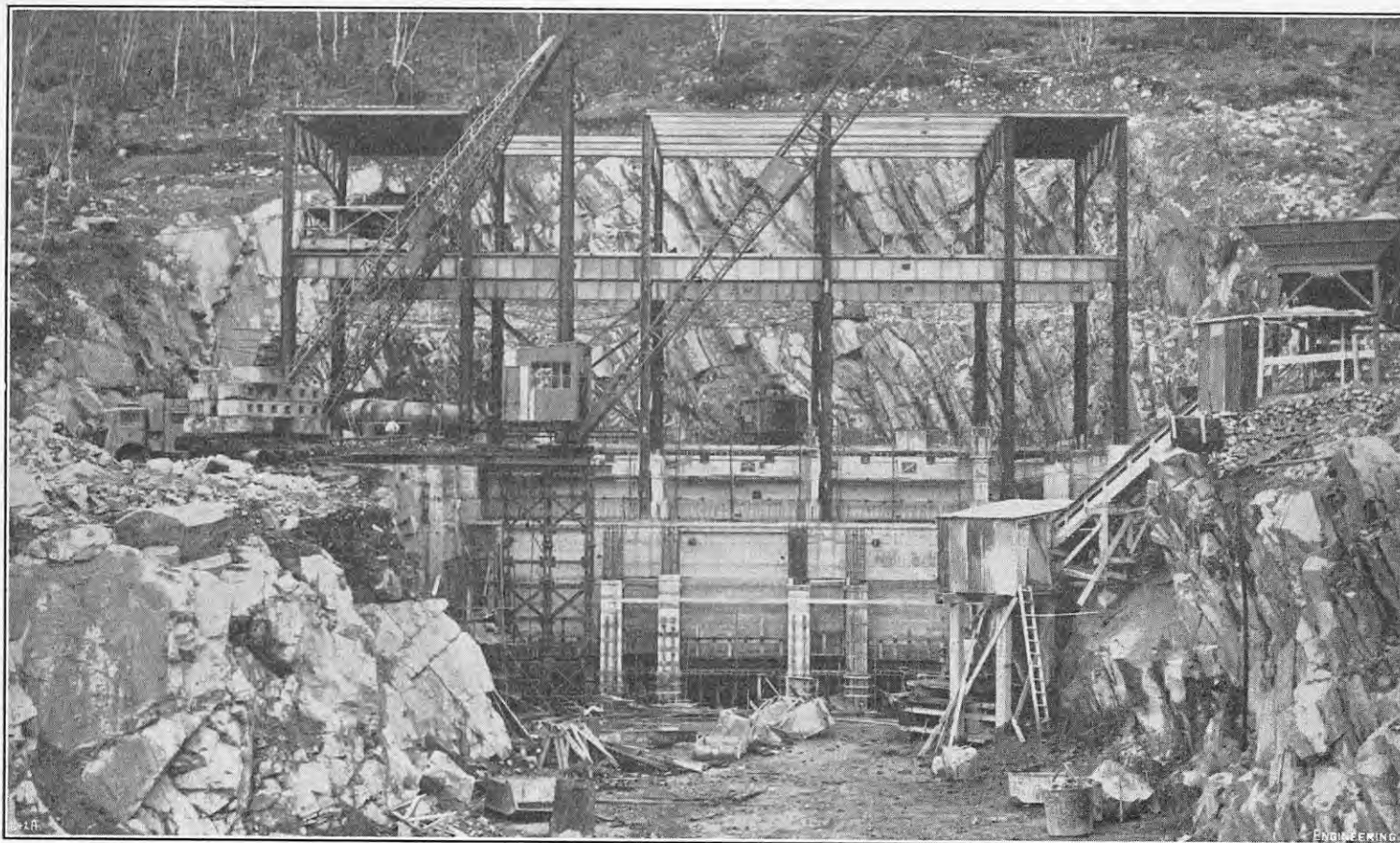


FIG. 1. GENERATING STATION UNDER CONSTRUCTION.

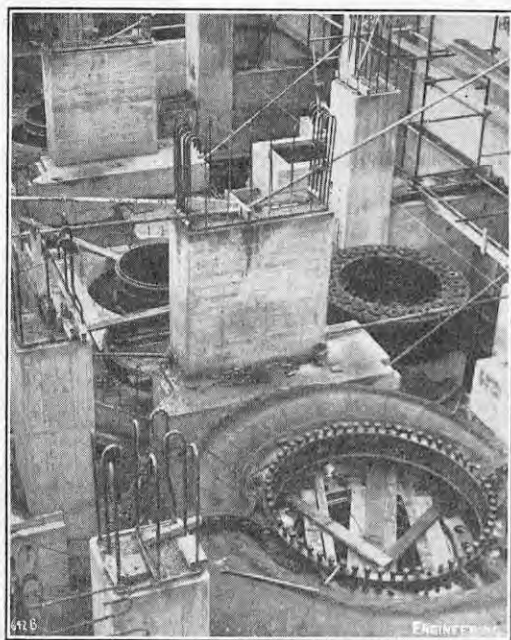


FIG. 2. INSTALLATION OF TURBINES.

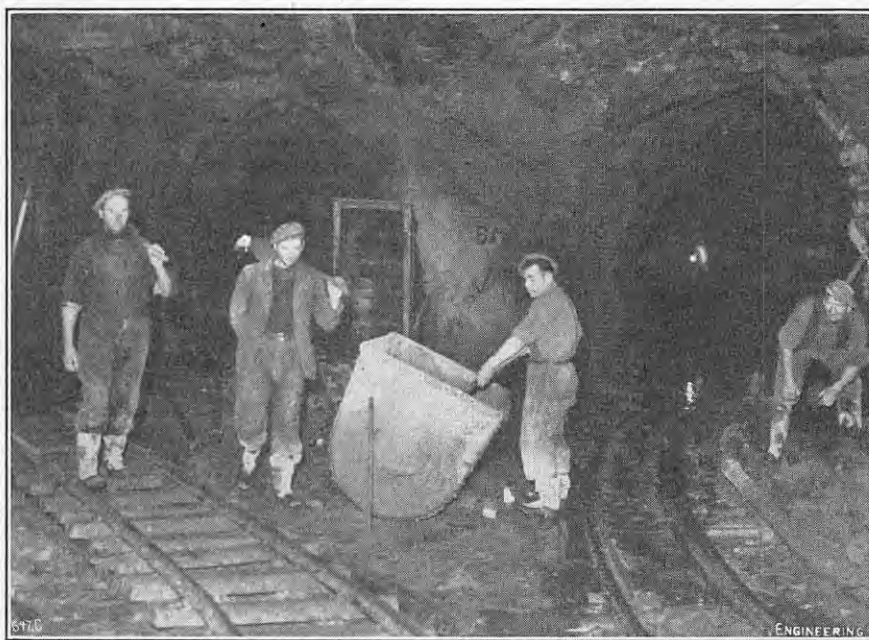


FIG. 3. CONSTRUCTION OF WATER SUPPLY TUNNELS.

PROGRESS AT ERROCHTY POWER STATION.

THE illustrations on this page show the present stage of construction of the Errochty hydro-electric power station, which is the last of the three generating stations associated with the North of Scotland Hydro-Electric Board's Tummel-Garry scheme. This, when finished, will provide approximately 300,000,000 units of electricity annually. The completed stations, those at Clunie and Pitlochry, were described in *ENGINEERING*, vol. 170 (1950). The partly-constructed Errochty power station, illustrated in Figs. 1 and 2, is situated near the western end of Loch Tummel, about 15 miles from Pitlochry, but the turbines will draw their water supply from the upper reaches of the River Garry and its tributaries. To make this possible, a tunnel six miles long and 15 ft. in diameter is being driven through

the hills from the power station to Glen Errochty, where a diamond-headed buttress dam, 1,310 ft. long and 127 ft. high, will be built. This will form a reservoir, $2\frac{1}{2}$ miles long and half a mile wide, the surface of which, when at its highest, will be 1,080 ft. above sea level.

The driving of the tunnel, done from both ends and also from intermediate points reached through an adit and the surge shaft, is nearly complete, but concreting the interior will take some months. The work is under the supervision of Sir Alexander Gibb and Partners, London. Some 1,000 ft. back from the power station, the main tunnel splits into three circular tunnels, each of 7 ft. 6 in. diameter, through which the water will be supplied to the turbines. The trifurcation is illustrated in Fig. 3. Three vertical Francis-type turbines, designed by Messrs. Boving and Company, Limited, and operating at a maximum head of 610 ft., are being installed, as illustrated in Fig. 2. Each will

drive an alternator of 25 MW maximum output, to be supplied by the General Electric Company, Limited.

In pursuance of the Board's policy of encouraging building in stone, the power station will be faced with stone excavated from the main tunnel. There will be no exposed pipes leading to the turbines, and the transformers will be hidden behind the building. The power will be supplied to the switching station by underground cable. At the other end of the tunnel, the excavator for the foundations of the dam is complete and a conveyor for the concrete aggregate is being installed. Construction of the dam will begin in the spring. Another 12 miles of diversion tunnels are being constructed from the site of the reservoir to collect the waters of a number of smaller streams. The Board have at present some 6,000 men working on power schemes at 12 different sites. Since they began operations, 70,000 additional consumers have been supplied.

ENGINEERING

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

Registered at the General Post Office as a Newspaper.

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

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ENGINEERING, LESQUARE, LONDON.

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Accounts are payable to ENGINEERING Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

SUBSCRIPTIONS.

ENGINEERING may be ordered from any newsagent in town or country and from railway book-stalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom and all places abroad, with the exception of Canada	£5 10 0
For Canada	£5 5 0

Subscriptions for periods less than twelve months are based on the price of a single copy, namely, 2s. 3d. post free.

ADVERTISEMENT RATES.

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

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

TIME FOR RECEIPT OF ADVERTISEMENTS.

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

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

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

INDEX TO VOL. 171.

The Index to Vol. 171 of ENGINEERING (January-June, 1951) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher. In order to reduce the consumption of paper, copies of the Index are being distributed only in response to such applications.

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ENGINEERING

FRIDAY, JANUARY 4, 1952.

VOL. 173.

No. 4484.

WE PRESENT

WITH this issue, ENGINEERING enters upon its 87th year of publication. Throughout the past 86 years, our front cover has been occupied by advertising matter; initially, the kind of small advertisements that would now be termed "classified," but for the greater part of the life of the paper with column-width advertisements by engineering firms. Many times have we been approached with suggestions to abandon this practice in favour of single large advertisements, more in accord with the fashion of the times, but always these blandishments have failed. It was felt that while, in the words of a valued French correspondent, the familiar cover might be *un peu triste* by comparison with some others, it was our "face," recognised as such the world over and worthy of retention for that reason, if for no other. Some of the firms whose names appeared on it have figured there for well over half a century, and their goodwill, thus manifested, has been as valuable to us as, we hope and believe, ours has been to them. To evict them from their time-honoured positions, even though with their co-operation, was an innovation not to be lightly undertaken.

Nevertheless, that step has now been taken, and to-day, January 4, 1952, ENGINEERING appears (outwardly, at least) in a new guise. From now on, the front cover will be devoted each week to a representation of some facet of the great and still expanding engineering industry, the progress of which it is our business to describe, illustrate, and promote. Some—as with the picture that has been selected to inaugurate this change of cover policy—will portray the fundamental handicrafts on which, when all is said, modern engineering still depends;

others, the newer skills which are essential to the profitable employment of the ingenious instruments and machines that modern super-accuracy has placed at the disposal of the engineer. Others again—and here we hope to earn the approval of those members of the Institution of Civil Engineers who, some six or seven years ago, were so daring as to organise a symposium on "The Aesthetic Aspect of Civil Engineering Design"—will be chosen deliberately to emphasise the fact, not always appreciated, that the works of the engineer can be beautiful in themselves, quite apart from any merit that they may acquire by being merely "functional." The field is a vast one, and we need fear no shortage of examples to illustrate its marvellous fertility; the difficulty is rather to select the *primus inter pares*.

"Having now," in the phraseology of Letters Patent, "particularly described and ascertained the nature of" this departure from ENGINEERING precedent, to the extent of indicating what, in future, our front cover will present, we feel it advisable to indicate also what it will not present. The subjects chosen for illustration will not be advertisements of any firm or product; they will be selected primarily for their pictorial value. Some will be readily recognisable; there is only one Sydney Harbour Bridge, only one Brabazon aircraft (so far, at least), only one H.M.S. Valiant, and it would be absurd to ban all portrayals of engineering subjects the designers or makers of which might be identifiable by those who know them by their works. The front cover picture will not be an indication of the editorial contents of the issue on which it appears, and, indeed, will bear no relation to the contents; there are practical reasons which would make such an association difficult to maintain consistently, but the complete detachment is also a deliberate policy. The cover stands by itself. It will demonstrate the breadth of this journal's scope; it will serve, we hope, to show something of the artistry that is innate in the finest manifestations of the engineer's profession and craft; it will, if our object is attained, stimulate the interest of the younger readers and sustain that of the not so young in what is, perhaps, one of the most richly satisfying of all the activities in which men can engage. More than that it is not designed to do.

Edward Gibbon, after writing "the last lines of the last page" of his *History of the Decline and Fall of the Roman Empire*, felt "a sober melancholy" that he had "taken an everlasting leave of an old and agreeable companion"; and we should be more than human if we did not experience, in some degree, a similar sentiment in comparing the issue of December 28, 1951, with the proof of the cover that encloses the present issue. A great deal of water has passed under many bridges since our front cover advertised, on January 5, 1866, the need of one "R."—the anonymous advertiser is nothing new—for "a Gentleman acquainted with Agricultural Machinery, to take the situation of Head Draughtsman in a large establishment in the country"; and J. W. Hackworth, son of the much more famous Timothy Hackworth, proclaimed, through the same medium, that he wanted "Accommodation for the Exhibition of a Specimen Engine . . . in the neighbourhood of New Cannon Street, E.C." It is at once stirring and sobering to think of the generations of engineers—some famous, many more merely industrious, but all contributing their quota towards the development of their and our profession and industry—who have scanned the front cover of ENGINEERING. We like to think that they did so to their benefit, and trust that their successors, scanning the covers that are to come, may feel that they also derive benefit from so doing, by having brought to their notice works of engineers' hands which are not only interesting in themselves, but may inspire still greater accomplishments in the future.

ENGINEERING CENTENARIES IN 1952.

THE issue of *ENGINEERING* of December 7, 1923, contained an abridgment of a paper by Dr. Ivor B. Hart, read before the Newcomen Society, on "The Dynamics of Leonardo da Vinci." To Leonardo da Vinci dynamics was "the paradise of the mathematical sciences"; yet it was only one of many subjects that he studied, for his fame is equally due to his work as a painter, a sculptor, an architect and an engineer. Indeed, the manuscripts that he left show that there were few branches of either science or technology that he did not study. He was essentially a forerunner of the scientific revolution of the Seventeenth Century and a great genius; and it is as such that the 500th anniversary of his birth will be celebrated this year. He was born on April 15, 1452 (Old Style), not far from Florence, and he spent most of his life in the north of Italy. Towards the end, however, he was patronised by Louis XII and Francis I of France, and by the latter monarch he was provided with a house at Cloux, near Amboise. There he died on May 2, 1519, at the age of 67. Unfortunately, his manuscripts were dispersed soon afterwards and it was not until the Nineteenth Century that their importance was realised. Since then, a vast literature has been devoted to his work, and the lectures and exhibitions now being arranged will, no doubt lead to a wider appreciation of the debt that is owed to him.

Among the many things that provided Leonardo with scope for his ingenuity was the textile industry, but the world had to wait 200 years for the inventions of Kay, Arkwright, Crompton, Hargreaves and the Frenchman, Joseph-Marie Jacquard, originator of the Jacquard loom for the weaving of figured goods. Jacquard's birthplace was Lyons, where his statue now stands; and the bicentenary of his birth, which falls on July 7 this year, will be celebrated by France, no doubt, as was recently commemorated the bicentenary of the birth of the steamboat pioneer, the Marquis de Jouffroy d'Abbans. Jacquard was nearly 50 before his invention began to attract attention, but his loom was exhibited in Paris in 1801 and thenceforward his life was no longer a continuous struggle against ill-fortune. Granted a pension by Napoleon, he passed the evening of his days at Oullins, near Lyons, and died there on August 7, 1834, at the age of 82. No less fruitful as inventors were Edward Cowper (1794-1852), one of the great improvers of the printing machine; Sir Samuel Brown (1776-1852), who improved chain cables and applied them to ships, piers and bridges; and Walter Hancock (1799-1852), a pioneer of steam-driven road carriages. Hancock was one of the brothers of Thomas Hancock (1786-1865), the pioneer of the rubber industry, and was born at Marlborough, Wiltshire. He was apprenticed to a London watchmaker, but turned to engineering, devising steam engines and applying them to the propulsion of omnibuses. His most notable vehicle was the "Enterprise," which for a short time in 1833, ran between Moorgate and Paddington in London.

The contemporaries of Cowper, Brown and Hancock included Major-General Thomas Colby, F.R.S. (1784-1852), for many years head of the Ordnance Survey; and the distinguished civil engineer, William Tierney Clark (1783-1852), also a Fellow of the Royal Society. From 1811 until his death, Clark was engineer to the Middlesex Water Works; and he was also the designer of the fine wrought-iron chain suspension bridge over the River Danube at Budapest. Erected at a cost of 650,000*l.*, the bridge was opened in 1849, but was destroyed in 1944 by the retreating Germans. It has since been reconstructed, much of the original English wrought iron being incorporated in the

rebuilt structure, and the bridge is in use again under the name of the Lanchid; but now, instead of the Hapsburg crown, the piers bear the sign of the hammer and sickle.

All of the men mentioned above had died before *ENGINEERING* was founded, but our columns have contained many notices of eminent engineers and men of science the centenaries of whose births occur in 1952. Among these may be mentioned Louis Brennan (1852-1932), known for his work on the dirigible torpedo, the mono-rail and the helicopter; James Edward Henry Gordon (1852-93) and Gisbert John Kapp (1852-1922), the electrical engineers; and the famous chemists and physicists, Sir William Ramsay (1852-1916), Antoine-Henri Becquerel (1852-1908), Emil Fischer (1852-1919), Henri Moissan (1852-1907), Jacobus Henricus van t'Hoff (1852-1911) and Albert Abraham Michelson (1852-1931), all six of whom are included in the earliest lists of Nobel Prizemen. The year 1852 was also notable for the placing on the Statute Book of the Patent Law Amendment Act, which effected a complete reform of patents procedure. It resulted also in the publication of all British patent specifications from 1617 to 1852, the founding of the Patent Office Library, and of the Patent Office Museum, which was the nucleus of the present Science Museum at South Kensington.

THE AMERICAN COAL-BURNING GAS-TURBINE LOCOMOTIVE.

THE latest published results of the coal-burning gas-turbine locomotive plant which is being developed in the United States by Bituminous Coal Research, Incorporated, are distinctly encouraging and must have given great satisfaction to the Locomotive Development Committee and to the many firms and workers associated with the project. According to a progress report covering the period June 1 to October 31, 1951, the plant had then been run on coal for a total of 150 hours, including one run of 43 hours, and a subsequent inspection of the exhaust end of the turbine showed no signs of deposit or erosion. The major obstacle to the design of a practical coal-burning gas-turbine locomotive has always been the elimination of the fly-ash particles in the stream of hot gases, so as to prevent erosion of the turbine blades. It seems that this difficulty is now nearing solution. The report also gives information on the equally important question of comparative fuel costs. Comparing the 4,250-h.p. gas-turbine locomotive with a Diesel locomotive consisting of two 2,250-h.p. units, the fuel costs at 4,250 h.p. are 25.60 dols. for the Diesel and 12.80 dols. for the gas-turbine, representing a saving of 50 per cent. of the Diesel fuel costs. There is, however, no difference in costs at 700 h.p.; below that figure the Diesel is cheaper, but above it, the advantage goes increasingly in favour of the gas turbine.

This comparison is based on the fuel costs prevailing in the United States at the time of the report. At an average price of 5.30 dols. per ton, including all freight and handling charges, a million B.Th.U. in the form of bituminous coal cost the railroads 22 cents, whereas Diesel fuel at 9.79 cents per gallon cost 76 cents per million B.Th.U. Thus, in spite of the lower thermal efficiency of the gas-turbine locomotive—a maximum of about 21 per cent. compared with about 34 per cent. for the Diesel—the gas-turbine locomotive, even in the earliest stage of its development, is showing great potentialities in this respect. It is too early yet to speak of relative capital costs, or—as would be necessary in this country—to bring the steam locomotive into the comparison.

Early last summer, at the Dunkirk works of the American Locomotive Company, the Allis-Chalmers

power plant and the coal equipment were each mounted on a steel underframe, 40 ft. long and 10 ft. wide. The turbine was first run on oil, and on September 23 it was run on coal. Five days later, when burning oil again, the plant developed 13.5 per cent. more than its guaranteed 3,750 shaft horsepower. During this acceptance test, the conditions remained substantially constant at 5,715 r.p.m., an air inlet temperature of 59 deg. F., and a turbine inlet temperature of 1,286 deg. F. The generator output was 3,973 h.p., equivalent to 4,404 shaft horsepower. The fuel flow was 3,120 lb. per hour of Diesel oil (effective heating value 17,808 B.Th.U. per pound), giving a specific fuel consumption of 0.71 lb. per shaft horsepower per hour. Combustion efficiency was 95.1 per cent.; the cycle efficiency was 20.17 per cent, but, allowing for heat loss from the fly-ash separator, which was only partly insulated during the test, the efficiency would have been 21.2 per cent.

The power developed by the four 1,000-h.p. traction generators to which the turbine is coupled is absorbed by resistors. The turbine is of the six-stage reaction type, designed for an inlet temperature of 1,300 deg. F. At maximum load, with the inlet air at 60 deg. F., it develops 16,260 h.p., of which the compressor takes 11,750 h.p., leaving 4,350 h.p. at the output shaft. The turbine efficiency averaged 87.5 per cent. from idling to full load. The compressor has 21 axial-flow stages, and tests showed a full-speed capacity of 65,000 cub. ft. per minute, with the efficiency ranging from 82 to 86 per cent. The regenerator has 4,311 tubes, outside diameter $\frac{1}{2}$ in., and the combustors have an efficiency, when burning coal, of 95 per cent. Coarse ash is removed in louver-type separators, but the remaining ash is eliminated in a fly-ash separator, which underwent several changes of design before a satisfactory performance was achieved. It comprises 26 "Dunlab tubes," operating in parallel. These tubes are modified cyclone separators; each is divided into two parts by an iris diaphragm—a disc fitted in the body of the separator, with a hole in the centre and four openings around the periphery. Four "razor blades," one at each opening, direct the dust-laden air into the discharge section of the tube, from whence a small proportion of the air is blown down with the dust. The clean air, spinning at more than 12,000 r.p.m., passes up through the central hole in the diaphragm and thence to the outlet. The pressure drop through the separator is only 4.7 lb. per square inch, equivalent to 5.9 per cent., and it is stated that "while it is premature to conclude that the ash separation problem has been completely solved, it can be said that the passage of small quantities of plus 10-micron ash does not result in rapid damage to the cylinder blades."

A sketch of the proposed locomotive shows two units each on two six-wheeled bogies, one carrying the coal-preparation plant, an air-brake compressor, a 275-h.p. Diesel engine for starting and "hostling," and a train-heating steam generator; the other contains the power plant. The number of Dunlab tubes in the ash separator will be increased to 36, thereby reducing the pressure loss and adding approximately 150 h.p. to the turbine-shaft output.

Mr. J. I. Yellott and Mr. P. R. Bradley, respectively the director and assistant director of research to the Locomotive Development Committee, stated in a covering letter to the chairman of the committee (Colonel Roy B. White) on October 31 that coal-fired testing was then in progress, and that at the conclusion of these tests a detailed report would be prepared. It is enlightening to reflect that the very change which marked the demise of the steam locomotive and the rapid rise of the Diesel locomotive in the United States also stimulated research on this new and promising way of making coal haul trains. Long may vested interests flourish, when they can do work such as this.

NOTES.

THE NEW YEAR HONOURS LIST.

THE names of many engineers, technicians and industrialists appear in the New Year Honours List published on Tuesday, January 1. The Rt. Hon. Sir John Anderson, G.C.B., G.C.S.I., G.C.I.E., F.R.S., has been created a viscount, while knight-hoods have been conferred upon Professor Leonard Bairstow, C.B.E., D.Sc., D.Eng., F.R.S., chairman, Aeronautical Research Council; Mr. G. P. Barnett, Chief Inspector of Factories; Mr. J. L. Blake, M.Sc., Comptroller-General, Patent Office; Mr. J. P. Bowen, C.B.E., M.I.C.E., lately engineer-in-chief, Corporation of Trinity House; Mr. R. F. Fryars, chairman and managing director, Associated Commercial Vehicle Sales, Ltd.; Mr. E. W. Goodale, C.B.E., M.C., President, Silk and Rayon Users' Association; Mr. H. E. Miller, chairman, International Rubber Development Board; Dr. D. R. Pye, C.B., M.I.Mech.E., F.R.S., lately provost of University College, London; and Mr. A. Williamson, C.B.E., M.I.C.E., chairman and managing director, William Beardmore & Co., Ltd. General Sir Brian H. Robertson, Bt., G.B.E., K.C.M.G., K.C.V.O., C.B., Colonel Commandant, Royal Engineers and Royal Electrical and Mechanical Engineers, has been promoted to Knight Grand Cross of the Order of the Bath; Vice-Admiral (E) The Hon. D. C. Maxwell, C.B., C.B.E., M.I.Mech.E., M.I.N.A., to Knight Commander of that Order; and Acting Air Marshal C. W. Weedon, C.B., C.B.E., M.A., M.I.Mech.E., A.F.R.Ae.S., to Knight Commander of the Order of the British Empire. Major-General C. Bullard, C.B.E., B.Eng., M.I.Mech.E., M.I.E.E., R.E.M.E., and Rear-Admiral (E) G. C. Ross, C.B.E., A.M.I.Mech.E., have been created Companions of the Order of the Bath. The new Commanders of the Order of the British Empire include Mr. G. L. Bailey, M.Sc., director of research, British Non-Ferrous Metals Research Association; Mr. J. L. Bartlett, M.I.N.A., deputy Director of Naval Construction, Admiralty; Mr. A. F. Bennett, M.I.E.E., director and joint general manager, Automatic Telephone and Electric Co., Ltd.; Mr. E. H. Browne, chief mining engineer and director-general of production, National Coal Board; Mr. H. H. Burton, director, English Steel Corporation, Ltd.; Mr. R. Freeman, M.B.E., M.I.C.E., lately consulting civil engineer, South Bank Exhibition; Mr. J. Ramsay Gebbie, O.B.E., M.I.N.A., managing director, W. Doxford & Sons, Ltd.; Dr. Harold Hartley, chairman, Radiation Ltd.; Dr. T. P. Hilditch, F.R.I.C., F.R.S., lately Campbell Brown Professor of Industrial Chemistry, University of Liverpool; Captain R. R. Kippen, A.M.I.N.A., marine manager, Ellerman Lines Ltd.; Dr. F. M. Lea, O.B.E., F.R.I.C., director, Building Research Station; Mr. A. E. H. Masters, M.I.Mech.E., chief scientific officer, Fighting Vehicles Design Establishment, Ministry of Supply; Mr. R. F. Newman, O.B.E., J.P., director and general manager, Transport Equipment (Thornycroft) Ltd.; Mr. M. W. Perrin, O.B.E., lately deputy controller, Atomic Energy Division, Ministry of Supply; Dr. D. Rebbeck, M.Sc., M.I.Mech.E., M.I.N.A., M.I.Mar.E., lately deputy chairman, Northern Ireland Festival Committee; Mr. H. L. Stevens, O.B.E., F.R.Ae.S., M.I.Mech.E., principal director of equipment, research and development (air), Ministry of Supply; Rear-Admiral (E) F. V. Stopford; Mr. W. F. Wegener, lately chief mechanical engineer, Malayan Railway; Engineer Captain H. Welch, O.B.E., R.N.; Brigadier R. P. Wheeler, F.R.I.C.S., deputy director-general and director of field survey, Ordnance Survey Department; Mr. T. H. Windibank, M.I.E.E., director, Crompton Parkinson Ltd.; and Dr. A. Winstanley, M.B.E., M.I.Min.E., deputy Chief Inspector of Mines. The honour of Officer of the Order of the British Empire has been conferred upon Comdr. (E) J. W. A. Adams, M.B.E., R.N.; Mr. F. C. Carter, M.I.E.E., staff engineer, Post Office Engineering Department; Mr. T. G. Christie, M.I.Mech.E., M.I.E.E., chief engineer, Northern Ireland Electricity Board; Mr. I. S. Dalglish, A.M.I.E.E., J.P., for public services in Woking; Mr. G. H. Fletcher, M.I.Mech.E., M.I.E.E., chairman, Sheffield and Doncaster District Committee, East and West

Ridings Regional Board for Industry; Mr. F. J. Forty, M.I.C.E., lately member of Festival of Britain Council for Architecture, Town Planning and Building Research; Mr. A. J. Golding, A.M.I.C.E., superintendent, Royal Ordnance Factory, Leeds; Mr. A. Graham, M.I.Mar.E., M.I.N.A., Surveyor-General of Ships, Singapore; Mr. J. Guild, senior principal scientific officer, National Physical Laboratory; Mr. H. H. Hagan, shipbuilding director, Lobnitz and Co., Ltd.; Mr. W. Hodgkinson, North Western Gas Board; Colonel F. R. W. Hunt, T.D., chief technical adviser, Vickers-Armstrongs Ltd.; Mr. R. James, M.I.Mech.E., principal, Glamorgan Technical College, Treforest; Mr. R. T. James, M.I.C.E., lately consulting engineer, South Bank Exhibition; Dr. W. H. G. Lake, works manager, Imperial Chemical Industries, Ltd., King's Norton; Lt.-Col. W. Law, M.C., M.I.C.E., city surveyor, Rochester; Mr. R. A. Lovell, A.M.I.Mech.E., senior engineer, Ministry of Transport; Dr. J. D. McGee, M.Sc., A.M.I.E.E., head of photo-electric research, Electric and Musical Industries Ltd.; Mr. J. Martin, M.I.C.E., fleet civil engineer, Malta; Mr. R. F. S. Pattenden, A.M.I.Mech.E., principal lecturer, Military College of Science; Comdr. (E) J. R. Patterson, D.Sc., A.M.I.Mech.E., R.N.; Mr. W. A. Rogers, M.C., M.I.C.E., county surveyor, Holland C.C.; Mr. R. T. Rolfe, F.R.I.C., chief metallurgist, W. H. Allen, Sons & Co., Ltd.; Mr. W. A. Royle, M.I.Mech.E., M.I.E.E., chief commercial officer, North Eastern Electricity Board; Mr. A. L. Simpkins, M.I.C.E., A.M.I.Mech.E., lately director of public works, N. Rhodesia; Mr. W. L. Sims, M.I.Mech.E., director, Wadkins Ltd.; Mr. J. A. P. Strachan, M.I.Mech.E., United Kingdom Treasury and Supply Delegation, Washington; Captain J. P. Thomson, A.M.I.N.A., A.M.I.Mar.E., lately marine superintendent, Eagle Oil and Shipping Co., Ltd.; Mr. J. Watters, shipbuilding manager, Cammell Laird & Co., Ltd.; and Major A. I. Wynne-Williams, M.C., consultant, United Kingdom Ministry of Supply Staff, Australia. Recipients of the M.B.E. include Mr. R. K. Blackwood, lately engineer with the Anglo-Iranian Oil Co. in Persia; Mr. H. Bradley, North Thames Gas Board; Mr. H. Bradley, South Durham Steel and Iron Co., Ltd.; Tr. E. Bradshaw, M.Sc., M.I.E.E., College of Technology, Manchester; Mr. T. T. Callison, A.M.I.E.E., Bonar Long & Co., Ltd.; Mr. P. G. Campling, M.I.Mech.E., M.I.E.E., Eastern Electricity Board; Mr. P. W. Colley, A.M.I.Mech.E., Birmingham and Midland Motor Omnibus Co., Ltd.; Mr. C. W. Croxon, Department of Scientific and Industrial Research; Mr. J. A. Hamilton, Marine Aircraft Experimental Establishment, Ministry of Supply; Mr. G. Harrold, M.I.Mar.E., Grayson, Rollo and Clover Docks, Ltd.; Mr. W. C. Holden, A.M.I.Mech.E., Vickers-Armstrongs Ltd.; Mr. L. P. Ingram, M.Sc., A.R.I.C., South Western Gas Board; Mr. J. Jones, M.I.Min.E., Northern Division, National Coal Board; Mr. H. C. A. Linck, A.M.I.E.E., Welsh and Border Counties Region, General Post Office; Mr. N. M. McCaig, Fisher and Ludlow, Ltd.; Mr. A. N. Mansfield, M.I.E.E., Merseyside and North Wales Electricity Board; Mr. T. Milner, F. Braby & Co., Ltd.; Mr. H. F. Morton, M.I.Mech.E., de Havilland Propellers Ltd.; Mr. F. R. Moultrie, Electrical Department, the Bahamas; Mr. J. W. R. Naden, Chesterfield Tube Co., Ltd.; Mr. C. A. Packer, A.M.I.Mech.E., G. & J. Weir Ltd.; Mr. A. J. Parsons, A.M.I.E.E., Mawdsley's Ltd.; Mr. A. Rogers, A.M.I.C.E., engineer and surveyor, Caerphilly; Mr. H. E. Sharp, M.I.Mech.E., J. I. Thornycroft & Co., Ltd.; Mr. F. E. Stone, M.I.Min.E., Inspector of Mines; Mr. G. Swain, James Neill & Co. (Sheffield) Ltd., and Lieut.-Comdr. (L) A. V. Wright, R.N. (ret.).

ELECTRICITY SUPPLY IN ONTARIO.

The Hydro-Electric Power Commission of Ontario has in recent years issued a condensed annual report showing the progress made in the extensive system under their control. The latest of these documents, which applies to the year ended December 31, 1950, discloses that the peak capacity of the plant operated in 64 hydro-electric and six thermal generating stations amounted to just over 2,730 MW, an increase of 448 MW, or 19.6 per cent.,

during the twelve months. The output from these stations was nearly 12,379 million kWh, and, in addition, 5,880 million kWh were purchased. The average consumption per consumer amounted to the high figure of 3,648 kWh, an increase of 48.3 per cent. since the end of the war. A feature of this development was the increase in the number of rural consumers, who amounted to 292,811 at the end of the period. These were served by over 34,793 miles of line and were responsible for a peak demand of 236 MW. Actually, some 67 per cent. of the farms in the Province had a supply of electricity, while the figure in Southern Ontario was over 75 per cent. An outstanding event during the year under review, and one which is likely to have a great effect on future developments, was the ratification by the United States Government of the Niagara Diversion Treaty. This will enable the Commission to develop additional power at Niagara and, in fact, by the end of the year the necessary surveying and sub-surface investigations for the tunnel and canal sections of a new 75-MW station were well advanced. This station, which will be fittingly known as the Sir Adam Beck Niagara generating station No. 2, will draw water from the river above the falls between Chippawa and the intake to an existing station. This water will be carried by a tunnel 45 ft. in diameter and 5½ miles long and thence through an open canal, 2½ miles long, to the station. In addition, a 192-MW hydro-electric station was being built at Mattawa on the Ontario River, and two large steam stations, one of 400 MW on Toronto Harbour and another of 264 MW on the Detroit River below Windsor, were being constructed. Since the date of the report, considerable progress has been made with all of these plants, and with a number of smaller stations. During the year, too, 605 route miles of 230-kV line were commissioned, as was a considerable mileage of lower voltage line.

ASLIB CONSULTING SERVICE.

To assist in establishing and developing information services and special libraries, Aslib have introduced, from January 1, a consulting service which will provide, on a fee basis, authoritative advice on any matter affecting the economical running of information services, such as, for example, the layout and use of premises, equipment, personnel, book selection, loan systems, circulating information, records of all kinds, etc. The service will make use of all Aslib resources and researches into library and information techniques. In the initial stages, the consulting service is receiving financial assistance through a Treasury grant administered by the Department of Scientific and Industrial Research, but it is intended that the service, which is at present regarded as an experiment, should become self-supporting as soon as possible, otherwise it may have to be abandoned. For the first consultation, no charge will be made; the consultant will assess the job and will make an estimate of the probable cost to the client, which will be kept to the minimum necessary to enable the service to pay its way. Reduced rates will be charged to members of Aslib. Further particulars may be obtained from the Director, Aslib, 4, Palace-gate, London, W.8.

SOCIETY OF BRITISH AIRCRAFT CONSTRUCTORS' DISPLAY.—The annual flying display and exhibition of the Society of British Aircraft Constructors are to be held from September 3 to 7. The last two days will be open to the public. Further particulars will be announced later.

ELECTRIC POWER FROM ATOMIC ENERGY.—A spokesman of the Atomic Energy Commission U.S.A., recently stated that electric power had been produced from atomic energy at the National Reactor Testing Station near Arco in south-eastern Idaho. In the course of the experiments heat was withdrawn from a breeder reactor by a liquid metal (the nature of which could not be disclosed) and used to generate steam for driving a 100-kW turbo-generator. The output of this set was then employed to supply the lighting, pumps and other equipment in the reactor building. It was also stated that the purposes of the experiment were to obtain information on the handling of liquid metals at high temperatures and to collect data on the extraction of heat from the reactor.

LETTERS TO THE EDITOR.

HIGHER TECHNOLOGICAL EDUCATION.

TO THE EDITOR OF ENGINEERING.

SIR,—I agree, to a certain extent, with Mr. Newhouse's letter in your issue of November 23, 1951, commenting on your leading article of September 28 on the above subject, but I disagree strongly with some other of his points. I agree that the term "Technological University" is a contradiction in terms and should not be used. To speak, however, of abhorrent concentration camps and such like exaggerations, in connection with the proposal of the Institute of Technology, spoils his arguments. There can be no doubt to my mind that, if we had in this country something like the Charlottenburg Technical High School and the Massachusetts Institute of Technology, or the one in Zürich, it would be a very great advantage. In Germany, at least, they got over the difficulty of equating the status of the university and the technical high school, by giving the power to the latter to grant degrees which, I believe, were at least equal to the degree granted by the universities.

First of all, the function of a university and of a "Higher Technological Institute" should, in the first place, be teaching and, in the second place, to an equal degree, the acquisition of knowledge, viz., research. Some British universities have fallen down on this. I remember, some years ago, being shown over the very fine engineering laboratories which had just been built for one of them. I asked the professor, who showed me round, what research they were doing. He replied "We have no time for research." This showed, to my mind, a very poor appreciation of the true function of a university. The German universities, on the other hand, in the past always laid great value on research. In fact, they would not grant a degree to a student unless he had been engaged upon and had published a piece of research work. Further, the German universities in the past did not teach such things as engineering and other branches of applied science. I can hardly imagine, for example, an engineering faculty in Göttingen in my time, although the place had a high reputation for research in science. In fact, in those days, some 50 years ago, it came to this, that the faculties of engineering and so forth, which in this country form part of the university, such as Birmingham, were hived off into separate institutions called technical high schools. I do not think that this was a good development. The best development is for the universities to expand and start new faculties with the spread of knowledge. This has been done in America, perhaps to too great an extent. I do not know whether there is a faculty in an American university for a retail trade, but I can quite imagine there being one.

It follows from Mr. Newhouse's argument, that the ideal education for a professional engineer is a general education until he is about 19 or 20 years of age, followed by three years in the engineering faculty, then obtaining his B.Sc. in Engineering, or the like. I would agree with this, except, perhaps, I would say 21 or 22 years of age, to obtain his degree.

Mr. Newhouse, to my mind, seems rather mixed up in what he says about research. He says that such research courses can best be undertaken at special institutions only remotely connected with universities. What kind of institutions has he in mind? I do not know of any in this country suitable for an engineering graduate to proceed to for research purposes. Mr. Newhouse has confused private, that is to say, companies' laboratories, with purely research establishments. Such private or companies' laboratories are entirely different; they are not educational institutions at all, even if they work on fundamental research. This is because the work in such private laboratories has a commercial end, namely, the financial advantage of the company supporting them. Research, from an educational point of view, must essentially be uncommercial. That is not to say, of course, that it should not have value either for the trade, profession, or nationally; but it must be followed

INVESTIGATION OF HYDRAULIC LOCK.

Fig. 1. PLUNGER B.

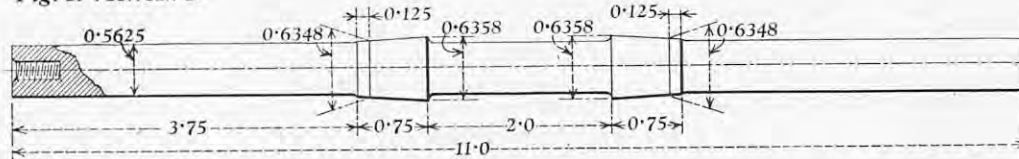
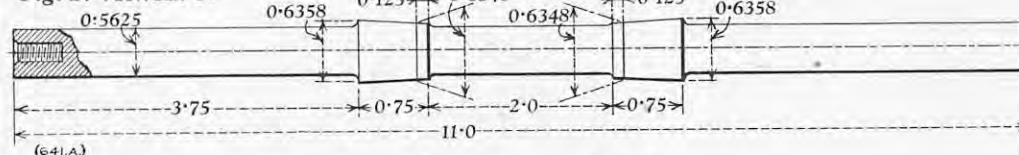


Fig. 2. PLUNGER C.



up by the researcher without any regard for a commercial end. In other words, it must be a pursuit of pure knowledge. For this purpose, expensive up-to-date plant is by no means a *sine qua non*.

If a university engineering graduate is to proceed to another institution for research, then, I submit, it can only be to an institution similar in character to Charlottenburg. The research in general should be carried out at the university itself. It is by no means obvious, as Mr. Newhouse says, that research by post-graduate students should be carried out in conjunction with the actual factories where the products are being made. To my mind, this puts a low value on research as a means of education. Research in a university is to train the mind of the post-graduate and to build up his character. He learns there to pursue knowledge for knowledge's own value. When he goes into the research laboratory of a works, he pursues knowledge for the sake of the profit-and-loss account of the firm. If then he has had insufficient previous training, he will acquire a low valuation of research as such and, incidentally, he will probably be a worse commercial researcher. To a certain extent, in the third paragraph from the end of his letter, Mr. Newhouse agrees with what I have said above, but his fundamental error is equating research in a university with research in a commercial laboratory.

To sum up, therefore, I am in favour of a Higher Institute of Technology, but it should not be called a Technological University. Such a large institution could only be in large centres of population, such as London. It should be a part of, or associated with, the university; it should, in fact, be the engineering or technological faculty of the university. It should not grant degrees on its own, which should be the province of the university. A technological institution of this character in London would be mostly populated by graduates engaged on research, and qualifying for the higher degree, say, M.Sc., D.Sc., or Ph.D. Its professors and lecturers should be the first men in their subjects in the country; before all, they should be research men, and would give lectures on the more advanced and specialised subjects. There are, in fact, the embryos of such a technological institute in London, in the School of Mines and the Central Technical College. Such an institute in London, embodying the highest teaching in its subjects, and above all, the leading research, would, I am sure, be of extreme value in this country. However, at the present moment, it is not practical politics. The first thing to be done is to spend what money is available in bringing up to date the laboratories and faculties in engineering in the existing universities. I hope, therefore, that Mr. Newhouse will not succeed in killing the idea of the Technological Institute.

I should like to make it clear, and I take it Mr. Newhouse will agree, that engineering could be as good a basis for an all-round education and training as any other branch of science, classics or history. The great value, which Mr. Newhouse rightly stresses, of attendance at a university, in that the student mixes with all other kinds of students, requires to my mind, no more emphasis. It is, I think, self-evident.

Yours faithfully,

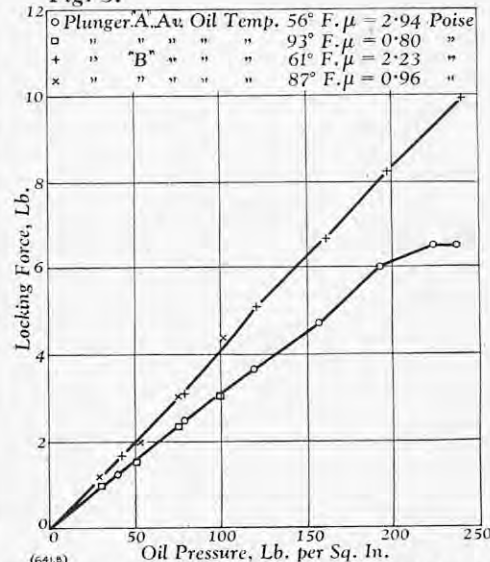
C. C. GARRARD.

Devonshire Club,

St. James's, London, S.W.1.

December 19, 1951.

Fig. 3.



PRELIMINARY INVESTIGATION OF HYDRAULIC LOCK.

TO THE EDITOR OF ENGINEERING.

SIR,—We have read Dr. Sweeney's article* on hydraulic lock with great interest, having been aware of the main features of hydraulic lock for over 20 years. It is exceedingly gratifying to learn at last of a rational explanation of this tiresome phenomenon. The explanation, which follows a very fine account of experimental work, appears, however, in rather an unobtrusive way (it is summarised in the first column of page 581). It seems, in fact, to have been passed over by the correspondents whose letters appear in your issues of November 16 and 23. In view of the interest of the subject we recently decided to test Dr. Sweeney's theory by carrying out a set experiment in an existing apparatus for investigating hydraulic lock.

The essential parts of the apparatus used comprise three plungers which were tested under oil pressure in a cylinder of substantially parallel bore with a nominal minimum diametral clearance of 0.0004 in. The plungers are denoted by the letters A, B and C, of which B and C are shown in Figs. 1 and 2, respectively; plunger A has the same dimensions in every respect except that the lands are parallel, 0.6358 in. in diameter. The plungers have lands between which pressure was applied; the lands are, for A, B, and C, respectively: parallel; tapering by 0.001 in. outwards or away from the region of pressure; and tapering by 0.001 in. inwards or towards the region of pressure.

Measurements of the hydraulic locking forces given in Fig. 3 show appreciable values of these forces for plungers A and B. For plunger C, in which the taper is inwards towards the region of pressure, the locking force was always zero. Comparison of the results with plungers B and C would appear to supply very strong support for Dr. Sweeney's argument and for the conclusion that hydraulic lock can exist even with perfect surfaces of no irregularity, provided only that there is a net oil film taper in the appropriate sense, i.e., away

* The article appeared on pages 514 and 580 of the issues of October 26 and November 9, 1951.

from the region of pressure. The test with the parallel plunger A is inconclusive at present, since the available accuracy of measurement does not afford a sufficiently close description of the mating surfaces. The tolerance for the male cylindrical dimensions given is certainly less than ± 0.0001 in. The diameter and parallelism tolerances of the internal bore are probably greater but would not exceed ± 0.00015 in. There is, therefore, some uncertainty over the precise values of the net oil-film tapers with plungers B and C, though there is no uncertainty over the senses of these tapers.

The three test plungers were made of medium carbon steel and the test cylinder of cast iron. The surface finish of the two tapered plungers is "fine ground." The surfaces of the parallel plunger and the inside surfaces of the cylinder are lapped to a fine matt unpolished finish.

Yours faithfully,

For W. H. Allen, Sons and Company, Limited.

A. C. HUTCHINSON,

Steam Turbine Design Department,
Queens Engineering Works,
Bedford.

December 30, 1951.

PRESTRESSED-CONCRETE STATICALLY-INDETERMINATE STRUCTURES.

TO THE EDITOR OF ENGINEERING.

SIR,—In the article on "Prestressed-Concrete Statically-Indeterminate Structures" in your issue of November 30, 1951, there is a statement at the bottom of column 3, page 678, to the effect that "the column analogy . . . is based upon the similarity between the expressions giving the end-fixing moments for an *encastré* beam and those giving the stresses in the extreme fibres of a short column that is eccentrically loaded." This is not strictly true, for the analogy itself is based on the similarity between the expressions giving the angle between the tangents at the ends of a beam, subjected to lateral load and end moments, but not necessarily *encastré* at the ends, and the stresses in an eccentrically-loaded short column.

The end-fixing moments of an *encastré* beam can then be quite readily found, even for a beam of varying section.

Yours faithfully,

WILLIAM MORSE,

Chief Technician.

Aircraft Section,

Alan Muntz and Company, Limited,
Heston, Middlesex.

[We are grateful to Mr. Morse for drawing attention to the unnecessary restriction, implied in our report, that the column analogy related to beams *encastré* at the ends. The wording should have covered the general case of all beams subject to end moments as well as lateral loading.—ED., E.]

OBITUARY.

MR. C. E. ALLEN.

It is with much regret, which will be shared by an unusually large number of his friends in technical journalism and in the machine-tool industry, that we record the death, on December 24, of Mr. Clarence Edgar Allen, editor of our contemporary, *Machinery*, from its establishment in 1912 until his retirement, on account of ill-health, in March of last year. He was 80 years of age.

"Clary" Allen—the name by which he was best known—came of a Northamptonshire family, but was born in Nottingham, on November 21, 1871. His schooling was received in London, and on leaving school he entered King's College, London, to study medicine. Before long, however, he realised that his true *métier* was engineering, to which he applied himself at King's College and

subsequently at the Northampton Institute, Clerkenwell, and at Birkbeck College. He had entered upon an engineering apprenticeship, at the mature age of 28, with the Craven Engineering Works, in Hoxton, and two years later acquired an interest in the business. This, apparently, did not last long, for he had obtained further engineering experience with Messrs. Manning, Wardle and Company, at Leeds, and with Messrs. Marshall, Sons and Company, at Gainsborough, before, in 1899, he became acting editor of *Fielden's Magazine*, now *The Engineering and Boiler House Review*. His name appeared on the title page as editor in 1902, and he continued to hold that office when, in 1904, the periodical was reconstituted as the *Engineering Review and Trader*. Concurrently, he carried on a practice as a consulting engineer, and travelled extensively to attend machine-tool and other engineering exhibitions, almost wherever they were held. In 1912, when the production of *Machinery* was in train, he was appointed editor. The first issue appeared on October 3 in that year, and thereafter, until his retirement less than a year ago, his life was devoted to its interests. He became a director of the Machinery Publishing Company in 1927, but that position also he was obliged to relinquish at the same time as his editorship. He was an associate member of the Institution of Mechanical Engineers and of the Institution of Electrical Engineers; and though, in later years, he rarely attended meetings of either, there were few who had a wider acquaintanceship among their members, or who will be better remembered by them.

MR. ARTHUR POLLITT.

In last week's issue, we referred briefly to the death, on December 23, of Mr. Arthur Pollitt, deputy controller, London Division, for the British Electricity Authority; but that issue had to be prepared longer in advance of the publishing date than is usual, because of the Christmas recess, and a memoir of Mr. Pollitt had perforce to be deferred. An outline of his professional career is therefore given below.

Arthur Pollitt was born in Lancashire, at Winton, near Eccles, on March 21, 1891. He claimed to be descended from a family of Huguenot silk weavers; in which connection it may be remarked that the surname Pollet was recorded in Eccles 350 years ago. His general education was received at the Salford grammar school and his technical education mainly at the Royal Salford Technical Institute, concurrently with his apprenticeship to Messrs. Browett, Lindley and Company, Limited, Manchester, between 1906 and 1911. On its completion, he spent a few months at sea, but, towards the end of 1912, took a position as draughtsman with Messrs. Hick, Hargreaves and Company, at Bolton. This appointment, however, did not last long, neither did his next, with the British Westinghouse Electrical and Manufacturing Company, at Trafford Park; for, in October, 1913, he transferred to the Brush Electrical Engineering Company, at Loughborough, and remained there for six years as a contract engineer, specialising in Diesel engines. He left them in 1919, to become assistant chief constructional engineer in the Manchester Corporation electricity department, where he was engaged mainly on the construction of Barton power station. When Mr. (afterwards Sir) Leonard Pearce, who was for many years chief electrical engineer at Manchester, became chief engineer of the London Power Company, Pollitt followed him to London to be chief assistant constructional engineer. Six years later, he was appointed chief constructional engineer, retaining that position until 1948, when he was made chief generation engineer (construction) in the London Division of the British Electricity Authority. Two years later, in October, 1950, he became deputy divisional controller, the position that he occupied at his death.

Mr. Pollitt was a member of the Institution of Mechanical Engineers, the Institute of Marine Engineers and the Manchester Association of Engineers, and an associate member of the Institution of Electrical Engineers. He was also a member of the Court of Assistants of the Worshipful Company of Horners.

HEAT TRANSFER IN AIR-COOLED GAS-TURBINE BLADES.

By H. COHEN, M.A.

MUCH interest is focused at the present time on the possibilities of using cooled turbines in gas-turbine plant. The considerable increases in output and efficiency to be gained by operating at temperatures as much as 1,000 deg. F. higher than are possible with uncooled turbines have been described in many recent papers; and attention has also been drawn to the reduction in initial and maintenance costs made possible by using cooled turbines constructed of materials of low alloy content, operating in the lower temperature ranges. A number of cooling systems for the turbine blades have been proposed, including the use of forced convection by air or liquid, free convection by liquid, and "sweat-cooling." The satisfactory design of any one of these systems depends mainly on the accumulation of a wide variety of reliable heat-transfer data. There is a great store of such information already available, but much of it can be applied only with some reservation; for instance, in the case of an internally air-cooled turbine blade, the question arises whether the well-established heat-transfer formula for circular pipes can be applied to what is effectively a very short length of pipe having the cross-sectional shape of a turbine-blade. When a core is inserted to improve the heat transfer, thereby reducing the required quantity of coolant, the passage will take the form of a turbine blade-shaped annulus. In such cases, the method is frequently employed of using the formula for a circular section, replacing the "length" in the Nusselt and Reynolds numbers by the "equivalent" diameter, defined as four times the flow area divided by the wetted perimeter.

This article briefly describes an experimental investigation into the latter problem, carried out in the Mechanical Engineering Department of the University of Durham, at King's College, Newcastle-upon-Tyne, at the suggestion of Messrs. C. A. Parsons and Company, Limited. It is hoped that the data presented will be of value not only in the design calculations for internally air-cooled gas-turbine blades, but also in associated problems involving heat-transfer in short circular annuli, a form of duct which frequently occurs in the construction of gas-turbine components.

Tests were made with two pieces of apparatus identical in construction apart from the cross-sectional shape of the internal passage, which was circular in one and shaped like a turbine blade in the other; they are referred to hereafter as A and B, respectively. Simplified sectional drawings of the turbine-blade apparatus B are shown in Figs. 1 and 2, on page 22. In both cases, the heat-transfer surface was formed by the hollow inside a substantial block of copper, 6 in. long. In A, the internal diameter was 3 in.; in B, the cross-section was that of a typical reaction-turbine blade of 3-in. chord, the surface thus corresponding to a scaled-up version of a normal gas-turbine blade, approximately three times full size. The copper block was electrically heated, and the inner surface temperature was measured by a number of buried copper-constantan thermocouples. Means were provided for mounting cores of various sizes inside and concentric with the heat-transfer surface. The whole heat-transfer section was thermally insulated from the inflow and outflow ducts, and was completely enclosed by water-jackets, so that any heat loss from the test surface otherwise than by convection could be measured. Compressed air was supplied to the annulus and tests were carried out for a range of Reynolds numbers (based on the equivalent diameter) between 5×10^3 and 5×10^5 , with air inlet temperatures and surface temperatures ranging from 55 deg. to 93 deg. F. and from 167 deg. to 554 deg. F., respectively. The apparatus is illustrated in Fig. 3, on page 22.

For each test, the surface heat-transfer coefficient, based on heated surface area only, was calculated using the logarithmic mean temperature difference between the surface and the coolant. Correlation of the test data was based on the assumed relation-

HEAT TRANSFER IN GAS-TURBINE BLADES.

Fig. 1.

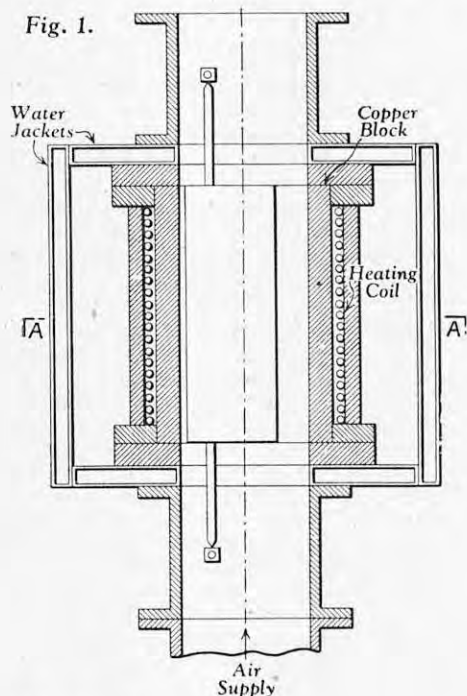


Fig. 2. SECTION A-A

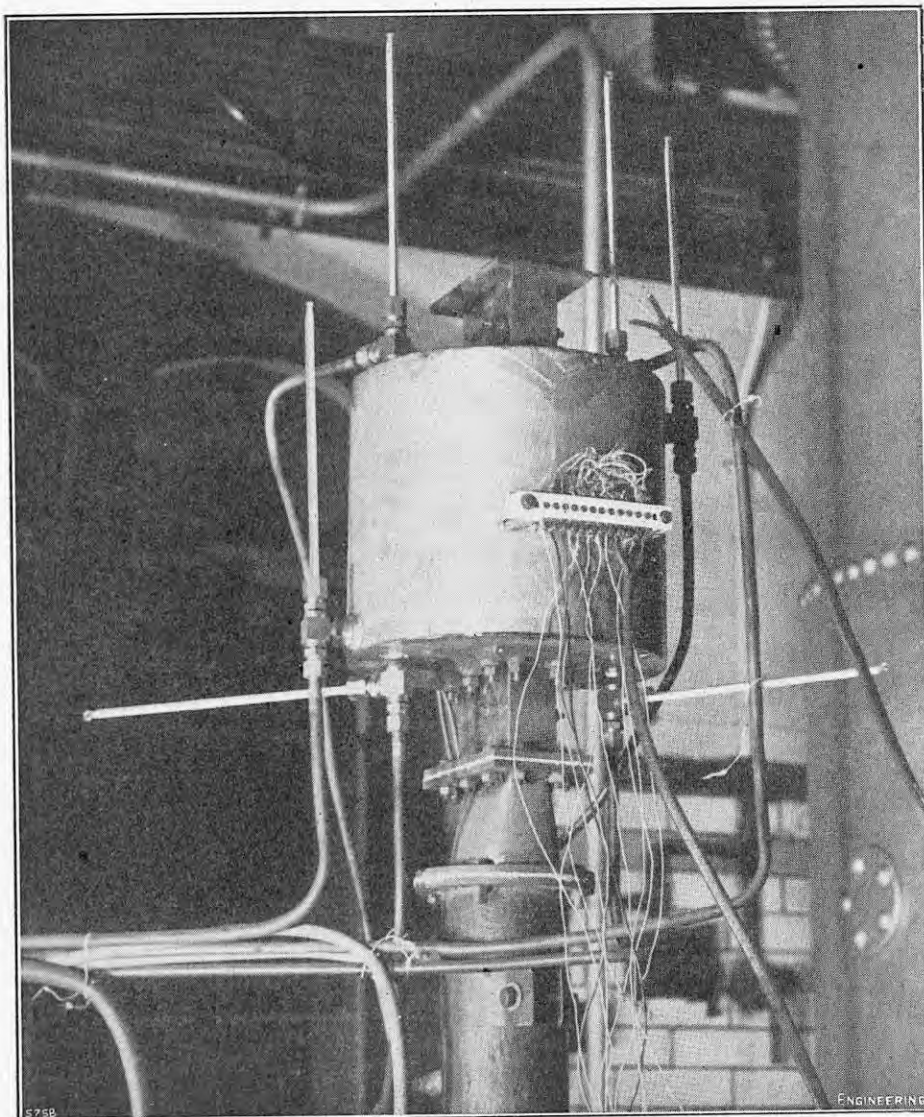
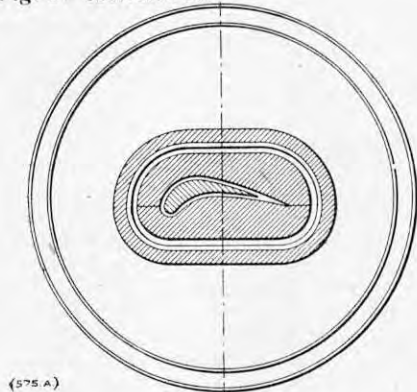
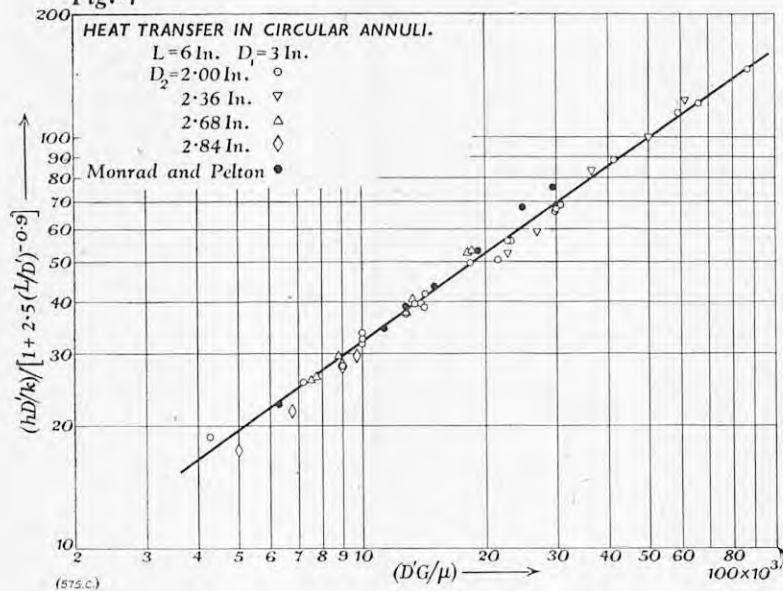


FIG. 3. EXPERIMENTAL APPARATUS.

Fig. 4



ship that the Nusselt number would be a function of the Reynolds number and other non-dimensional quantities, such as the ratio of length to equivalent diameter and the ratio of the internal and external diameters in case A. Since no fluid other than air was used in any of the experiments, inclusion of the Prandtl number was unnecessary. The results of the two test series are separately considered below.

For circular annuli (A), the final and most satisfactory correlation of the test data is shown in

Fig. 4, herewith, the equation of the line being

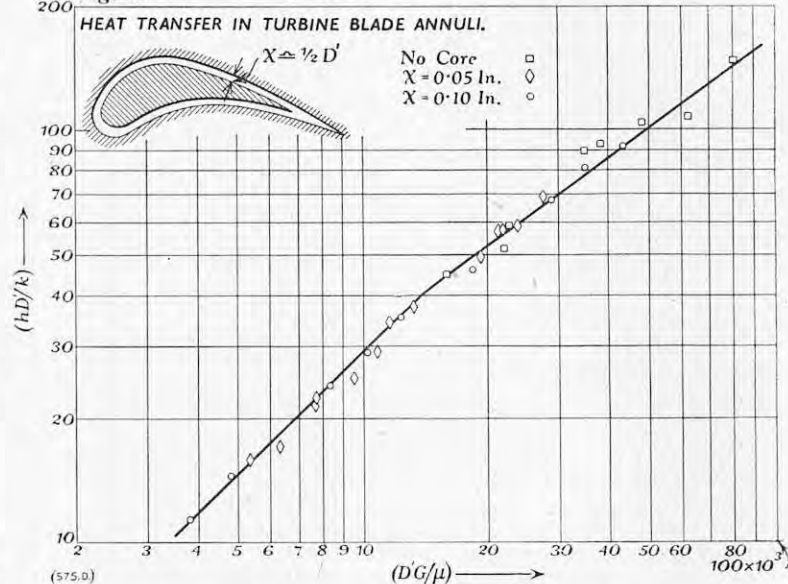
$$N_u = 0.020 \left[1 + 2.5 \left(\frac{L}{D^1} \right)^{-0.9} \right] R_e^{0.8} \quad (1)$$

where N_u = Nusselt number, $\frac{h D^1}{K}$.

R_e = Reynolds number, $\frac{D^1 G}{\mu}$.

h = surface heat-transfer coefficient, B.Th.U. per square foot per hour per deg. F.

Fig. 5.

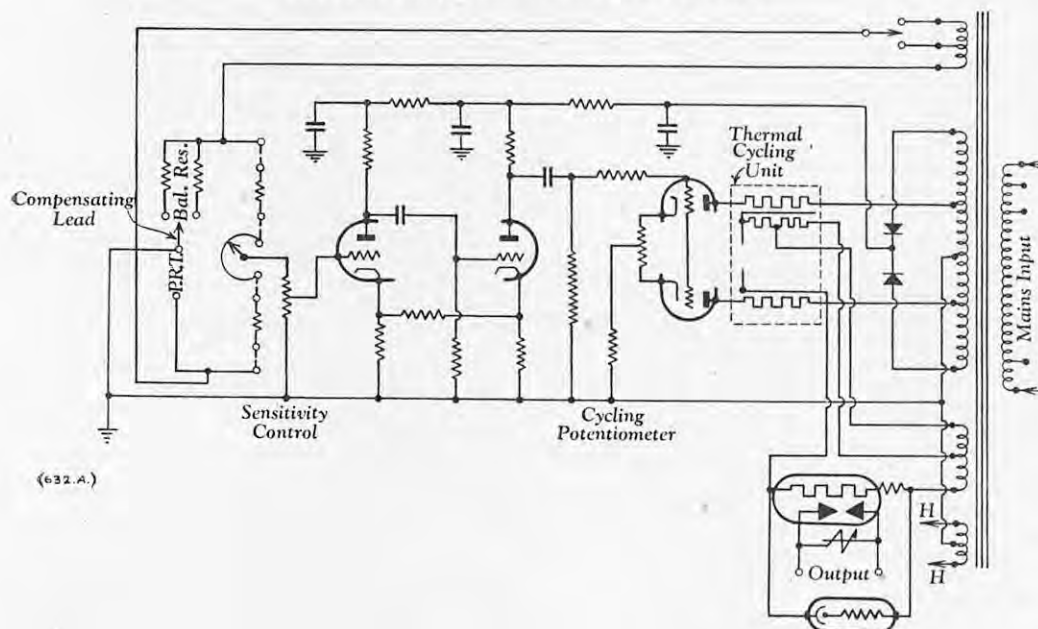


D_1, D_2 = external and internal diameters, in feet.
 D^1 = equivalent diameter ($= D_1 - D_2$), in feet.
 L = length of annulus, in feet.
 K = thermal conductivity of coolant at bulk temperature, B.Th.U. per square foot per hour per deg. F.
 μ = absolute viscosity of coolant at bulk temperature, lb. per foot per hour.
 G = flux density, lb. per square foot per hour.

The formula for N_u given by equation (1) will be

COMPENSATED TEMPERATURE REGULATOR.

SUNVIC CONTROLS, LIMITED, LONDON.



recognised as that for air in long circular pipes, multiplied by a factor involving the $\frac{L}{D^1}$ ratio, which arises from the fact that there is a considerably increased rate of heat transfer in an inlet section. The fact that a term involving the diameter ratio $\frac{D_1}{D_2}$ does not appear in equation (1) is confirmed by the findings of Wiegand and Baker,* and of Monrad and Pelton,† whose formulæ for heat transfer in long externally-heated annuli are in agreement with this equation. The results of Monrad and Pelton, who worked with water as coolant in an annulus of external and internal diameters 1.0125 in. and 0.54 in., are reproduced in Fig. 4.

For annuli of turbine-blade shape (B), the results of experiments with two core sizes giving annular gaps of width 0.10 in. and 0.05 in., and also for the case with no core, are shown in Fig. 5, opposite. The main result is that, for values of R_e greater than about 1.4×10^4 , the heat-transfer coefficient may be calculated from the circular-pipe formula

$$N_u = 0.02 R_e^{0.8} \quad (2)$$

The "length" in N_u and R_e is again the equivalent diameter, which, in this case, is approximately equal to twice the width of the gap.

At lower values of R_e , there is a change in the slope of the line and the appropriate formula has been found to be

$$N_u = 0.0028 R_e \quad (3)$$

If the results for the cases with cores are considered, there is close agreement with the findings of Washington and Marks,‡ who carried out heat-transfer experiments with air in a narrow rectangular section having a ratio of breadth to width of 40. They found that, for values of R_e greater than 1.3×10^4 , their data satisfied equation (2) and that, for lower values of R_e , the value of N_u fell away in a manner similar to that given by equation (3). This close agreement is to be expected, inasmuch as the narrow gap in the turbine blade can be considered as a narrow rectangular passage, bent round. With the two cores used, the ratios of breadth to width are approximately 60 and 120, which is the same order as that used by Washington and Marks. The $\frac{L}{D^1}$ ratios in these cases are 30 and 60, so that little, if any, effect would be expected, since the

influence of this factor is only appreciable at values of about 10 or less.

The $\frac{L}{D^1}$ ratio for the case without a core is 8, so that some entry effect would be expected, but this cannot be established without further data on shorter lengths of the same section. This has not been pursued, since it is considered most unlikely that hollow air-cooled blades for gas turbines will be used without some form of insert.

SCREW-THREAD MEASURING PARALLELS.—W. H. Marley & Co., Ltd., New Southgate Works, 105, High-road, London, N.11, have published a descriptive leaflet relating to their "Marleo" thread-measuring parallels, which are obtainable in sets for use in conjunction with micrometer gauges, to determine the effective diameters of a wide range of types and sizes of screw thread. The design of these parallels was based on recommendations by the National Physical Laboratory, Teddington, and they can be supplied accompanied by an N.P.L. certificate of accuracy at an extra charge. A set containing five pairs of parallels is now available for measuring unified threads.

ALMANACS AND CALENDARS.—We have received monthly tear-off wall calendars from the D.P. Battery Co., Ltd., Bakewell, Derbyshire; Philip Henderson & Co., 1, Wine Office-court, London, E.C.4; James Howden & Co., Ltd., 195, Scotland-street, Glasgow, C.5; Mayor and Coulson, Ltd., Bridgeton, Glasgow, S.E.; the Northern Manufacturing Co., Ltd., Albion Works, Gainsborough; G. C. Turner & Co., 3, Wrestler's-court, Camomile-street, London, E.C.3; and R. H. Windsor, Ltd., 16, Finsbury-square, London, E.C.2. Tear-off wall calendars having two months to each page have reached us from Holman Brothers Ltd., Camberne; the K.L.M. Royal Dutch Airlines, 196, Sloane-street, London, S.W.1; and Davey, Paxman & Co., Ltd., Standard Ironworks, Colchester. Wall calendars with tear-off sheets showing on each the current month in heavy type, and the preceding and following months in smaller type, have come to hand from the British Vacuum Cleaner and Engineering Co., Ltd., Leatherhead, Surrey; Brook Motors, Ltd., Empress Works, Huddersfield; the European public relations officer, Canadian Pacific Railway Co., 62, Trafalgar-square, London, W.C.2; Davidson & Co., Ltd., Sirocco Engineering Works, Belfast; Fischer Bearings Co., Ltd., Upper Villiers-street, Wolverhampton; C. Townsend Hook & Co., Ltd., 154, Fleet-street, London, E.C.4; A. A. Jones and Shipman, Ltd., Narborough-road South, Leicester; Russell Newbery & Co., Ltd., Dagenham, Essex; and Trans World Airlines, 200, Piccadilly, London, W.1. The British Thomson-Houston Co., Ltd., Rugby, have sent us a calendar of the last-mentioned kind, which, as in previous years, reproduces twelve natural-colour photographs of English, Welsh and Scottish scenes taken by employees of the company. C. A. Parsons & Co., Ltd., Heaton Works, Newcastle-upon-Tyne, 6, have sent us a monthly tear-off wall calendar containing twelve reproductions in colour of historic buildings in Newcastle.

COMPENSATED TEMPERATURE REGULATOR.

DIFFICULTIES are often experienced by industrial users of electricity, especially in these days of power shortages, by reason of fluctuations in the voltage and frequency of the supply. To take an example, the difficulties of maintaining automatically a steady temperature in an electrically-heated furnace are enhanced when the supply varies irregularly, especially if what is known as a proportional control is employed. Such a control may work by varying the "on" and "off" periods of part of the supply to the furnace in proportion to the deviation of the instantaneous temperature—as measured, for example, by an electrical-resistance thermometer—from some desired value. The temperature which is actually maintained by the automatic control under steady conditions is known as the control point. If the power input varies, the control point must vary in sympathy, for, were this not so, it would mean that the same temperature could be maintained under identical conditions of switching in the regulator with a different amount of input power. In particular, if the power applied to the furnace were reduced, for some reason such as a drop in mains voltage, the temperature would fall also and the proportional control would maintain a new, and lower, temperature with, of course, a different equilibrium ratio between the "on" and "off" periods in the regulator.

Associated with all such proportional controls, there is a proportional band, namely, the range of the controlled variable which corresponds to operation of the regulator over its entire range. In the case of an electric furnace, operated as mentioned above, the limits of the range are those furnace temperatures which would cause the supplementary power supply of the furnace to be either permanently on or permanently off; and there is a mode of operation of the regulator corresponding to each value of the temperature within the range. When the proportional band is wide, the change in the control point which results from an appreciable change in the power input is also large, because the rate of regulation is correspondingly slow. On the other hand, if the proportional band is narrow, full control is applied quickly and the departure of the control point from its original value is less. A narrow proportional band, however, demands a highly efficient furnace, i.e., one with low thermal inertia, otherwise the temperature will be liable to hunt badly. Such furnaces, however, are expensive.

To overcome the difficulties referred to above, Messrs. Sunvic Controls, Limited, 10, Essex-street, Strand, London, W.C.2, have produced a temperature controller, known as the RT2, which is compensated for changes in supply voltage and which, therefore, allows a wider proportional band and a less efficient and cheaper furnace to be used than might otherwise be possible. The operation of the controller will be understood from the diagram herewith. The measuring circuit consists of an alternating-current resistance-bridge with a resistance thermometer and a ballast resistance in adjacent arms. The ratio between the resistances in the other two arms can be varied by means of an accurate potentiometer, which is used to set the controller to maintain the required temperature. Any out-of-balance voltage from the bridge is amplified by a two-stage resistance-coupled amplifier, the gain of which may be varied by means of a potentiometer across the output of the bridge having its variable arm connected to the grid of the input triode. The potentiometer, therefore, acts as a sensitivity control and also provides a method whereby the control unit may be tested and adjusted under conditions of zero input.

The amplified output is applied to the grids of a double-triode valve, the plates of which are connected to a thermal cycling unit. The latter contains two bimetallic strips each fixed at one end and furnished with a contact at the other. Each strip carries a heater winding which is in the anode circuit of one half of the double triode, and the two anodes are fed directly through the heaters from a single secondary winding of a power transformer. As this part of the supply is not rectified, the potentials of the anodes oscillate at the mains frequency and are in anti-phase. The cathodes of the double-triode are connected to the ends of a potentiometer with its moving contact connected through a bias resistance to earth. By adjusting the setting of the potentiometer, therefore, the cathode potentials may be varied to control the currents through each half of the double-triode valve and, hence, through the heater windings. These currents, however, also depend on the amplitude and phase of the signal applied to the grids relative to those of the plates, and the amplitude and phase of the grid signal depend, in their turn, on the output from the alternating-current resistance-bridge, the phase reversing whenever the sign of the bridge output changes.

The bimetallic strips are mounted parallel to each other and are so arranged that they move in the same direction when their temperatures increase. It is

* "Transfer Processes in Annuli," by J. H. Wiegand and E. M. Baker. *Trans. Amer. I. Chem. E.*, vol. 38, pages 569-592 (1942).

† "Heat Transfer by Convection in Annular Spaces," by C. C. Monrad and J. F. Pelton. *Ibid.*, vol. 38, pages 593-611 (1942).

‡ "Heat Transfer in Rectangular Air Passages," by L. Washington and W. M. Marks. *Ind. Eng. Chem.*, vol. 29, pages 336-345 (1937).

evident, therefore, that on the application of a signal to the grids of the double triode, the free ends of the strips will move either towards or away from each other, depending on the sense of the input signal. This movement varies the relation between the "on" and "off" periods of the thermal cycling unit, which is formed by a hot-wire vacuum-switch in series with another secondary winding of the power transformer and a portion of a second heater winding on one of the bimetallic strips. The circuit is completed through the contacts on the bimetallic strips. The remainder of the heater winding is fed continuously from the transformer and provides compensation for changes of mains voltage for that portion of the furnace load (usually some 80 per cent.) which is not controlled.

It will be apparent, therefore, that, in the absence of any input signal, the thermal cycling unit will continue to switch on and off the residue of the power to the furnace at a rate varied only by fluctuations in the mains voltage, but that the rate of making and breaking the circuit containing the hot-wire vacuum switch will be varied whenever the resistance bridge becomes unbalanced and causes the currents in the first-mentioned heater windings to change. The bridge and amplifier circuits, therefore, provide the desired proportional control.

The controller, which weighs $8\frac{1}{2}$ lb. approximately, is designed to be mounted in a standard 19-in. Post Office-type rack, the front plate being half rack-size so that two units may be installed side by side. A neon lamp across the heater winding of the hot-wire vacuum switch indicates the action of the contacts of the cycling unit. The potentiometers for balancing the bridge and for adjusting the sensitivity, and a double-pole main switch, are mounted on the front of the case. A range selector switch and fuses in each mains lead are also fitted. The instrument is designed for alternating current supplies at 200 to 250 volts or 100 to 130 volts, and frequencies of 40 to 100 cycles per second. The hot-wire vacuum switch is rated for maximum currents of 15 amperes at 230 volts and 18 amperes at 110 volts. A surge suppressor is connected across the switch when inductive loads have to be controlled. Two industrial-type double-triode thermionic valves are used, one for the two-stage amplifier and the other for the output stage. The plate supply for the amplifier is fully rectified and smoothed, but no electrolytic capacitors are employed in the circuit.

The instrument is designed for a total resistance range of 11.5 to 48 ohms, corresponding to a temperature range from 30 to 1,100 deg. C., using a 10-ohm platinum-resistance thermometer. The resistance range is covered in six stages, which overlap. The minimum extent of the proportional band is 0.04 ohm, which represents less than 1 deg. C. with a 10-ohm thermometer. For optimum compensation for mains fluctuations, the controlled furnace current should be approximately 16 per cent. of the maximum.

(To be concluded.)

FILM ON EARTH-MOVING EQUIPMENT.—The Chaseside Engineering Co., Ltd., Station Works, Hertford, have announced that they are able to lend to approved applicants copies of a film dealing with earth-moving equipment. Although devised in the first place to demonstrate the capabilities of the firm's light excavator, it is of general interest. Should it prove difficult to screen the film, the company are prepared to supply a projector and operator and, if required, a speaker to answer technical questions.

BRITISH ELECTRICAL POWER CONVENTION.—In view of the necessity for economy at the present time, the Council of the British Electrical Power Convention have decided to limit their 1952 proceedings to 2½ days. The Convention will therefore be held at Bournemouth from the morning of Monday, June 16, to mid-day on Wednesday, June 18, and during this period the programme, which has already been agreed, will be carried out in full. The official electrical exhibition will not, however, be held.

PREHEATING OF INTERNAL-COMBUSTION ENGINES.—To overcome starting difficulties and, at the same time, protect internal-combustion engines against damage by frost, Eltron (London), Ltd., Accrington Works, Strathmore-road, Croydon, Surrey, have introduced a new type of "limpet" electric preheater which, it is claimed, brings the engine temperature to 100 deg. F. above that of the surrounding atmosphere. The heater is attached to the cylinder block by removing a core plug and inserting the head of a T-bolt in the core hole; the heater is then passed over the shank of the bolt and held firmly in position by tightening the nut, suitable packing being inserted between the heater and block. Alternatively, a 1½-in. diameter hole is drilled in a cover plate and the T-bolt inserted in this. The heater uses mains current, having a loading of 1,000 watts, the water in the cooling system circulating round the element under the influence of thermo-syphonic action.

LABOUR NOTES.

PLEAS for more steel for British shipbuilding are made by Mr. J. Ramsay Gebbie, the President of the Shipbuilding Conference, in a statement dealing with the industry's position and prospects, which was issued on Tuesday last. He considers that the shipbuilding industry in Britain requires an additional 50 per cent. more steel than it is at present receiving if it is to achieve its full economic production and utilise all its existing shipyard capacity and available man-power. The figures for the period up till the end of 1951 show that there is a record shipbuilding order-book for more than 1,100 ships, amounting to about six-and-a-half million tons gross, Mr. Gebbie states. At the present rate of production, these orders represent over four years' work for the shipyards.

If the steel were available to match the capacity and man-power of the shipyards, however, Mr. Gebbie continues, these orders could be overtaken in three years, in spite of the demands made by the rearmament programme. Shipbuilding is always a high earner of conversion foreign exchange and many of the contracts covered by the present order-books are likely to earn considerable sums in dollars, in addition. The total value of the contracts already booked is not less than six-hundred-million pounds at current prices, including some two-hundred-million pounds represented by ships for export to overseas owners direct. He feels that the Government should see to it that the new steel-allocation scheme will recognise "the urgent needs of this vital industry" in a much more practical manner than hitherto.

Great pressure of work in connection with naval building and refitting schemes is reported from the Royal Dockyards and the position seems likely to increase in severity as the national rearmament programme gains momentum. Steps are accordingly being taken to build up the labour force at the Dockyards. It is understood that the Admiralty are now recalling to its own service many draughtsmen and personnel in other technical grades who for some time past have been seconded to other Government departments. During the war years, large numbers of women were employed at the Dockyards and the possibility of engaging women for service in some of the less-skilled grades is again under consideration. The question of the employment of coloured persons for some classes of labour is also being advocated in some quarters, as a means of relieving the existing man-power shortage.

The joint demands put forward some time ago for an all-round increase of 20s. a week in the wages of women employed in the engineering industry were referred to the Industrial Disputes Tribunal at the beginning of the present week. Negotiations on these claims have been in progress for some weeks between the Engineering and Allied Employers' National Federation and the five unions supporting the interests of women employees in the industry, but without any settlement being reached. The unions concerned are understood to have rejected as insufficient an offer by the Federation of an all-round increase of 10s. a week and are believed to have expected wage advances equal to those recently conceded to men employees in the industry. In all, it is estimated that there are some 400,000 women who are employed on work which is recognised by both sides as "women's work," and who are likely to benefit from any increases in pay as a result of these claims. The Amalgamated Engineering Union and the Transport and General Workers' Union are two of the unions concerned in pressing these wage demands.

Some redundancy is reported to have arisen recently at the Hirwaun Trading Estate, near Aberdare, Glamorganshire. The district has been regarded since the war as a development area and a number of new factories, some connected with the radio industry, have been constructed during the last few years. Messrs. Sobell Industries, Ltd., who manufacture radio equipment and have a factory on the estate, declared at the beginning of this week that between six and seven hundred of their employees would shortly become redundant owing to bad trade. During the last week-end in December, another firm with a factory on the Estate, the Ferguson Radio Corporation, Ltd., had to dismiss about 150 employees for reasons of redundancy.

Trade-unionists' restrictive practices are condemned in an article in the current issue of *Socialist Commentary*, written by Mr. Sam Watson, a former chairman of the national executive committee of the Labour Party. Mr. Watson directs his attacks mainly against those practices which operate in the nationalised industries and under a Labour Government, but he is equally opposed, presumably, to corresponding restrictions

when they occur under private enterprise. He considers that conditions ruling when a Labour Government is in power, and industry is being run partly under public control and partly under the control of private enterprise, are something entirely fresh in the history of the trade-union movement, and that they demand a constructive attitude on the part of all workpeople and not a passive one. If nationalisation is to be worth while, it must be actively supported "in the mine, shop, and bench, by better co-operation, increased efficiency and greater production."

This realistic attitude to the nationalised industries demands, Mr. Watson suggests, that twentieth-century means of production should be adopted. Modern methods come into conflict with nineteenth-century rules, customs and practices, but this new approach to industry is imperative if the nation is to survive. The trade-union movement is not a single driving force conscious of its goal and of the means for achieving it. Mr. Watson, who is a trade-union leader in the Durham area of the National Union of Mineworkers, considers that trade-union members may support the nationalisation of the industry in which they work, but that that does not mean that they have worked out an effective policy for taking over the industry or that they have a clear conception as to how it is to play its part in the national economy. It does not mean that they have taken, or will take, educational steps to train technicians, supervisory and managerial staffs. It does not mean that they have thought out methods of joint consultation and conciliation. "It does not imply," he concludes, "that blueprints are to hand to achieve industrial efficiency and increased production, and that, to accomplish these twin principles, the trade unionists will abolish all those practices and customs which hinder this end."

A considerable number of wage increases, applicable to many classes of workpeople, are reported to have taken effect during November. According to statistics published in the December issue of the *Ministry of Labour Gazette*, some 3,096,000 workpeople in the United Kingdom received increases in their full-time weekly wages during the month and these were estimated to amount to 1,419,000l. a week net. The *Gazette* records that the increases principally affected employees in the engineering and allied industries, the shipbuilding and ship-repairing industry, the railway service, the iron and steel industry, the motor-vehicle retail and repairing trade, the gas industry, and the agricultural industry in Scotland. Among other classes of workpeople to benefit may be mentioned those engaged in food preserving, sugar-confectionery manufacture, and the textile bleaching, dyeing, printing and finishing trades.

As previously reported in these columns, there was an increase of 11s. a week in the engineering and allied industries and in the shipbuilding and ship-repairing industry for adult male employees engaged on time work and at payment-by-results rates. For workpeople employed by British Railways, there was an increase of 8 per cent. on the existing rates of pay. In the iron and steel industry, there were small increases payable under sliding-scale arrangements based on the interim index of retail prices. Skilled and semi-skilled adult male employees in the motor-vehicle retail and repairing trade received an increase of 3d. an hour in their minimum rates of pay. Other adult male employees in this trade received an increase of 2½d. an hour in their minimum rates.

Coal production in Great Britain during 1951 totalled over 222 million tons and thereby exceeded the highest estimate put forward in the Government's *Economic Survey* for the year. According to provisional figures issued by the Ministry of Fuel and Power on January 1, the production of deep-mined coal amounted to 211,131,800 tons, and of opencast coal to 10,985,700 tons, up to December 29 last. This total of 222,117,500 tons of coal mined during 1951 compares with estimates in the *Survey* for between 208 and 210 million tons of deep-mined coal and between 11 and 12 million tons of opencast coal. It will thus be seen that the mining of opencast coal fell just short of official expectations.

The Ministry's comparative figures for coal production during the twelve months ended December 30, 1950, are 204,123,500 tons of deep-mined coal and 12,185,100 tons of opencast coal, giving a total for that year of 216,308,600 tons. Statistics previously issued by the Ministry show that during the 51 weeks ended December 22, 1951, 7,774,500 tons of coal were lost owing to recognised holidays, 792,900 tons owing to industrial disputes, and 387,900 tons from other causes, making a total of 8,955,300 tons. Production lost for these reasons during the corresponding 51 weeks of 1950 amounted to 8,998,700 tons, in about the same proportions.

TORSIONAL FATIGUE MACHINE WITH TORQUE CONTROL.

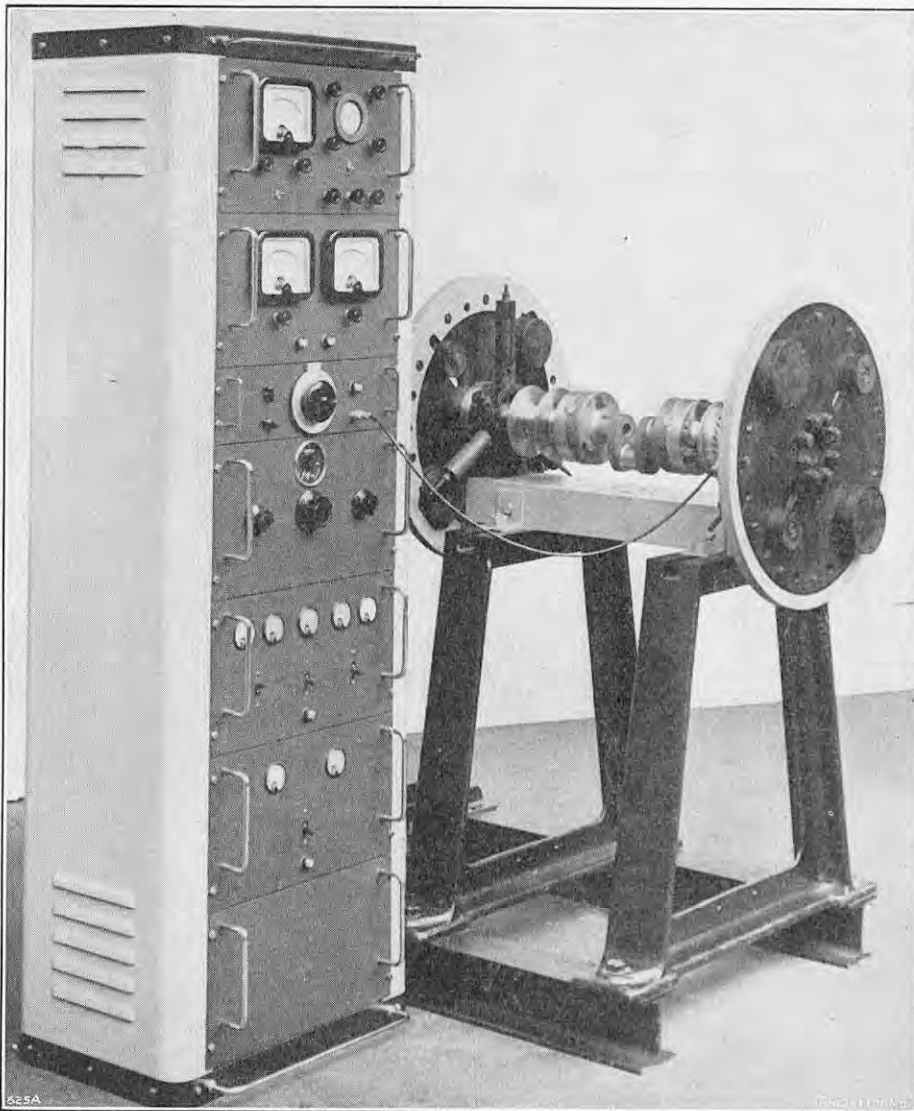


FIG. 1. FATIGUE MACHINE AND CONTROL CABINET.

TORSIONAL FATIGUE MACHINE WITH TORQUE CONTROL.*

By R. J. A. PAUL, B.Sc.(Eng.) and J. R. BRISTOW, B.Sc., Ph.D., A.M.I.Mech.E.

THIS report concerns the design of a torsional fatigue machine having controlled torque, developed mainly for work on cast crankshafts. Cast iron has relatively little notch-sensitivity; hence, in fatigue machines of the so-called constant-strain type, crack growth is very slow, and indeed, with the reduction in stress due to a specimen weakening on cracking, crack growth may virtually cease. This means that, whereas with steel—which is notch-sensitive—the end of a fatigue test may be clearly defined by the specimen breaking in half, with cast iron the end of a test has to be defined by taking some arbitrary size of crack—as judged by an observer—as constituting failure. This, naturally, produces a considerable scatter in results, giving a large error on fatigue limit.

It was, therefore, decided to construct a machine of the so-called constant-torque type in which the maximum torque, in a completely reversed torque cycle, is electronically controlled to ± 2 per cent. or better. (A variation of not more than 2 per cent. was considered to be satisfactory on the basis of previous experience.) Such a machine, it was considered, would produce—since the torque would not decrease on a crack starting—total failure of the specimen. The expectation that such a machine, giving total failure, would yield less scattered results than a machine of the constant-strain type has proved fully justified.

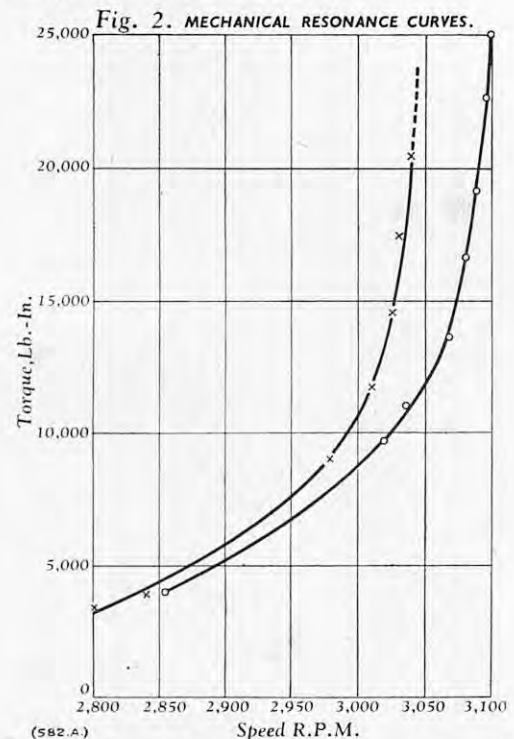
The machine is of the resonance type, being a freely suspended two-mass system, with the specimen—usually a one-throw crank—as the flexible element, maintained in torsional oscillation by a rotating out-of-balance mass which is driven by an electric motor through a

flexible coupling. The machine is run near resonance, control of torque being then exercised by control of motor speed. This is done electronically, as is the measurement of torque, using a capacity-type gauge. On failure of the test specimen, or indeed of the machine itself, the machine stops automatically. The electronic control equipment also provides a continuous indication of peak dynamic torque, of error between actual running torque and the desired torque at which the machine has been set to run, and of static torque. Response to, and indication of, static torque makes it possible to calibrate the equipment by dead loading. The machine and the cabinet housing the electronic control and measuring equipment are illustrated in Fig. 1; Fig. 10, on page 28, shows a typical fatigue failure.

The machine consists essentially of a freely-suspended system—which can be excited in a simple one-node “free-ended” oscillation by a rotating out-of-balance weight—comprising two inertia discs connected through extension shafts to each end of a one-throw crankshaft, or other specimen. The crankshaft is essentially the flexible element—since the extension shafts are stiff compared with it—and is placed at the nodal point of the system. Arrangement drawings of the machine are reproduced in Figs. 3 and 4, on page 26. The extension shafts provide a convenient way of supporting the oscillating system, and of attaching the inertia discs to the specimens. It is on one of these extension shafts also that the capacity-type torque gauge is fitted since they can be conveniently made sufficiently strong to be stressed well below the fatigue limit.

The entire oscillating system is restrained in position by three springs at each end attached to the periphery of the extension shafts and at 120 deg. to each other, the two vertical springs being stronger than the others, since they have to support the weight of the system. To arrest, if necessary, excessive movement of the system when running, adjustable rubber stops are provided between each spring.

The system is designed to be symmetrical about the



nodal point and for this purpose flanges to carry the capacity gauge, which is the torque-measuring device, are machined on both extension shafts. It has, however, not proved necessary to fit a dummy capacity gauge or, moreover, a dummy rotating out-of-balance mass arrangement. Static and dynamic balance about the axis of vibration has been maintained with the use of both fixed and movable masses on the inertia discs. These latter are fixed in radial slots and serve also to adjust the inertia to the required value.

Energy is fed into the system by only one out-of-balance rotating mass, driven through a flexible rubber coupling by a $\frac{3}{4}$ -h.p. direct-current motor. This type of coupling was found by experiment to give the best behaviour, more conventional types of flexible couplings (various universal-joint arrangements) proving too stiff.

The out-of-balance rotating mass, acting at a radius to the central axis of the system, exerts a harmonically-oscillating torque on the disc on which it is mounted. This torque is transmitted through the extension shafts and specimen to the other disc, and, the system being “free-ended,” the two discs oscillate out-of-phase, the system thus being maintained in “free-ended” torsional oscillations. The system is designed to oscillate near resonance in its lowest mode, i.e., with a single node at the centre, at an input speed of about 3,000 r.p.m. The exact resonance speed depends upon the shape and material of the specimen, and, for input torques of the order used in actual testing, only a small part of the resonance curve can be determined before the specimen breaks; portions of such resonance curves, using crankshafts in two different materials, are shown in Fig. 2. For input torques sufficiently low not to break the specimen, the dynamic magnifier at resonance is of the order of 100; at the higher normal running torques, it is considerably lower than this, due to the increase in damping capacity of the material for large deflections, and the machine is normally run at a dynamic magnifier of about 10 over a range of torques of about 12,000 lb.-in. to 25,000 lb.-in.

Referring to Fig. 2, if it is assumed that the operating point is at a speed of 3,075 r.p.m., then for a change in speed of 5 r.p.m. the torque increases by approximately 10 per cent. Thus, for a 2 per cent. change in torque the speed variation is one part in 3,075. This means that the speed of the motor must be controlled to better than approximately one part in 3,000 if torque is to be held constant to better than ± 2 per cent. More severe conditions are imposed on the control system if another operating point higher on the resonance curve is chosen, and these figures are only given to indicate the degree of speed control necessary to maintain the torque within the required limits. The requirements of such control are, of course, a disadvantage compared with a non-resonance type of machine; this disadvantage, however, is outweighed by the advantages of the low input power required for the resonance type as has already been pointed out, and also by the fact that no large forces are exerted on the foundation of the machine.

As has been already mentioned, the machine is actuated by only one out-of-balance rotating mass,

* Report No. 1951/6 of the Motor Industry Research Association, Great West-road, Brentford, Middlesex. Abridged.

TORSIONAL FATIGUE MACHINE WITH TORQUE CONTROL.

GENERAL ARRANGEMENT OF MECHANICAL SYSTEM.

Fig. 3.

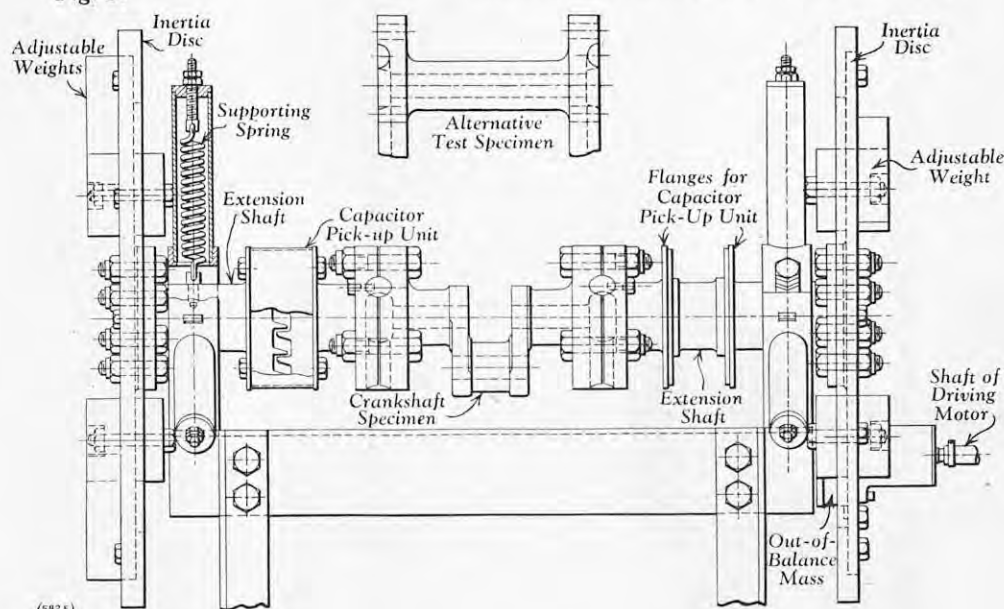
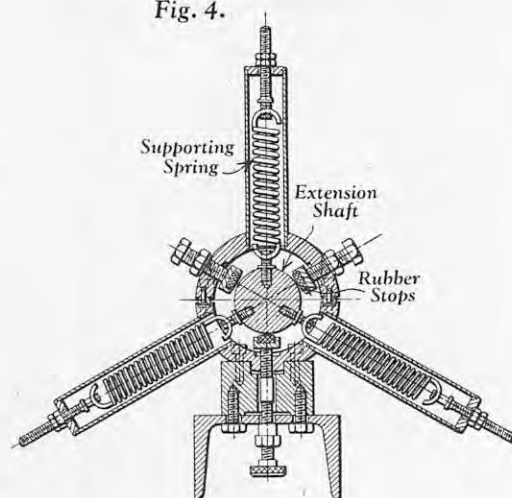


Fig. 4.



which means the system is subject to unbalanced force which produces some bending effects. The machine was originally designed with two rotating masses, the one driven from the other through a cross-shaft gearing arrangement carried on the inertia disc. This arrangement, however, had to be abandoned since the "impact" on each tooth engagement of the gears produced a high-frequency vibration in the system. It was found that bending effects due to using only one mass were fortunately of negligible importance, the bending resonance being at a very low speed and well outside the normal operating range of the machine.

In such a machine as this, there must be no backlash in the elastic system, all parts must be rigidly fixed to each other, and all must be accurately located axially. These are the reasons for the unusual method used to attach the test specimens to the rest of the system, which results in a rather unusual shaped specimen; a crankshaft test specimen is shown in Fig. 9, on page 28. Both extension shafts and both ends of the specimen carry large heavy flanges which have three large radial semi-circular grooves in the surfaces, as shown in Figs. 3 and 9. Hard nitrided-steel cylindrical pins fit in these grooves and the two pairs of flanges are held together by bolts at right-angles to the pins. The grooves are made by boring in a jig, and the arrangement is very rigid, without backlash; it accurately "centres" the specimen, and is very easily dismantled and reassembled.

A block outline diagram of the equipment is given in Fig. 6, on page 28, and a complete circuit diagram in Fig. 5, opposite. The component values are given in Table I, on this page.

Change in the capacity of a capacitor pick-up unit, which is mounted on one of the extension shafts, (Fig. 3), is proportional to the torque in the shaft. This pick-up unit forms part of the tank circuit of an electron-coupled Hartley oscillator, and variations in its capacity produce variations in the oscillator frequency, i.e., under dynamic conditions a frequency-modulated signal is produced. Thus the frequency of the oscillator is a measure of the torque. The frequency-modulated signal is fed into a parallel L-C tuned type of discriminator in which the frequency variations are converted into amplitude variations. The output from the discriminator is thus a frequency-modulated signal with an amplitude-modulation envelope, the amplitude of which is a measure of torque. This signal is fed into a diode detector stage in which envelope detection takes place. The output from this stage is coupled directly to a direct-current voltmeter, capacitively to a valve voltmeter (reading peak-to-peak alternating-current voltage), and to a cathode-ray oscillograph. With this arrangement, measurement of static and dynamic torque is achieved together with a pictorial representation of the torque cycle.* Calibration of the instrument is carried out by applying known static torques to the machine and recording the direct-current voltage change. The peak-to-peak alternating-current valve voltmeter is directly calibrated against the direct-current voltmeter. A typical calibration curve is given in Fig. 7, on page 28.

* The torque-meter part of the equipment is similar to that described by C. H. G. Mills; *Jl. Sci. Inst.*, vol. 25, page 151 (1948).

TABLE I.—VALUES OF COMPONENTS.

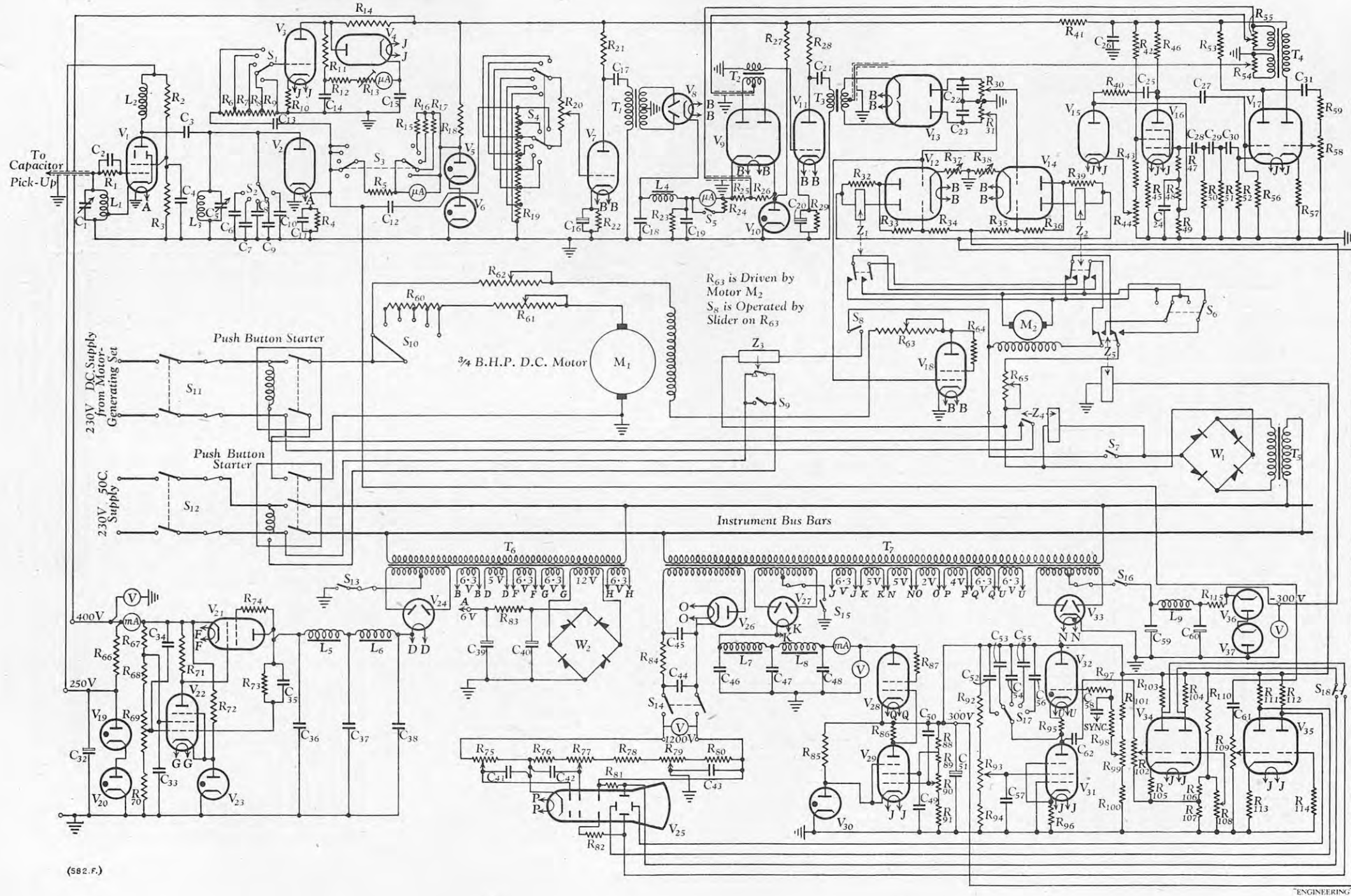
R ₁ ... 100 kΩ	R ₂₄ ... 100 Ω	R ₄₇ ... 50 kΩ	R ₇₀ ... 30 kΩ	R ₉₃ ... 250 kΩ
R ₂ ... 30 kΩ	R ₂₅ ... 100 kΩ	R ₄₈ ... 500 kΩ	R ₇₁ ... 300 kΩ	R ₉₄ ... 100 kΩ
R ₃ ... 50 kΩ	R ₂₆ ... 100 kΩ	R ₄₉ ... 500 kΩ	R ₇₂ ... 25 kΩ	R ₉₅ ... 1.0 kΩ
R ₄ ... 100 kΩ	R ₂₇ ... 90 kΩ	R ₅₀ ... 50 kΩ	R ₇₃ ... 2.0 MΩ	R ₉₆ ... 800 Ω
R ₅ ... 580 kΩ	R ₂₈ ... 50 kΩ	R ₅₁ ... 50 kΩ	R ₇₄ ... 100 Ω	R ₉₇ ... 250 kΩ
R ₆ ... 1.6 MΩ	R ₂₉ ... 1.0 kΩ	R ₅₂ ... 10 kΩ	R ₇₅ ... 50 kΩ	R ₉₈ ... 250 kΩ
R ₇ ... 200 kΩ	R ₃₀ ... 100 kΩ	R ₅₃ ... 50 kΩ	R ₇₆ ... 50 kΩ	R ₉₉ ... 250 kΩ
R ₈ ... 100 kΩ	R ₃₁ ... 100 kΩ	R ₅₄ ... 250 kΩ	R ₇₇ ... 50 kΩ	R ₁₀₀ ... 10 kΩ
R ₉ ... 100 kΩ	R ₃₂ ... 100 kΩ	R ₅₅ ... 250 kΩ	R ₇₈ ... 200 kΩ	R ₁₀₁ ... 50 kΩ
R ₁₀ ... 220 Ω	R ₃₃ ... 1.0 MΩ	R ₅₆ ... 1.0 MΩ	R ₇₉ ... 500 kΩ	R ₁₀₂ ... 250 kΩ
R ₁₁ ... 100 kΩ	R ₃₄ ... 2.0 MΩ	R ₅₇ ... 800 Ω	R ₈₀ ... 50 kΩ	R ₁₀₃ ... 30 kΩ
R ₁₂ ... 180 kΩ	R ₃₅ ... 2.0 MΩ	R ₅₈ ... 500 kΩ	R ₈₁ ... 2.0 MΩ	R ₁₀₄ ... 30 kΩ
R ₁₃ ... 10 kΩ	R ₃₆ ... 1.0 MΩ	R ₅₉ ... 500 kΩ	R ₈₂ ... 2.0 MΩ	R ₁₀₅ ... 1.0 kΩ
R ₁₄ ... 40 kΩ	R ₃₇ ... 2.0 kΩ	R ₆₀ ... 4 × 20 Ω	R ₈₃ ... 6.0 Ω	R ₁₀₆ ... 10 kΩ
R ₁₅ ... 2.3 kΩ	R ₃₈ ... 2.0 kΩ	R ₆₁ ... 20 Ω	R ₈₄ ... 30 kΩ	R ₁₀₇ ... 600 Ω
R ₁₆ ... 770 Ω	R ₃₉ ... 100 kΩ	R ₆₂ ... 840 Ω	R ₈₅ ... 7.5 kΩ	R ₁₀₈ ... 10 kΩ
R ₁₇ ... 130 Ω	R ₄₀ ... 100 kΩ	R ₆₃ ... 900 Ω	R ₈₆ ... 300 kΩ	R ₁₀₉ ... 2.0 MΩ
R ₁₈ ... 10 kΩ	R ₄₁ ... 8.0 kΩ	R ₆₄ ... 100 Ω	R ₈₇ ... 100 Ω	R ₁₁₀ ... 400 kΩ
R ₁₉ ... 7 × 300 kΩ	R ₄₂ ... 100 kΩ	R ₆₅ ... 2.0 kΩ	R ₈₈ ... 100 kΩ	R ₁₁₁ ... 30 kΩ
R ₂₀ ... 1.0 MΩ	R ₄₃ ... 10 kΩ	R ₆₆ ... 7.5 kΩ	R ₈₉ ... 100 kΩ	R ₁₁₂ ... 30 kΩ
R ₂₁ ... 50 kΩ	R ₄₄ ... 2.0 kΩ	R ₆₇ ... 80 kΩ	R ₉₀ ... 20 kΩ	R ₁₁₃ ... 450 Ω
R ₂₂ ... 2.0 kΩ	R ₄₅ ... 1.0 kΩ	R ₆₈ ... 20 kΩ	R ₉₁ ... 100 kΩ	R ₁₁₄ ... 50 Ω
R ₂₃ ... 100 kΩ	R ₄₆ ... 200 kΩ	R ₆₉ ... 20 kΩ	R ₉₂ ... 50 kΩ	R ₁₁₅ ... 2.0 kΩ
C ₁ ... 50 pF	C ₁₄ ... 4.0 μF	C ₂₆ ... 0.5 μF	C ₃₈ ... 8.0 μF	C ₅₀ ... 0.5 μF
C ₂ ... 100 pF	C ₁₅ ... 4.0 μF	C ₂₇ ... 0.01 μF	C ₃₉ ... 2000 μF	C ₅₁ ... 16 μF
C ₃ ... 100 pF	C ₁₆ ... 50 μF	C ₂₈ ... 0.003 μF	C ₄₀ ... 2000 μF	C ₅₂ ... 0.5 μF
C ₄ ... 500 pF	C ₁₇ ... 2.0 μF	C ₂₉ ... 0.003 μF	C ₄₁ ... 2.0 μF	C ₅₃ ... 2.0 μF
C ₅ ... 60 pF	C ₁₈ ... 6.0 μF	C ₃₀ ... 0.003 μF	C ₄₂ ... 2.0 μF	C ₅₄ ... 0.05 μF
C ₆ ... 50 pF	C ₁₉ ... 6.0 μF	C ₃₁ ... 0.01 μF	C ₄₃ ... 2.0 μF	C ₅₅ ... 0.005 μF
C ₇ ... 100 pF	C ₂₀ ... 50 μF	C ₃₂ ... 48 μF	C ₄₄ ... 1.0 μF	C ₅₆ ... 0.002 μF
C ₈ ... 150 pF	C ₂₁ ... 0.5 μF	C ₃₃ ... 0.25 μF	C ₄₅ ... 1.0 μF	C ₅₇ ... 2.0 μF
C ₉ ... 200 pF	C ₂₂ ... 0.5 μF	C ₃₄ ... 0.25 μF	C ₄₆ ... 8.0 μF	C ₅₈ ... 0.5 μF
C ₁₀ ... 250 pF	C ₂₃ ... 0.5 μF	C ₃₅ ... 0.005 μF	C ₄₇ ... 8.0 μF	C ₅₉ ... 16 μF
C ₁₁ ... 200 pF	C ₂₄ ... 0.01 μF	C ₃₆ ... 8.0 μF	C ₄₈ ... 8.0 μF	C ₆₀ ... 16 μF
C ₁₂ ... 2.0 μF	C ₂₅ ... 0.01 μF	C ₃₇ ... 8.0 μF	C ₄₉ ... 0.5 μF	C ₆₁ ... 4.0 μF
C ₁₃ ... 4.0 μF				
L ₁ ... 19 μH	L ₃ ... 10 μH	L ₅ 22H (120 mA)	L ₇ 22H (120 mA)	L ₉ 10H (60 mA)
L ₂ R.F. Choke	L ₄ ... 10 H	L ₆ 22H (120 mA)	L ₈ 22H (120 mA)	
V ₁ ... 4061A	V ₉ ... 6H6	V ₁₇ ... 12AU7	V ₂₄ ... U52	V ₃₁ ... EF37
V ₂ ... EA50	V ₁₀ ... 85A1	V ₁₈ ... 12E1	V ₂₅ ... E4205-B-7	V ₃₂ ... EN31
V ₃ ... 6C5	V ₁₁ ... 6C5	V ₁₉ ... VR150/30	V ₂₆ ... U22	V ₃₃ ... U50
V ₄ ... EA50	V ₁₂ ... 6N7	V ₂₀ ... VR105/30	V ₂₇ ... U50	V ₃₄ ... B65
V ₅ ... VR105/30	V ₁₃ ... 6H6	V ₂₁ ... 12E1	V ₂₈ ... 12E1	V ₃₅ ... B65
V ₆ ... VR105/30	V ₁₄ ... 6N7	V ₂₂ ... 6SJ7	V ₂₉ ... EF37	V ₃₆ ... VR150/30
V ₇ ... 6C5	V ₁₅ ... 6AL5	V ₂₃ ... VR150/30	V ₃₀ ... VR105/30	V ₃₇ ... VR150/30
V ₈ ... 6H6	V ₁₆ ... EF41			
Z ₁ ... Relays.	Z ₂ ... Relays.	Z ₃ ... Relays.	Z ₄ ... Relays.	
Z ₅ ... Coil resistance 10 kΩ				

The torque is controlled by altering the operating point on the mechanical resonance curve of the machine. This is done by controlling the speed of the direct-current shunt-wound driving motor by automatic adjustment of its field current. It was desirable to have the control in two parts: (1) to correct, with negligible time-lag, for small but rapid and sporadic fluctuations, and (2) to correct for very slow changes—due to warming-up of the driving motor, changes in damping capacity of the specimen, etc.—which were of greater

magnitude than the sporadic fluctuations. This is accomplished as follows. The output from the diode detector is amplified and then rectified to give a direct-current voltage. (An input attenuator to the amplifier controls the value of direct-current voltage produced for a certain torque signal.) This direct-current voltage is applied to one side of a modulator stage, the other side being maintained at a fixed reference direct-current potential. The difference between these two direct-current voltages for any setting of torque signal repre-

EQUIPMENT CIRCUIT DIAGRAM FOR TORSIONAL FATIGUE MACHINE.

Fig. 5. CIRCUIT DIAGRAM OF ELECTRONIC CONTROL AND MEASURING EQUIPMENT.



(582.F.)

ENGINEERING

TORSIONAL FATIGUE MACHINE WITH TORQUE CONTROL.

Fig. 6. BLOCK DIAGRAM OF ELECTRONIC CONTROL AND MEASURING EQUIPMENT.

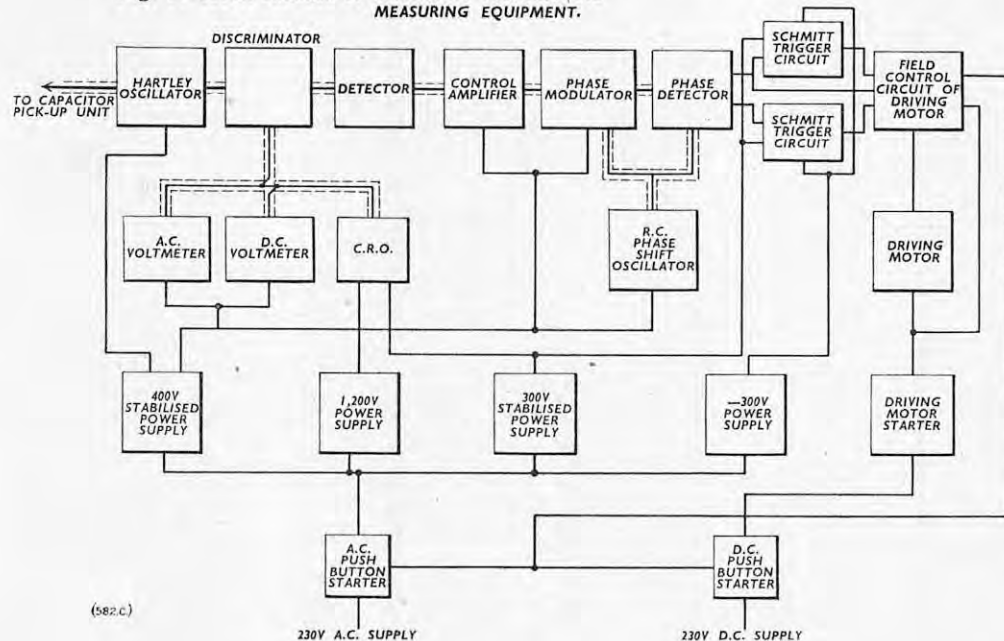


Fig. 7. CALIBRATION CURVE, D.C. VOLTS AND TORQUE.

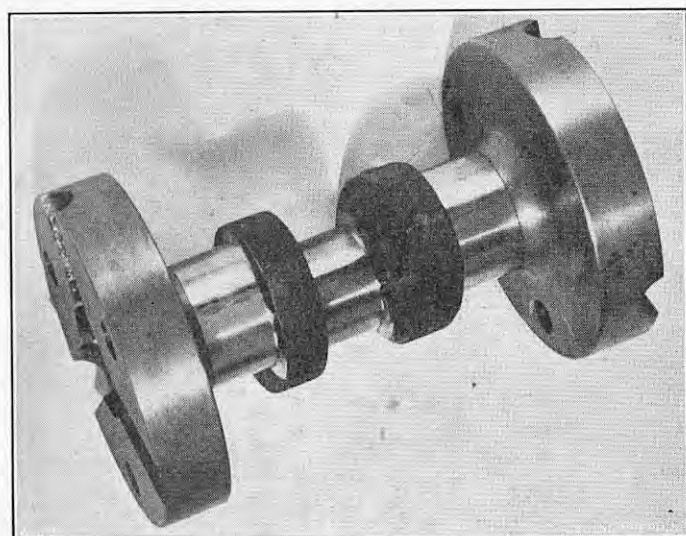
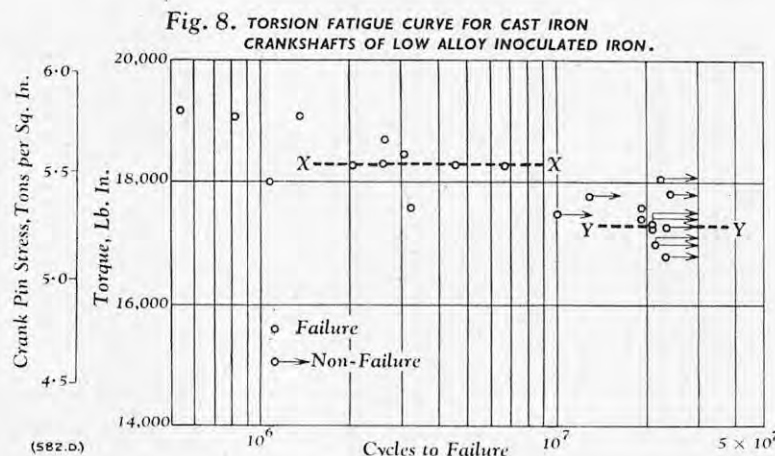
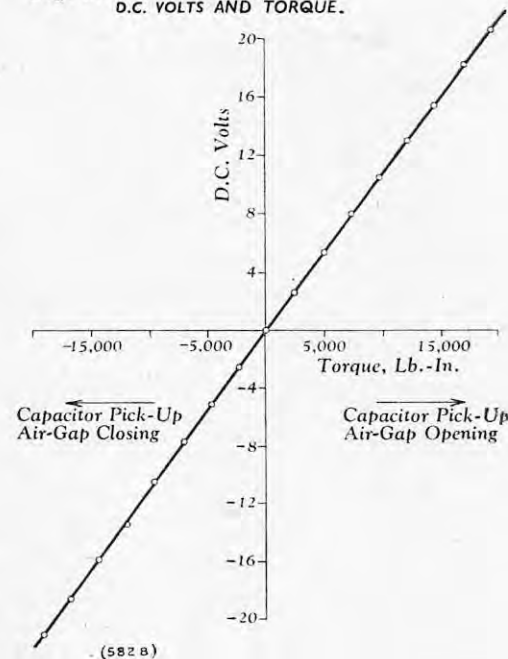


FIG. 9. CRANKSHAFT TEST SPECIMEN.

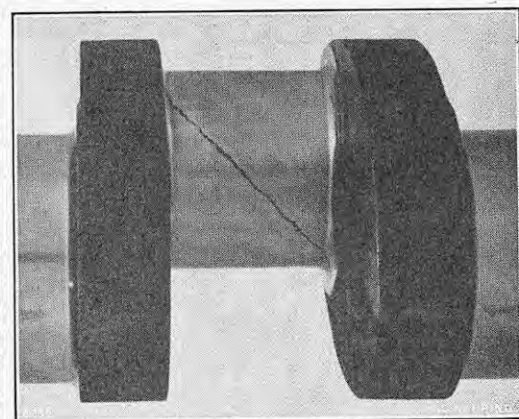


FIG. 10. TYPICAL FATIGUE FAILURE.

sents an error-voltage proportional to the difference between the actual running torque and the desired running torque. The modulator provides an alternating voltage that indicates the sense as well as the magnitude of the error-voltage; if the polarity of the error-voltage is changed, this is indicated in the output. The alternating-current error-voltage is amplified and fed into a phase-detector stage, the output of which is a differential direct-current signal symmetrical with earth and with a polarity that responds to the sense of the error-voltage. Thus, if the torque changes from any particular setting an error-voltage results which causes the potential of one side of the output of the phase detector to increase with respect to earth, while the other side decreases by the same amount.

In order to provide a control with negligible time-lag, and with a correction factor which is proportional to the magnitude of the error-voltage, one side of the phase-detector output is applied to the grid of a tetrode valve placed in the field circuit of the driving motor. Then an increase in error-voltage results in increased current through the valve, and the increase in field current of the motor decreases the speed until the torque is reduced to its former value or, of course, vice versa. The operating range of the valve control is ± 1 per cent. variation in torque. Under normal operating conditions the value of torque is maintained well within these limits.

To control the slow fluctuations, which are of greater magnitude than the valve control can handle, the differential direct-current output of the phase detector is applied to two Schmitt trigger circuits* in each of which is placed a relay. The contacts of the two relays are wired in such a manner that the supply to a small servo motor, operating a rheostat placed in the field winding of the driving motor, can be switched on or off and that the direction of rotation of the motor can be reversed. The Schmitt trigger circuits are so arranged that an increase in torque, of 1 per cent. above a particular setting, triggers one circuit, and operates its relay, which brings the servo motor into

operation. The direction of rotation of the servo motor is such that it reduces the resistance of the rheostat and thus increases the field current of the driving motor resulting in a decrease in speed and consequently a decrease in torque, as before. A decrease in torque of 1 per cent. triggers the other circuit and in a similar manner results in an increase in speed, and thus an increase in torque.

This latter control is not instantaneous, but variation in torque has been found to be confined to a range of ± 2 per cent., provided that the rate of change of torque is less than the time-lag. This condition would normally be the case except when the specimen is breaking rapidly. It has been found by experience that specimens tested in the machine break suddenly and that the torque then drops almost to zero. Under these conditions control of torque is obviously impossible and a cut-out device is incorporated in the control to shut down the machine.

It was found during initial tests on the machine that the voltage fluctuations of the laboratory direct-current supply were of such magnitude and character that stable operation for prolonged periods was difficult to obtain and that the motor-controlled rheostat, controlling the field current of the driving motor, was in continuous operation with some hunting apparent. In order to obtain satisfactory operation it was found necessary to incorporate a motor-generator set, the voltage output of which is controlled by a regulator to $\pm \frac{1}{2}$ per cent. It was also necessary to couple a high-inertia flywheel to the driving motor of the machine, to increase the "time-constant" of the system.

As an example of the type of results obtained with this machine the S-N curve for torsional fatigue failure of cast iron crankshafts—of M.I.R.A. "standard" design with 2-in. diameter journals in low-alloy inoculated iron—is given in Fig. 8.

After the fatigue limit had been determined approximately—i.e., all the points on the curve shown had been determined except those on the torque level X-X and Y-Y—as being probably about 17,800 lb. in.

(i.e., between the highest non-failure and lowest failure) four tests were run at the torque level X-X, about 18,300 lb. in., giving four failures and three tests run at the torque level Y-Y, about 17,300 lb. in. giving three non-failures. Hence, it can be assumed with some certainty that the fatigue limit lies between 17,300 and 18,300 lb. in., or the fatigue limit is $17,800 \pm$ (less than) 3 per cent. It is estimated that in work on bending fatigue strength of cast-iron crankshafts under constant-strain conditions the fatigue limit was only defined within about ± 10 per cent.

Acknowledgements are due to Mr. H. E. Dingle, who was responsible for the detailed design of the mechanical system.

* O. H. Schmitt; *Jl. Sci. Inst.*, vol. 15, page 24 (1938).

SMOKE ELIMINATOR FOR SHUNTING LOCOMOTIVES.

Fig. 1.

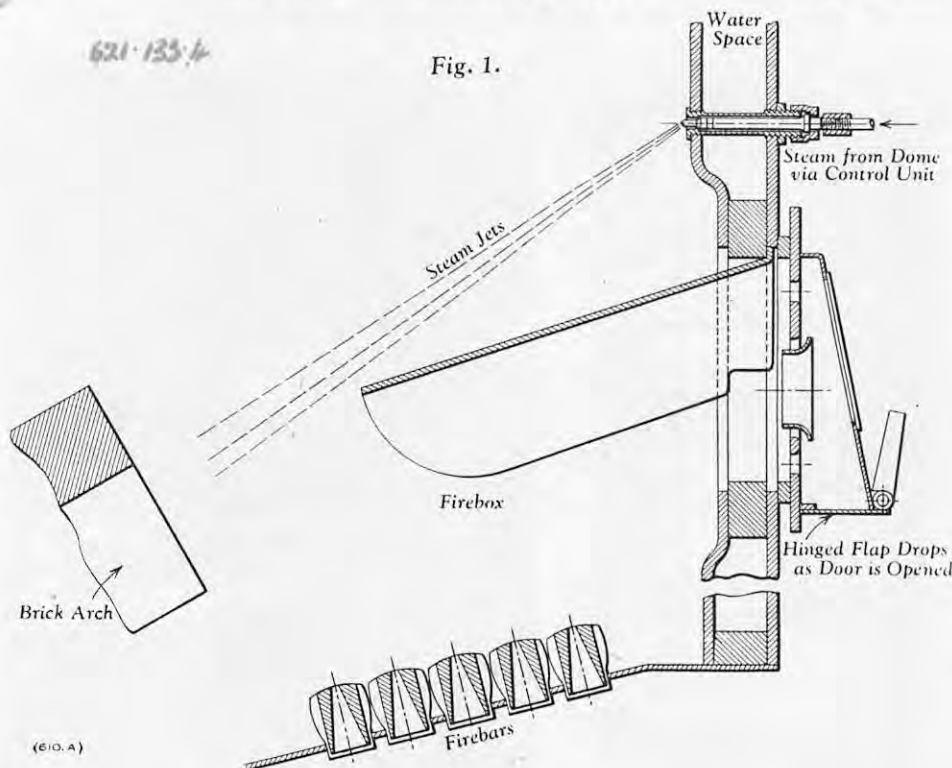
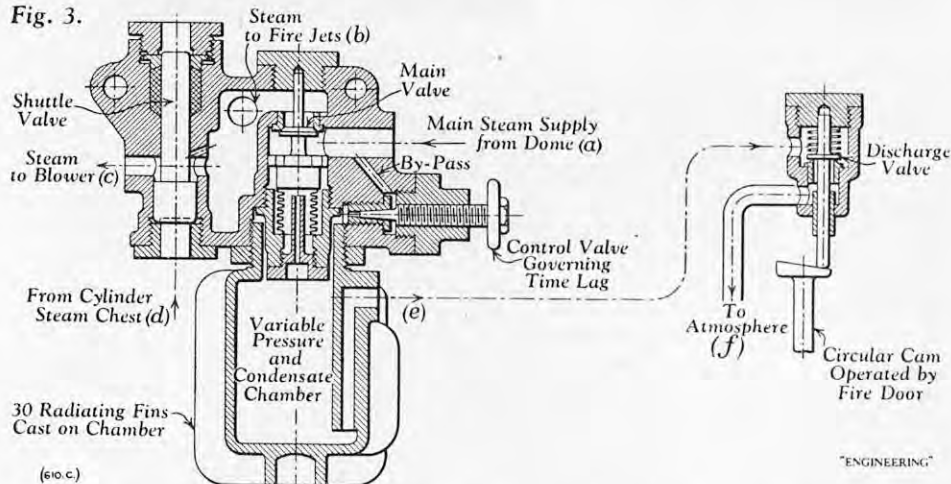


Fig. 3.



AUTOMATIC SMOKE ELIMINATOR FOR WORKS SHUNTING LOCOMOTIVES.

THE addition of coal to the fire-bed of a locomotive should not produce much smoke, provided small quantities are added regularly and the locomotive is running. In the case of works shunting locomotives, however, the engine is very often stationary when, or immediately after, coal has been added. The Appleby-Frodingham Steel Company, Scunthorpe, Lincolnshire, have been endeavouring to stop the production of smoke by their works locomotives since 1943, using a method based generally on the Marcotty system, which was developed originally for use on main-line locomotives.

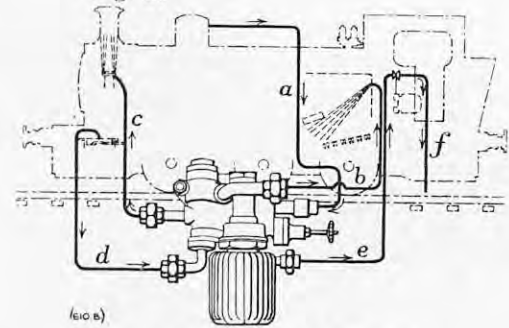
The basic principle of the Marcotty system is to induce turbulence in the firebox when the locomotive is standing, and to compel the hot gases to follow a longer path close to the fire-bed; this is done by steam jets, directed as shown in Fig. 1. At the same time, an adequate supply of secondary air is admitted through inlet flaps in the fire-hole door, an auxiliary supply of steam to the blower being provided for the purpose. This system proved to be quite effective in eliminating most of the smoke, but, due to the frequent stops of shunting locomotives, it was uneconomical in fuel; steam was used even when the fire-bed had burned to a bright condition and dense smoke was not being produced. The modification which the company have introduced is designed to cut off the supply of steam to the jets, and of auxiliary steam to the blower, a fixed time after the fire-hole door has been closed. The apparatus, moreover, is designed so that it does not depend too much on the human element.

Fig. 2 is a diagram showing the connections to the

automatic control unit, and Fig. 3 is a section of the unit itself and of the small valve which is actuated by the opening and closing of the fire-hole door. The reference letters *a* to *f* are used to show the same connections in both figures. Referring to Fig. 3: when the fireman opens the door preparatory to firing, the discharge valve is opened by means of a circular cam, thereby allowing the discharge of condensate and the release of pressure from the chamber of the control unit, through the connection *e* and thence to waste through *f*. The chamber communicates with the inside of a flexible bellows which is coupled to an extension of the main valve. The extension of the main valve, together with the outside of the bellows, always being subject to steam at boiler pressure through connection *a*, the main valve now opens and allows steam from the boiler to pass to the firebox jets through connection *b*, and to the blower through connection *c*.

When the fire-hole door is closed, the discharge valve closes with it; the pressure in the chamber is then built up by steam which is by-passed from connection *a*, through a needle valve. After a time, the pressure in the chamber is sufficient to overcome the pressure on the valve extension—which has a smaller active area than that of the bellows. The main valve then closes, and steam to the jets and blower is cut off. The needle valve is set to allow an interval equivalent to the estimated period of smoke emission plus a margin before the pressure in the chamber rises sufficiently. If the locomotive regulator is opened before the main valve is automatically closed, steam from the steam-chest, passing through the connection *d*, acts on a shuttle valve which is thereby closed, cutting off auxiliary steam to the blower; the draught is then maintained by the exhaust. Steam to the firebox jets, however, will continue to flow until the end of the set period, whether or not the locomotive is running.

Fig. 2.



TRADE PUBLICATIONS.

Direct-on Contactor Starters.—A leaflet received from Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, 17, deals with direct-on contactor starters for non-reversing squirrel-cage motors of capacities up to 7½ h.p. at 550 volts.

Circuit-Breakers and Motor Starters.—The English Electric Co., Ltd., Industrial Motor Works, Bradford, have sent in a number of pamphlets containing maintenance instructions and spares lists of their S.S. circuit-breakers and O.S., O.S.R., and O.R. motor starters.

Diesel Engines.—Davey, Paxman & Co., Ltd., Colchester, have issued two leaflets on the industrial and marine applications of their Mark V 6RPH Diesel engines, which are six-cylinder units, pressure-charged or naturally-aspirated, developing between 200 and 312 b.h.p.

Intercommunication Telephones.—Details regarding the apparatus made by them for use in telephone intercommunication systems in both factories and professional establishments are given in pamphlets received from Communication Systems, Ltd., Strowger House, 8, Arundel-street, London, W.C.2.

Speed Indicating Equipment.—Speed indicating equipment for commercial and passenger vehicles is described in a pamphlet issued by Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, 17. It consists of an alternating-current generator and a moving coil voltmeter, which is calibrated in miles per hour.

Hydraulic Marking Machine.—For producing impressed marks on agricultural machinery, contractors' plant, pneumatic tools, automobile suspension springs, cartridge cases, etc., Funditor, Ltd., 3, Woodbridge-street, London, E.C.1, have introduced a hydraulically-operated marking machine which is specified in a leaflet they have issued.

Automatic Feeder.—Henry Simon, Ltd., have introduced the "Velo-feeder," a motor-driven unit which delivers, at a controlled variable rate, such materials as coke, gravel, kibbled oil cake, bran, etc. Its capacity, with coke, is 9 tons an hour, and with gravel 21 tons an hour.

Cam-Operated Contactor Controllers.—Cam-operated contactor controllers for direct-current motors up to 125 h.p. and for alternating-current motors up to 200 h.p. are dealt with in a descriptive leaflet received from Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, 17.

Visual-Aid Equipment.—Brief details of a range of visual-aid equipment, including episcopes, diascopes and epidiscopes, film projectors and microscope attachments manufactured by Newton and Co., Ltd., 72, Wigmore-street, London, W.1, are given in a leaflet issued by the firm. Individual items in the list are described more fully in separate leaflets.

Window Wiper for Railway Use.—A window wiper, operated by a compressed-air motor driving a spindle to which the wiper arm and blade are attached, is described in a pamphlet issued by Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, 17. It is designed for use on all classes of railway rolling stock where compressed air is available.

Ships' Deck Machinery.—Clarke, Chapman & Co., Ltd., Gateshead, 8, Co. Durham, have published new leaflets on some of their deck machinery, including two-speed steam cargo winches; a derrick topping unit for raising, fixing and lowering ships' cargo derricks in conjunction with cargo winches; an electric winch for topping ships' derricks; patent roller bowstoppers; and a screw-operated wire-rope stopper for ships' rigging.

BOILER EXPLOSION AT GUILDFORD POWER STATION: ERRATUM.—We much regret that in the abstract of the report on the preliminary inquiry into the boiler explosion at Guildford power station, published on page 749 in our issue of December 14, 1951, we inadvertently described Mr. F. J. Colvill as Assistant Secretary, Marine Safety Division, Ministry of Transport. Mr. Colvill is, of course, Engineer Surveyor-in-Chief.

AUTOMATIC COMBUSTION-CONTROL SYSTEM FOR INDUSTRY.

A SIMPLE automatic control system has been developed recently for mechanically-fired boilers and furnaces which can be applied economically to small industrial installations, thereby making possible considerable savings in fuel consumption. In this system, which is manufactured by Messrs. UniTherm, Limited, 19, Chatsworth-road, Hayes, Middlesex, the load is measured by a pressure-sensitive or temperature-sensitive element and actuates the dampers controlling the draught through the furnace. The rate of air flow, or gas flow, through the furnace is measured and, through a coal/air-ratio controller, varies the rate of coal feed from the mechanical stoker as required to maintain a predetermined coal/air ratio. Means are provided for re-setting the coal/air-ratio controller to allow for changes in fuel quality or grading. The method for controlling the rate of coal feed is simple and effective: the mechanical stoker is driven by a constant-speed motor, but the time cycle during which the motor is running, based on one minute, is varied by the controller. Thus, for full output, the motor runs continuously; for 50-per cent. output, the motor runs for 30 seconds in every minute, and for 25-per cent. output, 15 seconds in every minute. Owing to the short time cycle and to the cushioning effect of the mass of fuel, the intermittent stoking does not give rise to fluctuations in combustion conditions. The manufacturers claim that it can, in fact, give some advantage on certain types of stoker when using coal with a tendency to cake, since the large masses tend to be broken up. It is usual to calibrate the combustion-control equipment for each particular plant by running tests on the site at various loads; the results of these tests determine the shape of a cam forming part of the fuel/air-ratio controller, which is shown in Fig. 1. Fig. 2 illustrates a vertical boiler, fired by an underfeed type of stoker and fitted with combustion-control equipment.

The operation of the UniTherm system may be understood by referring to the diagram reproduced in Fig. 3, which shows the equipment fitted on a natural-draught stoker-fired boiler. In this case, the control system comprises a master regulator and a coal/air ratio controller. In response to the load on the boiler, a small geared motor in the master regulator raises or lowers the gas-outlet dampers, through a sprocket and a section of roller chain in the example illustrated; with other types of boiler, the damper may be regulated by a crank and linkage. The regulator motor is controlled by a two-way mercury switch with a "mid-off" position, carried on a weighbeam. A bellows connected to the steam space causes a force proportional to the steam pressure to be applied at the centre point of the weighbeam, one end of which is attached to an adjustable tension spring opposing the pressure load. At the other end, a cam follower rests on a cam rotated by the output shaft of the motor. Thus, an increase in boiler pressure tilts the weighbeam and the mercury switch, switching on the motor and so adjusting the dampers and simultaneously rotating the cam so that the beam returns to a horizontal position as the adjustment is completed. The regulator responds to very small changes in steam pressure. In installations where the temperature is required to be the controlled element, the bellows forms part of a system filled with a volatile liquid which expands and contracts as the temperature varies.

In the installation shown in Fig. 3, opposite, since the rate of air flow is directly related to the amount of gas passing through the boiler, the latter quantity is metered in the coal/air ratio controller. In a natural-draught boiler, the resistance of the boiler passes provides a convenient pressure difference for measuring the rate of flow of the gas. The measuring element comprises two bell floats, sealed in transformer oil, suspended from either end of a weighbeam; the gas pressures from the tapping points are fed to the undersides of the bells. The force on the weighbeam due to the pressure difference is resisted by an adjustable spring. Changes of the differential pressure cause angular movements of a contact arm linked to the weighbeam, so that the arm is brought into contact with a cam, rotating at a speed of 1 r.p.m., at a point on its profile appropriate to the rate of gas flow, thus setting the timing cycle during which the stoker motor is in operation. The contact between the arm and the cam provides a starting impulse only, thereby avoiding difficulties due to rubbing contact. To compensate for changes in the quality of the fuel, the loading spring can be adjusted and, if necessary, the zero position of the contact arm can be altered. The control range of the equipment extends down to approximately 20 per cent. of the maximum; below this, another electrical circuit comes into operation and shuts down the plant until the steam pressure falls. The equipment provides automatic compensation for changes in fire-bed resistance; the gradual accumulation of clinker on a manually-cleaned grate restricts

AUTOMATIC COMBUSTION-CONTROL EQUIPMENT.

UNITHERM, LIMITED, HAYES, MIDDLESEX.



FIG. 1. COAL/AIR RATIO CONTROLLER.

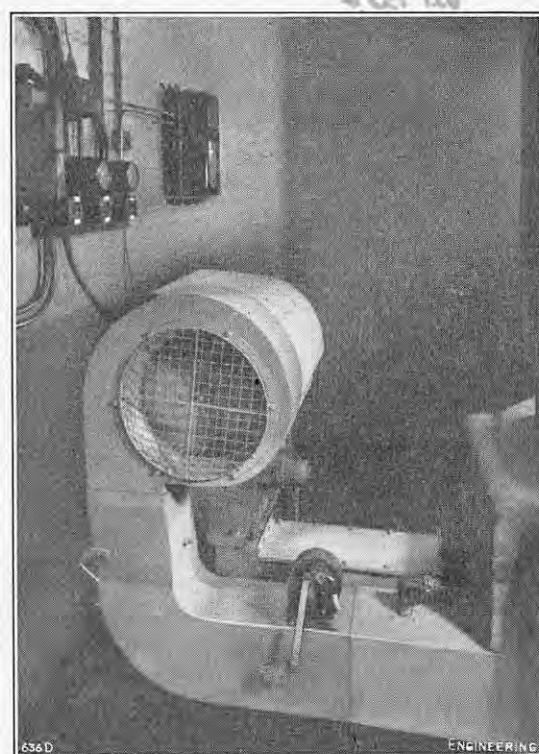


FIG. 2. COMBUSTION-CONTROL EQUIPMENT ON UNDERFEED STOKER-FIRED VERTICAL BOILER.

the air flow, and the coal feed is reduced accordingly. Eventually, this causes the steam pressure to fall, and the master regulator opens the dampers so that the increased fire-bed resistance is overcome.

A more complex installation is shown in Fig. 4, opposite, for a boiler fitted with both forced-draught and induced-draught fans; the electrical circuits are also shown. The master regulator controls the forced-draught damper, and balanced draught conditions are maintained by a furnace-pressure regulator, which consists of a geared motor, provided with limit switches, linked to the damper blade. The motor is controlled by a two-way and "mid-off" mercury switch mounted on a weighbeam carrying an oil-sealed float. Changes in the furnace pressure, fed to the underside of the float, move the beam about its pivot against a loading spring. The damper movement causes an immediate response in furnace pressure, and no proportioning mechanism is required. Power for the control operation is provided by single-phase capacitor-type motors; since both windings are identical, reversal by a single-pole two-way switch is possible. In the case of a Lancashire boiler installation, where appreciable effort is required to move the dampers, three-phase motors would be used, controlled by reversing contactors.

In Fig. 4, the fuel/air-ratio controller measures the air supplied by the forced-draught fan. Since high static pressures are encountered in such systems, the float system of pressure measurement previously described is replaced by an orifice plate inserted in the air duct. In order to avoid maintaining the stoker-contactor circuit through the arm and cam, the contact *a*, which is ganged with the stoker-contactor switches, is arranged in parallel with the arm and cam, and completes the circuit when the contactor closes. At the end of each cam revolution the circuit is broken by the momentary opening of a switch *b*, operated by the cam motor, and the coal feed is stopped until the cam contacts the arm again and completes the contactor circuit. At loads below the control range, i.e., about 15 to 20 per cent. of maximum capacity, the control operates on the on/off principle. A switch *c* in the master regulator is closed only when the forced-draught damper is fully open. Another switch *d* is opened momentarily by the cam motor near the end of the cycle, but, so long as the stoker-contactor is closed, this does not interrupt the supply to the fan motor, since there is an alternative path through the contacts *e*. Under falling load conditions, the master regulator closes the dampers and thereby opens switch *c*; if the load continues to fall below the control range, the dampers are closed until the air-flow rate is insufficient to bring the contact arm on to the path of the cam, and therefore the stoker contactor is not closed during

the cycle. The momentary opening of the switch *a* interrupts the supply to the fan contactors, and thus the mechanical-draught plant is stopped. The firing plant remains shut down until falling steam pressure operates the master regulator, closing the switch *c* and automatically re-starting the fans and the stoker. Alternative manual control, not shown in Fig. 4, can be provided if desired.

The UniTherm control system can also be applied to batteries of boilers, and can be used to regulate both the temperature and the furnace atmosphere of industrial furnaces used for heat-treatment, forging operations, etc.; in this case the master regulator is actuated by a thermocouple.

PREVENTING FORMATION OF ICE ON CONDUCTOR RAILS

THE London Transport Executive have issued details of further steps they are taking to reduce interference with traffic by the formation of ice on conductor rails; though, unfortunately, the problem of automatically and economically switching in the baths of anti-freeze liquid that are fitted to the rails is still largely unsolved. Before the anti-freeze baths were introduced, the only cure for interference due to ice was to run "sleet" locomotives, equipped with ice-crushers, wire brushes and sprays of anti-freeze liquid, over the affected line, but since 1947 attention has been directed to prevention rather than cure. At that time it was decided to provide de-icing baths, built into the conductor rails, from which anti-freeze liquid was spread along the rail surface by the shoes of passing trains, as described in *ENGINEERING*, vol. 164, page 479 (1947). By using these baths continuously in cold weather, it was hoped that sleet locomotives could be abolished, but trouble arose due to the liquid being splashed on to rolling stock. Day-to-day use of the baths was therefore adopted, in accordance with weather forecasts received from the Meteorological Office.

Still there was a disadvantage: men had to be ready to switch in the baths, and to do it at least three "traffic hours" in advance of icing conditions so as to allow time for the liquid to spread along the rails. In practice, therefore, sleet locomotives were still required to be held in readiness. Economy in the use of de-icing measures was sought, however, especially in view of a rise in the price of de-icing liquids. The practicability of using baths alone depends largely on the time to build up an adequate layer of liquid. Baths with non-sprung rollers were satisfactory in this respect on a section of the Bakerloo line last winter;

AUTOMATIC COMBUSTION-CONTROL EQUIPMENT.

UNITHERM, LIMITED, HAYES, MIDDLESEX.

(For Description, see Opposite Page.)

Fig. 3. CONTROL APPLIED TO NATURAL-DRAUGHT BOILER.

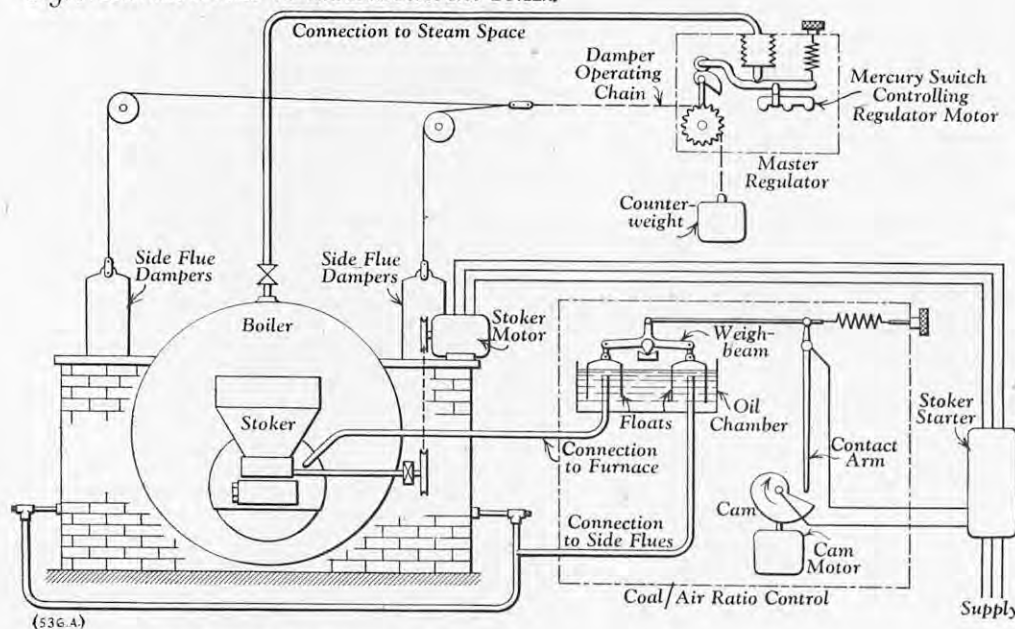
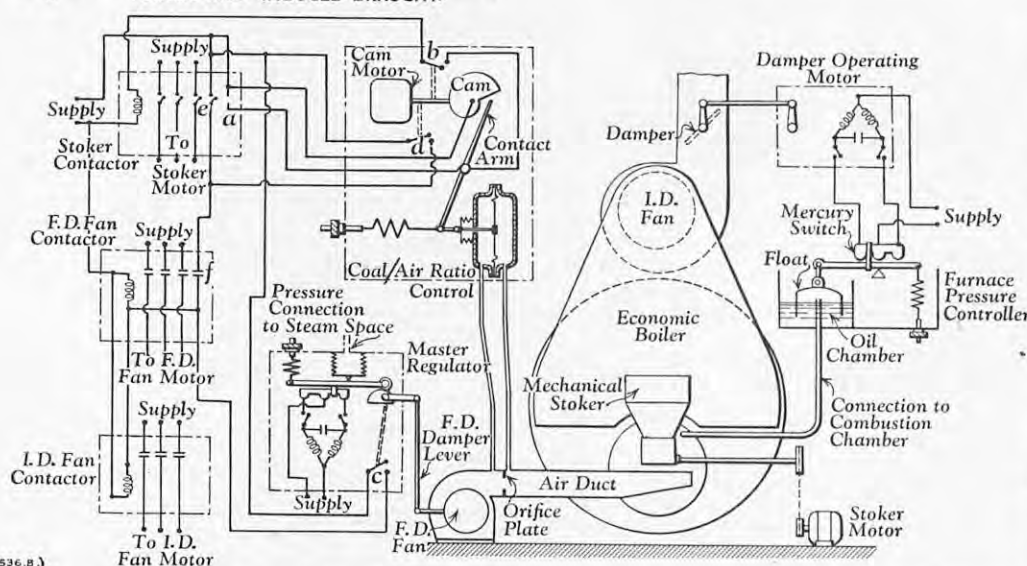


Fig. 4. CONTROL APPLIED TO ECONOMIC BOILER, FORCED AND INDUCED DRAUGHT.



sleet locomotives were not required at any time. On this line the rolling stock has motor control circuits fed from batteries, but on some of the other stock the control current comes through the shoes, and only one of these shoes needs to be isolated from the rail by ice for all the motors on the train to be affected. As different types of rolling stock have different types of positive shoes, experiments are to be carried out this winter to determine the fluid-spreading efficiency of each.

Several thermostatically-controlled baths were tried last year, but vibration was found to switch them in sooner than was intended; the design is therefore being modified. In any case, the widespread use of thermostatic control would be uneconomical as there are times when rail temperatures fall below freezing point without danger of icing. So far, no really satisfactory method of switching in automatically has been devised; mechanical switching by means of a lever below the train is impracticable owing to the risk of fouling other equipment, while the cost of an electric system, actuated from a train or from control points, would be extremely high.

Two more "meteorological stations," similar to that at Baron's Court, were installed near Kingsbury and Queensbury last autumn; they comprise instruments for recording air temperature and humidity, and rail and ground temperatures (see *ENGINEERING*, vol. 169, page 465 (1950)). Charts from these stations are being studied at the Meteorological Office so that the weather forecasters will be able to predict rail temperatures rather than air temperatures; this will be of great assistance to the traffic controller in deciding whether or not to put de-icing precautions into effect. During the cold months, forecasts of icing conditions

are received from the Meteorological Office every afternoon in one of three categories: "strong risk," "risk" or "no risk." As a further aid, remote-reading dial thermometers are being connected to dummy lengths of rail at four extremities of the London Transport system so that actual rail temperatures can be communicated to the traffic controller at any time.

NOISE AT LONDON AIRPORT.—The effect on houses of vibration from aircraft in flight, in the vicinity of London Airport, is to be studied. The Minister of Transport and Civil Aviation, Mr. J. S. MacLay, agreed to this step when, on December 13, he received a deputation representing residents' associations of the area. It is alleged that houses are being damaged by vibration.

BRISTOL UNIVERSITY.—Mr. Winston Churchill, M.P., as Chancellor of Bristol University, conferred several honorary degrees and laid the foundation stone of the new engineering school of the University on Friday December 14. Degrees of Doctor of Science in Engineering were awarded to Sir Charles Lillierap, until recently the Director of Naval Construction, Admiralty, and to Mr. A. E. Russell, chief designer, Bristol Aeroplane Company, Limited.

ENGINEERING LIBRARY AT LEICESTER.—Copies of trade catalogues, instruction hand-books and house journals would be welcomed for the use of engineering students in a new library which is to be opened shortly at the College of Technology and Commerce, The Newarke, Leicester. Such material should be addressed to the Chief Librarian, College of Technology and Commerce, Lero Buildings, Painter-street, Leicester.

CONTRACTS.

THE DEMOLITION & CONSTRUCTION CO., LTD., 3, St. James's-square, London, S.W.1, have obtained the contract for the removal of the existing roof coverings over platforms 9 and 10 at Euston Station, London Midland Region, British Railways. MELLOWES & CO., LTD., Corporation-street, Sheffield, have received the order for the re-roofing of these platforms with the firm's patent roof glazing.

THE WESTINGHOUSE BRAKE AND SIGNAL CO., LTD., 82, York-way, King's Cross, London, N.1, have received orders for automatic vacuum-brake equipment up to a total of 922 sets. These are to be fitted to various types of wagons which are being built for the Western Australian Government Railways.

The Toronto Transportation Commission has awarded a contract for the construction of 104 rapid transit cars to the GLOUCESTER RAILWAY CARRIAGE AND WAGON CO., LTD., Gloucester. These cars, which will be about 57 ft. long and 10 ft. wide, will run on the Yonge-street subway and will have accommodation for 62 passengers. Each car will be fitted with four 68-h.p. 600-volt motors, which will be constructed by CROMPTON PARKINSON & CO. LTD., Chelmsford. The control equipment will be manufactured by the BRITISH THOMSON-HOUSTON CO., LTD., Rugby.

THE BIRMINGHAM RAILWAY CARRIAGE AND WAGON CO., LTD., Smethwick, Birmingham, 40, have received an order from the Sierra Leone Development Co. for three A1A-A1A Diesel-electric locomotives for 3-ft. 6-in. gauge lines. The locomotives are to be built to the approval and inspection of MESSRS. LIVESLEY AND HENDERSON and will each be fitted with a 1,000-h.p. engine, to be supplied by SULZER BROS. (LONDON) LTD., 31, Bedford-square, W.C.1. The electrical equipment is to be supplied by CROMPTON PARKINSON, LTD.

CRYPTON EQUIPMENT LTD., Bridgwater, a company of the LANCASHIRE DYNAMO GROUP, have received a repeat order from the Manchester Ship Canal Co. for the supply of selenium metal rectifiers for vehicle-battery charging.

THE HUNSLET ENGINE CO., LTD., Leeds, 10, have received an order from the New Zealand Government Railways, for ten 30-ton, 3 ft. 6 in. gauge, six-wheel 250-b.h.p. Diesel-mechanical locomotives for shunting and light train working. They are to have the firm's transmission comprising a friction main clutch and four-step gearbox. The top speed is to be 25 m.p.h., and the starting tractive effort 16,800 lb. The fittings are to include roller-bearing axleboxes and Westinghouse air brakes.

HARRY FERGUSON, LTD., 37, Davies-street, London, W.1, inform us that 6,733 Coventry-built Ferguson tractors were dispatched from the Banner-lane factory of the Standard Motor Co., Ltd., in November. Of these, 5,282 were exported, 416 to South Africa, 1,492 to Australia, 370 to New Zealand, 400 to India, 466 to Turkey and 1,304 to Scandinavia, including Finland. Tractors released for the home market numbered 1,451.

THE BRISTOL AEROPLANE CO., LTD., Filton, Bristol, have received an order from Silver City Airways Ltd., 1, Great Cumberland-place, London, W.1, for six specially-built long-nosed freight aeroplanes for use as air ferries for motor cars, motor cycles and bicycles. The new aircraft will each be able to carry three small cars and 20 passengers. The order is worth 500,000l.

DAVID BROWN & SONS (HUDDERSFIELD) LTD., have received through their South African Associates, David Brown & Sons S.A. (Pty.) Ltd., Johannesburg, an order for a 28-in. Radicon worm reduction gear which will provide the drive for the man-hoist winding gear serving a 500-ft. colliery shaft. Approximately 6 ft. high, 5 ft. long and 3 ft. wide, and weighing 4½ tons, the gear, of 60:1 ratio, will connect a 150-h.p. slip-ring motor, with a speed of 735 r.p.m. and a double-drum winding spindle operating at 12.25 r.p.m. The normal unbalanced man-load in the cage will be 12,600 lb. Moreover, this load will be applied to the reduction gear in both directions of rotation. One of the essential requirements is that, in the event of emergency, when the brake is applied suddenly before the current has been switched off, the reduction gear unit must be capable of withstanding, for short periods, the load equal to the maximum torque of the motor, which will be approximately 300 h.p.

JOHN BROWN & CO., LTD., Clydebank, have received an order for the construction of two liners for the Canadian service of the Cunard Steam-Ship Co., Ltd. The ships will each have a gross tonnage of 20,000 and will have a speed of about 20 knots. They are intended to carry two classes of passengers, first class and tourist.

CABLE BELT, LTD., Inverness, have received a repeat order from the Scottish Division of the National Coal Board for their new type rope belt conveyor, to be installed at Kingshill No. 1 Colliery, and to extend to 2,600 yards. Another conveyor is for Argyll Colliery, and this will give a vertical lift of 950 ft.

NOTES ON NEW BOOKS.

The Effect of Brake Shoe Action on Thermal Cracking and on Failure of Wrought Steel Railway Car Wheels.

By H. R. WETENKAMP, O. M. SIDEBOTTOM, and H. J. SCHRADER. University of Illinois Engineering Experiment Station Bulletin No. 387. Office of Publication, 358, Administration Building, University of Illinois, Urbana, Ill., U.S.A. [Price 60 cents.]

A RECENT issue of the widely known University of Illinois Bulletins reports the substantial progress already achieved in an investigation, conducted jointly by the Engineering Experiment Station and the Technical Board of the Wrought Steel Wheel Industry, of failures due to brake-block heating of two sizes of car wheels, 33 in. and 36 in. in diameter, formed by forging and rolling so that the flanged rim is integral with the "pan" and the hub of the wheel. Two main types of test, respectively simulating a rapid "stop" under high braking force, and a long-continued "drag" under moderate sustained force, were made with laboratory equipment, producing thermal cracks in the treads and fractures through the rims and disc centres, both phenomena being typical of service failures. Variations in the design, metallurgical properties and mode of manufacture were studied, and analyses of residual strain and permanent deformation, static tests of mechanical properties, and lateral flange-thrust fatigue tests on full-sized wheel-axle assemblies were included in the investigation. Numerical results summarising the effects of the variable physical factors and experimental conditions are presented with admirable clarity by tables and graphs, and the text is otherwise illustrated by excellent photographs and diagrams. The major conclusions reached are that decrease of carbon content and decreased thickness of the "pan" or central plate of the wheel, in both cases within limits imposed by other considerations, are the most effective agents in increasing the resistance of integral wheels to thermal braking failures. In view of the number of wheels of this type which went into service on British railways during the war, and of the similarity, in some respects at least, of the effects of brake application on all types of railway wheels, the report merits close study by mechanical engineers.

Servicing Guide to British Motor Vehicles.

By J. N. McHATTHE, A.M.I.Mech.E., M.S.A.E. The Trader Publishing Company, Limited, Dorset House, Stamford-street, London, S.E.1. [Price 63s. net.]

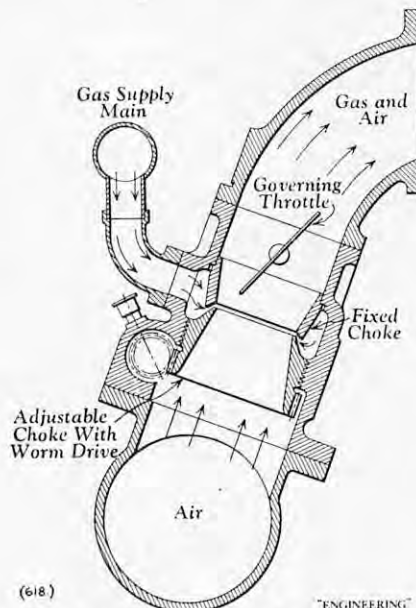
ONE of the many troubles that beset garage proprietors is the difficulty of maintaining a correct and up-to-date technical library to which they may refer when carrying out repairs or adjustments to a strange vehicle. Purchase of the many different instruction books and service manuals represents a considerable outlay and when they have been obtained it is always necessary to keep them up to date by pasting in the various amendments. Furthermore, the required information is not necessarily found easily as the various car manufacturers have their own very different ideas as to the layout of their instruction books and the information they should contain. There is much to be said, therefore, for a standard form of instruction book and this ideal is approached as closely as it is ever likely to be by the *Servicing Guide to British Motor Vehicles* which contains service data sheets for 52 different post-war cars, commercial vehicles and tractors. The guide is based largely on the service data sheets published from time to time in the *Motor Trader*, and to ensure clear presentation, the data on each vehicle is presented, so far as practicable, in a standard form. The information given covers most of the points on which guidance is likely to be wanted, and the repair estimator's job is lightened considerably by remarks such as "the gearbox can be lifted through the floor without removal of the engine." All the data required in connection with routine maintenance of each vehicle is placed at the end of each sheet including a chassis diagram, oil and water capacities and a table of recommended lubricants. A glossary gives full details of the terminology used throughout the book and an appendix includes a number of useful conversion factors and tables.

THE "OLD N'IONS."—The first award of a travelling bursary, created from funds collected by members of the "Old N'IONS," the past-students' association of Northampton Engineering College, St. John-street, London, E.C.1, as a 1939-45 war memorial, was made to Mr. W. E. Murphy. As a consequence, Mr. Murphy, after completing his training at the College, has recently been able to travel in Austria, Switzerland, Italy, Germany and France, working and observing the technical procedures and customs of the peoples in those countries.

MIXING AND GOVERNING VALVE FOR GAS ENGINES.

IN gas engines that are designed for operating on various gases, such as manufactured coal gas, sewage gas, or natural gas supplied from oilfields, of widely different calorific values, it is often convenient to adjust the ratio of the gas and air mixture to suit the particular gas in use while the engine is running. A gas-mixing and governing valve designed for this purpose has been developed by the National Gas and Oil Engine Company, Limited, Ashton-under-Lyne, and is installed in their gas and dual-fuel engines of the M4A and R4A series, with outputs ranging from 62 to 350 brake horse-power. In the large multi-cylinder engines, each cylinder has its own mixing and governing valve, the hand controls for the mixture ratio being interconnected.

A section through the valve and the inlet duct to the cylinder is shown in the accompanying illustration. It will be seen that the gas inlet is through a slot formed between the two halves of a venturi, one of which is fixed and the other screw-mounted so that it can be moved axially relative to the fixed half. The area



of the slot, and thus the amount of gas entering in relation to the air, can be varied by adjusting the movable venturi choke, on which is machined a worm wheel engaging with a manually-operated worm drive. In order to obtain the optimum mixture ratio under running conditions, the manufacturers suggest that an orifice plate should be inserted in the gas main, with tapings from either side connected to a manometer to give a reading of the differential pressure. The engine is then run under a steady load, and the mixture strength is adjusted to give the lowest reading on the manometer, equivalent to the least rate of gas consumption.

ELECTRICITY SUPPLY STATISTICS.—During November, 1951, 5,488 million kilowatt-hours were generated in stations controlled by the British Electricity Authority, the North of Scotland Hydro-Electric Board and the Lochaber Power Company, compared with 5,365 million kilowatt-hours during the corresponding period of 1950, an increase of 2.3 per cent. The electricity sent out during the first eleven months of 1951 was 51,092 million kilowatt-hours, an increase of 10.3 per cent. over that of the corresponding period in the previous year. The installed capacity of the British Electricity Authority was 15,161 MW, an increase of 169 MW during the month, while that of the North of Scotland Hydro-Electric Board was 616 MW. The overall increase during the past twelve months was 1,012 MW, or 6.9 per cent.

CONVENTION ON ELECTRICAL CONTACTS.—A Convention on Electrical Contacts will be held at Loughborough by the East Midland Centre of the Institution of Electrical Engineers from Monday, April 7, to Wednesday, April 9, 1952. The aim of the convention, which is to be opened by Dr. W. G. Radley, is to consider broadly the whole problem of contact behaviour and to discuss contact research. The proceedings will be divided broadly between light and heavy duty contacts, and a fairly full programme of papers has already been proposed. Further details will be published in due course. In the meantime, inquiries may be addressed to the honorary secretary of the Centre, Mr. R. G. L. Ryan, Brush Electrical Engineering Company, Limited, Loughborough; or to the programme organisers, Dr. J. H. Mitchell and Mr. R. C. Woods, Eriasson Telephones, Limited, Beeston, Nottingham.

BOOKS RECEIVED.

Report by the Ministry of Fuel and Power and National Coal Board Joint Working Party on the Drainage of Firedamp from Mines. Secretary of the Working Party, Mr. A. T. Gregory, Ministry of Fuel and Power, Westminster House, 7, Millbank, London, S.W.1. [Gratis.]

Transients in Power Systems. By PROFESSOR HAROLD A. PETERSON. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 6.50 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 52s. net.]

Principles of Electrical Engineering. By PROFESSOR WILLIAM H. TIMBIE, VANNEVAR BUSH, and PROFESSOR GEORGE B. HOADLEY. Fourth edition. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 6.50 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 52s. net.]

The British Electrical and Allied Industries Research Association. Technical Report No. F/T 172. Cathodic Corrosion of a Lead Cable Sheath. By DR. G. MOLE. [Price 9s.] No. G/XT 35. *Note on the Quantity and Constitution of Gas Liberated during Arcing in Oil.* By C. E. R. BRUCE and W. BEVAN WHITNEY. [Price 10s.] No. G/XT 66. *The Gases Liberated during Arcing in the Side-Blast Baffle Circuit Breaker.* By C. E. R. BRUCE and W. BEVAN WHITNEY. [Price 7s. 6d.] No. G/T 257. *Intrinsically Safe Electrical Apparatus: Relation of Igniting Current to Circuit Inductance for Inflammable Mixtures with Air of Carbon Monoxide, Coal Gas and Hydrogen.* By DR. E. M. GUENAUT and E. ATHERTON. [Price 7s. 6d.] No. L/T 214. *The Electrical Breakdown of Gases at 2,800 Megacycles per Second.* By W. A. PROWSE and W. JASINSKI. [Price 18s.] No. L/T 244. *Barium Titanate Twinning at Low Temperatures.* By R. G. RHODES. [Price 6s.] No. M/T 102. *A Single Frequency Instrument for the Measurement of Interference with Television Reception due to Ignition Systems.* [Price 3s.] No. M/T 105. *The Study of Balanced Harmonics in an Overhead Ring Main System (East Cornwall Tests).* By A. BUTTERWORTH and DR. H. R. J. KLEWE. [Price 15s.] No. M/T 108. *An Improved Harmonic Analyser and Noisemeter.* [Price 3s.] No. Q/T 126. *The Causes and Effects of Water in Oil-Immersed Transformers. A Critical Résumé.* By M. R. DICKSON. [Price 9s.] Offices of the Association, Thornecroft Manor, Dorking-road, Leatherhead, Surrey.

The College of Aeronautics, Cranfield. Report No. 48. Stability of the Compressible Laminar Boundary Layer with an External Pressure Gradient. By J. A. LAURMANN. The Librarian, The College of Aeronautics, Cranfield, Bletchley, Buckinghamshire. [Price 5s.]

LAUNCHES AND TRIAL TRIPS.

S.S. "DEPTFORD."—Single-screw collier, built by S. P. Austin and Son, Ltd., Sunderland, for the British Electricity Authority, London, W.1. Second vessel of a series of three. Main dimensions: 257 ft. by 39 ft. 6 in. by 18 ft. 6 in.; deadweight capacity, about 2,700 tons on a draught of 17 ft. 1 in. Direct-acting triple-expansion engine of reheated design, developing 800 i.h.p. at 78 r.p.m., constructed and installed by George Clark (1938), Ltd., Sunderland, and one coal-burning forced-draught boiler. Speed on trials, 11 knots. Trial trip, November 28.

M.S. "SENIORITY."—Single-screw cargo vessel, built by the Goole Shipbuilding and Repairing Co., Ltd., Goole, for F. T. Everard & Sons, Ltd., London, E.C.3. Main dimensions: 225 ft. by 37 ft. 10 in. by 16 ft.; deadweight capacity, 1,815 tons on a draught of about 15 ft. 8 in. Sirron four-cylinder Diesel engine, developing 800 b.h.p. at 250 r.p.m., constructed by the Newbury Diesel Co., Ltd., Newbury, Berkshire. Speed, 10½ knots. Trial trip, December 4.

H.M.S. "EDDYBEACH."—Single-screw vessel for carrying oil in bulk, built by the Caledon Shipbuilding and Engineering Co., Ltd., Dundee, for the Naval Store Department, the Admiralty, London, S.W.1. Main dimensions: 286 ft. overall by 44 ft. by 18 ft. 6 in.; deadweight capacity, 2,095 tons on a draught of 17 ft. 2 in.; gross tonnage, 2,157. Triple-expansion steam engines developing 1,750 i.h.p. at 227 r.p.m., constructed by Lobnitz & Co., Ltd., Renfrew; and two oil-burning cylindrical boilers constructed by the Caledon Co. Speed in service, 12 knots. Trial trip, December 10.

S.S. "CROFTER."—Single-screw cargo liner, built and engaged by John Readhead & Sons, Ltd., South Shields, for Thos. and Jas. Harrison, Ltd., Liverpool. First vessel of an order for two. Main dimensions: 442 ft. between perpendiculars by 59 ft. 8 in. by 37 ft. 8 in.; deadweight capacity, about 10,400 tons on a draught of 26 ft. 8 in. Triple-expansion steam-reciprocating engines combined with low-pressure Bauer-Wach exhaust turbine and three forced-draught oil-fired boilers, developing 4,200 i.h.p. at 88 r.p.m. Service speed, 12 knots. Trial trip, December 11.