B.O.A.C. OVERHAUL BASE FOR AIRCRAFT ENGINES AND PROPELLERS.

NEARLY ten years ago, a brief description appeared in ENGINEERING (on page 464 of our 154th volume, 1942) of the British Overseas Airways Corporation engine-overhaul factory on the Treforest estate in South Wales. The base had then been in existence for two years and most of the engine-overhaul plant had been transferred from the combined Imperial and British Airways overhaul shop at Croydon Airport. At that time (1942), the Treforest base was wholly engaged on work for the Ministry of Aircraft Production, consisting mainly of the overhaul and repair of air-cooled radial engines of Royal Air Force aeroplanes. During the period of the second World War, more than 10,000 engines were reconditioned at Treforest. After the conclusion of the war, the organisation was reduced to meet peace-time needs, and, until 1949, the direction of the factory was supervised by the Repair Division Headquarters which was centred at Brentford and, for a short time, at Purley. The Division also supervised the aircraft-component overhaul base which was then at Croydon Airport. When the Croydon base was moved to London Airport in 1949, the Treforest factory became virtually autonomous and directly responsible to the Chief Engineer (Operations) of the Corporation and latterly, since the Engineering Department of the Corporation was re-organised, to the Deputy Operations Director (Engineering).

Since the end of the war, the factory has developed remarkably and is now one of the largest organisations of its kind in the world. At the moment, it is still devoted to the overhaul of air-cooled radial engines ranging from 600 h.p. to 3,500 h.p., and their associated propellers. It is probable, however, that long-term development plans for the base will cover facilities for gas-turbine engines. Its primary function consists of overhauling the time-expired air-cooled engines and propellers of the Corporation's air liners, comprising, at present, Pratt and Whitney Wasp Major R.4360 28-cylinder four-row radial engines, developing 3,500 h.p. (installed in Stratocruisers); Bristol Hercules 763 14-cylinder two-row radial engines developing 2,100 h.p. (installed in Hermes aircraft); and Wright Cyclone R.3350 BA-3 and BD-1 series 18-cylinder two-row radial engines, with direct fuel injection, developing, respectively, 2,200 h.p. and 2,500 h.p. (installed in Constellation aircraft). A large number of American engines installed in aeroplanes of the Royal Air Force are also overhauled at Treforest, among which is the smallest engine with which the factory deals, the Pratt and Whitney R.1340 nine-cylinder single-row radial engine developing 600 h.p., fitted in Harvard training aircraft. In addition, the base overhauls other marks of Bristol Hercules engines for the West African Airways Corporation, British West Indian Airways and Iraqi Airways; Pratt and Whitney R.1830 engines for British European Airways, Aer Lingus, East African Airways Corporation, Bahamas Airways, Aden Airways, Cyprus Airways and other operators; certain Wright Cyclone R.3350 BD-1 engines for Qantas Empire Airways, and some BA-3 engines for South African Airways and Pan American Airways. It may be recalled that, in 1950, the Treforest factory became the first, and is still the only organisation in the United Kingdom, to hold an American Civil Aeronautics Administration certificate, which authorises them to carry out overhauls on engines and propellers used by American operators.

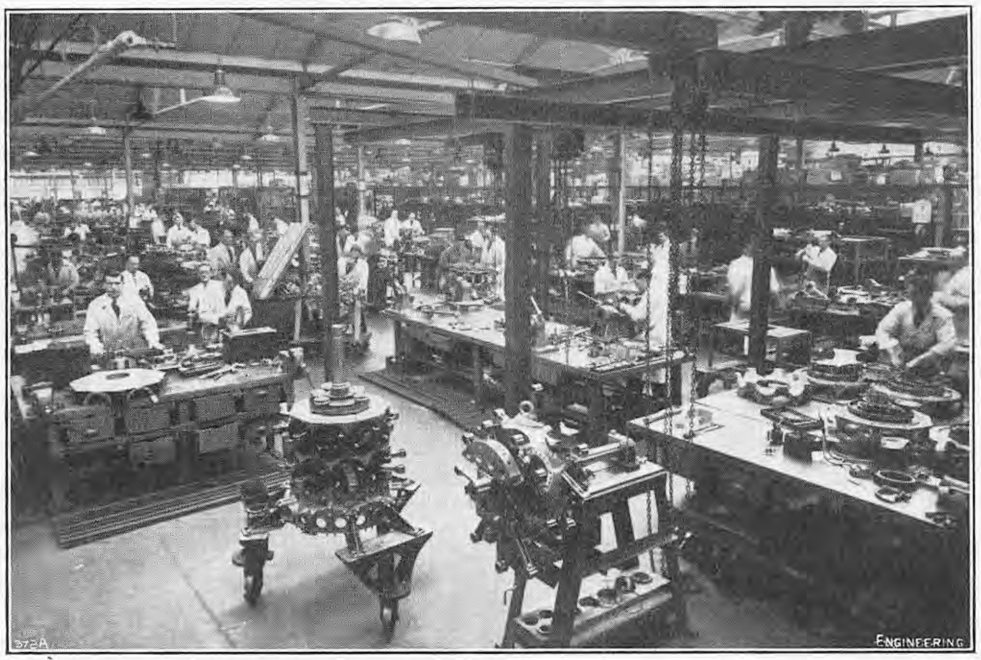

FIG. 1. GENERAL VIEW OF ENGINE OVERHAUL SHOP.

FIG. 2. DISMANTLING SHOP.

ENGINE OVERHAUL SYSTEM.

In general, the base operates on a plan of a four to six weeks' turn-round for the overhaul of engines and two to three weeks for propellers. For the benefit of certain operators of the Pratt and Whitney R.1830 engines, a pool of reconditioned engines is maintained at Treforest, so that when an engine in service becomes due for overhaul the airline returns the time-expired engine and a reconditioned engine from the pool is immediately issued to them in exchange. A system of part serial numbers and records is maintained to ensure that the parts and components of one airline are not confused with those of another which may have a different modification standard and operating methods. This recording and marking system also ensures that a complete case history of every component which passes through the factory is available at any time, providing a valuable source of information for the development engineers of the airways corporations and the engine manufacturers.

Owing to the wide range of the engines serviced, and the fact that new types of engine are fairly frequently coming into service, the layout of the factory is necessarily flexible. There is one large building where the main engine-overhaul operations are carried out; two smaller shops dealing, respectively, with carburettor and propeller overhauls; and, a mile or two away from the Treforest estate, the engine test beds. It is customary to work a partial night shift but at certain times a full sectional night shift may be worked to ensure that the factory output does not fall behind schedules and production is thus kept in balance.

In Fig. 1 can be seen a general view, and Fig. 2 shows the dismantling shop in the main building, a layout of which is reproduced in Fig. 3. The engines arrive in wooden crates by road, and are unloaded by overhead lifting tackle on to cradles. At present, the large Pratt and Whitney R.4360 engines are dismantled individually, remaining on the same stand during the operation. Other types of engine, however, are dismantled into sub-assemblies on a flow-line basis; after removal of the reduction gearing, which is placed on a table at the side of the dismantling cradle to be broken-down by other operators, the engine is transferred to the next stage along the line, for removal of the cylinders and pistons. Rear cover, supercharger, connecting rods and crankshaft are then successively removed. All the components of each individual engine are kept together at this stage on mobile tray-stands.

The dismantled parts of one complete engine are next transferred to one of a battery of cleaning tanks containing a cresylic-acid-base cleansing agent. After soaking for approximately three hours, the parts are rinsed in hot water and transferred to a paraffin cleaning shop to remove oil, carbon and sludge remaining after the soak in the cleaning tanks. The cylinders and pistons then go to the blasting shop, which contains prunus-blasting machines for removing the hard carbon deposits on pistons, sand-blasting machines for providing a keyed surface for those parts which are to receive a metallising treatment, and a vapour-blasting machine for providing a clean fine-grained finish for those parts which are not further treated. In the latter machine fine carborundum is borne by water vapour under pressure. The outside surfaces of cylinders of American engines are coated with 99 per cent. pure aluminium by a spraying process in which aluminium wire is fed through an oxy-acetylene flame and sprayed on to the sand-blasted surface; this gives protection against corrosion. In the case of Bristol Hercules engines, the cylinders of which are anodised, the spraying treatment is unnecessary. The remainder of the cleaning section comprises buffing machines on which highly-finished steel and non-ferrous parts are polished. Meanwhile, all the metal piping and baffles removed in the dismantling shop have been reconditioned in the coppersmiths' shop and passed as a complete set to the inspection department; any parts to replace scrapped components are drawn from the stores.

In the inspection department, all highly-stressed steel components are inspected with the aid of magnetic crack-detection machines, while non-ferrous parts are checked for cracks by chalk dye-test and acid-etch methods. All these components are marked with a "Corporation" serial number (if not already so marked) before passing to the main inspection bay for dimensional checking and inspection to the standards laid down in the manufacturer's handbook for each engine; this work is done by women under the supervision of male inspectors. For ease of control, the inspection of the Pratt and Whitney Wasp Major engine is carried out in a separate bay. In the main inspection bays, every component is issued with an inspection sheet in duplicate; among other matters they identify the airline to which the component belongs. Particulars of the measurements and checks are entered on the sheets, one copy of which is passed to the stores adjacent to the inspection bay. This action requisitions replacements for rejected parts which are then passed to the progress bay; after issue the sheet passes to the costing department. The other copy is filed in the inspection department with all other records of the engine.

Reconditioning Processes.

When the inspection of components is complete, they are segregated according to engine type and customer; this does not apply to Wasp Major components, which are identified with an individual engine through the whole overhaul process. Components are passed to the reconditioning and salvage bays, which operate in conjunction with a machine shop. Salvage schemes are prepared by a design office attached to the factory, and the work on the components is done by skilled workmen. One particularly interesting aspect of salvage work is the use of hard-chromium plating to build up worn components. The worn part is ground to less than standard dimensions and is then transferred to the hard-chromium plating shop where it is coated with wax on areas which are not to be built up, the ground area being left exposed. It is then immersed in a chromic acid bath, the current density, time and temperature being carefully controlled to produce the required thickness of dense hard chromium plating, from 0·001 in. up to 0·010 in. thick. Thus, the component is built up to greater than standard dimensions and is then passed to the machine shop for grinding to standard size, followed by a stress-relieving treatment in temperature-controlled ovens. The resulting finish is of high quality and is very often an improvement on the original finish. This process cannot be used for bearing surfaces, however, since hard chromium is a poor oil retainer.

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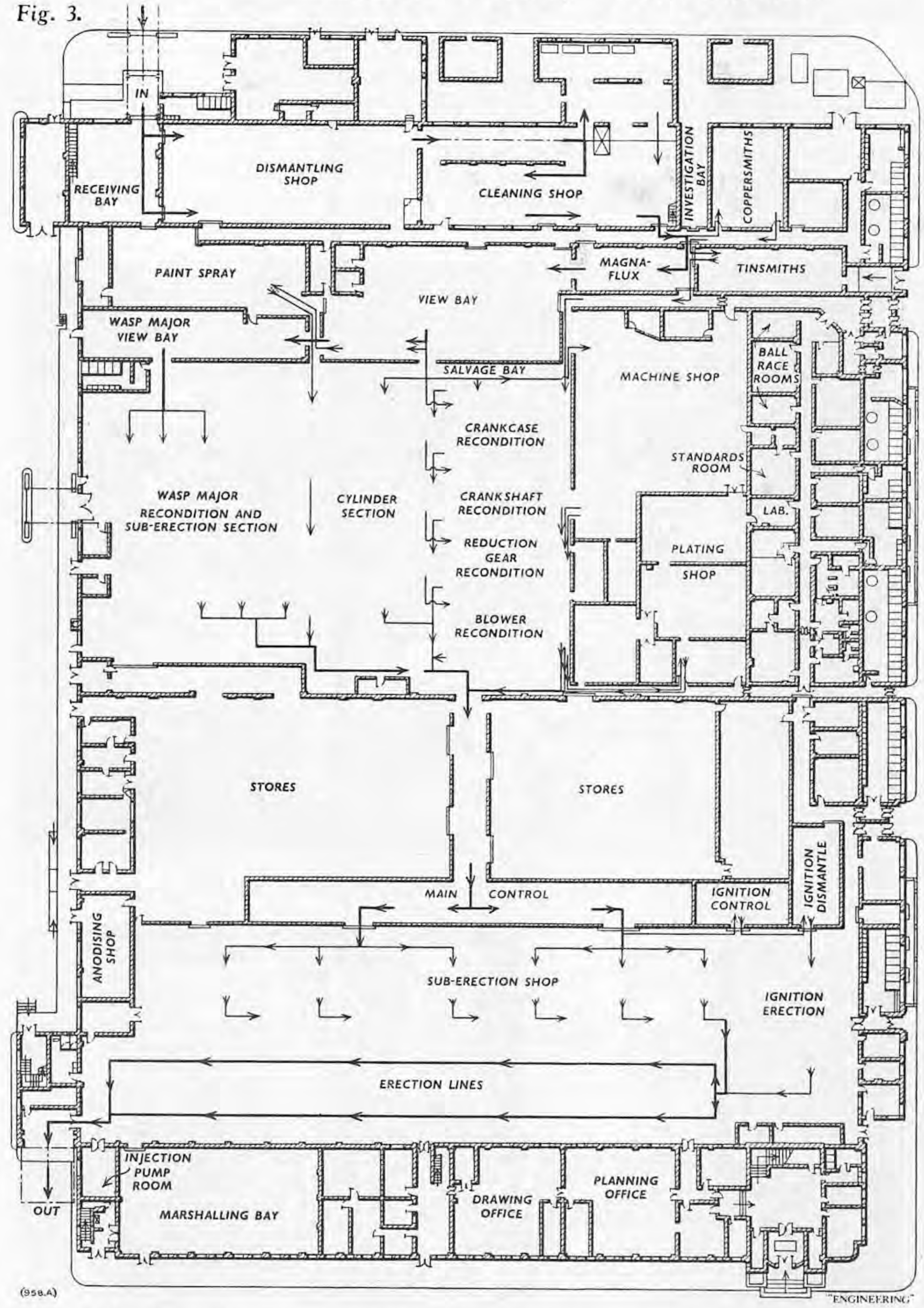
Fig. 3.



Other engine parts are passed to the main plating shop, shown in Fig. 4, opposite, which is adjacent to the hard-chromium plating shop; it is here that lined bearings are reconditioned and anti-corrosion coatings are applied. The plating shop contains tanks for cadmium, tin, nickel, copper, silver, lead and indium plating, as well as the necessary acid-stripping solutions. Silver which has been stripped from the bearings is recovered and sold to the bullion dealers. Some of the differing practices of the various engine manufacturers are of interest. The patented lead-indium bearings of Pratt and Whitney engines require the deposition of copper on the steel shell, to hold the silver backing for the lead coating which provides the good lubricating properties, a final coating of indium being deposited which gives protection against corrosion. The lead thickness ranges from about 0·0005 in. to 0·0015 in. and the thickness of indium deposited is from 6 to 8 per cent. by weight of that of the lead coating. The preparation of unserviceable silver-backed bearings for re-plating with lead-indium requires great care; they are burnished and polished to reveal any foreign metal which has become embedded, and which has to be picked out by hand. They are then reburnished before plating. The lead-indium process is also used for reconditioning the bearings of Wright engines, though the manufacturers themselves use a lead-tin coating. Silver plating has also been adopted by the Corporation to replace the original Babbitt-metal lining of the Hercules reduction-gear oil-feed sleeve. Wright engines have a patented process for piston-ring grooves, which are plated with a layer of nickel, 0·0005 in. to 0·00075 in. thick, to give good wearing qualities. To prepare for plating, the pistons are first cleaned by a light turning operation; they are masked with tape and lacquer, baked to harden the lacquer, degreased and scrubbed with pumice, etched with a 50 per cent. nitric acid solution, and rinsed. They are then immersed for about $2\frac{3}{4}$ hours in the

B.O.A.C. OVERHAUL BASE, TREFOREST.

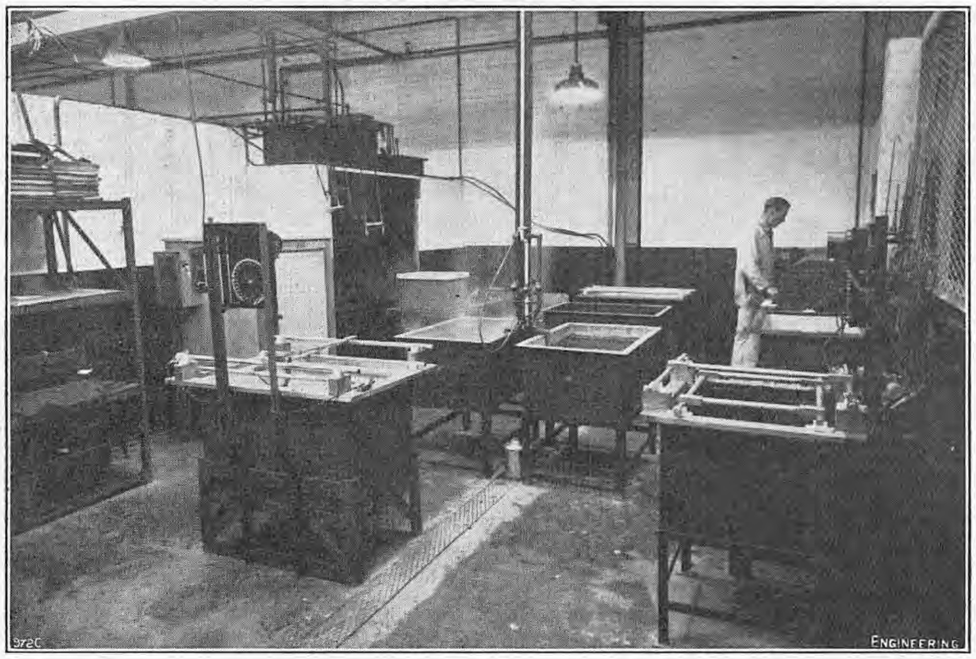


FIG. 4. PART OF MAIN PLATING SHOP.

FIG. 5. PROGRESS BAY.

plating bath—a non-electrolytic steam-heated bath containing an alkaline nickel-chlorine-sodium-hypophosphite solution. During plating, the pH value of the solution is kept constant by adding ammonium hydroxide at half-hourly intervals. After plating, the masking is removed and the pistons are baked at a temperature of 440 deg. to 460 deg. F. to harden the nickel deposit. All parts with an interference fit are flash tinned which, in addition to giving anti-corrosive properties, provides a lubricating surface which prevents spalling. Magnesium-alloy components are treated in a chromating bath for surface protection.

On completion of the rectification and salvage operations, the finished components are passed to the progress bay, shown in Fig. 5, above, which constitutes the main control of outward progress. Adjoining the progress bay is the main stores from which, as previously outlined, replacement components are issued on receipt of inspection sheets rejecting faulty parts. The function of the progress section is to collect together complete sets of engine parts which are then issued to the assembly shops. Concurrently with the work on the main engine components, the ignition equipment, magneto and harness, undergo an overhaul on similar lines—stripping, cleaning, inspection, repair and assembly. A photograph of the harness-overhaul bay is reproduced in Fig. 9, on Plate VI. After assembly the magnetos and harness undergo extensive performance checks on special rigs. The harness is subjected to a high-voltage test, and the magnetos undergo a four-hour slow and high-speed endurance test.

In the assembly shop (Fig. 10, on Plate VI), the sub-assemblies are built up prior to the final erection of the engines on a line system, the order of the dismantling process being reversed (again, excepting the Wasp Major engine). After assembly, a final inspection is completed befoıe the engine is transported, in its cradle, to the test-beds. After engines have been tested, in conformity with the requirements of the Air Registration Board, Aeronautical Inspection Directorate or Civil Aeronautics Administration, a percentage of each type is returned for complete dismantling and inspection to ensure a continued high standard of workmanship throughout the whole overhaul process. When a completely new type of engine enters service, a 100 per cent. inspection after test is carried out for the initial period, after which the percentage is progressively reduced.

BALL AND ROLLER BEARINGS.

Before passing on to the other buildings occupied by the Corporation at Treforest, there are certain important services in the main building which should be described. With the exception of self-aligning spherical races, which are sent out to specialist firms, all ball and roller bearings, ranging in size from rocker-arm roller races slightly more than 1 in. in diameter to main roller bearings up to about 10 in. in diameter, are overhauled in two rooms adjacent to the machine shop. They are stripped and cleaned; the tracks are lightly polished, and are then examined by magnetic crack detectors before passing to the viewing room for dimensional checks and for inspection of surface damage. When a race shows signs of overheating, hardness checks are taken before proceeding with the work. All rollers are grouped in sizes in 0·0002-in. steps, and in re-assembling a bearing, rollers from only one size step are used. Where necessary, the worn tracks are ground and are fitted with oversize rollers up to a maximum of 0·005 in. After grinding, the tracks are re-examined for cracks. Before re-assembly, the races of Pratt and Whitney engines and Bristol engines are transferred to the plating shop for flash-tinning, to prevent corrosion during storage or in the engine. This practice originated at Treforest during the second World War, after it was found that the front thrust races of engines fitted in certain Royal Air Force aircraft became so badly corroded that they had to be replaced at each overhaul; the adoption of flash-tinning reduced the mortality rate from 100 per cent. to about 20 per cent. Wright Cyclone roller races, which are given a protective treatment during manufacture, are not tinned.

The repair base possesses a well-equipped standards room (Fig. 11, on Plate VI) for calibrating all the measuring instruments used throughout the workshops. Among the instruments in the standards room may be mentioned a tuning-fork controlled stroboscope for calibrating the numerous test-rig tachometers, contour projectors, a surface-finish recorder, an air comparator for checking Bendix injection-pump plungers and bores, a setting rig for torque spanners (which are colour-coded according to loading), electro-comparators, thread-measuring machines, etc. A 100 per cent. inspection of re-ground ball and roller tracks is carried out in the standards room. Similarly, the first component of a batch in quantity production in the machine shop is subjected to extensive checks; subsequently, percentage checks only are made. The routine static balancing of supercharger impellers is also carried out in the standards room.

PETROL INJECTION PUMPS.

In the main building is a plant for testing the direct petrol-injection pumps of Wright Cyclone engines. This test rig, which was designed and built by the Repair Division of the Corporation, and is illustrated in Figs. 6 and 7, on page 132, has some unusual features. Its purpose is to measure accurately the quantity of fuel delivered by each of nine plungers in a swash-plate type of pump. This is done by directing the output of each plunger to a calibrated measuring jar, thus recording the total quantity delivered by each pump over a known number of revolutions of the main pump shaft. For each test run the delivery over exactly 500 revolutions of the

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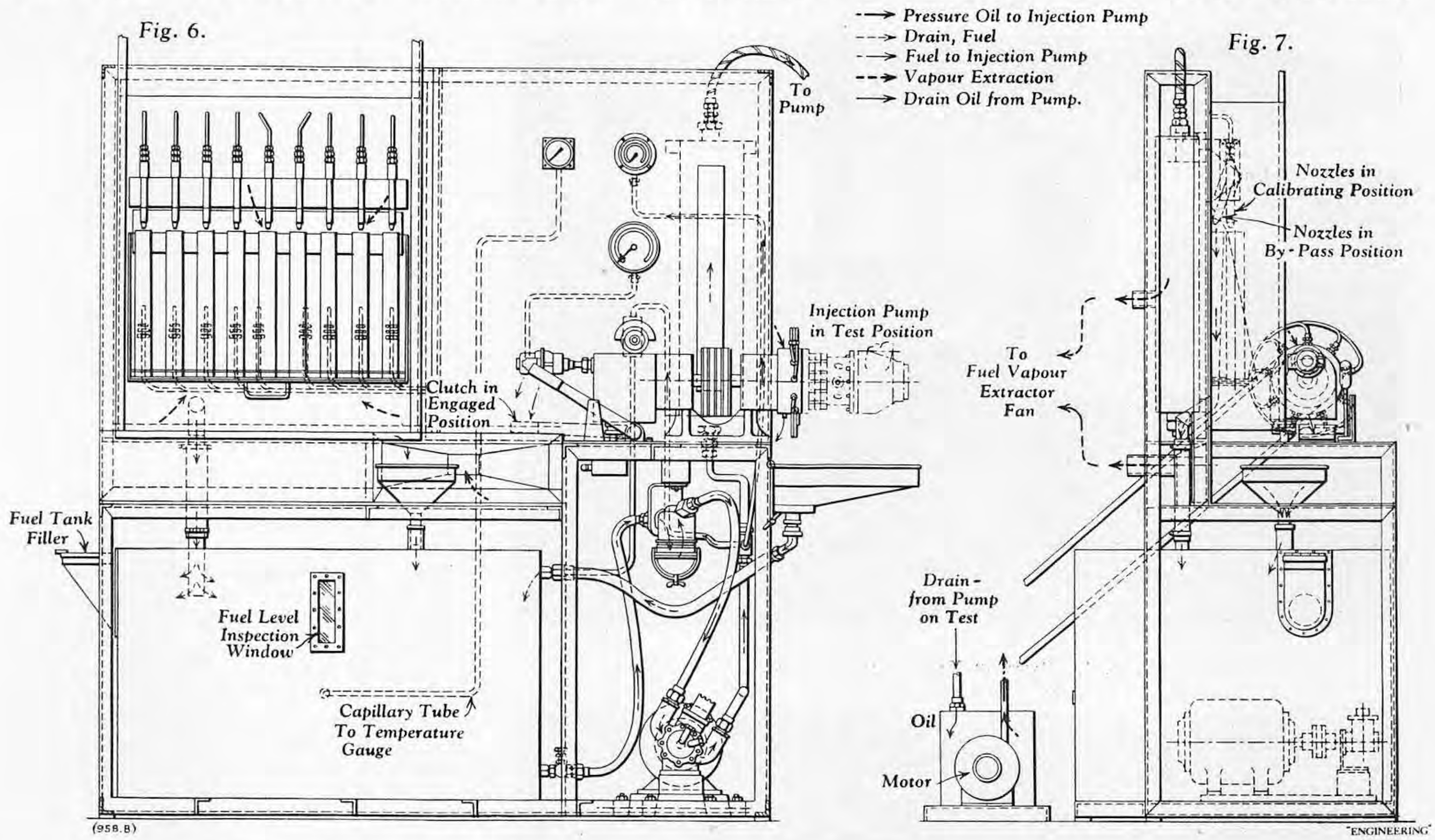

main shaft is directed to the nine calibrated jars by the automatic operation of an electrical solenoid, controlled by a cam mechanism which is coupled to the pump drive shaft through a clutch engaged by the test operator. With the clutch disengaged, the delivery nozzles are withdrawn from the jars and fuel passed by them is directed back to a 100-gallon fuel storage tank. As an example, at 780 r.p.m. the delivery of each plunger must be within the limits of 168-175 cc.

Adjacent to the design office which, as already mentioned, prepares repair schemes, is a technical library where modification schedules and technical literature is kept. The library staff are responsible for keeping the makers' handbooks, issued to the inspection staff, amended with the latest modifications. In adjoining rooms are the planning, progress and technical costing departments who follow the course of each engine and propeller through the factory.

Carburettors are overhauled in a separate block of buildings and follow through the same procedure of stripping, cleaning, inspection, repair, re-assembly and testing. In the test house, which is provided with extractor fans for removing petrol fumes, there are five carburettor test rigs—three Stromberg rigs for calibrating the flow over the complete speed range and for adjusting the automatic mixture-control unit on Bendix Stromberg carburettors (fitted to the Pratt and Whitney and Wright Cyclone engines), and two Hobson test rigs for carrying out flow tests at specified constant-boost and r.p.m. settings on the Hobson-R.A.E. carburettors of the Bristol Hercules engines. Fig. 12, on Plate VI, shows part of the carburettor test house. The Wright Cyclone R.3350 engines employ, as already noted, direct-fuel injection; the bulk metering of the fuel is, however, regulated by a Bendix Stromberg master control unit. For safety reasons, the switchgear, vacuum pump and a compressor for operating the test rigs are housed in an adjacent building.

FIG. 8. PROPELLER BALANCING RIG.

OVERHAUL OF PROPELLERS.

During the war years the propeller overhaul organisation was situated at Bath as a separate enterprise reporting to the management of the Propeller and Engine Repair Auxiliary, of which Treforest also formed a part. Upon the re-organisation of the Corporation at the end of the war, it was decided to remove the propeller factory from Bath and to integrate it with the engine overhaul

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(*For Description, see Page* 129.)

FIG. 9 MAGNETO AND HARNESS OVERHAUL BAY.

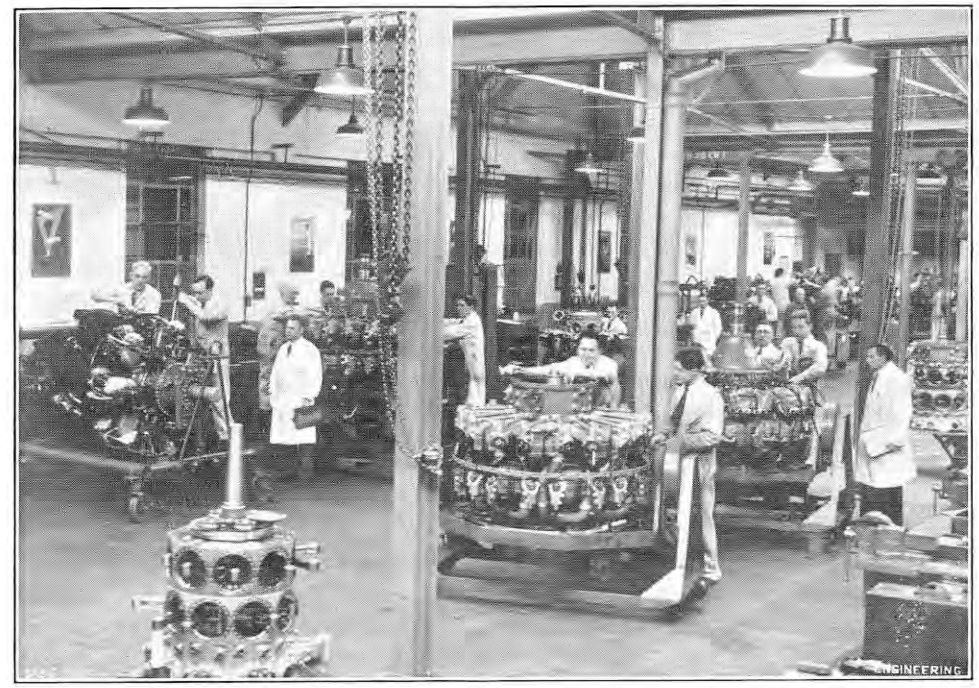

FIG. 10. ENGINE ASSEMBLY LINES.

FIG. 11. STANDARDS ROOM.

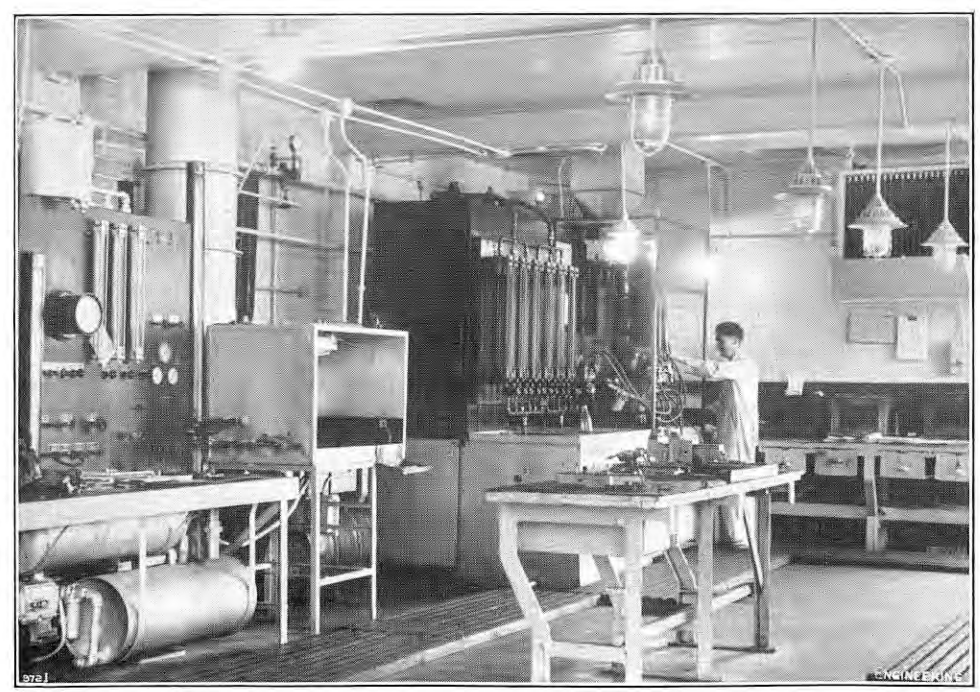

FIG. 12. PART OF CARBURETTOR TEST HOUSE.

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(*For Description, see Page* 129.)

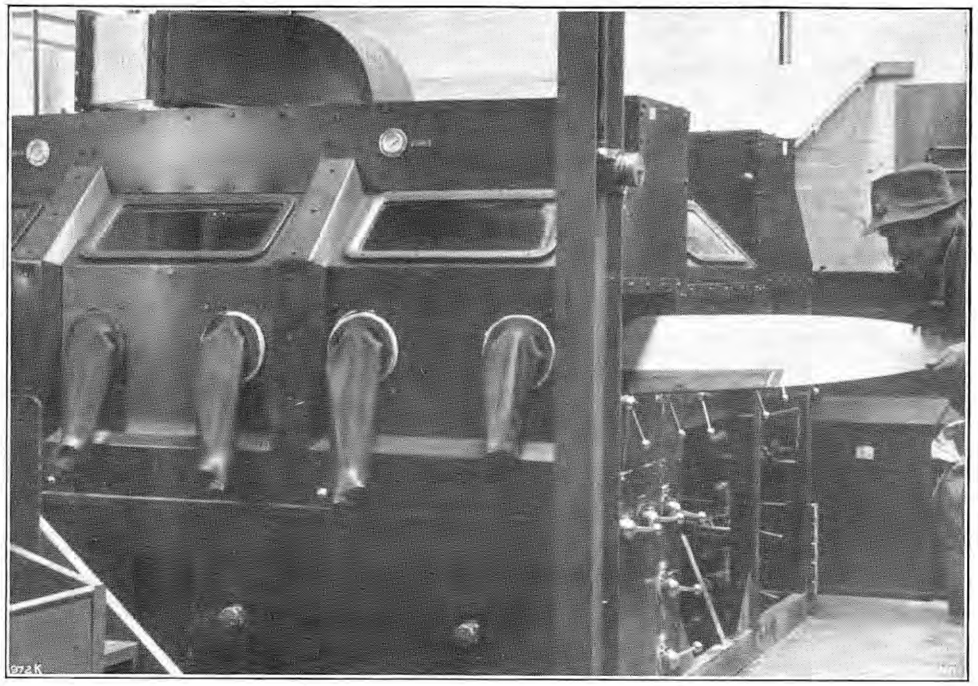


Fig. 13. Vapour Blasting Machine in Propeller Shop.

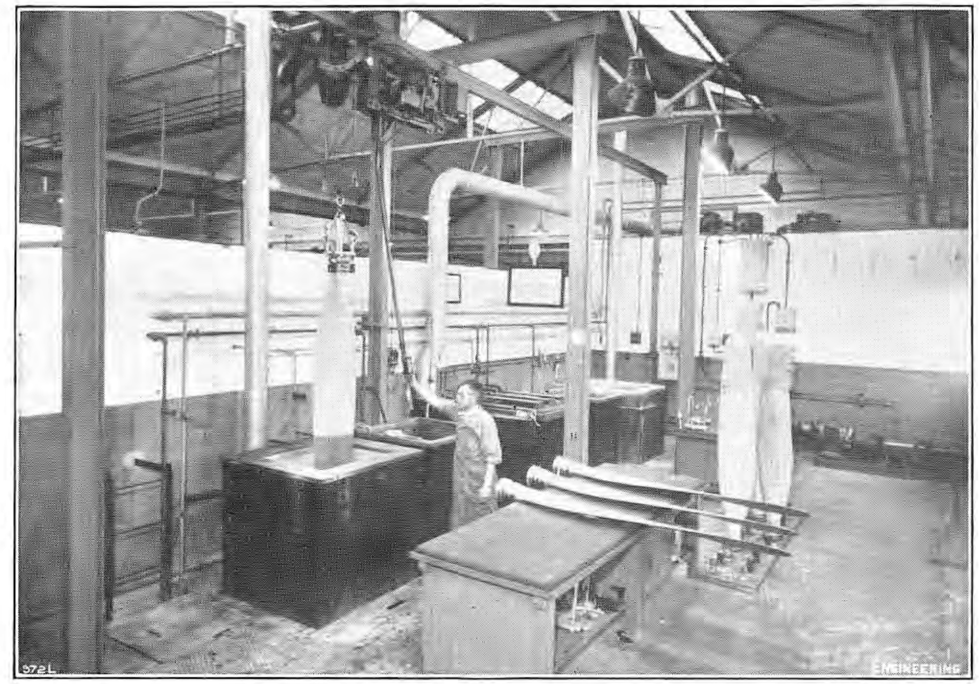


Fig. 14. Anodising Propeller Blades.

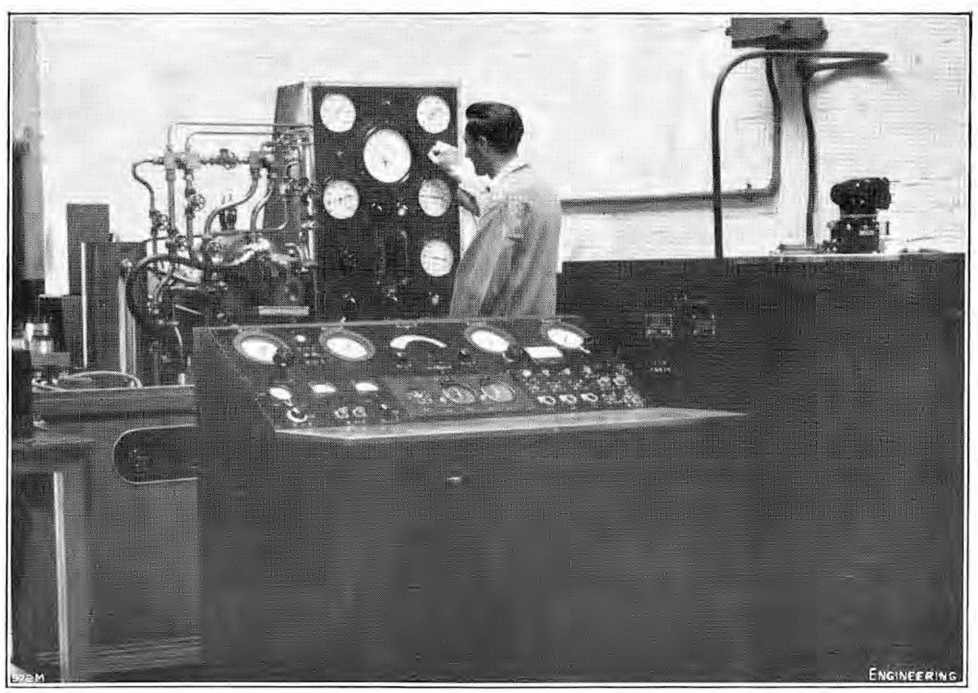


Fig. 15. "Greer" Test Rig for Constant-Speed Units, with de Havilland Rig at Rear.

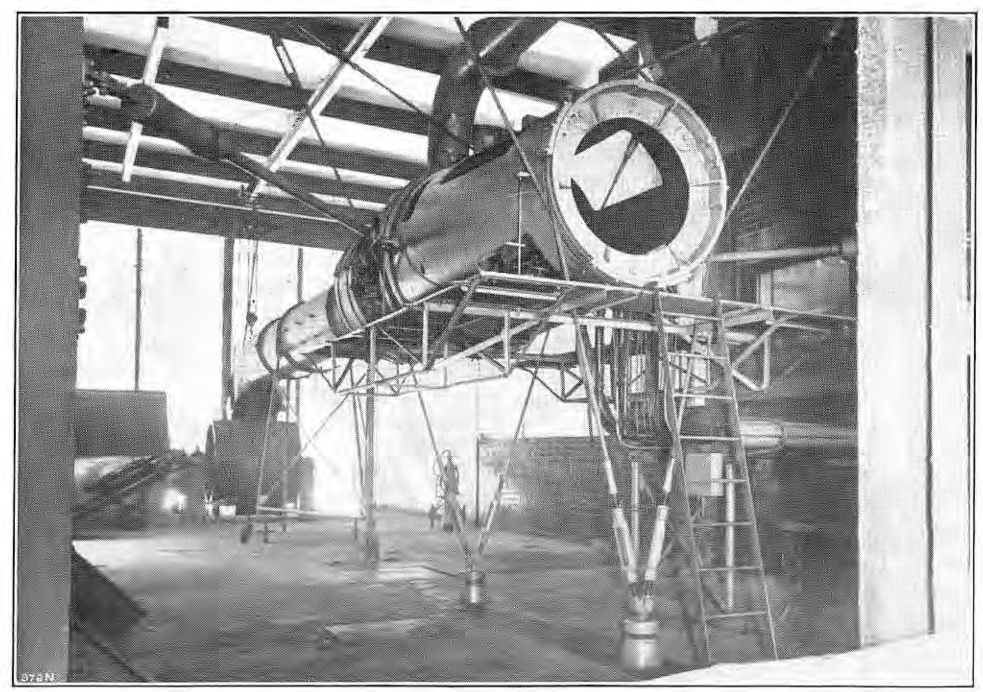


Fig. 16. Cable-Slung Engine Test-Bed.

unit at Treforest. The propeller shop was combined with the engine overhaul shops in the main factory at Treforest, but in 1949, when the Wasp Major and Wright Cyclone engines were introduced, the propeller shop was transferred to a separate factory to allow more room for the overhaul of these engines.

De Havilland and Hamilton hydraulically-operated propellers and Curtiss-Wright electrically-operated test fans (the function of which is described later) are overhauled in the shop and are subjected to the same overhaul procedure as for engines. During the course of overhaul, ferrous parts are inspected for cracks with electromagnetic crack-detection equipment; all nicks, burns and scratches on light-alloy blades are buffed out, and certain blades are given a special shot-blasting treatment for the purpose of stress-relieving the shank portion. An interesting item of equipment is a vapour blasting cabinet, illustrated in Fig. 13, on Plate VII, for providing a fine-grained surface finish to certain types of propeller blades, at the same time obviating the buffing process mentioned above; this process considerably lengthens the life of light-alloy blades since less metal is removed in obtaining the desired finish. Anodic treatment of propeller blades is carried out in the main engine overhaul shop, where special tanks were installed prior to the location of the propeller overhaul facilities in a separate factory. These tanks, which can be seen in Fig. 14, on Plate VII, are approximately 10 ft. deep and 3 ft. square; they are sunk into the ground to a depth of 6 ft. to permit blades being lowered into the tanks without making special alterations to the roof structure. Tanks are provided for cleaning, washing, anodic treatment and subsequent washing. On re-assembly, all propellers are subjected to a functional test of the pitch-changing mechanism, and, finally, to a static balancing check, when both the basic propeller and the operating mechanism housed in the front dome are balanced to within fine limits. Fig. 8, opposite, shows a propeller on the balancing rig.

Propeller constant-speed or governor units are also completely overhauled in the propeller shop. The most interesting part of this operation is the final test, when all units are subjected to exhaustive functional checks on one of three special test rigs, two manufactured by the de Havilland company in England and the third, an elaborate rig, developed by Greer Hydraulic, Incorporated, Brooklyn, New York, U.S.A. This is shown in Fig. 15, on Plate VII, with a de Havilland machine in the background. The unusual feature of the Greer machine is that the oil output of the governor is directed to a hydraulic ram, which is connected through a variable-speed mechanism to the electric motor driving the governor on test. Thus it is possible to simulate more exactly the operating conditions of the unit when fitted to an aircraft, and to check with great accuracy the ability of the constant-speed unit to maintain the speed at which it is set.

ENGINE TEST-BEDS.

There are 12 engine test-beds situated at Nantgarw, some 2 miles from the main factory, three of which are of the Heenan and Froude cable-slung type, shown in Fig. 16, on Plate VII, accommodating engines developing up to 4,000 brake horse-power, and provided with forced-draught cooling air from a Sirocco fan which is driven by a 550-h.p. electric motor. Variable-pitch Curtiss-Wright test fans are fitted to absorb the power developed by Wasp Major and Cyclone engines tested in these cells. To regulate the air and oil temperatures, a steam-heating plant and a cooling-water supply are provided. The steam-heating plant, with automatic firing, operates on waste engine-oil. The remaining nine test-beds are fixed rigidly to the ground and accommodate the Bristol Hercules and the smaller American engines, which are tested either with variable-pitch propellers or wooden test fans. Five of the nine cells were designed by Messrs. John Curran (Cardiff), Limited, while the remaining four were designed by the Directorate of Repair and Maintenance, Ministry of Aircraft Production. During the test, torque, fuel and oil consumption, and temperatures are checked at engine revolutions and manifold pressures appropriate to take-off, climb, maximum continuous power, maximum weak-mixture power, emergency power, etc. Due to the growth of housing in the neighbourhood, plans are in hand for the partial silencing of the test site. One of the cells has already been provided with a prototype silencing installation designed by Mr. Jack Cullum, acoustic consultant, Flowers-mews, London, N.19, comprising two rows of splitters at the inlet and exhaust ends of the test cell; the splitter panels are filled with rock wool. The result of this treatment is very effective and has reduced the noise level to less than half its original value. Ultimately, all the test-beds will be silenced.

After completing the test-bed runs, the engines are transferred either to a "British shop" or an "American shop" as appropriate, for final adjustments and "locking-up." The sparking plugs are removed and blanks or silica-gel de-humidifying plugs fitted. The carburettors are checked and inhibited, after which the engine is treated internally with inhibiting oil. Where the engine may be exposed to sea-water corrosion during transit, a protective varnish coating is applied, after which engines are wrapped in a Pliofilm envelope. All engines except those for "percentage" checks are packed in wooden crates, which have themselves been inspected, repaired and certified fit for transit. The collection and delivery of the engines is made by road, for which purpose a fleet of lorries is maintained by the Corporation. The journeys made by the transport section cover a considerable mileage, and it is not unusual for urgent requirements of the aircraft operators to be transported all night in order that an engine or propeller may be delivered in time to prevent a cancelled or delayed service. Regular journeys are made to the London area, Liverpool, the Midlands, Bristol and Scotland.

In conclusion, it may be said that there are three points which particularly impress visitors to the B.O.A.C. engine-overhaul base: its cleanliness, the efficiency with which the varied operations are co-ordinated, and the enthusiasm and skill which the executives and craftsmen bring to their work.

LITERATURE.

Analysis of the Four-Bar Linkage: Its Application to the Synthesis of Mechanisms.

By PROFESSOR J. A. HRONES and PROFESSOR G. L. NELSON. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 15 dols.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 120s. net.]

THE designer frequently requires some part of a machine to trace out a particular curve, such as a circle, an ellipse, or a helix, and this has to be done mechanically by a combination of links. The simplest link mechanism, and the one from which all the others are derived, is made up of four rigid members connected by four parallel pins, with the individual links moving in several parallel planes. In this four-bar linkage, or chain, all the links are of the same character so that their relative lengths, and not the fixing of any one of them, determine the action. Hence a linkage of this kind lends itself to numerous applications, as, for example, the crank and connecting rod or the valve gear of an engine, the drag-link mechanism, and the Ackerman mechanism for steering automobiles. Further, Hooke's joint bears the same relation to the four-bar chain that bevel wheels do to spur wheels, and the motion of a pair of elliptical wheels can be studied by reference to a four-bar chain. In its various forms, the mechanism provides a driving crank coupled, through a connecting rod, to a driven crank, and for general purposes of design the engineer requires expressions for the displacement, the velocity, and the acceleration of any point on the connecting rod when a given displacement is ascribed to the driving crank. The process of deducing these expressions is long and tedious, however, making the computational work a task which few designers will readily undertake. To the literature on the subject, Professor Hrones and his colleague here contribute a most comprehensive survey of the problem for the important case where the driven crank oscillates while the driving crank executes one complete revolution.

Following an explanatory section of 14 pages, the authors present 730 charts which together exhibit the displacement curves, or paths, for a network of points on the connecting rod of the mechanism for a wide variety of link ratios. Each curve consists of 72 dashes, and the distance between corresponding points of adjacent dashes, measured along the curve, is the displacement of the given point on the connecting rod for an angular displacement of 5 deg. of the driving crank. Since each chart more or less covers a page 17 in. in length and 11 in. in width, and the curves are accurate to $\pm 0 \cdot 01$ in., simple calculations suffice to estimate the velocity or the acceleration at any instant during the cycle of operation of the selected point on the connecting rod. Thus, with the driving crank rotating at constant speed, the mean velocity of the point along its path for a particular part of its cycle is simply the length of the appropriate dash divided by the time taken by the driving crank to rotate through 5 deg. Again, an approximate value of the acceleration can easily be obtained by vectorially subtracting the lengths of adjacent dashes and dividing by the square of the time required for the driving crank to move through 5 deg. Furthermore, for each set of link ratios there are five charts, and details of the motion of the driven crank are included in one of these five charts.

With the book before him, the designer in search of a mechanism to produce a desired motion has only to turn over the pages until he finds charts which show motion characteristics similar to those required. In many cases, a number of possible mechanisms exist, though careful study of the curves discovered in this way will often disclose to the student the linkage best suited to his requirements. If the curve on a given page does not completely yield the desired characteristics, the proportions of the right mechanism may be found by successive approximation, with a model, of cardboard or sheet aluminium, in which the link ratios have been made different from those stated at the top of the page.

Thus the book places at the disposal of the reader a very large number of graphical solutions to the equations for four-bar linkages operating in the manner specified above. Indeed, such linkages are often embodied into computing machines, so the charts may be used also as sources of information in the design of mechanical computers. Although, generally speaking, bar linkages do not operate as function generators with mathematical accuracy, they can nevertheless generate in a simple and direct way, and with sufficient flexibility and accuracy, functions that can be generated only by complicated combinations of computing elements. The degree of accuracy attainable may be improved by employing more than one four-bar linkage; the additional linkages introduce corrections to bring the maximum errors of the primary linkage within the prescribed limits. Two illustrative examples of this application are discussed in the explanatory section: in the first case, the linkage closely satisfies a function of the type $\phi = \theta^n$ over a certain range of values of θ; in the second case, the outpu position of the linkage is the logarithm of the inpu

ELECTRICITY SUPPLY IN ITALY.

FIG. 1. THE "CONCENTER" POWER STATION, GENOA.

position over a limited range. Altogether, this is a notable book, and a review can scarcely do justice to the wealth of data that it contains or its potential usefulness, whether the reader is engaged in the drawing office of an engineering establishment or in the mathematical laboratory of a university.

Industrial High Vacuum.

By J. R. DAVY, B.Sc., F.P.S. Sir Isaac Pitman and Sons, Limited, Parker-Street, Kingsway, London, W.C.2. [Price 25s. net.].

AT no point are the techniques of physics and engineering to be found in more intimate relationship than in the field of high vacua; a field which the author of this book, in a valuable introductory chapter, defines as referring to "pressures between 0·1 mm. and 0·0000001 mm. of mercury." Before the war, apart from their application to some electric-lamp bulbs, radio valves, etc., the processes involved had comparatively little industrial significance; but, in this sphere even more than most, the effects of scientific progress are cumulative, and there are now wide varieties of apparatus in commercial production which depend entirely for their success on the rapid creation and dependable maintenance of vacua which, while still not "perfect," are much nearer to that limiting state than could be accomplished even a decade ago.

Mr. Davy's book, in its 22 chapters and four appendices, presents an excellent survey of its subject, commencing with illustrated descriptions of the various forms of diffusion pumps, rotary pumps, seals, valves, gauges, etc., their conjunction in a layout intended for production purposes, and the main uses to which high-vacuum techniques are applied commercially. These chapters provide a necessary basis for an appreciation of those which follow, and which constitute roughly the second half of the book, dealing with the various application techniques; for example, the production by various means of ultra-thin films, the blooming of optical glass, the deposition of metals—a branch which has now many electrical and scientific uses, as well as a considerable commercial applicability for purely decorative purposes—and the development, for certain optical instruments, of semi-reflecting films, which will allow of simultaneous transmission and reflection. The last four chapters deal, respectively, with the properties of thin films, with vacuum metallurgy and vacuum dehydration, and with the kinetic theory. The appendices (on the emission of electrons from cathodes, the pressures used in various vacuum appliances, molecular rotary pumps, and non-vacuum anti-reflection films) are so short that, it would appear, they might well have been included in the general text of the appropriate chapters. The author has a rare gift for exposition and for the economical use of words; there are some books—and by authors of standing, too—which continually arouse in the reader a desire to rewrite passages differently, but that feeling has little opportunity for exercise in this instance. So much has been done by British investigators to advance the science of high-vacuum physics that the advent of a comprehensive British book on the subject is particularly to be welcomed.

PERMANENT COMMISSIONS FOR TEMPORARY R.N.V.R. ENGINEERING AND ELECTRICAL OFFICERS.—National Service R.N.V.R. engineering and electrical officers serving in the Royal Navy can now apply for permanent commissions in the Royal Navy under the "University Candidate" scheme of entry.

THE CHEMICAL SOCIETY'S RESEARCH FUND.—The research fund of the Chemical Society, which provides grants for the assistance of research in all branches of chemistry, has about 700*l*. per annum available for this purpose, the income being derived from a donation of the Worshipful Company of Goldsmiths, from the Perkin Memorial Fund, and from other sources. Applications for grants will be considered in November next and should be submitted on the appropriate form not later than November 15, 1952. Applications from Fellows of the Society will receive prior considerations Forms of application, together with the regulation. governing the award of grants, may be obtained from the general secretary, the Chemical Society, Burlington House, Piccadilly, London, W.1.

ELECTRICITY SUPPLY IN ITALY.

THE annual output of electricity in Italy increased from 15,349 million kWh in 1946 to 28,338 million kWh in 1951. This increase was progressive, except in 1949, when, owing to the shortage of water, the output fell below that of the previous year. Of the total output in 1951, just over 90 per cent. was obtained from hydro-electric plant, while 70 per cent. was generated by privately-owned supply companies. Some 13 per cent. was produced by industrial concerns for their own use, 6·5 per cent. by local authorities, and 3·5 per cent. by the State Railways. The preponderance of water power is also shown by the fact that in 1951, when the capacity installed by private companies increased by about 440 MW, 407 MW was obtained by this means. The new water-power stations included those of the Societa Edison di Milan at Santa Giustina (151 MW) and at Sonico-Cedegolo (49 MW), as well as those of the Societa Adriatica de Elletricita at Soversene (110 MW) and of the Terni Company at Monte Argento (44 MW).

In addition, the Societa Edison and the Societa Idroelettrica Piemonte have prepared an extensive scheme for the development of Lake Molveno, as well as of the River Sarca and its tributaries. This will involve the construction of ten power stations, with an aggregate installed capacity of 655 MVA. The average annual output will be 1,400 million kWh, of which 600 million kWh will be available during the winter. The first of these stations, which is known as Santa Massenza I, is excavated from the rock. Its present equipment consists of two 35-MVA sets, a 5-MVA set for local supplies and a 1-MVA auxiliary set. Four more sets, each of 70 MVA, are being installed. The alternators will generate at 15 kV and will be connected to five 70-MVA transformers in which the voltage will be stepped up to 230 kV. These transformers supply an open-air switching station, from which transmission lines run to the Piemonte system.

ELECTRICITY SUPPLY IN ITALY.

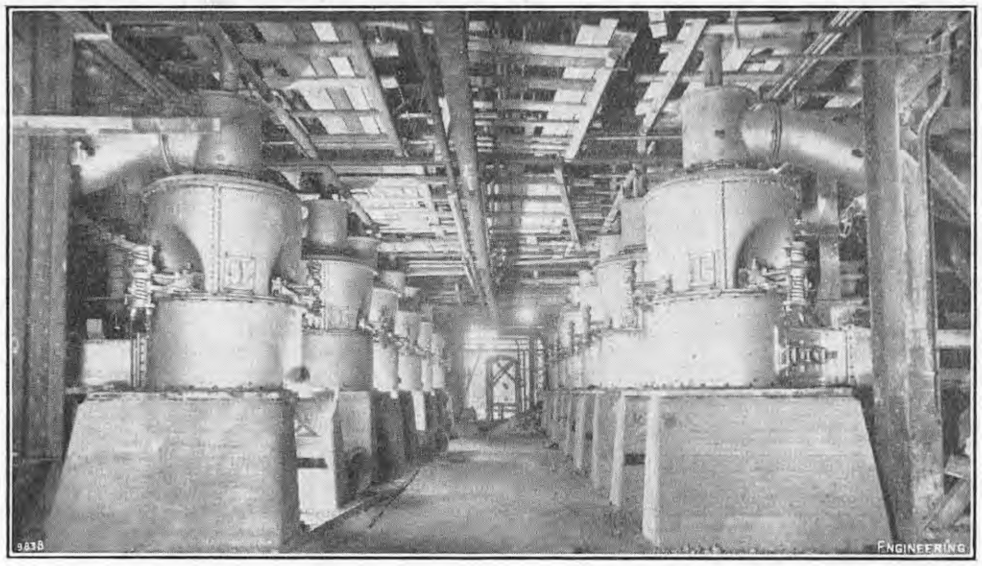


FIG. 2. COAL-PULVERISING PLANT AT THE CONCENTER POWER STATION.

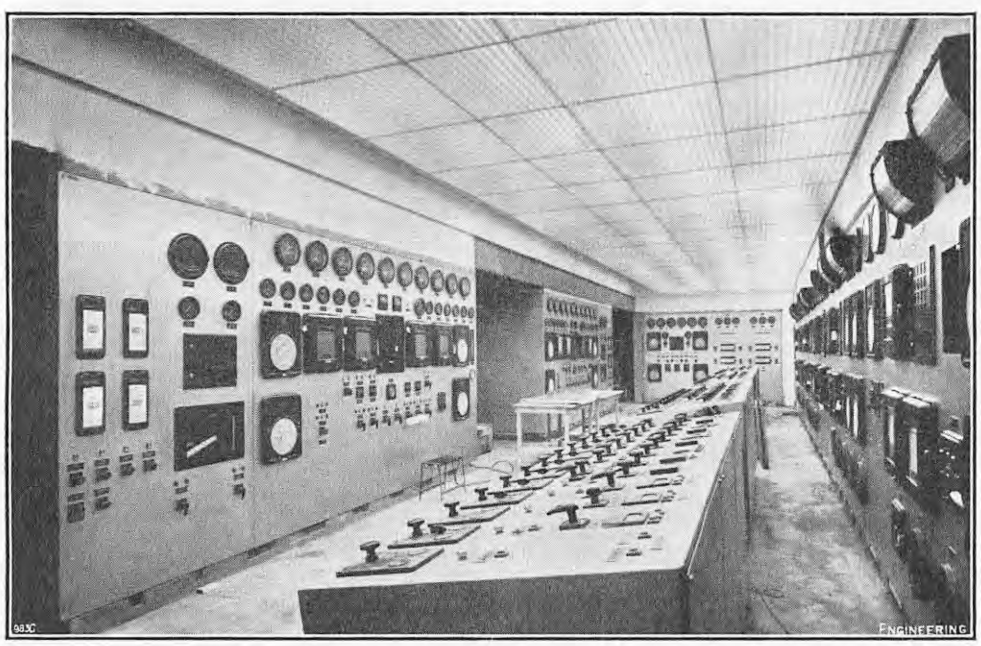


FIG. 3. STEAM-CONTROL BOARD.

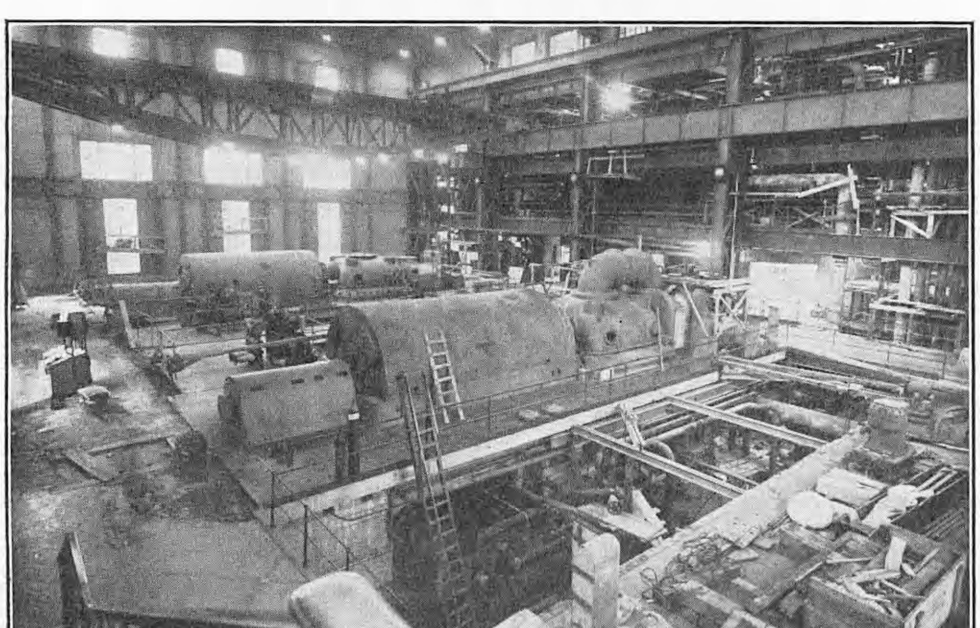


FIG. 4. 62·5-MW TURBO-ALTERNATORS.

The catchment area drained by this station covers about 240 sq. miles, and, in addition to the sources mentioned, includes a number of smaller rivers, the flow of which is diverted into the lake through a system of tunnels with a total length of 31·6 miles. The maximum capacity of the reservoir thus obtained is 8,260 million cub. ft. It is connected to a pressure tunnel 17,260 ft. long, into which water is pumped by two floating pumps and flows thence through steel penstocks to the power station, the gross head varying from 1,950 ft. to 1,520 ft.

An adjacent station, which will be known as Santa Massenza II, will drain a catchment area of about 120 sq. miles and will have an installed capacity of 31 MVA and an annual output of 108 million kWh. It will utilise the water of the Lake Ponte Pia and will operate at a head of about 700 ft. The water from both Santa Massenza stations will flow into Lake Cavedine and thence through a tunnel to a station at Torbole, which is now in course of construction at the head of Lake Garda. An interesting feature connected with these stations is that a 220-kV line will be run through the San Giacomo pass to connect with the Edison network and thence with the Swiss system.

The extensive development of the country's water power is, however, now leading to a position when all the economically available resources will be fully utilised. It is therefore clear that it will be necessary for thermal plant to be installed to provide a larger proportion of the electricity supply required in the future. For that reason, not only has the Concenter steam station at Genoa been extended by the installation of two 60-MW sets with the object of supplementing supplies in Liguria and Emilia, where water power is short; but new coal-burning stations are being built at Piacenza, Turin and Civitavecchia. In addition, a station is being constructed at Tavazzano, at which coal, oil and methane will all be used as fuel; and it is expected that two 62·5-MW sets will be put in operation during the present year. Further, the Societa Larderello increased the output of their six natural-steam stations to 1,580 million kWh in 1951, and have decided to build a further 50-MW station to utilise new natural-steam wells. This station will be ready for operation in 1954.

THE CONCENTER STATION.

The exterior of the Consorzio Centrali Termiche in Genoa, which is usually known as the Concenter, is illustrated in Fig. 1. It was opened in 1929, at which time the equipment consisted of two 25-MW main sets and a 3-MW set for auxiliary services. For the reasons mentioned above, this station has now been extended by the addition of four boilers and two 50-MW sets. It has been possible to carry out this work without much alteration to the buildings, as these were originally designed to accommodate plant with an aggregate capacity of 200 MW. The new steam-raising plant consists of four boilers constructed by the Combustion Engineering Company, Incorporated, New York, which have a maximum output of 290,000 lb. of steam per hour at a pressure of 853 lb. per square inch and a temperature of 900 deg. F. They have been designed for firing by both pulverised fuel and oil. The coal is pulverised in variable-speed mills of the Raymond type, illustrated in Fig. 2, opposite. The oil fuel is pumped from two tanks with a capacity of 14,130 cub. ft. through purifying and filtering plant and steam heaters. These tanks are connected by pipes to the depots of the principal oil companies in the port, so that the minimum of handling is necessary. The combustion chambers are 65 ft. high, and the hot gases, after passing through a two-stage superheater, a horizontal economiser, Ljungstrom air heaters, and mechanical and electrostatic grit arresters are exhausted into the chimney at a temperature between 300 and

338 deg. F. Burners are installed at each corner of the combustion chamber, three being designed for pulverised fuel and two for oil. The temperature of the superheated steam is controlled by electrically-operated equipment supplied by the Leeds and Northrup Company, of Philadelphia, and the boilers are regulated on the Bailey meter system so that the steam pressure at the turbine inlet is constant and fuel and air are supplied in the correct proportions. The ashes are collected in three silos, whence they are taken out to sea in barges. A view of the boiler-control room is given in Fig. 3.

The generating plant consists of two turbine sets, constructed by the Westinghouse Electric International Company, Pittsburgh, Pennsylvania. These machines, illustrated in Fig. 4, on page 135, have a continuous rating of 62·5 MW. Speed regulation is by oil governors. The condensers are separated into two halves by a diaphragm and a valve in order that they can be operated in parallel. Cooling water is drawn from the harbour by two vertical pumps. The condensate is delivered to the boilers by two pumps, one of which normally acts as stand-by. These turbines are directly coupled to hydrogen-cooled alternators, which generate three-phase current at 13·8 kV, with a power factor of 0·8. The main and pilot exciters are directly driven and the voltage is controlled by Brown Boveri regulators. The alternators are connected to oil-cooled transformers with a capacity of 75 MVA, in which the voltage is stepped up to 130 kV. The current is transmitted thence to indoor switchgear of the air-blast type and to a 'bus-bar system from which two feeders are run to the network of the Edison Company. This switchgear is automatically operated by direct current though it can also be worked by hand. The necessary supplies for the former purpose are obtained from a battery. The recent extensions make Concenter the largest steam-power station in Italy.

The Tavazzano Station.

As regards the employment of natural methane gas for power generation to supplement the available coal and oil supplies, investigations showed that considerable resources existed at Cortemaggiore, Caviaga, Ripalta and Cornegliano. It was therefore decided to build a station at Tavazzano with an installed capacity of 125 MW and an annual output of from 400 million to 700 million kilowatt-hours, to utilise both natural gas and fuel oil. Tavazzano was chosen as a site for this station because it is only about $2\frac{1}{2}$ miles from the Cornegliano gas field, the reserves of which are estimated to be sufficient for at least 15 years' operation, irrespective of the additional quantities that can be secured by drawing on the supplies in the Po Valley. Tavazzano is also conveniently situated on the Muzza irrigation canal, which is connected to the River Adda and from which about 283 cub. ft. of water per second can be drawn for cooling purposes. Moreover, it is an important focal point in the national high-tension transmission system and is close to such large load centres as Milan, Brescia and Piacenza. The development of this scheme was entrusted to the power department of the Montecatini Company and it was carried out in collaboration with the Siemens Schuckertwerke A.G., Berlin, and the Combustion Engineering Company.

Each of the two generating units consists of a boiler, turbo-alternator, transformer and the necessary auxiliary equipment. The two boilers, which were constructed by the Combustion Engineering Company, are installed in the open air. Each has a normal output of 360,000 lb. and a maximum output of 432,000 lb. per hour at a pressure of 1,870 lb. per square inch and a temperature of 968 deg. F. They are of the natural-circulation type with upper and lower drums. The combustion chamber has a volume of 25,080 cub. ft. The heating surface of the water walls is 1,744 sq. ft.

ELECTRICITY SUPPLY IN ITALY.

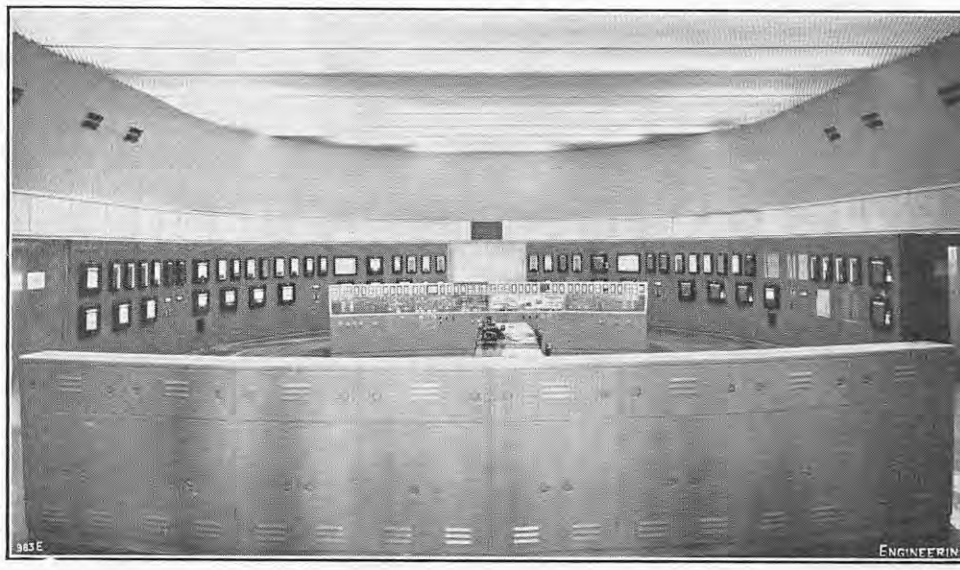


Fig. 5. Steam and Electric Control Room at Tavazzano.

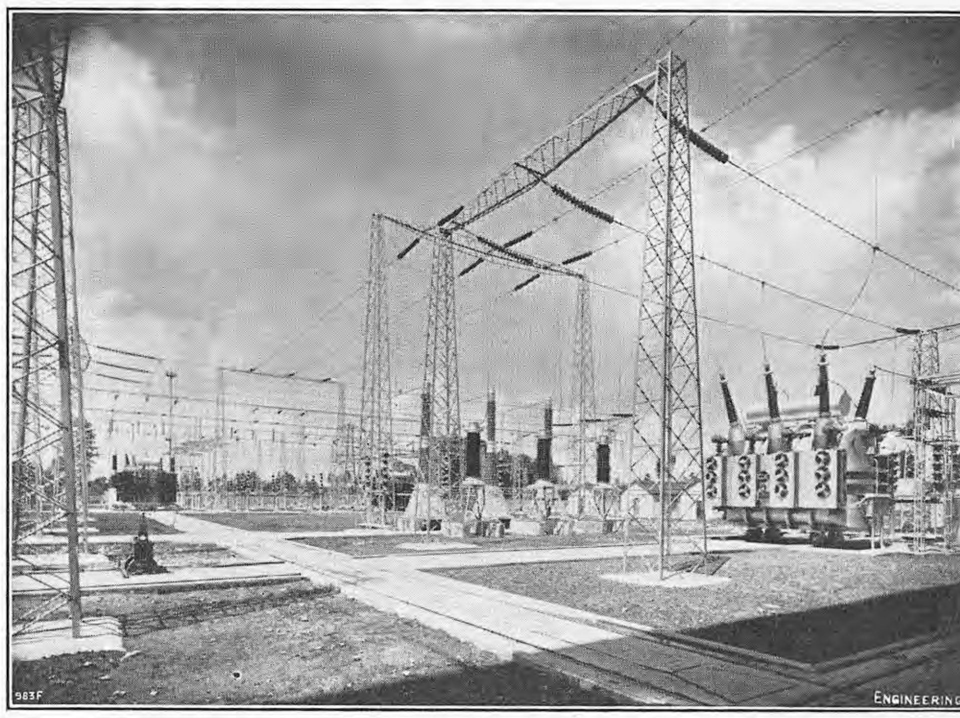


Fig. 6. Open-Air Transformer Station at Tavazzano.

Each boiler is provided with three sets of burners, one for methane, one for oil, and one for lighting up. The methane is transmitted to the boilers through filters; the oil is pumped from a tank, with a capacity of 106,000 cub. ft., through a steam-heated pipeline.

The main superheater has a heating surface of 22,700 sq. ft., and an intermediate superheater, the surface of which is 7,280 sq. ft. A constant superheat temperature is maintained at outputs varying from 296,000 to 430,000 lb. per hour. The heating surface of the air heater is 177,610 sq. ft. At maximum load the temperature of the gas in the combustion chamber is 2,156 deg. F., which is reduced to 320 deg. F. at the base of the chimney. The forced-draught and induced-draught fans are driven through hydraulic couplings by 6-kV motors. Control is effected from the room illustrated in Fig. 5, from which both the steam-raising and electrical plant in the station can be operated.

Steam is supplied at a pressure of 1,780 lb. per square inch and a temperature of 968 deg. F., and, after passing through the high-pressure turbines, is returned to the boilers at a pressure of 427 lb. per square inch for re-heating to 950 deg. C. It then passes to the intermediate and low-pressure turbines and is finally exhausted into twin condensers, which are cooled by canal water. The condensate is extracted by duplicate pumps and returned through a feed-heating system to the boilers, at a pressure of 2,310 lb. per square inch. Three centrifugal feed pumps are provided, each directly driven by a 1,250-kW, 6-kV motor running at 3,000 r.p.m.

The turbines are coupled to hydrogen-cooled alternators, each of which has a continuous rating of 85 MVA at 10·5 kV when running at 3,000 r.p.m. This output is reduced to 75 MVA when water instead of hydrogen is employed as the cooling medium. Each alternator is connected to a 75-MVA outdoor transformer in which the generating voltage is stepped up to either 130 kV or 220 kV for delivery to the high-tension transmission system. A view of this portion of the plant appears in Fig. 6. There are also two 6·3-MVA auxiliary transformers, which step the voltage down to 6,000 and 380 volts for use in the station. All the transformers are controlled from switchgear in the main turbine room, which is 213 ft. long and 121 ft. wide.

BRITISH GUIDED MISSILES.

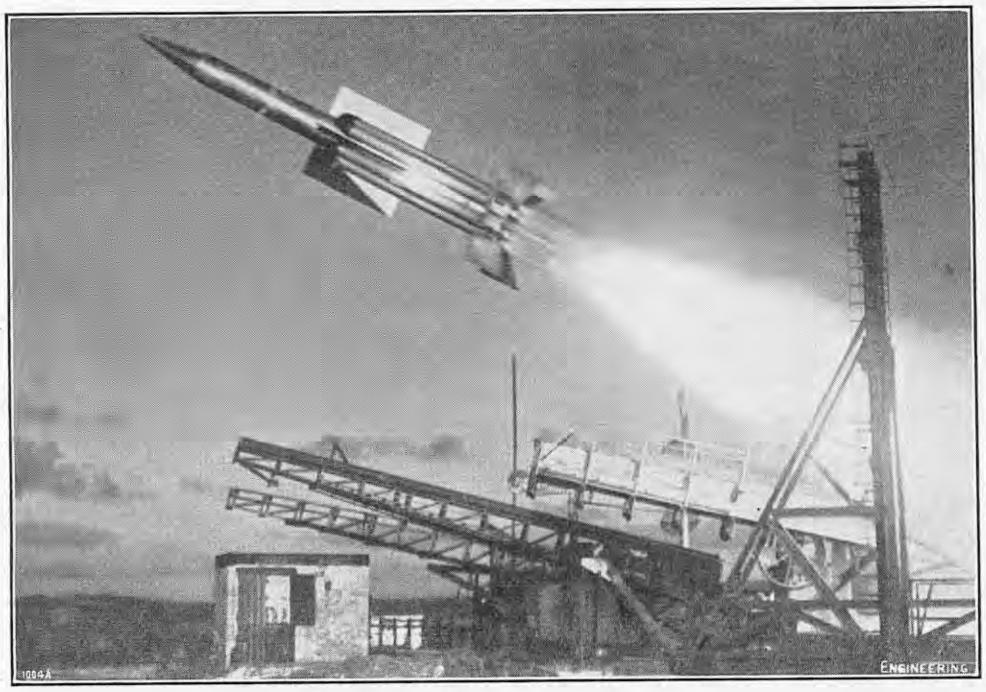


FIG. 1. ROCKET STARTING FLIGHT.

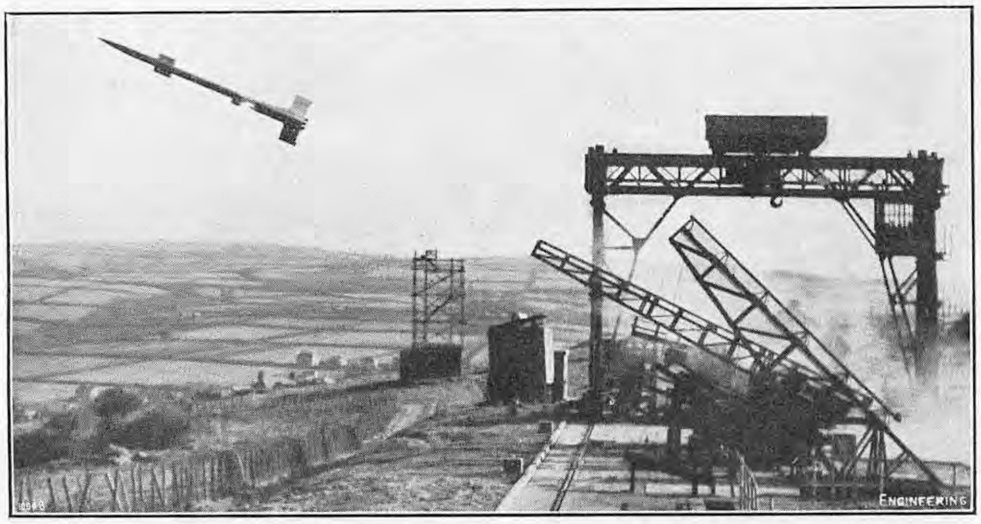


FIG. 2. ROCKET DROPPING BOOST MOTORS.

BRITISH GUIDED MISSILES.

VARIOUS hints that have been dropped from time to time, and the known development of a rocket-firing range in the more or less barren wastes of Australia, have indicated to the people of the British Isles that, behind a fairly close veil of secrecy, a great deal of quiet work has been done to develop the physics of rocket propulsion. On July 26, in South Wales, the Minister of Supply (Mr. Duncan Sandys, M.P.), after witnessing firing trials of guided missiles at his Ministry's experimental establishment at Aberporth, said that he had discussed, with some of the leading scientists, the possibility of developing guided rockets for anti-aircraft work. Without going into any detail, the Minister admitted that many of the most pressing technical problems had been overcome and that "these fantastic new weapons" were "within measurable distance" of going into production. Mr. Sandys added that guided rockets had been produced which could travel at over 2,000 miles an hour and could reach heights beyond the capacity of any bomber. They could steer themselves or could be steered by a single helmsman, and could twist and turn with a manœuvring ability four or five times that of a fighter aircraft. The basic research contributing to this end had been done mainly by Government research establishments, but the results had been made available to a number of firms, to whom had been entrusted the task of developing various operational types of rocket for specific purposes. Among the firms who are developing such special types are de Havilland Propellers, Limited, the Bristol Aeroplane Company, the Fairey Aviation Company, and Armstrong-Siddeley Motors, Limited. The types of rocket now in process of development will give about 200 lb. of thrust per second for every pound of fuel consumed. Fig. 1, herewith, shows such a rocket at the moment of launching, while it was being accelerated by the "boost" motors which provide the initial impetus. The operating period of these motors is a few seconds only, after which they fall off, and the rocket continues under the power of its main jet. Fig. 2, taken only a second or so later than Fig. 1, shows the boost motors (no longer emitting gases) about to be jettisoned, as can be seen by comparing the overall length of the missile in Fig. 1 with the length, appreciably greater, shown in Fig. 2.

The experimental rockets tested so far have used a variety of special fuels—alcohol, hydrocarbons and aviline; but as ordinary petrol and gas-turbine kerosine are more readily available, some of the latest rocket motors have been designed to use these standard fuels. Three types of oxidant have been tested, namely, liquid oxygen, nitric acid and hydrogen peroxide. The ground crews using these propellants have to wear special protective clothing, to guard against burns from some liquids and frost-bite from others.

EXPENDITURE ON INDUSTRIAL RESEARCH.

IT is impossible to travel around the industries of Britain without gathering the impression that vastly greater amounts of time, money and man-power are expended on research than was the case even a few years ago. It is interesting, therefore, to have definite information on the subject, such as is provided by the survey "Research and Development in British Industry," recently published by the Federation of British Industries, 21, Tothill-street, London, S.W.1. (Price 1*s.* 6*d.*, net.) The previous survey undertaken by the Federation covered the financial year 1945-46, and that now published relates to the year which ended on March 31, 1951. It is based on the replies to a questionnaire which was circulated to 1,400 industrial firms known, or thought likely, to be incurring expenditure on research and development. Unfortunately, only 361 replies were received and, of these, 60 were, for one reason or another, unsuitable for inclusion in the survey. The statistics relate, therefore, to 301 firms only, but these include many of the major firms. Firms spending less than 2,000*l.* annually on research were excluded from the survey, and the latter was confined to firms in seven industrial groups only, namely, chemicals; materials; metals; food, drink and tobacco; electrical engineering; mechanical engineering; and scientific instruments.

The replies showed that the firms spent nearly 24,000,000*l.* on research and development during the year under review. This figure compares with nearly 22,000,000*l.* spent by 420 firms five years ago, and 5,442,000*l.* spent by 566 firms in 1938. It was not considered possible to estimate accurately the present total expenditure by the whole of British industry, but a comparison with the 1945-46 figures suggested that the percentage increase was not less than 50. Figures obtained from the 107, mainly large, firms common to the two surveys, showed, in their case, an increase of over 100 per cent.

Expenditure alone, however, is not a very suitable basis for comparison, since costs rose and the value of sterling fell in the period between the surveys. Statistics of man-power are possibly a better guide and, in this case, the survey showed that the number of qualified staff employed on research and development increased by 52 per cent., approximately. The total number was 31,000, approximately, of whom about 8,500 had a university degree or a qualification considered equivalent. In the latter category, chemists were still the most numerous, though the increase in their number (25 per cent.) was not nearly so striking as that of engineers (82 per cent.). The annual expenditure on research and development per head of qualified staff ranged from approximately 2,000*l.* in the heavy electrical industry to nearly 4,700*l.* in the glass industry. The ratio of unqualified to qualified staff engaged on research and development was generally between 2 and 2·5 to 1, but was unusually high (5·2 to 1) in the light electrical industry.

Expenditure on research and development, expressed as a percentage of turnover, ranged, in the seven industrial groups considered, from 0·4 to 5·3. A uniform value was not to be expected. The individual values are significant as indicating the scale on which research and development are being conducted in the different industries. It is interesting to note that from 69 to 98 per cent. of the total expenditure on research and development was incurred on projects originating within firms' own organisations, and almost all of the remainder was expended on work undertaken to meet customers' requirements, as revealed by technical sales services. Only 1 to 2 per cent. of the total was spent on extra-mural, or sponsored, research.

The proportion of firms which were members of a co-operative research organisation, usually a research association, was 31 per cent., and of two or more such organisations, 45 per cent., figures not significantly different from those obtained previously. Research and development by the nationalised industries was not included, except in those cases where the constituent firms had retained their identity; nor was research undertaken by research organisations.

1,000-KW GAS-TURBINE ALTERNATOR SET FOR THE ROYAL NAVY.

W. H. ALLEN, SONS AND COMPANY, LIMITED, BEDFORD.

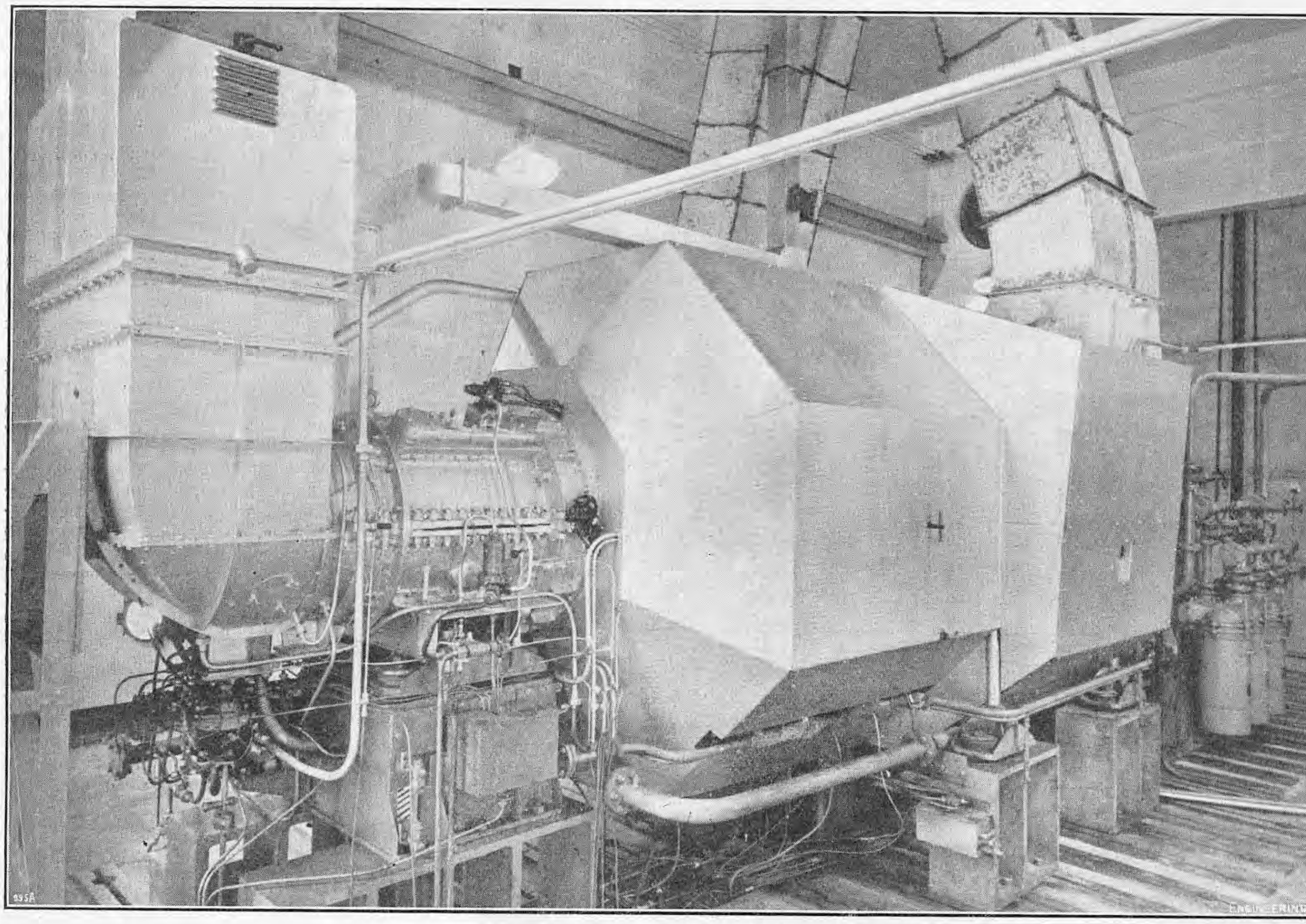


FIG. 1. GAS-TURBINE ALTERNATOR SET ERECTED IN TEST-HOUSE.

PERFORMANCE OF A 1,000-KW GAS-TURBINE.

THE Allen 1,000-kW gas-turbine alternator set has now been run for almost 1,000 hours and has repeatedly demonstrated its ability to meet sudden load changes without appreciable variation in speed of the turbine shaft. Its flexibility in this respect is about half-way between that of a steam turbine and that of a Diesel engine; a typical steam turbine does not change its speed more than $2\frac{1}{2}$ per cent. for a variation in load of about 40 per cent., and a Diesel engine has a similar characteristic for a variation of about 25 per cent.

The gas-turbine alternator set was built by Messrs. W. H. Allen, Sons and Company, Limited, Bedford, for the Royal Navy, and details of its design, with general arrangement drawings, were released at the end of 1951.* At that time a comprehensive series of performance, governing and endurance tests were in progress, the unit having already undergone preliminary tests, without its heat exchanger, at full speed, full load and overload, with only minor "teething" troubles. A number of improvements and modifications have been made in the course of the 1,000 hours of running, though the turbine itself has operated without trouble from the beginning. Most of the work carried out has been connected with the development of a suitable means of igniting the combustion chambers and with keeping the burners free from carbon when the gas-turbine is shut down. The company have recently been demonstrating the unit to engineers concerned with electric-power generation for industrial and marine purposes. We witnessed the tests which are described below on the occasion of a visit to the test-house at Bedford this week. The unit is shown in the test-house in Fig. 1, herewith, and Fig. 2 shows the instrument room. It is soon to be stripped and then installed at the Naval Marine Wing at Pyestock, Hampshire, for further running.

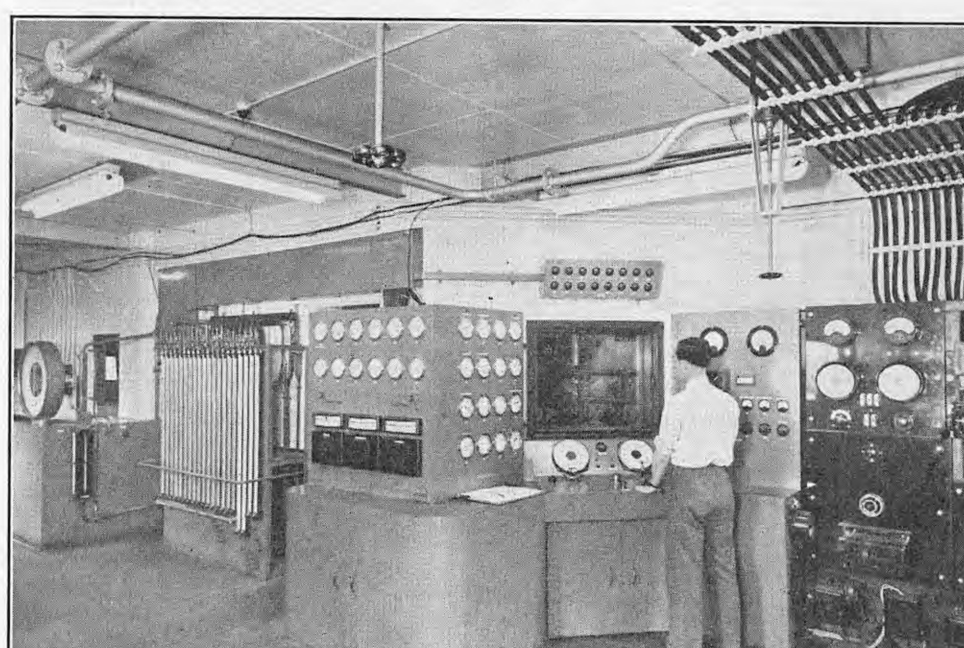


FIG. 2. INSTRUMENT ROOM IN TEST-HOUSE.

Curves of the estimated performance of the gas-turbine with heat-exchanger are given in Figs. 3, 4 and 5, opposite. The measured performance has actually been slightly below these values due to an air leak in the heat exchanger, but it is hoped to rectify this fault before the set is run at Pyestock. The fault was caused by the difficult annular shape of the heat exchanger, which arose from design

* See ENGINEERING, vol. 172, page 609 (1951).

PERFORMANCE OF 1,000-KW GAS-TURBINE ALTERNATOR SET.

W. H. ALLEN, SONS AND COMPANY, LIMITED, BEDFORD.

Fig. 3. EFFICIENCY AND FUEL CONSUMPTION.

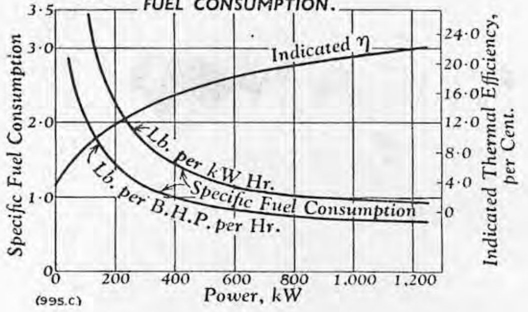


Fig. 4. OUTPUT (KW) AND FUEL FLOW.

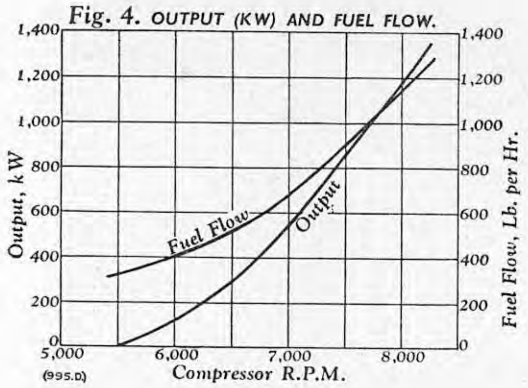


Fig. 5. MASS FLOW AND MAXIMUM TEMPERATURE.

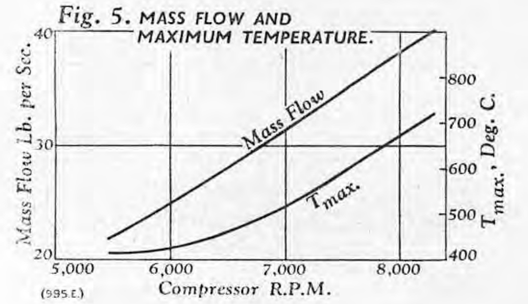


Fig. 9. SUDDEN LOAD CHANGES OF 250 KW.

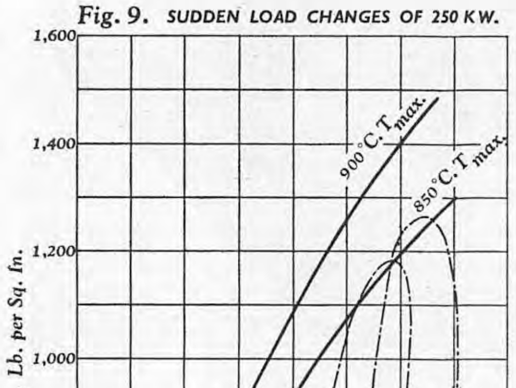


Fig. 6. ADIABATIC EFFICIENCY OF COMPRESSOR.

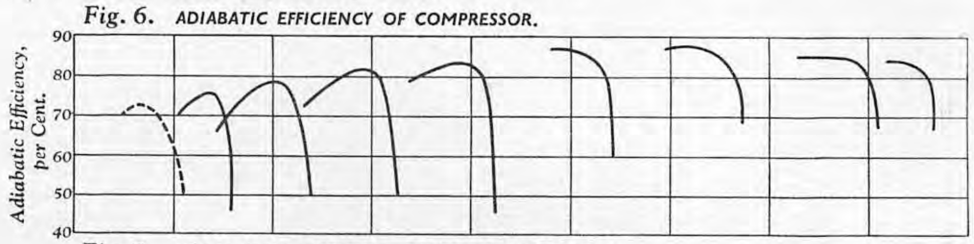


Fig. 7. TOTAL HEAD PRESSURE RATIO OF COMPRESSOR.

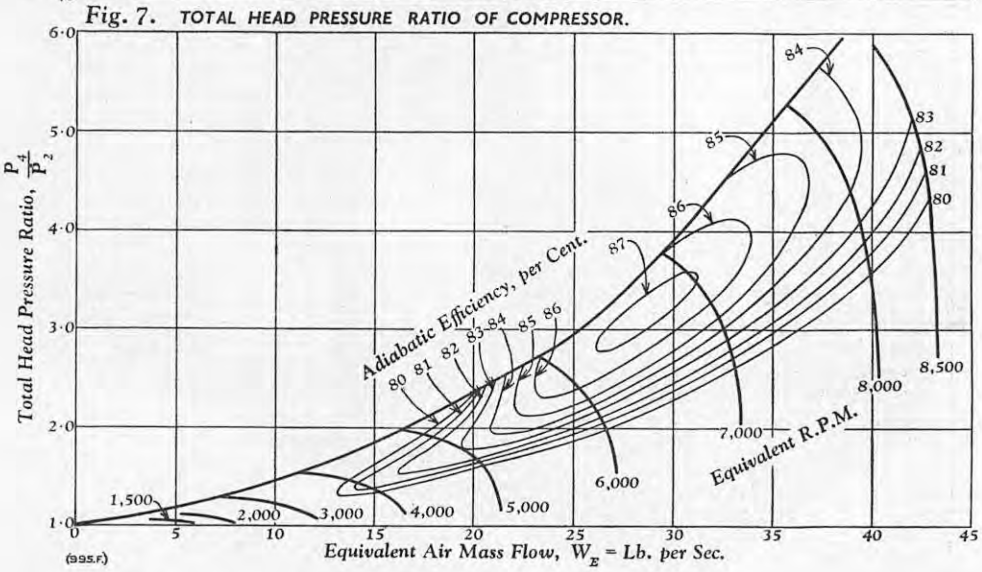
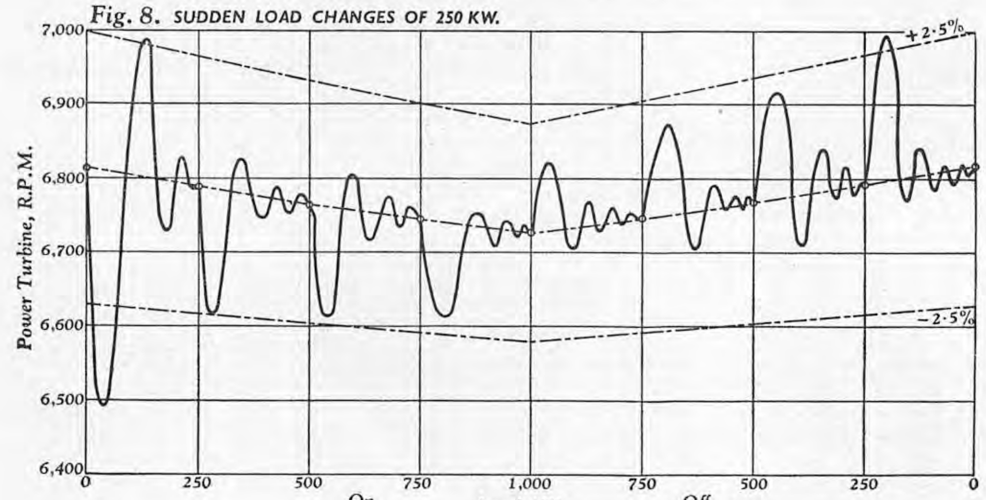


Fig. 8. SUDDEN LOAD CHANGES OF 250 KW.



limitations of space. The design efficiencies of the compressor and turbines had been proved by test rigs and have since been confirmed by running the set. The compressor characteristics are shown in Figs. 6 and 7. The equivalent air mass flow, in lb. per second, is given by the following equation, in which W_M = measured mass flow; T_2 and P_2 = total entry temperature and pressure.

$$W_E = W_M\left(\frac{29 \cdot 92}{\sqrt{288}}\right)\frac{\sqrt{T_2}}{P_2}$$

The governing targets set by the Admiralty have been reached for steady load changes between 0 and 100 per cent., and for sudden load changes of 25 per cent. with loads between 25 and 100 per cent. Moreover, the set will accept sudden load changes of 100 per cent., off and on. The measured speed changes of the alternator (which is coupled to the power turbine through reduction gearing) for various load conditions are given in the accompanying table. These results are shown graphically in Fig. 8, on this page. During load changes, the maximum fuel quantity supplied to the burners is controlled by an air-fuel ratio device, the effect of which is illustrated by Fig. 9, herewith. The temporary fluctuation of the ratio as the load is increased by 250-kW increments is shown by the chain-dotted lines. The calculated lines of constant $T_{max.}$ (turbine inlet temperature) for values of 850 and 900 deg. C. are also indicated; the effect of the air-fuel ratio device could be represented by a straight line running in the same general direction as the $T_{max.}$ curves, its position depending on the adjustment of the device. It is at this imaginary

Condition.	Speed Change, Per Cent.
For steady loads between 0 and 100 per cent.	1·2
Sudden increase in load—	
From 25 to 50 per cent.	− 2·5
From 50 to 75 per cent.	− 2·4
From 75 to 100 per cent.	− 2·2
Sudden decrease in load—	
From 100 to 75 per cent.	+ 1·55
From 75 to 50 per cent.	+ 2·1
From 50 to 25 per cent.	+ 2·3

line that the fluctuating chain-dotted line is caused to fall. For large reductions in load, turbine-air by-pass valves are opened by the governor.

At the test demonstration we attended on Monday, July 28, the fuel used was Diesel oil with a calorific value of 18,500 B.Th.U. per lb. The set was first run at the following steady loads (the corresponding speeds of the compressor are shown in brackets): 0 kW (4,800 r.p.m.), 250 kW (6,100 r.p.m.), 500 kW (7,000 r.p.m.), 750 kW (7,600 r.p.m.), 1,000 kW 8,000 r.p.m.). A series of sudden load changes in

FOUR-ROLL PLATE-BENDING MACHINE.

BRONX ENGINEERING COMPANY, LIMITED, LYE, WORCESTERSHIRE.

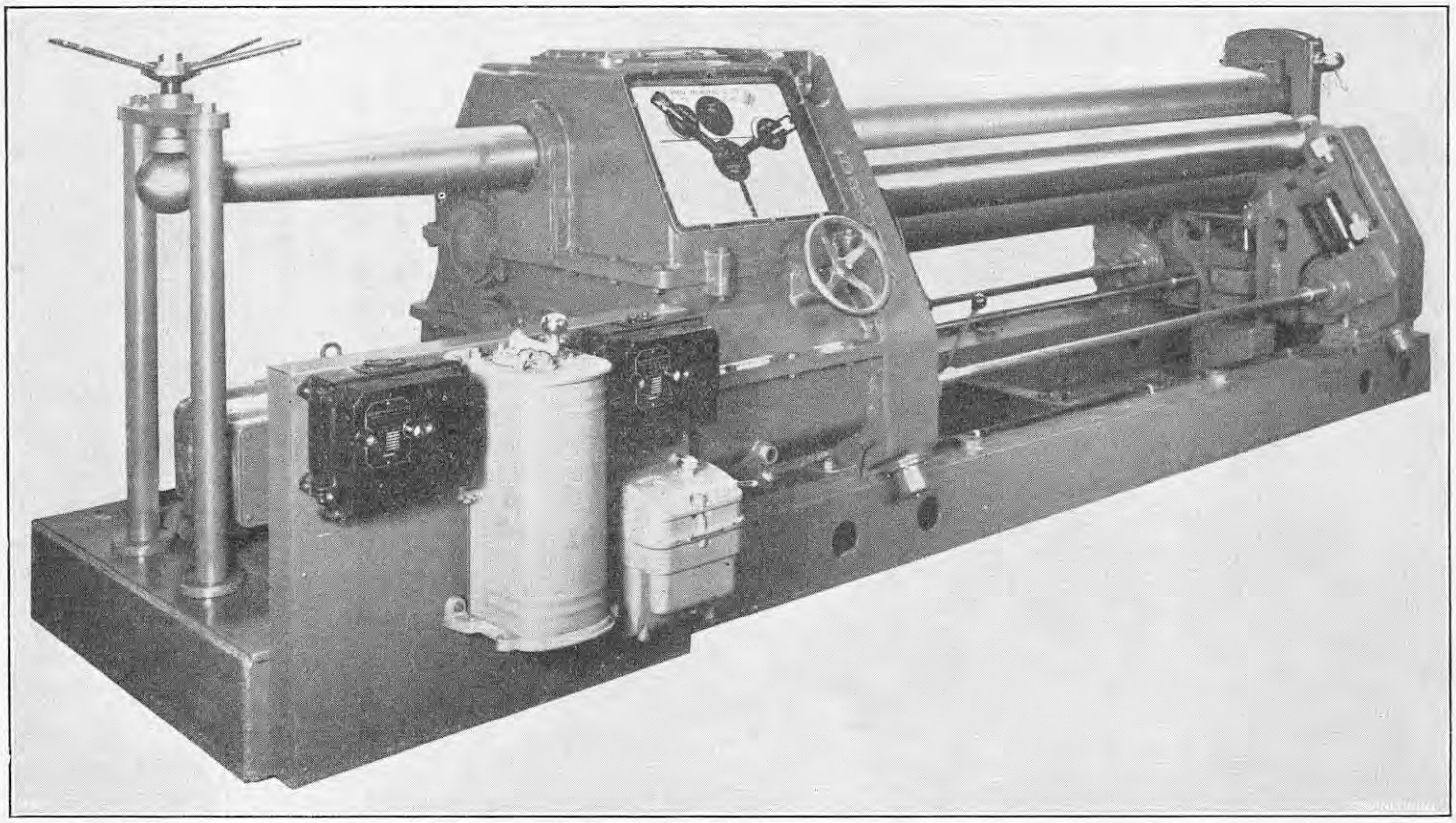


FIG. 1. GENERAL VIEW OF MACHINE, SHOWING CONTROL POSITION.

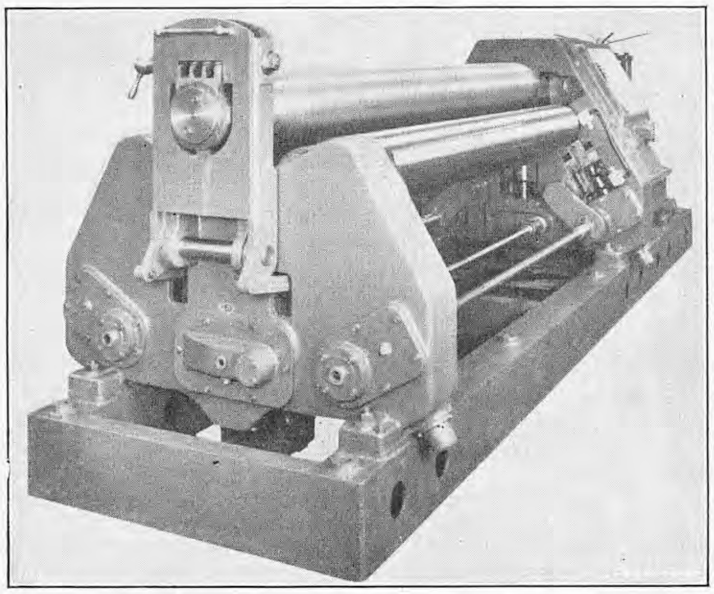


FIG. 2. END BEARING IN WORKING POSITION.

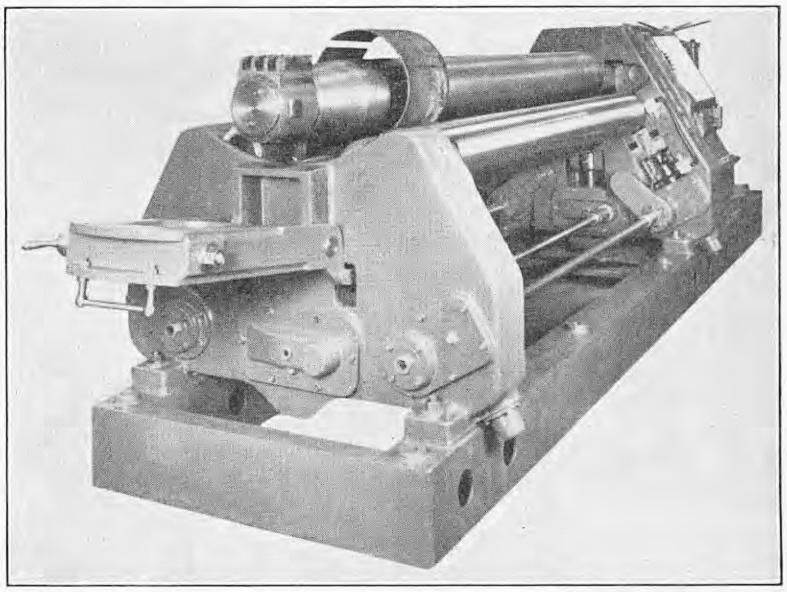


FIG. 3. END BEARING LOWERED TO RELEASE WORK.

250-kW steps up and down between 0 and 1,000 kW was then demonstrated. In each case the unit settled down to steady running within several seconds. A sudden 500-kW change, from 250 to 750 kW and back again, was then applied. To demonstrate the starting ability of the set it was shut down for a few minutes and then restarted. A glow plug in one of the combustion chambers, or high-tension spark igniters in two of the chambers, is first energised. The compressor rotor, driven by a starting motor, is run up to 500 r.p.m., when the fuel is turned on. Light-up occurs at about 1,000 r.p.m. The set is now accelerated by the starter motor and by opening the hand fuel throttle. At 3,500 r.p.m., the motor is shut off, and at about 4,700 r.p.m. (of the compressor), the power turbine has reached normal running speed and the automatic governor takes over, when the set is put on load. The whole procedure takes about 1½ minutes.

FOUR-ROLL PLATE-BENDING MACHINE.

THE plate-bending machine shown in the accompanying illustrations, which is made by the Bronx Engineering Company, Limited, of Lye, near Stourbridge, is of the four-roll type The simple and symmetrical arrangement of the rolls enables all normal bending operations to be carried out, and has particular advantages when working near to the edge of a plate, or when bending to a complete circle. The machine is capable of dealing with mild-steel plate up to 8 ft. by ⅜ in., or 5 ft. by ½ in. The general appearance of the machine is shown in Fig. 1, herewith, and in the arrangement drawings reproduced in Figs. 4 to 8, opposite.

The component assemblies—gearbox, roll housings, driving and roll-adjusting motors, and control gear—are all mounted on a fabricated steel base Both roll housings are of cast iron, and the lower part of each encloses worm gearing for adjusting the rolls. The left-hand housing also carries the driving gears in an oil-tight chamber. Two rolls, each 11 in. in diameter, are arranged on the same vertical centre line, and two more, each 9 in. in diameter, are set at an angle of 30 deg. from the vertical, one in front of and one behind the lower 11-in. roll. The positions of the rolls can be seen in Fig. 7. All four rolls are machined from solid forgings of 0·4 per cent. to 0·5 per cent. carbon steel, and are mounted in phosphor-bronze bearings.

The central 11-in. rolls are power-driven by a 15-h.p. slip-ring motor, running at 960 r.p.m., through a train of double helical gears mounted in the left-hand roll housing. A total ratio of 96 to 1 in the gear train provides a roll speed of 10 r.p.m. The top 11-in. roll is carried in fixed bearings, but vertical adjustment is provided on the bottom

FOUR-ROLL PLATE-BENDING MACHINE.

BRONX ENGINEERING COMPANY, LIMITED, LYE, WORCESTERSHIRE.

Fig. 4.

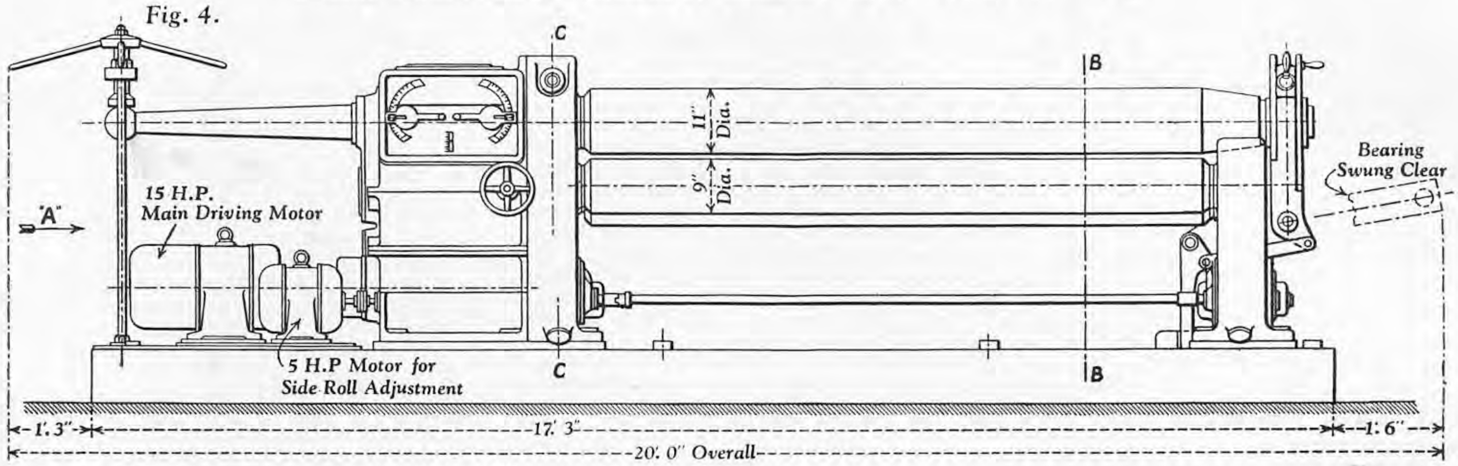


Fig. 5.

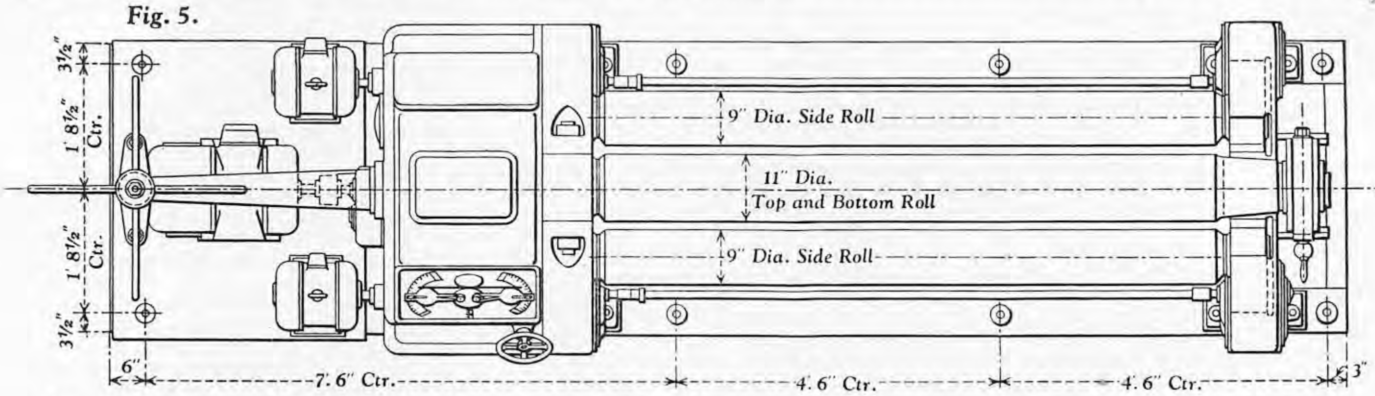
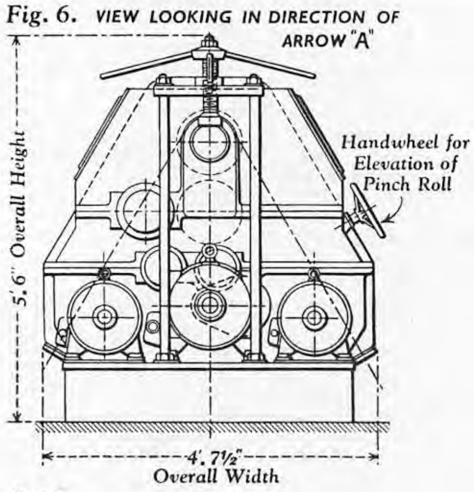


Fig. 6. VIEW LOOKING IN DIRECTION OF ARROW "A"



(973.D.)

Fig. 7. SECTION BB

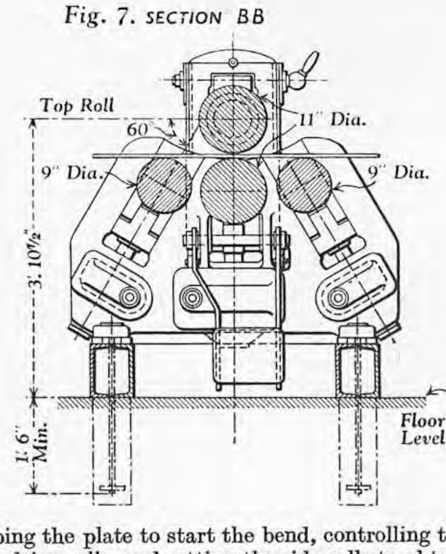
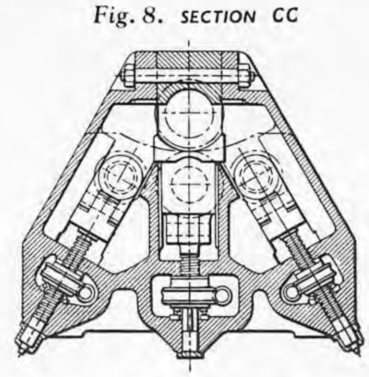


Fig. 8. SECTION CC



"ENGINEERING"

11-in. roll to enable the plate to be "pinched" or gripped at the commencement of a bend. Each bearing of the bottom roll is mounted in a slide which can be raised or lowered by a screw, driven through enclosed worm gear and connected by a horizontal shaft and bevel gears to the handwheel, which can be seen under the indicating dial in Fig. 1.

The side rolls are independently adjustable, and are also carried in slides controlled by screw and worm gear. In this case, however, power adjustment is provided, the worm shafts being carried through the drive housing to two 5-h.p. induction motors. Limit switches are fitted on the roll adjustment slides. Ball thrust races are used on the 11-in. roll adjusting worm wheels, and tapered roller bearings are fitted to the side roll-gear.

The machine is controlled by an operator standing in front of the drive gearbox, and the controls are grouped for this purpose. The group comprises a drum-type reversing controller for the main roll drive; a handwheel for setting the bottom roll; and two push-button reversing controls for the side-roll adjusting motors. A main switch is also provided at this point. All the controls can be seen in Fig. 1. Complete operation of the machine—gripping the plate to start the bend, controlling the main drive rolls, and setting the side rolls to obtain the degree of bend required—is thus carried out from the one position.

Provision is made for removing a complete cylinder by withdrawing the outer bearing housing of the top 11-in. roll, which swings outwards and downwards to allow the cylinder to be taken out. The release of a single locking pin frees the housing from the bearing, which remains on the roll, and the housing itself then swings away under the control of a counterbalance weight. The features of the counterbalanced bearing housing can be seen in Figs. 2 and 3. Fig. 2 shows it in the working position; in Fig. 3 it is swung clear. The counterbalance lever and part of the weight are visible in Fig. 1. To support the weight of the top roll when the outer end is free, a screw and hand capstan are arranged to bear on the ball end of an extension of the roll. This can be seen in Fig. 1.

To regulate the setting of the rolls, a dial indicator is provided. Light roller chain is used to transmit the movement of the roll bearings to the dial which can be seen at the front of the machine in Fig. 1. Black discs moving against a white background are used to represent the rolls, and, since the actual movement is multiplied by the connecting mechanism, the position of each roll is shown clearly. Each disc is marked with the name of the roll it represents. Mounted co-axially with the two discs representing the side rolls are two more discs, marked in outline only. These are normally hidden by the solid discs, in which slots are provided to show the words "rolls parallel." The use of the secondary discs is to show the relative setting of the two ends of the side rolls when they are used out of parallel for conical rolling. In Fig. 1, to the right of the main housing, can be seen a ball-ended lever. This operates a multi-jaw clutch on the shaft driving the front roll adjusting worm gear, and enables one of the worms to be disconnected while the other is still running; thus any required amount of movement can be given to one end of the roll for conical work. The amount by which the roll is out of parallel is shown by the outline disc on the indicator panel, which moves from its hidden position, obscures the words "rolls parallel," and enables the operator to see the relative positions of each end of the roll. A similar clutch is provided for the rear 9-in. roll at the back of the machine, and the out-of-parallel movements of this roll are indicated in the same way.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

The Late Mr. F. W. Benson.—Mr. Frank Walter Benson, of Gourock, formerly shipbuilding general manager to Scott's Shipbuilding and Engineering Co. Ltd., Greenock, died suddenly on July 20, while on holiday in Bilbao, Spain. Mr. Benson served his apprenticeship as a ship draughtsman with John Brown & Co., Ltd., Clydebank. As a young man he went to Spain, where he remained for 28 years, being latterly shipbuilding manager to the Sociedad Española de Construcción Naval, at Bilbao. In 1937, he returned to Scotland and joined the staff of Messrs. Scotts', retiring about two years ago. He was elected a member of the Institution of Naval Architects in 1915 and a member of the Institution of Engineers and Shipbuilders in Scotland in 1938.

Closure of Newmains Works.—The Development of Industry Committee of Lanark County Council are to communicate with various Government departments and the Scottish Council (Development and Industry) in an attempt to avert what they describe as "the serious consequences of the closure" of Coltness Iron Company's works at Newmains, mentioned in these notes last week. The company announced that they would complete existing orders within the next few months before closing permanently.

East Kilbride Development Corporation.—The following new appointments to the East Kilbride Development Corporation were announced on July 24 by the Secretary of State for Scotland:—Sir Andrew McCance, deputy chairman and joint managing director of Colvilles Ltd., and chairman of the Mechanical Engineering Research Board, and Councillor T. R. Patterson, formerly convener of the Town Planning Committee of Glasgow Corporation, are to succeed Mr. Sam Bunton and Mr. Hugh T. MacCalman, formerly chairman of the Clyde Valley Regional Planning Advisory Committee, who are due to retire on completing their terms of office on August 8.

Glasgow Trolley-'Bus Services.—Preparations are being made for the inauguration, early next year, of a trolley-'bus service between Clarkston, on the south side of Glasgow, and Firhill on the north. This service will be the first to traverse the city centre. Poles to carry the overhead wiring are now being erected in some of the main streets of the city, and the work of installation is generally well advanced. The existing trolley-'bus route in the eastern half of the city is to be extended.

Water Speed Records on Loch Ness.—An attempt on the world's water speed record of 178·4 m.p.h. is to be made on Loch Ness, perhaps in the autumn, by Mr. John Cobb. The motive power of the boat will be provided by a de Havilland Ghost jet engine. About 20 straight miles of water are available on the loch.

CLEVELAND AND THE NORTHERN COUNTIES.

Trade Link Between Middlesbrough and Australia.—The 9,827-ton twin-screw motorship Port Jackson has loaded at Middlesbrough Docks a steel and general cargo for Australia. Port Line ships have seldom used Middlesbrough as a loading port, but the hope is expressed that facilities for loading and discharging cargoes on Tees-side are such as fully to justify the establishment of a steady regular trade link between the busy north of England port and Australia. The Port Auckland has already been booked to visit Middlesbrough about August 12.

Newcastle-Carlisle Power-Transmission Line. —The Minister of Fuel and Power, in a letter to Mr. R. Speir, M.P. for Hexham, on the question of the proposed 275,000-volt overhead line from the Stella power station, Newcastle-on-Tyne, to Carlisle, has admitted that if farmers and landowners refuse to grant wayleaves, the route of the line might have to be altered. The Minister stated, however, that no major alterations could be made, and if wayleaves could not be obtained readily from farmers and others, the British Electricity Authority might ask for compulsory wayleaves. In this case, the Minister stated, the views of the farmers and landowners would be heard. It is reported that 90 per cent. of the farmers and landowners in the South Tyne area intend to refuse wayleaves. Organisations of cyclists, ramblers and youth hostels have protested that the Government have not been impartial in the matter, as the inquiry into the proposed route was conducted by an engineer nominated by the Ministry of Fuel and Power, and the Ministry gave the decision approving the scheme. The organisations claim that at no time has the plan been considered by independent and impartial persons.

Developments at Murton Colliery.—Mr. E. H. D. Skinner, chairman of the Durham Division of the National Coal Board, has cut the first sod of a new shaft, to be 22 ft. wide and 1,500 ft. deep, at Murton. The new shaft will combine Murton and Eppleton collieries, and will be equipped with two electric winding engines and two pairs of skips, winding from the upper and lower levels. The Murton and Eppleton pits are old collieries and have produced about 120,000,000 tons of coal, but it is understood that there are 124,000,000 tons of the fuel still workable, much of which will come from relatively thin seams. The output from the two pits will be drawn from the new shaft, and other existing shafts will be used for conveying colliers, materials and stone. The new shaft is part of a 7,000,000*l*. project which includes new coking plant at Murton, and the scheme is expected to be completed by 1958. The new mine's output will be about 1,400,000 tons per annum. The proposed new coke-ovens will make high-grade coke, and the surplus coke-oven gas will be taken by the Northern Gas Board.

Refusal of Company House Building at Gateshead.—Gateshead Corporation Estates and Housing Committee have again refused permission to Huwood Mining Machinery Ltd., to build approximately 100 houses for the company's own employees. The firm informed the Committee that many of its key employees, who would be the backbone of the labour supply for the next 20 or 30 years, had to travel considerable distances to work. The Committee rejected the proposal after a fear had been expressed that a building scheme of this kind might divert operatives and materials from the Council's housing schemes.

Survey of Industry on Tees-side.—The Northern Industrial Group and the North-East Development Association are to carry out a survey of industrial and social conditions on Tees-side. The work will occupy three years and cost 5,200*l*. The industrial future of Tees-side was also considered at a meeting of the Tees-side Industrial Development Board, when it was decided to intensify the search for new industries. A report submitted by Mr. T. H. Summerson, chairman of the Board's Industrial and Services Committees, stated that there had been an ominous rise in unemployment in the Board's area.

New Shipbuilding Berth at Sunderland.—Work is well in hand on the construction of a shipbuilding berth capable of accommodating vessels of more than 26,000 tons deadweight capacity, at the yard of Sir James Laing and Sons, Ltd., Sunderland. This will be the largest berth on the Wear. The first ship to be constructed on it will be a tanker of 18,000 tons, to be followed by a 26,400-ton vessel for Norway.

LANCASHIRE AND SOUTH YORKSHIRE.

Increased Production of Refractories.—The lighting of a new tunnel kiln at the Loxley works of Carblox Ltd., marks the completion of an expansion scheme which has been taking place over the last two years. It is the culmination of an association between Thomas Marshall & Co. (Loxley), Ltd., and the Morgan Crucible Co., Ltd., of London. A pilot plant to produce some new refractories proved insufficient to satisfy the requirements and new plant became necessary. The new plant will quadruple the 1950 output.

Coal Stocking and Export Policy.—Mr. H. C. Armstrong, fuel consultant to Thos. Firth and John Brown, Ltd., Sheffield, chairman of the Sheffield Chamber of Commerce Fuel Committee, and a member of the National Industrial Coal Consumers' Council, criticises the present scale of coal stocking by industrial concerns, and advocates the halving of present stocks to stop waste and provide more coal for export. Manufacturers, he states, are carrying stocks for about three and a half weeks, which he considers to be wasteful; if, he suggests, a proportion of this fuel were exported, considerable sums would be realised.

THE MIDLANDS.

Large Aircraft at Elmdon Airport.—The largest aircraft to use Birmingham airport at Elmdon, so far, landed there on July 23; it was a 40-seater twin-engined Bristol Wayfarer, owned by Aer Lingus. Four of these aircraft have been ordered by the Irish air line for their regular service between Eire and Birmingham The two runways at Elmdon are only 1,400 yards long and hitherto the largest aircraft using them have been Dakotas. The runways, which are not likely to be extended in the near future, owing to the economic situation, have limited the size of aircraft using the airport for some time. The Bristol Wayfarers will enable some increase in passenger-carrying capacity to be achieved.

Building Plan to Conserve Steel.—Birmingham Corporation are extending the use of load-bearing brickwork in the construction of blocks of flats, in order to save as much steel as possible. Seven blocks of flats are proposed at present; each will be of six storeys and will contain 68 flats. The reduction in steelwork is expected to amount to as much as 4 tons per flat.

Improvements to Water Supply at Worcester.—An extension to the Worcester waterworks, opened by Alderman T. S. Bennett, chairman of Worcester Council Water and Sewage Committee, on July 17, has made it possible to double the water supply to the city and the four neighbouring rural districts which the undertaking serves. The extension, which has cost 200,000*l*., is based upon a two-filter system through which river water is passed, and can handle up to 5,500,000 gallons of water a day. The city engineer, Mr. H. A. MacKrill, M.I.C.E., estimates that the period between filter cleanings can be extended from the normal 20 days to 75 or 80 days, with a considerable saving in operating costs.

Steel Supplies for the Gas Industry.—The question of steel supplies for the gas industry was raised at a meeting in Birmingham, on July 21, of the Gas Consultative Council for the West Midlands. Mr. G. le B. Diamond, chairman of the West Midlands Gas Board, said that shortage of steel was compelling the Board to delay some of the schemes they had in hand for increasing capacity. Progress was being retarded at the gasworks at Kingswinford, Smethwick, Worcester and Walsall, and the new carburetted water-gas plant at Nechells, Birmingham, had been delayed for a year. In view of the shortage of steel, the Board were concentrating on major developments at Swan Village, Birmingham, Coventry, and Stoke-on-Trent.

Removal of Two Factories.—The businesses of two associated companies, the Idoson Motor Cylinder Co., Ltd., Ballot-street, Smethwick, and T. & J. Foundry, Ltd., Wolverhampton-road, Oldbury, are being removed to the Hange Estate, Dudley-road, Tividale, Staffordshire, where they will be accommodated in a newly-built foundry. Some plant and equipment is being removed from the old works, and new plant has already been installed at Tividale. It is expected that the new foundry will be working by August 8.

Steelworks Training Courses.—For the third year in succession, a course of instruction in steelmaking for persons outside the industry is being held at the Bilston steelworks of Stewarts and Lloyds, Ltd. Previous courses have been attended by local schoolmasters, but the present one has been opened to training officers from other industries, and technical officers of the Ministry of Labour. The company state that it may be possible in the future to run a course lasting a week for anyone interested in the steel industry.

Blast-Furnace Labour.—The North Midland Regional Board of Industry at Nottingham have been told that there is a danger of serious labour difficulties arising from the recent agreement to reduce working hours at blast-furnaces from 48 to 44 a week. The Region, it is stated, has one-third of the blast-furnace operatives in this country, and is already relying on the importation of men from other areas.

SOUTH-WEST ENGLAND AND SOUTH WALES.

Transformer and Switchgear Manufacture in South Wales.—The first eight of 16 large transformers made at the Blackwood (Mon.) factory of South Wales Switchgear Ltd., left the factory for Cuba on July 21. The plant is estimated to be worth 50,000 dols. Mr. A. J. Nicholas, director and general manager of the firm, said that the order was the direct result of his visit to America last year. The purchasers, he said, had expressed some doubt whether the firm could deliver on time, but the schedule had been kept. The company were also engaged upon a very large switchgear and transformer contract for Pakistan.

Wood-Wool Factory, Cardiff.—A new wood-wool factory is to be established near Cardiff. Mr. Hugh Llewellyn, development officer, has informed the Cardiff Development Committee that, within the nex two or three years, it would employ between 100 and 200 people.

RAPID DISCHARGE OF IRON-ORE CARGO.—When the steamer Oakland arrived at Newport Docks recently to unload a cargo of 10,037 tons of iron ore, a new port record was set up when 5,703 tons were discharged in a single day. The whole of the cargo was unloaded in a net working time of 36¾ hours, an average rate of discharge of 273 tons an hour.

RECOVERY OF COAL FROM RIVER BEDS.—Reporting to a meeting of the Glamorgan River Board, the chairman, Alderman Percy J. Smith, said that, at the present time, small coal was being recovered from the rivers Taff and Rhymney at the rate of over 32,000 tons a year. As recovery methods were improved, they would play a part in bringing back both fish and vegetable life to the Taff.

SILTING-UP PROBLEMS AT COLLIERY TIPS.—Spoil tipped from Glamorgan coal mines is silting up brooks and streams and causing flooding in the country, a House of Lords Select Committee on the Glamorgan County Council Bill was told last week. Before concluding their hearing, the Select Committee allowed a clause, objected to by the National Coal Board, requiring owners of land adjoining streams obstructed by spoil from tips to remedy the obstruction. The clause was amended to ensure the sharing of costs among all the parties in default. For the Coal Board, Sir Andrew Clark, Q.C., said it was often impossible in South Wales to site tips away from rivers. The clause, he said, was fundamentally bad because it was contrary to the principles of natural justice and quite unworkable.

TRADE PUBLICATIONS.

Woven-Wire Filters and Strainers.—Intermit, Limited, 37, Bradford-street, Birmingham, have sent us an illustrated brochure describing their range of filters, ventilator gauges, etc. Carburettor floats and other small precision pressings are also illustrated.

Selenium Rectifiers.—Standard Telephones and Cables, Ltd., Rectifier Division, Boreham Wood, Hertfordshire, have sent us a bulletin giving the dimensions and weights of their SenTerCel spindle-mounted rectifier stacks. It also contains an explanation of the coding system which is used to describe them.

Stainless-Steel Welding Electrodes.—Details of a new series of lime-type stainless-steel welding electrodes are contained in a folder received from Rockweld, Ltd., Croydon, Surrey.

Electric Furnaces.—Well-illustrated descriptions of their horizontal hairpin electric furnaces appear in a catalogue recently published by Wild-Barfield Electric Furnaces, Ltd., Elecfurn Works, Watford By-pass, Watford, Hertfordshire.

Electric Heating Elements.—For the immersion heating of water and other liquids, and for heating internal-combustion engines and air in ducts, Eltron (London), Ltd., Accrington Works, Strathmore-road, Croydon, Surrey, manufacture electric heating elements. A wide range of types and sizes is listed in their new leaflet No. 52.

NOTICE OF MEETING.

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.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*North London Branch*: Wednesday, August 6, 8.15 p.m., The Three Jolly Butchers Hotel, Wood Green, N.22. "Modern Installations in Large Buildings," by Mr. W. F. Parker.

PUBLIC WORKS AND MUNICIPAL SERVICES CONGRESS AND EXHIBITION.—The biennial congress and exhibition of the public works and municipal services, which is being organised jointly by the Public Works and Municipal Services Congress Organising Council and the Municipal Agency, Ltd., will be held at Olympia, London, W.14, from Monday, November 3, to Saturday, November 8, 1952. This congress is a combination of the former public works, roads and transport congress and exhibition and the public health and municipal engineering congress and exhibition, and will cover a wide range of subjects, including electric power supply to rural areas, water hygiene, sewage disposal, municipal transport, housing and educational matters. The exhibits will include a variety of heavy-engineering plant, heavy-gauge aluminium buildings, and prefabricated garages, huts and sheds of concrete, asbestos and wood. The address of the Municipal Agency is 68, Victoria-street, London, S.W.1.

BRITISH STANDARD SPECIFICATIONS.

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

Underfeed Stokers.—A first revision of B.S. No. 749, originally issued in 1937, has now been published. It specifies the requirements for underfeed stokers of the ram or screw type, rated up to 1,200 lb. of coal per hour. All applications are covered except those concerned with metallurgical or other high-temperature furnace plant. The 1937 edition, now superseded, dealt only with screw-type stokers primarily intended for use in conjunction with domestic and central-heating boilers of the sectional type. For the guidance of users, appendices are included giving general recommendations on installation and maintenance (including the application of automatic control, for which stokers of the underfeed type are particularly suitable), rating by heat output, and suitable fuels. [Price 3*s*., postage included.]

Flanged-Steel Check Valves for Petroleum Industry.—Another specification in the series now being prepared for the petroleum industry has recently made its appearance. This, B.S. No. 1868, covers cast- or forged-steel check valves with integral flanges, of the swing, piston and ball types. The seat rings are renewable and are either shoulder-seated or bottom-seated. The specification covers check valves of classes 150, 300, 400, 600, 900, 1,500 and 2,500, which represent their respective primary service pressure ratings, in lb. per sq. in., at certain stipulated temperatures. Provisions relating to design and manufacture, materials, workmanship, marking, tests, inspection, dispatch, and the manufacturer's guarantee are included. The publication also contains several appendices of tabulated matter and six detailed drawings illustrating the valves covered by the specification. [Price 10*s*. 6*d*., postage included.]

Code of Practice on Sanitary Appliances.—The Council for Codes of Practice for Buildings, Construction and Engineering Services, Lambeth Bridge House, London, S.E.1, have now issued, in final form, Code No. 305 which covers sanitary appliances. Comprehensive descriptions are given of all commonly-used appliances, distinction being made between those which are connected to the soil system and those connected to the waste system. A long section deals with such matters as the grouping of appliances, the ventilation of sanitary compartments, and the sound insulation of, and supports for, appliances. Specific recommendations are also made regarding the types, situation, and methods of installation of appliances in various kinds of buildings such as houses, flats, shops, schools, hospitals and offices. [Price 3*s*., postage included.]

Solid-Drawn Aluminium-Bronze Tubes.—A new specification, B.S. No. 1867, covers solid-drawn aluminium-bronze tubes for general purposes. It is concerned with the 7 per cent. aluminium type of aluminium-bronze alloy and in it is set out the preferred method of designating tubes of ⅛ in. up to and including 6 in. outside diameter. The permitted tolerances on the diameter, thickness and length of tubes within this range are given in tabular form. Other sections of the specification relate to chemical composition and analysis, hydraulic and mechanical tests, and inspection procedure. A mercurous nitrate test is also specified and the method of conducting this is given in detail in an appendix. [Price 2*s*. 6*d*., postage included.]

ROYAL STATISTICAL SOCIETY.—An examination for the certificate of the Royal Statistical Society will be held on March 26 and 27, 1953, and, for the Society's diploma, on March 25, 26 and 27, 1953. The closing dates for applications to be received are January 31, 1953, and November 30, 1952, respectively. Both examinations will take place in London, but others may be arranged at certain overseas centres, if sufficient candidates apply. Entry forms and copies of the regulations may be obtained from the secretary of the Society, 4, Portugal-street, London, W.C.2.

ELECTRICITY SUPPLY STATISTICS.—The electricity generated by the British Electricity Authority, the North of Scotland Hydro-Electric Board and the Lochaber Power Company during June, 1952, amounted to 4,165 million kWh, compared with 4,166 million kWh during the corresponding month of 1951, a decrease of 0·02 per cent. The total generated during the first six months of 1952 was, however, 31,290 million kWh, compared with 30,791 million kWh during the corresponding period of 1951, an increase of 1·6 per cent. At the end of June, 1952, the installed capacity of the generating plant was 16,636 MW, an increase of 8·7 per cent. over that at the end of June, 1951.

PERSONAL.

SIR BERNARD DOCKER, K.B.E., chairman of the Birmingham Small Arms Co. Ltd., has been appointed, in addition, managing director of the company. MR. L. CHAPMAN, managing director of William Jessop & Sons Ltd., has been elected a director of the Birmingham Small Arms Co.

MR. JOHN RYAN, C.B.E., M.C., has been elected chairman of the British Standards Institution, 24, Victoria-street, London, S.W.1, in succession to SIR ROGER DUNCALFE, who has been elected vice-president. VISCOUNT WAVERLEY, P.C., G.C.B., F.R.S., has been re-elected President for the third year.

DR. J. W. JENKIN, B.Sc. (Lond.), A.R.I.C., F.I.M., head of the development and research department of Tube Investments Ltd., has been appointed to the Council of the British Iron and Steel Research Association, on the nomination of the Iron and Steel Institute.

MR. WILLIAM E. MILLER, M.A. (Cantab.), has been nominated President elect of the British Institution of Radio Engineers, 9, Bedford-square, London, W.C.1.

MR. H. C. WILTSHIRE, M.Sc., M.I.Mech.E., M.I.E.E., M.I.I.A., deputy head of the Department of Aircraft Economics and Production, College of Aeronautics, Cranfield, Bletchley, Buckinghamshire, has been awarded the travelling scholarship for 1952, to the United States, offered by the Institute of Industrial Administration, in conjunction with the English Speaking Union.

MR. S. J. EARDLEY, M.B.E., A.M.I.Mech.E., has retired from service with the Ministry of Fuel and Power as regional fuel engineer, North Eastern Region, Leeds, and has joined Hayes Heating and Steam Services Ltd., as their northern area manager, at Crow Nest Works, Elland-road, Leeds, 11.

MR. ERIC SHAW, sales director of the Oughtibridge Silica Firebrick Co. Ltd., has been elected a member of the Council of the Refractories Association of Great Britain.

MR. G. W. ALEXANDER, B.Sc., M.I.E.E., A.M.I.Min.E, and MR. A. T. PURSE, LL.B., F.C.I.S., have been appointed directors of Powell Duffryn Technical Services Ltd., 19, Berkeley-street, London, W.1.

MR. A. C. EDRICH, A.M.I.C.E., has been appointed permanent way engineer (railways), London Transport Executive, 55, Broadway, S.W.1.

MR. A. ROBERT JENKINS, J.P., A.I.Mech.E., deputy managing director, Robert Jenkins & Co. Ltd., Rotherham, has been installed as President of the Institute of Welding, 2, Buckingham Palace-gardens, Buckingham Palace-road, London, S.W.1, for 1952-53. The new vice-president of the Institute is MR. H. B. FERGUSSON, M.I.N.A., M.I.Mech.E., M.E.I. Canada.

MR. H. W. DAVIES, divisional transport officer, West Midlands Division, National Coal Board, has been appointed a member of the Transport Users' Consultative Committee, for the West Midland Area, in succession to MR. A. G. C. TROLLOPE.

MR. C. F. BERRIDGE, Divisional Transport Officer, East Midlands Division, National Coal Board, has been made a member of the Transport Users' Consultative Committee for the East Midland Area in succession to MR. J. MENHENEOTT.

MR. G. H. FOOT, B.Sc.(Eng.), A.C.G.I., A.M.I.E.E., has joined the equipment division of Mullard Ltd., Century House, Shaftesbury-avenue, London, W.C.2 in charge of the telephone product group. MR. E. D. HART, M.A., A.Inst.P., A.M.I.E.E., has also joined the firm's equipment division as head of the technical department. He is responsible for market surveys and technical publications.

MR. A. D. BOOTH, DR. T. W. F. BROWN, MR. K. DEUTSCH, MR. R. MEREDITH, MR. H. S. PEISER and MR. J. SAVAGE have been elected Fellows of the Institute of Physics, 47, Belgrave-square, S.W.1.

MR. IAN QUIGLEY, B.Sc., A.M.I.E.E., has been appointed sales manager (export), lamps and lighting, for the British Thomson-Houston Co. Ltd., Crown House, Aldwych, London, W.C.2.

MR. W. E. FULLER has been appointed information officer of the research and development division of the British Steel Founders' Association and not of the Association itself, as erroneously stated on page 79, *ante*. MR. T. A. COSH, B.Sc., A.R.T.C., A.I.M., has joined the research and development division's metallurgical research staff.

MR. A. B. SETON, M.B.E., late sales manager, South Eastern Gas Board, has been appointed sales director to Willey & Co., Ltd., Vulcan Stove Co., Ltd., Sutherland Meter Co., Ltd., and Nicholls & Lewis Ltd. subsidiary companies of United Gas Industries Ltd. with effect from August 31.

The London sales office and the railway-signalling department of NIFE BATTERIES, Redditch, Worcestershire, have been transferred from 50, Grosvenor-gardens, S.W.1, to new premises at 53, Victoria-street, S.W.1. (Telephone: ABBey 1412.)

THE NATIONAL INSTITUTE OF AGRICULTURAL ENGINEERING.

(*For Description, see Page* 148.)

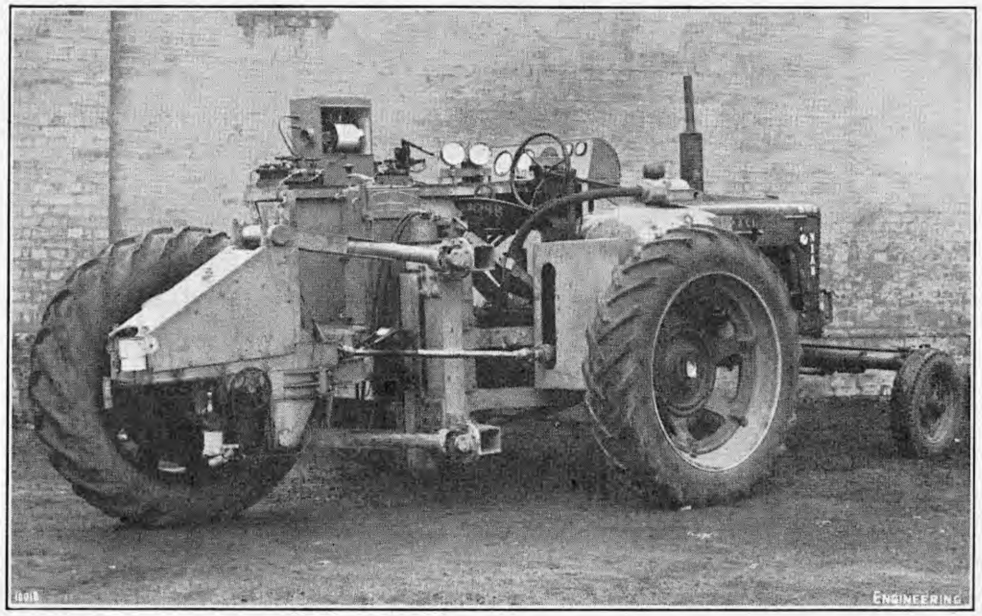


FIG. 1. SINGLE-WHEEL TESTING MACHINE.

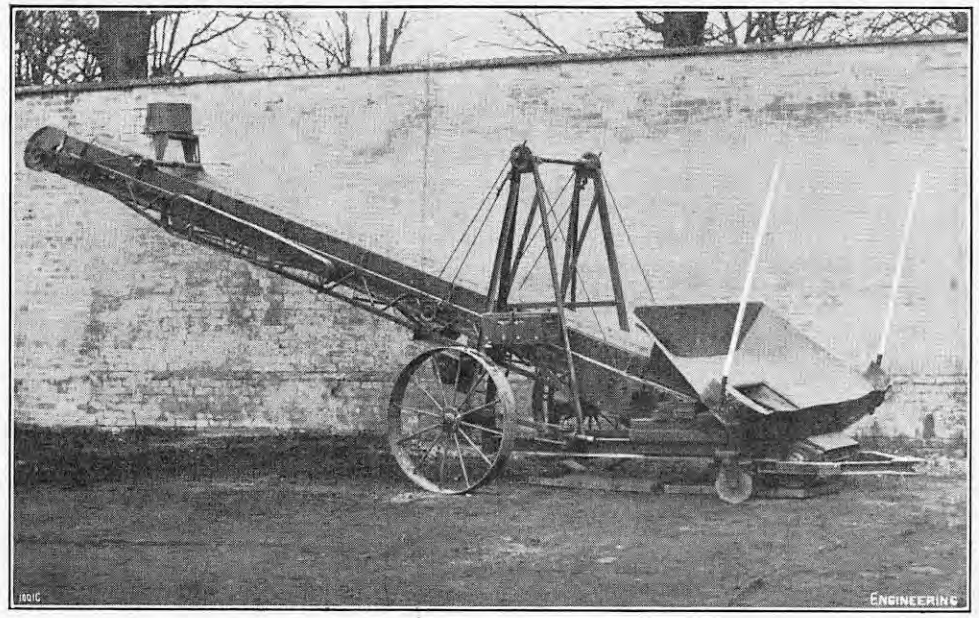


FIG. 2. POTATO ELEVATOR-LOADER.

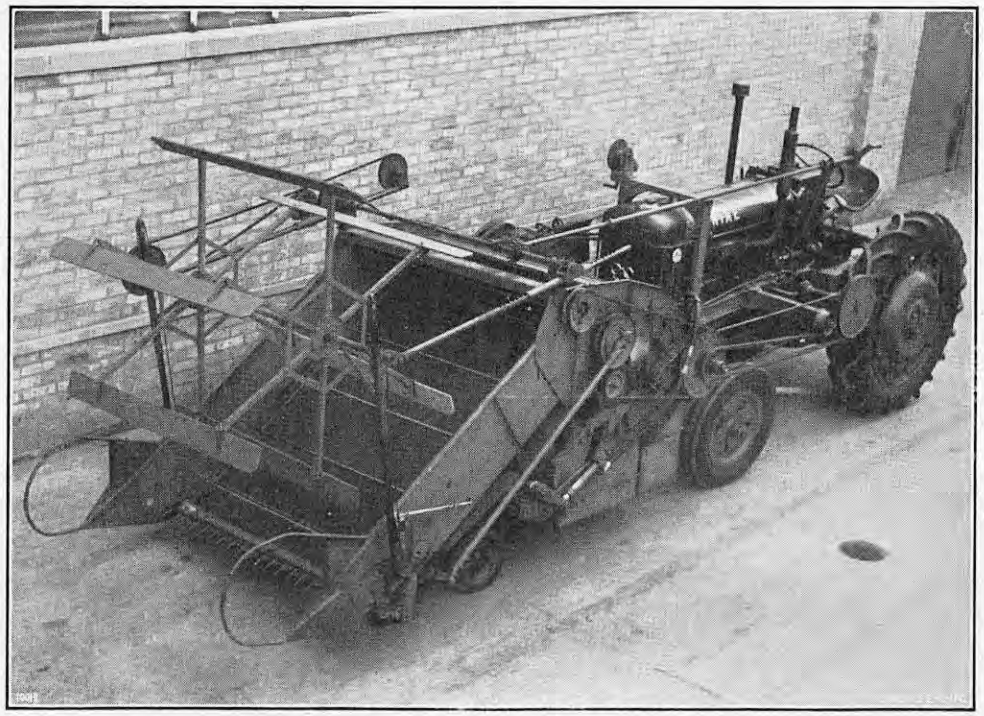


FIG. 3. TRACTOR-MOUNTED COMBINE HARVESTER.

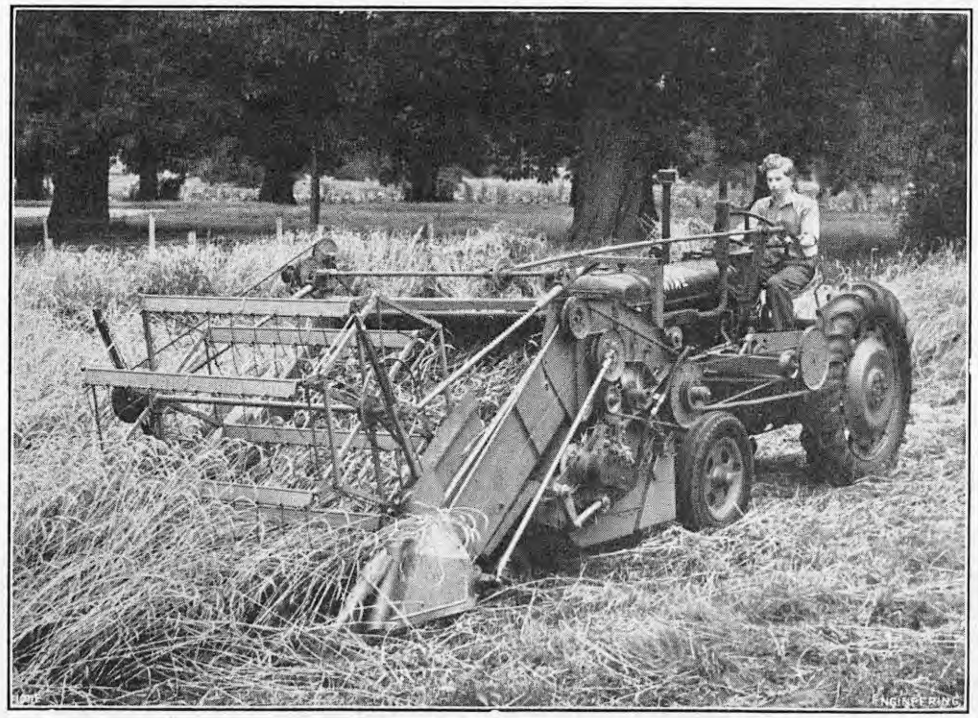


FIG. 4. COMBINE HARVESTER AT WORK ON TRIAL PLOT.

ENGINEERING

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INDEX TO VOL. 172

The Index to Vol. 172 of ENGINEERING (July-December, 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, AUGUST 1, 1952.

VOL. 174. No. 4514.

THE FUTURE OF THE IRON AND STEEL INDUSTRY.

THE promised White Paper on the Government's proposals for the denationalisation of the iron and steel industry* was published by H.M. Stationery Office on Monday of this week; and it may be said at once that, setting all purely party political considerations aside, as they should be, it appears to present a sound and workmanlike scheme. That the Opposition will oppose the eventual Bill when it comes before Parliament is inevitable, but they will be hard put to it to advance any valid arguments against the proposals so far as the national interest is concerned. In broad outline, indeed, the draft arrangements are a reversion to a system of control which has been thoroughly tested already with satisfactory results, modified in certain details on lines that, it is believed, had been accepted in principle by former Ministers who now find themselves on the other side of the House, but which circumstances compelled them to discard, or, at least, not to try to enforce. Briefly, the proposals would have the effect of handing back the industry to private ownership while maintaining a close and effective supervision over its operations through the medium of a Board, responsible to the Government and under a statutory obligation to report annually to Parliament through the Minister of Supply.

The White Paper divides the proposals into two parts, dealing respectively with the questions of public supervision and of transfer of ownership. Taking them in that order, it is seen that the Government propose to place supervision in the hands of an Iron and Steel Board with statutory duties and powers, consisting of not more than 12 persons, who would be appointed by the Minister of Supply. It is laid down that their qualifications for membership of the Board would include "experience in the iron and steel industry, in the engineering and other industries using iron and steel, and in trade unions." There would be an independent chairman and "some additional" independent member—number unspecified. Members of the Board would be appointed for a maximum term of five years and would be eligible for re-appointment. "It is intended," to quote the White Paper, "that all the main processes which make up the iron and steel industry . . . shall come within the purview of the new Board, thus bringing the whole industry again under the supervision of a single authority and ending the present distinction between nationalised and non-nationalised sectors." It is made clear, however, that "the Board will not be concerned with the extensive engineering and other extraneous activities which, though not part of the iron and steel industry, were brought under the control of the Iron and Steel Corporation because they happened to form part of the activities of the companies which were nationalised." An example of these is the old-established Yorkshire Engine Company.

The "main processes," referred to in the preceding paragraph, are listed in an appendix, which is of sufficient importance to be quoted in full. They comprise:

"1. The quarrying or mining of iron ore or the treatment or preparation of iron ore for smelting.

2. The smelting of iron ore in a blast furnace with or without other metalliferous materials, or the production of iron by any other process.

3. The production of steel by any process.

4. The casting of iron or steel by any process.

5. The processing, with or without heat, of iron or steel by rolling or forging (excluding drop forging and blacksmiths' hand forging).

6. The production from iron or steel of hot-finished tubes or pipes or bright bars.

7. The production of tinplate or terne plate."

These headings and divisions appear to be clear as well as comprehensive, but it may be noted that (on the authority of the Ministry of Supply) "quarrying and mining" includes opencast working; die stamping is classed with drop forging and therefore is not included in the Board's responsibilities; and electrically-welded tubes, which are heated only locally and incidentally in the course of welding, are not classed as "hot-finished" and, therefore, are also outside the Board's purview.

Apart from their general function and duty of supervising the industry in order to promote "the efficient, economical and adequate supply of iron and steel," the Board would be specifically charged with the responsibility of keeping under review the development of production capacity, prices, supplies of raw materials, research and technical training, arrangements for joint consultation between management and employees (on matters other than wages and conditions of service), and safety, health and welfare arrangements. It is stated definitely that the powers of the Board would not extend beyond the producing industry—for example, to steel-using industries or the activities of metal merchants—but, in the next paragraph of the White Paper, there is a proviso which might, in certain circumstances, cut across this demarcation; for it is stated there that while, "so long as the present emergency powers or similar powers under other legislation continue to be exercised," the Government will consult the Board regarding the application of such powers to the industry, they may, "in appropriate cases," authorise the Board to exercise them on behalf of the Government.

The powers that it is proposed to vest in the Board regarding the supervision of capital development are wide and one section, at least, may be

* *Iron and Steel Industry.* Cmd. 8619. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 4*d.* net.]

controversial. The iron and steel companies will have the initiative in proposing development schemes, but "it will be the Board's duty" to discuss these plans and to satisfy themselves that the proposals are consistent with the proper development of the industry as a whole. If, however, the Board reach the conclusion that a particular scheme, if allowed to go forward, "would seriously prejudice the efficient and economical development of the industry," they would have an effective power of veto, subject to the right of the company concerned to appeal to the Minister of Supply. There is not likely to be any serious objection to such a manifestly sensible arrangement, though there does appear to be a possibility that the Treasury may come into the picture in practice, which it does not do in the White Paper; but the next paragraph may give rise to some argument. With the prefatory remark that the national interest might, on occasion, make it desirable for the Board to undertake schemes of capital development which, on commercial grounds, no company would be prepared to undertake, it is proposed to "give powers to the Minister of Supply to arrange in such cases, after consultation with the Board, for the provision and operation of the additional works or other facilities required." The point is emphasised, however, that these powers would be vested in the Minister and not in the Board, because it is held that, "if the Board are to preserve impartiality in the performance of their duty of supervising the industry as a whole, they must remain free from responsibilities of ownership or management in respect of particular concerns."

The Board would have power to fix maximum prices for sales in the United Kingdom, but the Government would reserve power to intervene in the price-fixing, "should the public interest so require." Presumably, they would do so through the Minister of Supply; but this is not certain, as the following paragraph states that the Board's price-fixing powers would not be exercisable in respect of any product, the price of which was controlled by Order under Defence Regulations—though the Minister of Supply would be required to consult the Board before making such an Order for the price control of any product or raw material of the iron and steel industry, including scrap.

The various proposals regarding the supply of raw materials, research and training, and the financing of the Board's operations—it is proposed to give them power to make a levy upon the companies in the industry—need not be cited in detail; but it may be noted that the Board would arrange for the periodical publication of statistics relating to the industry (which the companies would be under an obligation to furnish) and, as previously stated, would make an annual report to the Minister of Supply, who would lay it before Parliament.

Under the heading of "Transfer of Ownership," the White Paper is brief, but to the point: "The Bill will provide for the dissolution of the Iron and Steel Corporation of Great Britain, and for the transfer of the securities of the nationalised companies to a Holding and Realisation Agency," appointed by the Treasury and consisting of "a small number of persons possessing the necessary qualifications and experience." The Agency would be required to obtain Treasury approval of the terms of proposed sales of securities, and of the timing of such sales—which, it is recognised, may take several years to complete. A point of some interest is the proposal that, before disposing of securities, "the Agency may effect such regroupings of the undertakings or alterations in the capital structure of companies as may be desirable," but would be required to consult the new Iron and Steel Board before taking action to re-group. Where practicable, in selling securities, the Agency would give priority to former shareholders.

Regarding finance, the Agency would provide this (with the approval of the Treasury) during the transition period, but would not intervene in day-to-day management. Money received by the sale of securities or from dividends would be paid by the Agency to the Treasury, which would meet the Agency's expenses of operation. The Iron and Steel Stock would become part of the National Debt and would be renamed $3\frac{1}{2}$ per cent. Treasury Stock, 1979-81; and the Agency would be empowered to accept it (and most other Government Stocks, at their current market value) in payment for the securities of the iron and steel companies. The Agency would make an annual report to the Treasury, to be laid before Parliament.

Taking the proposals as a whole, we feel that they represent a thoroughly common-sense and workable way of unscrambling an egg which its own producers must have had difficulty in convincing even themselves was more than "good in parts"—and few and insignificant parts. It is to be hoped that the public at large will buy this White Paper in quantity and study it carefully. It has been prepared after consultation with the Iron and Steel Corporation of Great Britain, the British Iron and Steel Federation (who support it wholeheartedly), the Iron and Steel Consumers' Council, the Trades Union Congress (who "wished to reserve their position," but would not surprise us if eventually they expressed approval, possibly qualified), and a number of representative associations. It has the great advantage that it formulates definite proposals for the supervision of the whole iron and steel producing industry, while avoiding the complications of the associated "fringes" that characterised the transfer of ownership to the Corporation. In effect, it restores the authority formerly exercised by the Iron and Steel Control of the Ministry of Supply during the war, and the advisory Iron and Steel Board which was put out of action by the Act of 1948. That Board, under the statesmanlike direction of the late Sir Andrew Duncan, functioned excellently, and we have no doubt that, given a complement of men of standing and vision, and a chairman of comparable calibre, the new Board would prove equally beneficial to this vital industry and to the nation.

DUST IN FACTORIES.

A QUESTION of some interest to an employer in whose factory someone "kicks up a dust"—in the real sense—was raised in a case which recently came before the Court of Appeal. A man who was employed in the hand-finishing shop of a coach factory suffered from dermatitis. The trouble was said to have been caused by the dust which arose when he was using sandpaper when polishing fillets of *monsonia*, a species of West African walnut. There is little doubt that, "cause and effect" being established, he could have made a claim under the old Workmen's Compensation Act, and that he might now make a claim under the Industrial Injuries Act as for an injury due to an accident arising out of and in the course of his employment; but could he also prefer a claim against the factory owner as for a breach of statutory duty, or for negligence at common law? This was the question in the case referred to (*Ebbs* v. *James Whitson & Co., Ltd.* (1952) 1 *Times* L.R. 1428).

The facts were that, having been employed (early in 1950) in the manner described for about a month, he began to have skin trouble, and in May of that year a doctor diagnosed dermatitis. In February, 1951, the sufferer brought suit alleging that there had been a breach of their statutory duty by his employers, his claim being based on Sections 4, 42, and 47 of the Factories Act, 1937. It may be remarked that Section 42 (which relates to the provision of washing facilities) was not relied on at the hearing. The plaintiff also alleged that the employers had no safe system of work, and had failed and neglected to inquire whether such dust was liable to cause dermatitis.

The case was heard by Mr. Justice McNair. Evidence was laid before the judge that the dust from *monsonia* wood is, in fact, toxic; that it does sometimes—though rarely—cause dermatitis, and that, apart from ventilation, there was no known method of rendering the dust harmless. Section 4 of the Factories Act, 1937, provides that: "Effective and suitable provision shall be made for securing and maintaining by the circulation of fresh air in each workroom the adequate ventilation of a room, and for rendering harmless, so far as is practicable, all fumes, dust, and other impurities that may be injurious to health generated in the course of any process or work carried on in the factory." It was contended, on behalf of the plaintiff, that this imposed a twofold duty on the factory owner; firstly, to provide adequate ventilation, and, secondly, to render harmless (*inter alia*) dust, so far as is practicable, that may be injurious to health. To this argument, however, the judge did not accede, holding that the words "by the circulation of fresh air" must be read as governing both the first and the second parts of the section.

As to Section 47 of the Act, which provides that where any process involves the production of "any substantial quantity of dust" all practicable means shall be taken to prevent inhalation, the judge said: "It seems to me to be fully arguable that Section 47 is primarily, if not wholly, directed to measures for preventing the inhalation of dust, and, further, that the measures are only required to be taken when, in connection with any process carried on, there is either given off a dust which is likely to be injurious or offensive to the persons employed in the factory, in the sense of likely to be injurious according to the estimation of a reasonably well-informed factory occupier, or which the actual occupier knew, or ought to have known, to be likely to be injurious; or dust is present, of any kind, in substantial quantities." He went on to say that, on the evidence before him, the dust from *monsonia* was not likely to be injurious in the sense indicated, and, in any case, the simple process of sandpapering would not produce it in substantial quantities. He also said that it was clear, on the evidence, that mechanical exhaust appliances were never used in hand-finishing shops.

As to the question of liability at common law, he pointed out that, while an employer must not expose his workpeople to unnecessary risk, he was not satisfied that, on the state of knowledge in 1950, an employer could not then have been supposed to know that exposure to the dust from *monsonia* wood was dangerous. This judgment has now been affirmed by the Court of Appeal, where Lord Justice Denning said something which may be useful for future reference in relation to the meaning of Sections 4 and 47 of the Factories Act: "It would be very strange," he said, "if a person who could not succeed under Section 47 because the dust was not likely to be injurious, could, nevertheless, recover under Section 4 on the ground that it might be injurious. In my opinion, therefore, Section 4 must be read as confined to defects of ventilation and does not extend to descriptions of protection in other respects." The Lord Justice was here referring to a suggestion, made in the course of the case, that the employers should have provided barrier cream or protective clothing.

The broad result of the case is that the owner of a woodworking hand-finishing shop, where there is likely to be dust, is generally protected if he has an adequate system of ventilation. If, however, the materials used are such as he should reasonably know to be likely to produce injurious dust, or any substantial quantity of dust of any kind, he must take steps to prevent inhalation, and, if practicable, provide exhaust appliances.

NOTES.

CLAYTON FELLOWSHIPS AND GRANTS, 1952.

UNDER the terms of the Clayton Bequest, the Institution of Mechanical Engineers have made the following awards for special experience, post-graduate studies, or research in mechanical engineering. The awards amount in total value to about 5,200*l*. for the year 1952. Clayton Fellowships to Mr. B. J. Beale, B.Sc. (Eng.), G.I.Mech.E., 3, Birtley Green, Bramley, near Guildford, for research on heat transfer; Mr. J. R. Botterill, B.Sc. (Eng.), G.I.Mech.E., 11, Spring Grove, Harrogate, for research on condensation mechanism in a turbulent steam-air mixture in a jet-type condenser; Mr. F. J. Feltoe, B.Sc., G.I.Mech.E., 22, Dalton Road, Sandfields, Port Talbot, for a tour of observation of steel plants in Britain and the United States, to study the efficient production and use of steam throughout a steelworks; Mr. E. J. Forster, B.Sc. (Eng.), A.M.I.Mech.E., 38, Mornington Avenue, Bromley, Kent, for research on radiation from flames in cold-walled combustion chambers; Mr. P. M. Moreton, A.M.I.Mech.E., 188, Manor Way, Whitchurch, Glamorgan, for a tour of observation of steelworks in Britain and the United States, to make a survey of quality control; Mr. D. J. Myles, B.Sc. (Eng.), G.I.Mech.E., Newzella, Fergus Square, Arbroath, Angus, for an experimental investigation of the pressure rise in the rotor of a rotodynamic pump, using a centrifugal fan as the test machine; Mr. H. Naylor, B.Sc. (Eng.), G.I.Mech.E., 30, Glenaire Drive, Baildon Green, Shipley, Yorkshire, for research on lubrication in wiredrawing; Mr. J. R. Willetts, B.Sc.(Eng.), G.I.Mech.E., 127, Glendower-road, Perry Barr, Birmingham, 22, for a tour of observation of high-pressure power plants in the United States, to study the theory and practice of superimposition of high-pressure plant on low-pressure power plants; Mr. R. G. Woolacott, B.Sc. (Eng.), G.I.Mech.E., 61, Hartswood-road, London, W.12, for a theoretical investigation of the rate of heat transfer from saturated steam to water sprays and jets; Mr. C. E. H. Morris, B.A., S.I.Mech.E., Brynderi, Pontardulais, Swansea, for a tour of observation of steelworks in Britain and the United States, to make a survey of quality control. Clayton Grants to Mr. C. K. Gulland, B.Sc. (Eng.), S.I.Mech.E., 100, Lambeth-road, London, S.E.1, for continuation of research on the vapour diffusion-absorption refrigerator; Mr. J. R. Plant, B.Sc. (Eng.), G.I.Mech.E., 12, Berkshire-avenue, Burnley, Lancashire, for a post-graduate course in soil mechanics; Mr. J. L. Raynes, B.Sc. (Eng.), G.I.Mech.E., 9, Lonsdale-road, Bournemouth, for a post-graduate course in gas-turbines for aircraft; and Mr. T. F. Roylance, G.I.Mech.E., 31, Sinfin-avenue, Allenton, Derby, for continuation of an investigation of the performance of a thermal regenerator.

APPLICATION OF SCIENTIFIC RESULTS.

A deputation from the Parliamentary and Scientific Committee waited on Lord Woolton, the Lord President of the Council, on Monday, July 28, to press for action by the Government in encouraging and facilitating the wider application of the results of scientific research, the expansion of the work of the Department of Scientific and Industrial Research, the extension of research in veterinary medicine and agriculture, an increase in the number of scientists and technologists, and the improvement of means for publishing and circulating scientific information. The deputation was led by Viscount Samuel, President of the Committee, and it included Viscount Waverley, past-President, Sir Ralph Glyn, Bt., M.P., deputy chairman, Mr. M. Philips Price, M.P., vice-president, and Lieut.-Commander Christopher Powell, secretary. The deputation based their representations on a memorandum which drew attention to the findings of a number of official organisations and to the remarks of various authorities. In the House of Lords recently it had been said that the time lag between discoveries and their application was due to lack of publicity, especially inadequate facilities for printing and circulating scientific information; to restrictions on labour and materials; the burden of taxation; lack of available capital for development and enterprise; and the shortage of highly trained technologists. The concluding words of a recent report of the D.S.I.R. Advisory Council were: "If this country is going to be prosperous, British industry must make science a real and living force in its daily life. There is no need to learn this lesson, as we have learnt so many in the past, through bankruptcy and unemployment, but time is getting short." The D.S.I.R. post-war plans called for an increase of scientific and administrative staff from the 1946 figure of 2,160 to about 4,000. The present staff was now only 3,000; yet, the average net recruitment had dropped to 110 per annum. The D.S.I.R. building programme was badly in arrears and the provision for running expenditure did not meet requirements. On the question of scientific man-power, the Committee urged the Government to consider the present situation in the scientific Civil Service and the Defence Ministries, with a view to ensuring that those appointed to the scientific grades had at least as good prospects of pay and promotion to the highest positions as those in the administrative grades. The Committee also represented to the Lord President that the problem of scientific information called for inquiry and action on the part of the Government. The Lord President expressed his keen interest in the points which were raised and promised to give them careful consideration.

FIREPROOF CONVEYOR BELTING IN COAL MINES.

By early next year, according to the National Coal Board, a quarter of the total production of conveyor belting for the coal mines of this country may be made of PVC (polyvinyl chloride); which, if used instead of rubber, greatly reduces the risk of fire. This characteristic of PVC belting was emphasised by Sir Andrew Bryan in his report on the Cresswell Colliery disaster in September, 1950, when 80 lives were lost. The matter was fully discussed at the International Safety in Mines Conference at Buxton, early in July, when it was decided that all rubber belting should be replaced by the PVC type "at the earliest possible moment"—a joint decision of the National Coal Board, the miners and the belting industry. At present, this country has more PVC belting in use in collieries than any other, but many other countries are understood to be interested. There are now about 18,000,000 ft. of conveyor belting in use underground, of which 9,000,000 ft. are being replaced each year. Of the 18,000,000 ft., not more than a million feet is PVC, and, at the present time, only a fraction of the replacements can be PVC as the total production is at present only 500,000 ft. a year. Before belting can be approved by the National Coal Board, it must be fully tested on the surface and underground. Obviously, no manufacturing firm will undertake large-scale and expensive conversion of machinery until their products, produced on "pilot" plants, have obtained official approval. One firm, however, are in fairly regular production of the new type of belting. Some ten other firms have received small experimental orders and are awaiting the results of the tests on their samples, or are in process of producing samples for test.

B.T.H. SUMMER SCHOOL IN ELECTRICAL ENGINEERING.

At the invitation of Mr. E. H. Ball, managing director, and his fellow directors of the British Thomson-Houston Company, Limited, a Summer School in Electrical Engineering—the second to be arranged—was held at the company's works and at Coton House, their apprentices' residential centre, from Monday, July 14, to Friday, July 18. The School was largely attended, the participants including various professors of electrical engineering, lecturers from technical colleges, educationalists, etc. They were received at the opening session by Mr. Ball, after which an address was delivered by Sir John Hacking, President of the Institution of Electrical Engineers, who outlined the views of the Council of that Institution on the future provision of technological education in this country. The Council were "not enamoured," he said, "of the idea of a technological 'university'," on the lines of either the Elektrische Technische Hochschule or the Massachusetts Institute of Technology; and it was their hope that developments in the existing universities, and the "up-grading" of existing technical colleges, would provide the urgently-needed facilities for expansion. Outside the universities, the additional facilities proposed should be concentrated at, and confined to, a few technical colleges, which would maintain an especially close liaison with industry. Sir John also referred to the development of high-voltage electrical transmission systems—for example, the 380-kV system in Sweden and the 275-kV grid in Britain—and explained the reasons why the latter voltage had been adopted *pro tem.*, while preparations were going forward for an increase to 380 kV, should this eventually prove to be necessary. Later, under the chairmanship of Mr. L. J. Davies, the B.T.H. Director of Research and Education, papers were delivered by Dr. K. J. R. Wilkinson and Mr. D. F. Welch. In the evening, a dinner was held, with Mr. H. Jack, chief electrical engineer of the company, in the chair, after which Professor E. B. Moullin, past-President of the Institution of Electrical Engineers, delivered an address. The next four days were devoted to technical sessions, at which some 19 lectures were given by experts in different branches of electrical engineering; and to visits to various sections of the company's works and to the Rugby College of Technology and Arts, with which the apprentice-training activities of the B.T.H. works are closely co-ordinated. On the Thursday afternoon, July 17, a discussion was held on "Aspects of Education and Training of Mutual Interest to Universities and Industry," the main topics being "Suggestions for arousing interest in Science and Engineering in the Public Schools and Grammar Schools," "Is Graduate Apprenticeship Necessary?" and "The B.T.H. Engineering Research Fellowship."

LLOYD'S REGISTER SHIPBUILDING RETURNS.

In Great Britain and Northern Ireland a large amount of tonnage was completed during the quarter ended June 30, 1952, according to Lloyd's Register Shipbuilding Returns, published on July 23. The total was 405,600 tons gross, compared with 267,511 tons—an unusually low figure—for the previous three months. The tonnage commenced in the June quarter, however, was small, being 205,641 tons, as against 324,831 tons for the January-March quarter. Such periodical fluctuations are to be expected. Work in hand in this country at the end of June totalled 343 ships of 2,076,241 tons gross, a decrease of 194,380 tons compared with the previous quarter, but on the same date plans had been approved or material ordered for 321 ships not yet commenced, of 2,531,623 tons—a figure which has been increasing steadily since the September quarter of 1950, when it was only 831,642 tons. Abroad, steamships and motorships under construction at the end of June totalled 847 ships of 3,537,942 tons gross, an increase of 127,995 tons in comparison with the figure for March last. The leading shipbuilding countries abroad, using the tonnage of work in hand as an index, were the United States, 636,064; Japan, 456,633—an increase of 62,438 tons over the previous quarter; Germany, 405,806; and Holland, 402,082. It is noteworthy that the overseas countries in which the largest amounts of tonnage were being built for registration elsewhere than in the country of build, or for sale, were Japan (241,350 tons), Holland (223,706 tons), Sweden (204,505 tons), and Germany (172,425 tons). Great Britain and Northern Ireland, however, were responsible for 36·2 per cent. (627,388 tons) of the total tonnage under construction in the world for countries other than the country of build. This country, also, is making a larger addition to its fleet than any other; the total was 1,486,353 tons, the United States being second with 620,009 tons. Oil tankers continue to represent a substantial part (45·9 per cent.) of the world's shipbuilding. For the June quarter, oil tankers of 1,000 tons and upwards under construction totalled 226 ships of 2,576,385 tons, which was 82,717 tons more than in March. This country led, with 100 ships of 1,130,486 tons (representing 54·4 per cent. of the total tonnage under construction); then Japan, with 21 of 302,550 tons; Sweden, 26 of 253,795 tons; the United States, 15 of 235,324 tons; Holland, 15 of 163,209 tons; Italy, 11 of 150,100 tons; and Germany, 11 of 102,143 tons.

LETTER TO THE EDITOR.

WATER HAMMER IN PIPE-LINES.

TO THE EDITOR OF ENGINEERING.

SIR.—The problem of "water-hammer" in hydraulic pipe-lines and conduits may cause considerable trouble and expense to engineers responsible for the operation of hydraulic plant, involving the possibility of control valves having to be closed in less time then is appropriate for the operation. The problem is, of course, not new and has received its share of attention—both theoretical and experimental—in the past 50 years. I have had occasion, during the past two months, to re-examine the theory from the point of view of lectures given to Final B.Sc.(Engineering) students of London University, at Kingston. It became apparent that the treatment given to the strain-energy of the conduit was inadequate. Working from Kelvin's "strain-energy function"—based on the mathematical theory of elasticity—I have derived a new formula for the maximum intensity of fluid stress in a simple pipe-line, under the assumption that the valve controlling the flow is closed instantaneously. The new, rational formula states that :—

$$p = C_p \sqrt{\frac{K \rho v^2}{1 + \frac{K}{E}\left(\frac{k r_m}{c d}\right)} + p_1^2} \quad . \quad (1)$$

where p is the greatest intensity of fluid stress set up in the conduit under the conditions quoted above; p_1 is the mean intensity of fluid stress in the conduit under conditions of free, unobstructed flow, the mean velocity of flow being v. K is the bulk modulus (of compressibility) for the fluid; E is Young's modulus for the material of the pipe-line; $\rho \left(= \frac{w}{g} \right)$ is the density of the fluid; d is the diameter of the pipe bore; r_m is the mean radius of the pipe, measured to mid-wall thickness; and $c = \frac{d}{2t}$, where t is the thickness of the pipe wall. C_p is a "pressure coefficient" to allow for losses of energy, as in noise and vibration of the pipe system.

The quantity k in equation (1) is a dimensionless function of c, of Poisson's ratio$\left(\frac{1}{\sigma}\right)$ and of the ratio $\frac{G}{E}$, where G is the modulus of torsional rigidity for the material of the pipe. The value of k is given by :—

$$k = \left[\left\{ \frac{\sigma}{(\sigma + 1)(\sigma - 2)} + \frac{2G}{E} \right\} (3c - 1)^2 \left(1 - \frac{2}{\sigma}\right)^2 + \frac{4G}{E} \left\{ 3c - 2c^2 + \frac{2}{\sigma}(7c^2 - 3c + 1) - \frac{1}{\sigma^2}(11c^2 - 9c + 1) \right\} \right] \quad . \quad . \quad . \quad (2).$$

There is no difficulty in its evaluation for a given pipe system.

Equations (1) and (2) check very well with the results of Joukowsky's experiments, on the assumption that the pipe-wall thicknesses are 0·4 in. for the 4-in. diameter pipe (cast iron) and 0·5 in. for the 6-in. diameter cast-iron pipe. The value of C_p works out at 0·966 for the 4-in. pipe-line and 0·980 for the 6-in. pipe-line, giving a mean value of 0·973.

Equation (1) is the simplest form of the Adams formula for maximum fluid pressure due to water hammer.

Yours faithfully,
L. E. ADAMS, B.Sc.(Eng.) (Lond.),
Carnegie Scholar.

11, Milner-road,
Kingston-on-Thames, Surrey.
May 12, 1952.

BRUSH SCHOLARSHIP AWARD.—The board of the Brush Electrical Engineering Co. Ltd., Loughborough, have awarded their annual scholarship to Mr. R. G. Beckett, a 20-year-old Brush student apprentice, who joined the company in January, 1950. The value of the scholarship is 150*l*. per annum, for three or four years, and enables the holder to study for an honours degree in electrical or mechanical engineering.

THE NATIONAL INSTITUTE OF AGRICULTURAL ENGINEERING.

WREST PARK, Silsoe, Bedfordshire, the home of the National Institute of Agricultural Engineering, was open for inspection on Wednesday and Thursday of last week so that those interested could see the work in progress and gain an impression of the activities of the Institute. Open days were last held two years ago and on that occasion a special exhibition was staged in marquees against backgrounds of explanatory matter and diagrams designed to illustrate how the work of the Institute falls under the three main headings of research, development and testing. Although these three headings still cover the main items of the Institute's programme, it was felt that visitors this year would be cognisant of this, and, on this assumption, it was decided to confine the displays to matters representative of the current work of the various departments and to stage them in and around the buildings and fields where the work is usually carried out. This arrangement, it was considered, would allow the open days to be held with as little interruption as possible to the normal routine.

Although some 30 different exhibits were set out for inspection, these by no means covered the full activities of the Institute. This can well be understood from the fact that there are nine different departments of the Institute, any of which may be concerned with a large number of separate investigations. From the average engineer's point of view, however, the work carried out by the mechanical engineering department is probably of the most interest. This department's work can, for the sake of convenience, be divided into five categories, namely: testing; investigations of testing techniques; tractor research; development of special equipment for engineering and agricultural researches; and the development of agricultural machinery. This division is not exact, because it does not correspond either to a strict division of the staff or of the work in hand, the lines of demarcation between many of the activities being difficult to define. Nevertheless, it provides a convenient means of subdividing the work of the department for descriptive purposes.

TESTING.

Testing activities are confined mainly to tractors, grain and grass driers and ancillary equipments, such as tyres, carburettors, fans, etc. In each case an N.I.A.E. standard test has been established and in June, 1951, a British Standard test for tractors was published. This test is comparable to the Nebraska test and meets the requirements of the British tractor industry. It does not, however, include that part of the N.I.A.E. test which deals with the field performance under practical operating conditions, including ploughing and working on gradients. It will be appreciated that standardisation of field performance tests is somewhat difficult, but, on the other hand, they are of great use to farmers. Grain and grass drier tests have often involved sending teams to the actual installations. Setting up the instruments used in connection with these tests proved to be a slow and laborious procedure, and to ease the task of the teams the truck used to transport the equipment has been fitted out with a range of instruments. This truck was on view during the open days, when it was shown in use in connection with tests being carried out on a representative grass drier. The instrument panel is mounted on rubber and carries eight double-point recording millivoltmeters and ancillary equipment which enable temperatures to be recorded at various points, a number of different ranges up to 2,500 deg. F. being available.

INVESTIGATION OF TESTING TECHNIQUES.

Grass driers also serve to illustrate the investigation and development of testing techniques, as in 1948 a serious demand arose for the testing of these machines. The development of a suitable technique proceeded during the 1948 and 1949 seasons, when 13 grass-drier tests were completed. By the end of the 1950 season the Institute felt they could claim that a standard test had been established capable of determining the characteristics of a grass drier without an unreasonable expenditure of time and labour. There remained, however, one outstanding problem, as in many tests analyses of wet and dried samples indicated a gain of protein in the drier. Although a number of experiments have been carried out, this problem remains unsolved. The obvious sources of error, such as sampling, have been eliminated and a comparison is now being made with different methods of drying wet samples, including freeze drying, at present the standard method, oven drying and the use of high-frequency dielectric heating. This investigation is being made in co-operation with the chemistry department of the Grassland Research Station. In the meantime, the existing method is being employed as this does give consistent results, the small gain in protein being included in the report when applicable. It is understood that the errors are not large and do not hide any serious damage to the feeding value during drying.

HYDRAULIC CAR FOR DRAWBAR LOAD.

One of the requirements for testing, and carrying out researches into the performance of, tractors is the provision of some means of applying a drawbar pull which can be varied at will. Hitherto, this has been accomplished by arranging for the tractor under test to haul an electrical loading car, the design of which is based on the transmission assembly of a standard tractor with the addition of a forward pair of wheels. As this unit is towed forward, the rear wheels drive a generator from the belt-pulley power take-off, a chain being employed for this purpose. The output from the generator is absorbed by resistances and the speed of the generator can be varied by selecting different gears in the transmission assembly. This loading car has proved eminently satisfactory in service and has been in such demand that it has proved necessary to produce a second car. It was decided, however, to employ hydraulic means for absorbing the power on the new car as the parts were more easily obtainable and less expensive and maintenance problems would be reduced. The hydraulic loading car, which was being demonstrated during the open days, is illustrated in Fig. 5, above. As in the case of the electrical car, the design is based on a tractor transmission unit, but in this case two such units are used. These are set back to back as shown in the illustration, and are joined to each other by a trunnion fixture which permits the two units to articulate when turning. Each unit is arranged to drive a hydraulic pump by means of a roller chain from the associated belt-pulley power take-off and the loading is altered by varying the pressure on a relief valve incorporated in the discharge line from each pump. One of the pumps and the driving chain can be seen in Fig. 5, just behind the leading nearside wheel. It should, perhaps, be mentioned that the illustration shows the car in an incomplete state.

TRANSPORTABLE TRAILER WEIGHBRIDGE.

One of the many problems encountered in the testing of grass driers was that of weighing accurately trailers bringing grass from the field to the drier. During the 1948 and 1949 seasons, ordinary commercial wheel weighers were used but these proved unsatisfactory as, in addition to being insufficiently accurate, they were difficult to handle. After consideration of a number of different schemes it was decided to build a mobile weighbridge which could be folded to form a trailer for purposes of transport. This was completed in time for the 1950 season and has proved quite satisfactory in service. When in use, the platform is supported by four small weighing machines disposed one at each corner and each capable of measuring up to 2 tons by increments of 2 lb. To convert it into a trailer, the stiffening members are removed and the two ends of the platform are folded upwards to form the trailer sides, after which the various ancillary parts such as the drawbar, wheel arms, wheels, etc., are added to complete the unit. This weighbridge has proved insufficient to meet the demands and accordingly a second unit is now being constructed which is scheduled for completion in time for use at the R.A.S.E. potato-harvester trials this year. It incorporates several refinements, the most important of which is a considerable reduction

AGRICULTURAL ENGINEERING DEVELOPMENT.

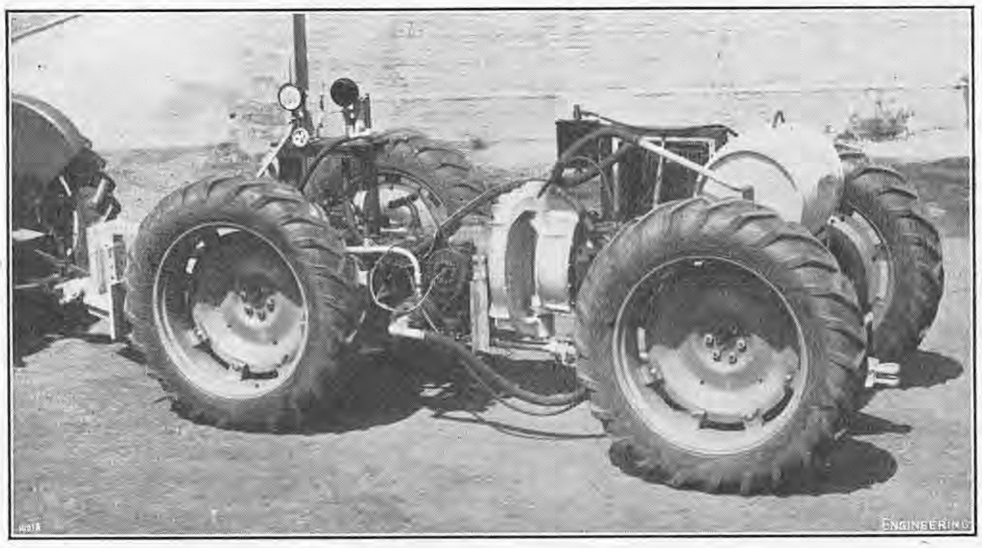


FIG. 5. HYDRAULIC CAR FOR LOADING TRACTOR DRAWBARS.

in weight brought about by the use of light alloys. This will enable the unit to transport its own weighing machines, the previous model being too heavy in itself to be able to do this.

SINGLE-WHEEL TESTER.

Investigations into the performance of wheels is one of the oldest researches of the Institute. The single-wheel testing machine, which was shown in an uncompleted form during the 1950 open days, has been considerably developed and is now in use on a fundamental study of the relationship between slip and rolling resistance and an investigation of the performance of tractor strakes. It is shown in its latest form in Fig. 1, on page 144, from which it will be seen that the test wheel is located behind a standard tractor. The wheel is driven through an electrical transmission assembly while the rear wheels of the tractor are kept in gear, electricity for this purpose being provided by a generator driven from the tractor power take-off. The test wheel pushes the equipment along and as its speed is altered the force it exerts, and the torque required to drive it, vary in accordance with its own characteristics. The useful work done by the wheel is circulated and the tractor engine balances the losses. A hydraulic compression dynamometer is used to measure the drawbar force, and torque is measured by supporting the end of the final-drive worm in a hydraulic chamber, the pressure induced in the chamber giving a measure of the torque. Drawbar force and torque are recorded, together with the revolutions of the test wheel and the forward distance travelled, and the results are subsequently calculated from the recorder charts. A small rubber-jointed track measures the forward distance and also drives an electric tachometer which indicates the forward speed and, by comparison in a ratio-meter with wheel speed, the percentage slip. Judging from field trials carried out so far, there appears to be little doubt that the unit will prove satisfactory for investigations into wheel efficiencies. It is envisaged that it will be available on occasions for the routine testing of tyres, such tests up to the present having been made by reference to the drawbar performance of a tractor fitted, in turn, with different types of tyre. A comparison on the single-wheel tester will be much more informative.

POTATO-HANDLING EQUIPMENT.

The work done by the mechanical-engineering section towards the development of special equipment for agricultural research is, possibly, exemplified by the potato elevator-loader illustrated in Fig. 2, on page 144, and the tractor-mounted combine harvester illustrated in Figs. 3 and 4, on the same page. The potato elevator-loader was developed as a result of investigations into methods of handling potatoes carried out in co-operation with the potato-storage investigation team of the Agricultural Research Council. These investigations involved a study of the technical and economic problems concerned with the shed storage of potatoes in Great Britain. From the outset it was realised that economy of space would require storage heights in excess of 6 ft. and the use, therefore, of a mechanical loader. Accordingly, C. H. Johnson (Machinery) Limited, Adswood-road, Stockport, were asked to build a prototype machine for the 1949 harvest. The conveyor consists of a fabricated-steel boom 26 ft. long between drum centres and constructed from light angle and tubular sections. The belt, which was chosen so as to provide a means of removing loose soil, consists of a standard wire-mesh unit manufactured by the British Wedge Wire Company, Limited, Warrington. It has a width of 20 in. and is fitted with $1\frac{1}{2}$-in. wooden triangular-section cleats to prevent roll-back of the potatoes, being supported on the carrying side by flat rollers and on the return side by angle-iron guides provided with replaceable hardwood inserts. Both drum shafts are supported in self-aligning ball bearings and the conveyor is driven by a three-phase 3-h.p. squirrel-cage motor mounted directly under the boom, the speed reduction being arranged to give a belt speed of 120 ft. per minute.

The hopper, which is designed to receive loads directly from tipping trailers, is 7 ft. 9 in. wide and is equipped with an adjustable feed control opening. It is attached to the conveyor boom by four bayonet-type fixings so that it can be removed easily and replaced by side trough extensions when the elevator is used for sacks and bales. The conveyor is pivoted at the rear to a fabricated-steel frame and is suspended from a superstructure by wire ropes which are led back to a winch which, to dispense with the usual ratchets, is operated by a non-reversing worm-reduction gear. This elevating gear gives a variable discharge height of from 3 to 17 ft. The wheels are 42 in. in diameter and are arranged so that they can be slewed through 90 deg., and the elevator, as a consequence, moved sideways to direct the discharge where required. Practical tests have shown the machine to be quite satisfactory both for elevating potatoes in bulk and for general purposes. The design is inherently simple and, should the occasion arise, no difficulties should be encountered in producing it in quantity.

TRACTOR-MOUNTED COMBINE HARVESTER.

The tractor-mounted combine harvester, which was developed for harvesting cereal trial plots, is of more than usual interest in that it employs an endless belt in association with an extended " concave " for the threshing mechanism. The possibility of using this arrangement had been under consideration at the N.I.A.E. for some time, the theory being that, if the threshing drum were made sufficiently large, complete separation of the grain from the straw could be achieved within the drum. The virtue of this idea, particularly in connection with trial plots, was that it might lead to the design of a harvester which could quickly and easily be cleaned out, thus overcoming the main objection to the use of a combine harvester for plot work. Accordingly, a trial rig was built and the results obtained made it seem likely that a full-scale shakerless combine harvester based on the endless belt mechanism would give a performance comparable to that of a conventional machine.

The full-scale machine was built in time for the 1949 harvest and has been in continual use since, modifications being incorporated from time to time as experience was gained. It is shown in its final form in Figs. 3 and 4, on page 144, from which it will be seen that it is mounted at the front of a Fordson tractor; this is fitted with a Perkins P6 Diesel engine. The cutting and feeding mechanism has been taken from an Allis-Chalmers Model " 60 " combine harvester, and has been suitably modified. The main frame of the unit is supported at the front by castor wheels and at the rear by a pivot attachment designed so that the complete unit is able to rise and fall in relation to the tractor. The crop is elevated by a canvas belt to the top end of the concave and then passes successively between the threshing belt and concave, between the belt and a screen, and finally between a deflector drum and the finger grate. The grain, chaff and weed seeds fall into bins and the straw leaves the machine at the finger grate. The threshing belt is fitted with rubber-moulded rasp-type beater bars which are bonded and riveted to the belt. The belt is 5 ft. wide and the pitch of the beater bars approximately $9\frac{1}{2}$ in., which gives a rate of 4,300 impacts a minute at a speed of 3,400 ft. per minute. The threshing belt is driven from the belt pulley power take-off and the auxiliaries from the rear power take-off. A hydraulically-operated skid jack is provided at the rear of the tractor. This is arranged so that the off-side rear wheel of the tractor can be raised clear of the ground, its use enabling all components of the combine to be run up to speed before the tractor moves forward into the crop. It can also be used to reduce the forward speed of the tractor when a particularly heavy patch of crop is being harvested.

The foregoing deals briefly with the work of the Mechanical Engineering department; no reference has been made, for example, to their several other activities, such as the development of sugar-beet and forage harvesters and a hydraulic transmission for the propulsion of agricultural tractors. The proposed hydraulic transmission, however, was described in full in an article by Mr. H. J. Hamblin, head of the engineering department, published on page 637 of our issue for May 23 this year. In brief, it consists of hydraulic motors arranged inside the driving wheels and supplied with fluid under pressure from an engine-driven pump. At present, this research is being confined to experiments with a single wheel aimed at determining whether a reasonable efficiency can be obtained. No mention has been made either of the activities of the other departments of the Institute, mainly because their work is of a more specialised nature. The agricultural testing department, for example, carries out some 50 tests a year on a wide variety of agricultural implements ranging from beet harvesters to seed drills. The work of the grain department is concerned, mainly, with the machinery and ancillary equipment required on the farm for dealing with grain harvested by combines. Two distinct types of plant have been developed by this department, namely, a platform drier for drying grain in sacks and a ventilated silo for drying during bulk storage. The primary work of the instrument department is to give assistance to the other departments by carrying out special investigations, developing new laboratory techniques, giving advice on instruments, carrying out calibration tests, etc. As a long-term policy, the soil physics section of the soil department is investigating the possibility of measuring soil properties and their relationship to various tillage implements, it being their opinion that, until more is known on this subject, the design of most implements must be a matter of trial and error. The soil department, it may be mentioned, were responsible for the development of the one-way mounted plough which was exhibited in the Country Pavilion at the South Bank Exhibition of the Festival of Britain.

LABORATORIES FOR STEEL RESEARCH.

UNITED STEEL COMPANIES, LIMITED, ROTHERHAM.

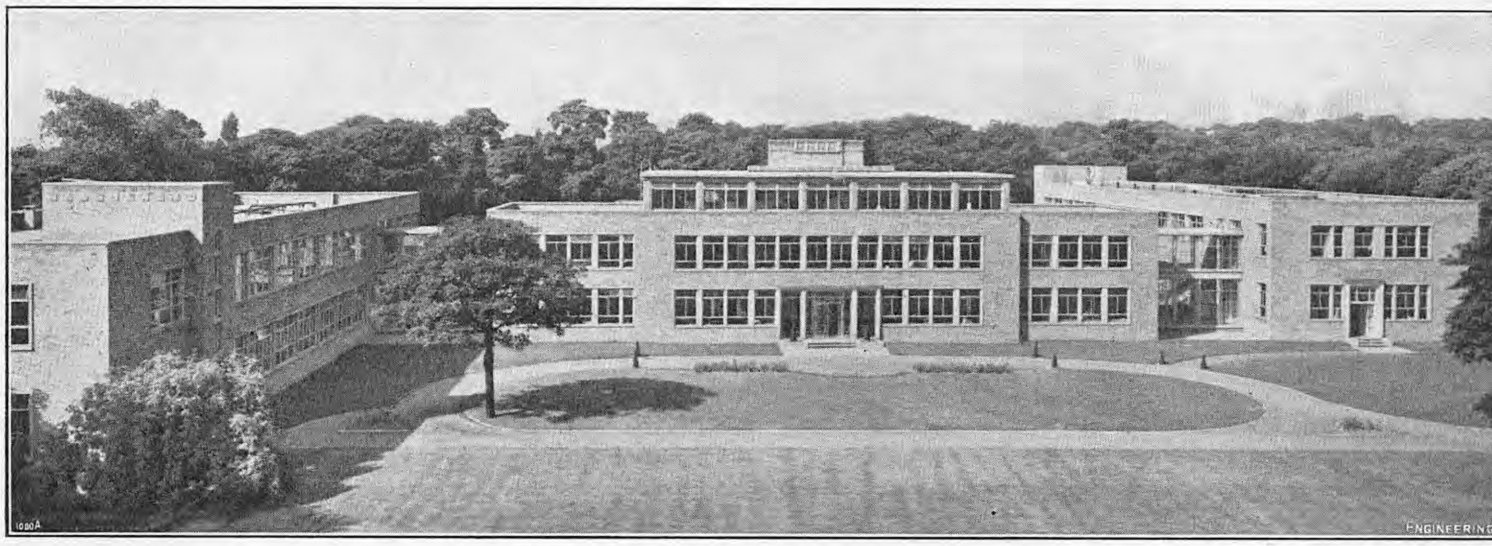


FIG. 1. GENERAL VIEW OF LABORATORIES.

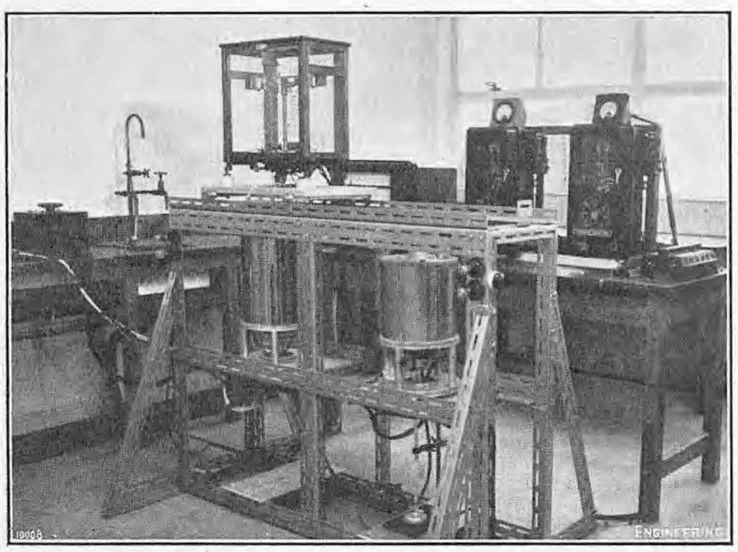


FIG. 2. CONTINUOUS-CORROSION APPARATUS.

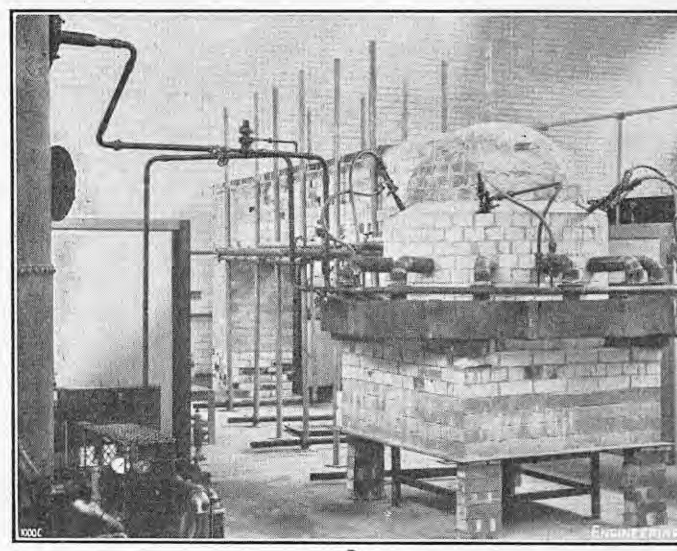


FIG. 3. INTENSE-COMBUSTION FURNACE.

THE SWINDEN LABORATORIES OF THE UNITED STEEL COMPANIES.

In a previous issue of ENGINEERING (vol. 171, page 128 (1951)), a short account was given of laboratories, then under construction at Rotherham, for the United Steel Companies, Limited. On July 24, the finished laboratories, now fully equipped and occupied, were opened for inspection. The buildings, which are illustrated in Fig. 1, on this page, stand in what was formerly a private estate at Moorgate, about 1¼ miles from the centre of the town. An adjoining mansion house, formerly known as Red House, provides accommodation for the director and administrative staff, and also contains a library, conference room, canteen and kitchens. The mansion has been renamed Swinden House, and the laboratories are known as the Swinden Laboratories, in memory of the late Dr. Thomas Swinden, who was, for a number of years, director of the companies former research laboratories at Stocksbridge. The growth of the research and development undertaken by the companies may be gauged from the fact that when the Stocksbridge laboratories were opened in 1934, the total staff employed numbered only 25. By 1945, the number had grown to 66. The present strength of the establishment at Rotherham is 180, of whom some 40 are university graduates and over 80 of the remainder are trained in some branch of technology. In addition, each of the companies has its own research and development department.

The new laboratories have a floor area of 60,000 sq. ft., and comprise four main blocks. That which contains the main entrance, seen in the centre of Fig. 1, has laboratories on the ground floor, offices belonging to the development engineers on the first floor and a design and drawing office on the top floor. The block to the left contains laboratories for metallurgy, welding and the study of metals at high temperatures, on the ground floor, and others for metallurgy and general physics on the first floor. Most of the block on the right of the illustration is occupied by chemistry laboratories, but there are also laboratories devoted to spectroscopy, X-ray analysis, and the study of refractories. The fourth block is a single-storey building situated behind the principal block. It is in two main sections. One of these contains a large bay used for development work and the other accommodates a well-equipped machine shop which not only supplies the laboratories with the large number of test-pieces required for assessment work, but also provides a substantial part of the laboratory equipment required. There are, besides, laboratories for studying air and hot gas flow in furnaces and for heat treatment. All four blocks of buildings are connected by covered corridors. The architects were Messrs. J. Mansell Jenkinson and Son, and the contractors were Messrs. G. Longden and Son, Sheffield.

The laboratories serve the largest group of iron, steel and coke producing units in the British Commonwealth, providing the individual companies with answers to problems which arise in production. The companies own their own sources of certain essential raw materials, in particular, iron ore. They make over a million tons of iron per annum, and mine 3½ million tons of ironstone. In addition, 120,000 tons of haematite are mined by them annually in Cumberland. The companies also use a large amount of coke, most of which they make. Some 2½ million tons of coal are used annually for this purpose. Research on factors affecting the quality of coke is also undertaken, but at separate laboratories at Orgreave, near Rotherham. Gases and oils are also studied, since the companies use considerable quantities of gas and oil fuels annually, and refractories, since good firebricks are important in furnace work. The companies make over 2 million tons of steel annually by the Bessemer, open-hearth and electric processes, a field of activity which offers unlimited scope for research, not only on methods of manufacture, but also on means for improving the quality, producing the requisite chemical and physical properties, and lowering the cost of the product.

The general properties of new steels are assessed at the laboratories by means of standard mechanical tests, but each steel must also be studied in relation to the particular conditions under which it is to be used. Before all the requirements have been met, many changes in composition and manufacturing procedure may be required. Work is constantly in progress to determine the effect of variations in composition on both the micro-structure and mechanical properties of steels, and new products having special characteristics, such as good strength at high temperatures and high resistance to corrosion, are under development. The small quantities of experimental steels needed for research are made

LABORATORIES FOR STEEL RESEARCH.

UNITED STEEL COMPANIES, LIMITED, ROTHERHAM.

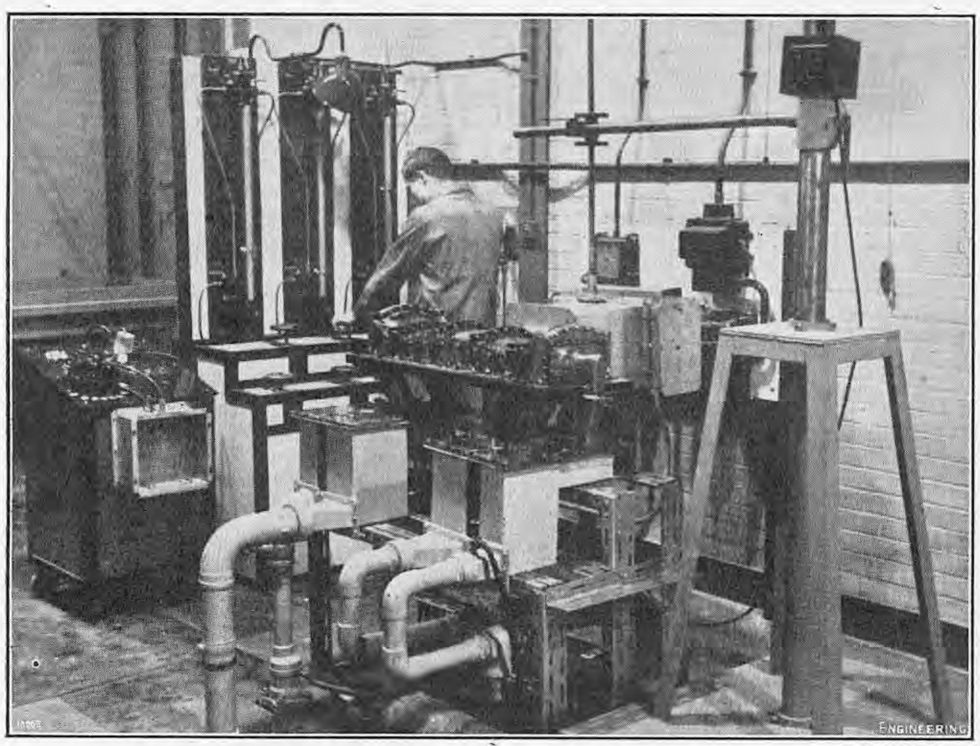


FIG. 4. MODEL OF OPEN-HEARTH FURNACE.

in a small high-frequency induction furnace capable of melting up to 18 lb. of metal in either an acid or a basic lining. The larger ingots can be forged and reduced to a size which permits their mechanical properties to be determined.

The facilities in the chemical laboratories at Rotherham include means for chemical and spectrographic analysis, corrosion testing, chemical metallurgy and the determination of gases in metals. Routine analysis, however, is undertaken mainly at the laboratories of the individual firms, although the latter collaborate with the central laboratory in developing and improving methods of analysis. The work on corrosion covers a wide range of materials. Equipment designed and used in the laboratories for measuring continuously the corrosion and scaling of steels at high temperatures in various atmospheres is illustrated in Fig. 2, opposite.

A knowledge of the thermal, electrical, magnetic and other physical properties of steels is important in many applications. The laboratories contain equipment for determining such properties accurately at both normal and high temperatures. The techniques employed have, on occasion, required special apparatus to be devised and constructed in the laboratories. Information is also obtained on the properties of non-metallic substances, for example, on the thermal conductivity and expansion of refractories, the electrical conductivity of graphite electrodes and the properties of quenching oils. Thermal data obtained in the laboratories are used as a basis for deciding on the heat treatment suitable for new steels. Critical thermal ranges receive particular attention and S-curves are prepared to show how the isothermal transformation of austenite is affected by both time and temperature.

Ultrasonic methods of flaw detection, electrolytic polishing, magnetic sorting and photo-elastic methods for determining stress distributions are also studied and employed in the laboratories. Considerable use is made of electrical-resistance strain gauges. More recently radioactive tracers have been used to determine the rate of wear of blast-furnace linings. The widespread use of electronic equipment has led to the provision of an electronics laboratory where such equipment is constructed and maintained. As an example of the work done, the electronic controllers required for maintaining the desired temperature in the creep-test furnaces, of which there are a considerable number in the laboratories, were built in the electronics department.

Mention has already been made of the interest attaching to blast-furnace design. Problems of combustion and air-flow are extensively studied in the laboratories with the aid of models of furnaces. In the hot-model laboratory, equipment, illustrated in Fig. 3, opposite, has been developed for inducing intense combustion. The burner is designed on the lines of the flame tube of an aircraft jet-engine. The model furnaces are run on paraffin, gas-oil, and even heavy fuel-oil. The correct assessment of scale effect is somewhat difficult, because thermal as well as aerodynamic aspects must be considered. The earlier models were one-twelfth scale, but models of scales up to one-third of full size have been built.

Since comparatively little was known about the flow of the gases in furnace chambers, the research department started a detailed investigation of the subject, beginning with the construction of a number of small-scale partially transparent models of furnaces. In order to determine the gas flow, it was simulated by means of water, containing aluminium particles in suspension, which was circulated through the furnaces, the streamlines being revealed by brilliant illumination of the aluminium particles. A model of an open-hearth furnace in the hydraulics laboratory, used for this purpose, is illustrated in Fig. 4, on this page. Some unexpected results were obtained. In particular, considerable recirculation of the flow was observed, which was found later to occur in full-size furnaces also, good agreement being obtained between the model and full-scale results. Attempts are now being made to design furnaces with improved flow patterns, but there is some uncertainty as to what type of flow gives the best results, questions of combustion, heat transfer and the wear of the refractories all having to be considered.

Although this account of the work of the Swinden Laboratories is far from complete, enough will have been said to make clear that the field of research and development covered at Rotherham is a very wide one. The laboratories work in close collaboration with other similar organisations both at home and abroad. It is part of the general policy of the companies to publish the results of their research, and this, combined with visits abroad by members of the staff and the reception at the Swinden Laboratories of numerous visitors from overseas, has led to contacts all over the world, the value of which to British industry cannot easily be calculated.

POLLUTION OF SEA-WATER BY OIL.

A STATEMENT issued recently by the General Council of British Shipping outlines a scheme for a renewed and intensified study of the pollution of sea-water by oil pumped overboard by tankers in the course of the tank-cleaning operations which are necessary prior to surveys or repairs, or before transferring a tanker from the carriage of one kind of oil to another. The statement recalls that the first steps taken in this country to deal with oil pollution were in 1922, when, after consultations between the Board of Trade, shipowners' organisations, oil companies and harbour authorities, the Oil in Navigable Waters Act was passed. This Act prohibits the discharge of oil or oily waste within the territorial waters of Great Britain and Northern Ireland, that is, within three miles of the coast. Two years later, British shipowners again inquired exhaustively into the whole question and, following consultations with shipowners of other countries, the International Chamber of Shipping recommended its members to instruct shipmasters to take every precaution to prevent any cause of complaint.

In 1926, a conference in Washington drew up a draft convention providing for the establishment of zones extending up to 50 miles and, in exceptional circumstances, 150 miles, from the coast, within which the discharge of oil was to be prohibited. This convention was never ratified by the Governments concerned, but British shipowners (and shipowners of other countries) of their own accord instructed their masters not to discharge oil or oily waste within 50 miles of any coast. This rule is incorporated in standing instructions to shipmasters, who are well aware of its importance. It will be seen, therefore, that British shipowners have not only recognised for many years the serious consequences that follow the pollution of sea-water by oil, but have recommended and voluntarily adopted for general use what were considered to be effective measures to combat the evil.

Since the war, however, developments have drastically and probably permanently changed the pattern of the oil trade, and that change may have contributed to the undoubted increase of oil pollution of British coasts. Five or six years ago, the majority of oil imports consisted of oil which had been refined already. To-day, the great expansion of refining in the United Kingdom and Continental ports means the importation of crude oil on a large scale. In 1938, under one-fifth of the petroleum oils imported into the United Kingdom consisted of crude oil. In 1949, the proportion was one-third, but now it is nearly two-thirds. Between 1938 and 1951, the total imports of all kinds of petroleum oils have more than doubled. To-day, about six times the pre-war quantity of crude oil is being imported into this country alone, and the import of crude oil to the Continental refineries has also increased considerably.

Certain refined oils present no problems ; in fact, the Oil in Navigable Waters Act, 1922, gives harbour authorities the power to designate places at which tank washings from petroleum spirit cargoes, which rapidly and completely evaporate, may be discharged within harbour limits. In contrast, pollution by fuel oil can have serious effects, particularly on animal and bird life. Fuel oil costs about 9*l*. a ton and a modern ship may use up to 50 tons a day and more ; so that, apart from any other consideration, it is never wilfully wasted. The practice is growing among British shipowners to fit separators in passenger and dry-cargo ships, in order that fuel oil from bilge and ballast water may be recovered and, if of a suitable grade, consumed as fuel. There are, however, certain classes of vessels, notably tankers, in which the fitting of separators appears to offer no solution.

For example, when a 15,000-ton tanker carrying crude has discharged its oil, there may remain in the tanks some 25 tons of "sludge"—a heavy, viscous, waxy substance, too solid to be pumped out, but which must be removed before a ship can be repaired. It has a low flash-point and its use as fuel in ships is out of the question. A separator on board is no use in the removal of sludge. After a cargo of crude oil has been discharged, even if the tank drainings have been passed through a separator, the sludge remains and has to be disposed of in some other way—either to a shore receiving-station, or overboard while far out at sea. British shipowners are already using to the fullest extent the existing shore facilities, the provision of which is at present being increased.

The General Council of British Shipping have set up a special policy committee, under the chairmanship of Sir Colin Anderson, to re-examine, as a matter of urgency, practical measures to deal with oil pollution in all its forms. The industry is also co-operating with a group of organisations interested in methods of prevention. Though much is known on certain aspects of oil pollution, there are still large gaps in knowledge of the behaviour and capacity to persist under various weather conditions of oil deposited out at sea. It is the object of the research, referred to above, to gain more knowledge on these matters.

What is planned is something akin to the "Kon-Tiki" experiment, in which the Pacific was crossed by a team of observers on a raft, with the intent to ascertain the means whereby the original inhabitants of remote islands reached those shores. The present project has been planned by three of the tanker companies owned by major oil companies. On board an observation vessel will be oil and shipping experts and scientists, who will follow the drift of both crude oil and fuel oil discharged into the sea as part of normal tank-cleaning operations at distances exceeding 50 miles from the coast, to determine the rate and direction of flow and to take samples at intervals for analysis to determine the consistency of the oil, whether it coagulates, breaks up or sinks and, in fact, what happens to the oil from the time it is discharged into the sea. It is expected that the whole experiment, which representatives of Government departments have been invited to watch, and which will commence shortly, will take about two months to complete.

It may yet be proved that oil discharged hundreds or miles away can cause the soiling of British beaches, or that oil put into the sea just outside the 50 miles radius will, in that distance, disperse and become harmless before reaching land. Thus the data collected from the experiment should prove of great value in dealing with the latest manifestations of oil pollution, though there are no immediate ways to guarantee a cure.

A law enacted by this country, forbidding the discharge of oil at sea anywhere, could apply to British nationals only, and to foreigners within United Kingdom territorial limits. It could not apply to the large volume of foreign shipping passing the coasts of Britain on its way to and from North European ports. International agreement would be required, therefore, for the adoption of any further measures found to be necessary or desirable. The International Chamber of Shipping is being kept informed of the action now being taken by British shipping in order that foreign shipowners also may have the advantage of the experience which it is hoped to gain.

Reports on Flame-Failure Controls for Gas-Fired Installations.—The Gas Council, 1, Grosvenor-place, London, S.W.1, have issued two reports by the Industrial Gas Development Committee: Report No. 51/4/107, on the Spersom G.805 Control Pilot 2-in. B.S.P., and No. 51/4/108, Spersom G.807 Multi-Burner Control Pilot. In each case, the construction of the control is described and results of performance tests are given. Both are reported to satisfy the Committee's requirements for flame-failure devices. The Spersom controls are made by Sperryn & Co., Ltd., Moorsom-street, Birmingham, 6.

Air Transport Advisory Council.—The Minister of Transport and Civil Aviation, Mr. Alan Lennox-Boyd, announced in the House of Commons on July 24 that the Lord Chancellor had re-appointed Lord Terrington, K.B.E., as chairman of the reconstituted Air Transport Advisory Council. Mr. Lennox-Boyd stated that he had appointed Viscount Runciman, O.B.E., A.F.C., as the Council's deputy chairman, and Sir John Ure Primrose, Mr. Gerard D'Erlanger, C.B.E., and Mr. J. J. Taylor, O.B.E., as members of the Council. The Minister added that the directive under which the Council would work was at present being considered by them, as guidance for their form of procedure.

LABOUR NOTES.

Leaders of the Trades Union Congress met the Prime Minister at 10, Downing-street on July 24, at their own request, and made full representations to him respecting the decision of the Minister of Labour to refer back to twelve Wages Councils their proposals for wage increases, on behalf of more than a million employees in the distributive and allied trades. The economic committee of the T.U.C. had decided that a strong protest should be made regarding the action of the Minister, Sir Walter Monckton, on this matter, as they considered it to be an abuse of the powers conferred upon him by the Wages Councils Act, 1945. Mr. Winston Churchill, who was accompanied by Sir Walter, promised that the views of the trade-union representatives should receive careful consideration.

The meeting was stated subsequently to have been very cordial in character and to have lasted for about an hour and a quarter. Only matters relating to the Wages Councils were considered and there was no discussion of wage-restraint problems generally. The deputation from the T.U.C. was led by Mr. Lincoln Evans, C.B.E., secretary of the Iron and Steel Trades Confederation and chairman of the T.U.C. economic committee. The other members were Sir Vincent Tewson, general secretary of the T.U.C., Mr. G. Woodcock, the assistant secretary, Mr. Tom Williamson, general secretary of the National Union of General and Municipal Workers, Mr. R. Willis, secretary of the London Society of Compositors, and Mr. A. Birch, general secretary of the Union of Shop, Distributive and Allied Workers. The last-mentioned union is the one most concerned in the wage proposals referred back for further consideration. Members of the T.U.C. economic committee were due to meet Sir Walter Monckton yesterday afternoon to discuss the whole matter further, but the outcome of that meeting was not known at the time of going to press.

It was arranged on Tuesday that Sir Walter should meet representatives of the employers' side of the Retail Distributive Trades Conference yesterday, after his discussions with the T.U.C. economic committee. The employers wrote to Mr. Churchill at the week-end asking that Sir Walter should receive a deputation from them, as they wished to present their point of view regarding the reference back of the wage proposals for the retail distributive trades. They stated in their letter that an additional 25 million pounds would have to be found annually, if the proposed increases were granted. In their opinion, there could be no justifiable challenge to the right of the Minister of Labour to refer back the proposals. The letter added that the Retail Distributive Trades' Conference was established, in 1936, under the auspices of the Minister of Labour, and that it was continuously functioning on labour and kindred problems. The employers' side accordingly claimed to be in the same position in relation to the employers' sides of the retail Wages Councils, as the T.U.C. General Council was to the employees' sides.

Demands by the three principal railway unions for higher pay were rejected for the second time on Monday last. At a meeting in London of the Railway Staff National Council, which comprises members representing both the Railway Executive and the unions, delegates from the Executive re-affirmed that the unions' claims for an all-round wage increase of 10 per cent. and increased rates for work performed on Saturday afternoons, were not acceptable. These claims were originally presented to the Executive in May and refused outright on June 23, principally on the ground that the rise in the cost of living, since the previous increase in railway wages, did not justify the new demand. In this connection, it may be recalled that an all-round increase of 8 per cent. was conceded in November, 1951, and ante-dated to the previous September 3, on the recommendation of the Railway Staff National Tribunal.

The executive bodies of the three unions concerned, the National Union of Railwaymen, the Associated Society of Locomotive Engineers and Firemen, and the Transport Salaried Staffs Association, met separately on Tuesday to consider what further action should be taken respecting their current claims and decided that these should be referred immediately to the Railway Staff National Tribunal for arbitration. This body consists of one representative from each side of the railway service and an independent chairman. It is expected that the Tribunal will commence the hearing in the course of the next week or so.

In his opening speech in the debate in the House of Commons on the economic situation, Mr. R. A. Butler emphasised that it was necessary to avoid rises in the cost of production. The country could not afford them in the face of severe price competition from overseas for so many ranges of goods. The Government's policy had ensured that there should be reasonable restraint in the distribution of profits and, with respect to wages, moderation must be the key word. Everyone should know that increases in wages, not matched by increases in production, would force up prices and diminish the nation's prospects of attaining the level of exports so necessary to its salvation. If, owing to increases in prices, British industry lost world markets and suffered reductions in exports, or, if the cost-of-living spiral started whirling again, the country would risk falling right back to bankruptcy.

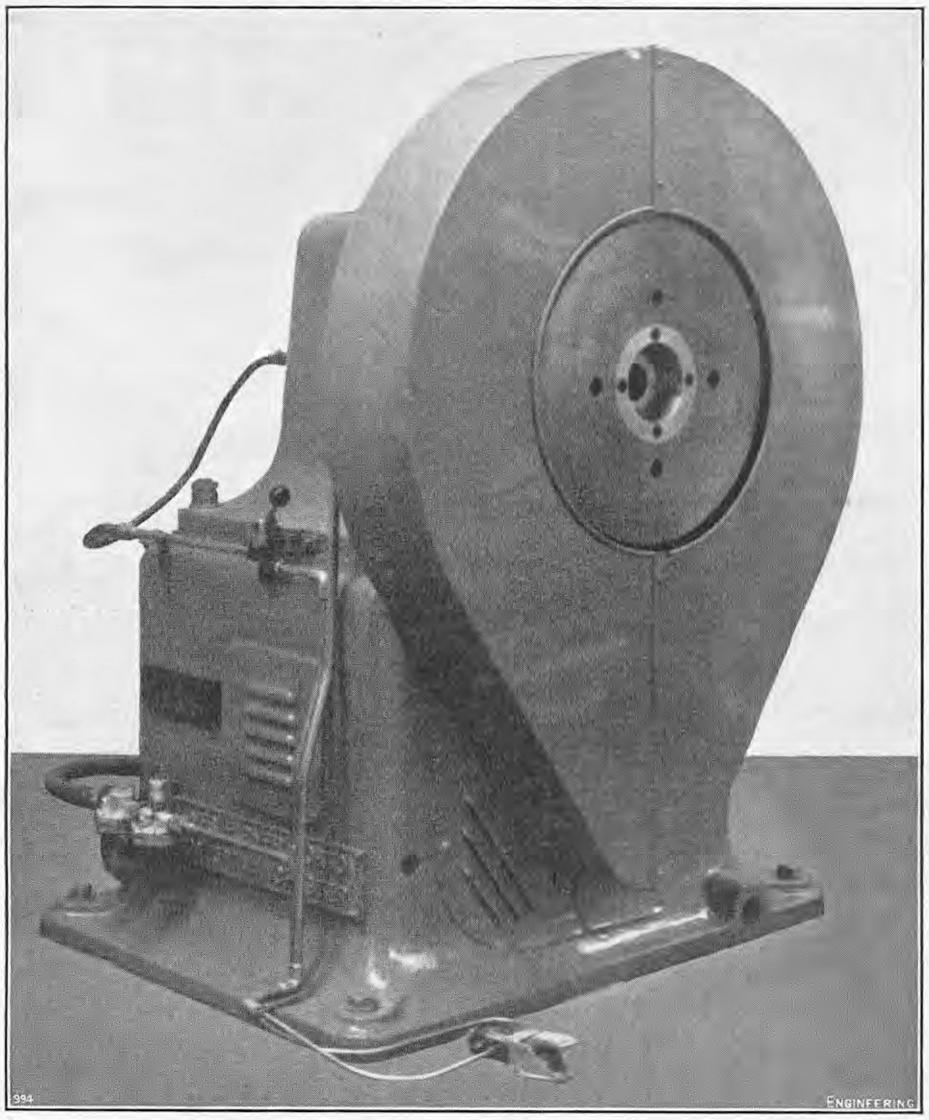
In such circumstances, Mr. Butler continued, the pound would lose its value and it would not be possible to pay for the nation's daily bread or for the materials used in its daily work. The expansion of the country's earnings, visible and invisible, to the extent necessary to enable it to pay its way was a formidable task. This expansion had to be achieved, however, irrespective of what world conditions might be, but the task would be infinitely eased if world conditions were favourable. Britain alone could not bring about an expansion of world trade. To achieve such a result, Britain needed the help of the Commonwealth sterling area and of Canada, as well as the goodwill of the United States, to assist with capital for oversea development and the purchase of this country's available raw materials and manufactured goods.

Firm opposition to proposals for wage restraint is expressed in many of the motions which have been put down for consideration at the 84th annual session of the Trades Union Congress, the preliminary agenda for which was issued in London on Monday. A motion tabled by the National Union of Tailors and Garment Workers requests the General Council of the T.U.C. to resist to the utmost any question of wage restraint until adequate price controls and food subsidies have been restored. The Association of Engineering and Shipbuilding Draughtsmen asks the Congress to declare that it supports the efforts of the unions to defend the living standards of their members by the submission of wage claims, and that it rejects any policy of so-called "restraint" or "moderation," designed to secure the withholding of such wage claims. Somewhat similar views are expressed in a motion submitted by the Post Office Engineering Union. The Electrical Trades Union, in another motion, affirms its complete opposition to the Government's policy of wage restraint.

The National Union of General and Municipal Workers desires the Congress to declare its strong opposition to the Government's policy, which has placed the greatest burden on that section of the population least able to bear it. The union desires the rejection of attempts to restrict justifiable wage increases, as these are necessary to ease the burden of rising living costs. It also asks for a reconsideration of food subsidies, a reduction of purchase tax and a strict limitation of profits and dividends. At the same time, the union recognises that there is a need to reduce oversea spending during the crisis respecting the balance of payments and appreciates that any measures for that purpose must impose additional hardships on the whole nation. The Amalgamated Engineering Union expresses its serious concern at the demands of Britain's re-armament programme on the nation's economy.

ROTARY SWAGING MACHINE.

SIR JAMES NORTON AND COMPANY, LIMITED, SALFORD.



INVERTED-TYPE ROTARY SWAGING MACHINE.

WE illustrate on this page a new type of inverted rotary swaging machine, recently constructed by Sir James Farmer Norton and Company, Limited, Adelphi Ironworks, Salford, 3. Swaging machines of the rotary-spindle type, in the production of which the firm have specialised for some 85 years, are extensively used for pointing the ends of ferrous and non-ferrous bars, etc., before drawing them through dies, and for swaging ferrules and shackles on wire rope. This new machine, however, hammers the work with rollers of hardened steel.

The machine shown above is No. 1 size in a designed new range, and will swage steel bars up to $1\frac{1}{2}$ in. in diameter, steel tubes up to $2\frac{1}{4}$ in., non-ferrous bars up to 2 in. in diameter and non-ferrous tubes up to 3 in. in diameter. The intention is to build other sizes of machines to swage up to 6-in. tubes. The machine (listed as No. 1 S.I.) is of robust construction, with a box-section head of close-grained cast iron, bored to take the large-diameter shank of the steel spindle. The front end of the spindle is machined, hardened and then ground on its cylindrical surface and front face, and along the faces of the slots in which slide the four-piece die and hammer blocks. The dies and hammer blocks also are ground all over. The hammer blocks carry renewable hardened-steel rollers which make contact with the main striking rollers when transmitting the blows to the dies. A renewable plate, of hardened steel, is bolted to the front face of the spindle and serves to retain the hammer blocks, roller race and flywheel. It is bored out in the centre to take a die-retaining plate, which can be readily removed when the dies are to be changed. The main roller race consists of a phosphor-bronze cage containing the 12 hardened and ground striking rollers; the race also acts as a roller bearing for the flywheel, which is of cast iron, machined all over and carefully balanced. Shrunk into the bore of the flywheel is a hardened and ground steel ring, finish-ground in the bore to the clearance required for the roller race.

The drive is by an endless and non-stretching flat belt from the pulley on the motor spindle to the periphery of the flywheel, the motor being contained in the box-section cast-iron base which supports the head casting. It is mounted on a pivoted base to allow ready adjustment or removal of the belt. All openings in the base are fitted with louvred covers, and the drive and flywheel are completely enclosed by a two-piece guard of sheet steel. To control the length of the swaged portion of the bar or tube, the hollow spindle has an adjustable centre tube, fitted with a stop end. The machines can be supplied with or without mechanical, hydraulic or pneumatic stock-feeding mechanism.

A feature of note is the inclusion of an air-operated silencing device, which positively closes the dies and relieves the hammer blocks from the striking rollers when the machine is running, but not swaging. When swaging, the dies and hammer blocks are automatically released, so that, in feeding the work-piece forward, no additional force is needed to overcome the relieving mechanism. No wear can occur except when the machine is swaging and there is practically no noise when it is idling. A Norgren "Vitalizer" is incorporated in the air-supply line, so that an oil mist ensures constant lubrication of the guide faces of the dies and hammer blocks, and also of the main roller race carrying the striking rollers. An auxiliary feed from the main air supply is connected to the rear end of the hollow spindle and, under the control of a hand valve, directs a blast of air, cleaned by the Vitalizer, on to the dies to dislodge any swarf adhering to the die faces. These features, which are standard equipment on the No. 1 S.I. machine, may be added to the existing types of rotary-spindle machines if desired.

SIGNALS RESEARCH AND DEVELOPMENT ESTABLISHMENT.

THERE are, in all, five Government establishments in Britain which are engaged in developing communications and radar equipment for the fighting Services. Although much of the equipment used by the three Services is basically similar in design and employs the same fundamental principles and techniques, the uses to which it is put and the requirements which it has to fulfil in service are sufficiently diverse to warrant and, indeed, make imperative a separate effort to meet the needs of each service. This is not to say, however, that inter-Service collaboration does not exist. In fact, the work done for the Army and the Air Force is the responsibility of the Ministry of Supply and is administered under a single controller and a principal director, who maintain close relations with the corresponding naval authorities. There are, besides, regular meetings of the heads of the establishments.

It goes without saying that the effectiveness of a fighting force depends largely on the efficiency of its communications. This is particularly true of the army under modern conditions of land warfare. The Signals Research and Development Establishment, which is situated at Christchurch, and caters for the needs of the Army, was originally the Signals Experimental Establishment and developed as an offshoot from the Inspectorate of Engineering and Signals Stores. Both were administered under the War Office until their transfer to the Ministry of Supply during the second World War. The Signals Experimental Establishment was initially at Woolwich, but was later moved to Horsham and thence to its present site. The work of the Establishment is shared by four divisions concerned with research, development, engineering and technical services, respectively, but the partition is by no means rigid. Research is encouraged wherever the need for it arises, provided the requisite facilities exist, and some projects which begin as research are pursued into the development stage within the research division.

Line signalling is the oldest form of electrical communication and the line equipment used by the Army is of wide variety. It ranges from simple telephonic connections between two points to trunk networks, and from hand-keyed Morse to automatic telegraph machines. The Lines Group at the Signals Research and Development Establishment (S.R.D.E.) is concerned with the development of the lines and the associated equipment, the ultimate aim being to produce wire and cable with improved transmission characteristics for a given size and weight, and to devise faster methods of laying cable or erecting overhead lines. At the present time, five new types of cable and three new types of overhead supports are being developed.

Line circuits equipment not only involves considerable provision and maintenance, but is also heavy and bulky when it has to be transported. It is important, therefore, that it should be efficient. Improved telephone switchboards, signalling units, carrier-telephone equipment, audio repeaters, carrier-telegraph equipment and machine-telegraph instruments are all under development at S.R.D.E. A two-wire audio repeater which has been produced makes high-quality telephony possible over 25 miles of field cable, and, because each unit effectually provides a four-wire circuit, a number may be connected in series when a greater distance has to be covered. A page-teleprinter which has also been developed weighs only 47 lb., complete with its dust-proof and immersion-proof covers, as compared with 190 lb. for the present Army teleprinter and case. The new machine is also 50 per cent. faster in its action. Equipment for testing telephone and telegraph instruments and circuits has also been developed at the establishment. The Lines Section also undertakes research, and recent work in this category includes an attempt to synthesise speech from a number of slowly varying components. The ultimate aim is to reduce the frequency band-width necessary for intelligible telephony, so that a single line may be used for multiple communication.

Under modern battle conditions, words of command and other oral messages must often be given by telephone, and must be clearly understood even when the background of acoustical and electrical noise is considerable. A tank commander, for instance, on suddenly seeing an enemy tank or anti-tank gun, must take immediate action, and his orders to the loader and gunner must be intelligible at once. The acoustic problems associated with army communications are the responsibility of the Electro-Acoustics Group at S.R.D.E., the function of which is to ensure that the wireless and line equipment developed at the establishment is provided with suitable microphones, telephone receivers and loudspeakers. A detailed study is being made of oral communication in noisy surroundings, the work being conducted in armoured fighting vehicles under field conditions and also under controlled conditions in the laboratories at Christchurch. Facilities have been provided for producing noise of the character and intensity experienced in armoured fighting vehicles and also for conducting speaking and listening tests with or without superimposed electrical interference. Among other work undertaken by the Electro-Acoustics Group is the development of loudspeaking equipment and loud-hailers. Research and development work is also in progress on magnetic-tape recording.

The development of new wireless sets for the Royal Corps of Signals and for regimental use is the responsibility of the Radio Group at S.R.D.E. The signals equipment consists of multi-channel micro-wave and very-high-frequency sets for use in difficult terrain where land lines are out of the question or where speed of installation is of great importance. Regimental sets are intended for use in forward battle-areas and are of four types, namely, company to platoon infantry man-pack sets; battalion to company infantry man-pack sets; vehicular sets for short or medium ranges; and vehicular sets for longer ranges. Except for the last, which are amplitude-modulated and work on normal high frequencies, the regimental sets use very high frequencies and frequency modulation.

Considerable progress has been made in improving the efficiency and reducing the bulk and weight of the sets. The newer models are hermetically sealed and are capable of withstanding extremes of climate in all parts of the world. Another important feature of the sets is that they do not require to be tuned to the distant transmitter by the user. Each set is free-tuned and contains a crystal calibrator to which the local oscillator is aligned, and the radio-frequency and oscillator circuits have been made sufficiently stable to make frequent checking of the tuning unnecessary. When such tuning is necessary, each set can be tuned to the correct frequency without reference to any other set and without requiring the transmitter to radiate. The Radio Group also undertakes the development of test equipment suitable for maintaining the new sets.

The high mobility of the modern army calls for equipment which is easily portable, easy to erect and dismantle, able to withstand rough usage and capable of repeated use. Mention has already been made of hermetic sealing as applied to radio sets. The possibility of the equipment having to survive immersion in water during a beach landing, or river-crossing, has also to be considered. The waterproofing of equipment, such as wireless sets, telephones, switchboards, teleprinters, motors and generators is the task of the Vehicle Fitting Group within the Engineering Division at S.R.D.E. Waterproof containers require to be easily stowable and transportable. They must also be easy to fit and remove, suitable for repeated use, and, in certain instances, so designed that the equipment can be operated through the container when immersed. Many ingenious types of container have been devised to meet these requirements.

Considerable advances have also been made in the design of aerial masts suitable for rapid erection in difficult country. The older forms of mast were assembled on the ground before erection, a procedure which sometimes required the clearance of a considerable area of bush or woodland and often resulted in detection by enemy aircraft. Towards the end of the second World War, and since its conclusion, various types of aerial have been developed which involve a top load on the mast which may be as much as 250 lb. Clearly, such a load could not be raised by the older methods. A mast was, therefore, developed at S.R.D.E. capable of meeting all requirements and suitable for vertical assembly. By its use, extensive clearance of the surrounding ground is unnecessary. A 70-ft. mast of this type can be erected in a few minutes by a team of six men, and the height may be extended to 100 ft. when ten men are available, the four additional men being required to control a second set of guy-wires which are then necessary. A mast covering the range from 30 to 50 ft., and capable of erection by three men has also been produced. It can carry a top load of up to 50 lb. at heights not exceeding 36 ft. A 30-ft. telescopic aerial-mast, which has also been developed, can be attached to any fighting vehicle and extended when it is desired to increase the range of the wireless set. When suitably insulated at its base, the mast itself can be used as an aerial. It can also be used as a groundmast and can be erected by one man if a spike, supplied as part of the kit, is first driven into the ground.

The packing and protection of equipment and stores, to prevent their damage or deterioration in transit or in storage at their destination, is an important matter. Much of the equipment used in the earlier stages of the second World War suffered severe damage and, in some instances, 90 per cent. of stores were considered useless on their arrival. Great progress has been made, however, in developing protective coatings and cushioning equipment, so that, although packaging costs have increased, the loss of equipment by damage or deterioration is now very small. Work in this category is the responsibility of the Pan-Climatic Packaging Group at S.R.D.E. During the group's investigations, equipment which simulates conditions of storage and transport in the Services has been developed and installed in the laboratories, and all prototype equipment is subjected to extensive mechanical shock and pan-climatic storage tests.

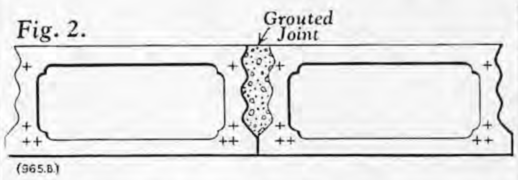
(To be continued.)

TESTS OF CONCRETE FLOOR BEAMS.

CONCRETE LIMITED, HOUNSLOW, MIDDLESEX.

Fig. 1. Set of Beams on Test-Bed.

Fig. 2.



TESTS OF PRE-CAST PRESTRESSED CONCRETE FLOOR BEAMS.

For many years Messrs. Concrete Limited, Hounslow, Middlesex, have been manufacturing and fixing hollow pre-cast reinforced-concrete beams, which are placed side by side to form floor slabs for warehouses and other structures, the floors so formed having been known by the trade name "Bison." More recently, since 1948, in fact, they have been making similar floor beams in prestressed concrete and, in order to check the effectiveness of the prestressed reinforcement, it has been the practice of the firm to take daily one or more beams from each batch and subject them to a bending load sufficient to cause cracking.

The beams are made in units 14 in. wide and from $4\frac{1}{4}$ in. to $8\frac{1}{2}$ in. deep, of the required length up to 40 ft. The sides of the beams are formed with longitudinal corrugations and the beams are placed side by side to form a slab of the required width, the space between each pair being grouted up as shown in the sketch, Fig. 2. In this sketch, the positions of the prestressing wires are indicated by small crosses. In design, the grouted joint is not considered to contribute to the resistance to bending stresses, but is allowed for in calculating the shear resistance. The compressive stress in the concrete due to the tension in the steel wires is normally under 1,500 lb. per square inch, but in exceptional cases a compressive stress of up to 2,000 lb. per square inch may be allowed. The prestressing wires are usually of 10 s.w.g. (0·128 in. diameter) and are specially treated to ensure an effective bond between the wire and the concrete. Some beams have been made with prestressing wire of 0·200 in. diameter. The wire is tensioned to 60 per cent. of the ultimate strength of the steel, but in calculations the tension is taken as 50 per cent. of the ultimate strength, the difference being allowed for losses due to creep, shrinkage, etc.

The daily routine tests are carried out in the works within a few days of manufacture, and usually within 24 hours of stripping from the mould; the general practice is to test about one in ten. Those of the worst appearance are always selected for testing, and in some cases beams previously condemned as completely sub-standard have been included. In view of these circumstances, it is considered safe to assume that the average results obtained in a large number of such tests are below the normal standard to be expected.

The method of testing is to support the beam at each end, giving it a 2-in. bearing, and apply the load equally to the third points, so as to give a uniform bending moment between them. The load is applied by a hydraulic recording jack, which is calibrated at regular intervals, and the deflection is measured at the centre of the beam by means of a dial gauge. The general arrangement of the test

TESTS OF PRESTRESSED CONCRETE FLOOR BEAMS.

CONCRETE LIMITED, HOUNSLOW, MIDDLESEX.

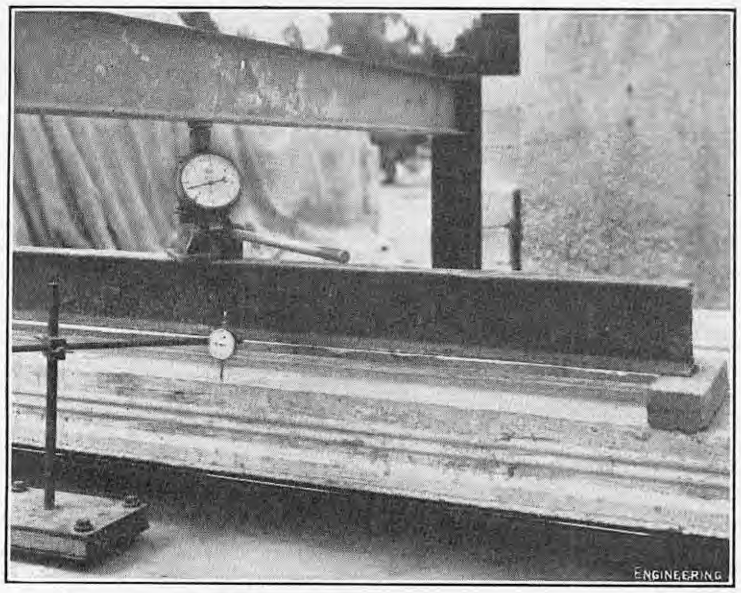


FIG. 3. BEAM DEFLECTED 0·452 IN.

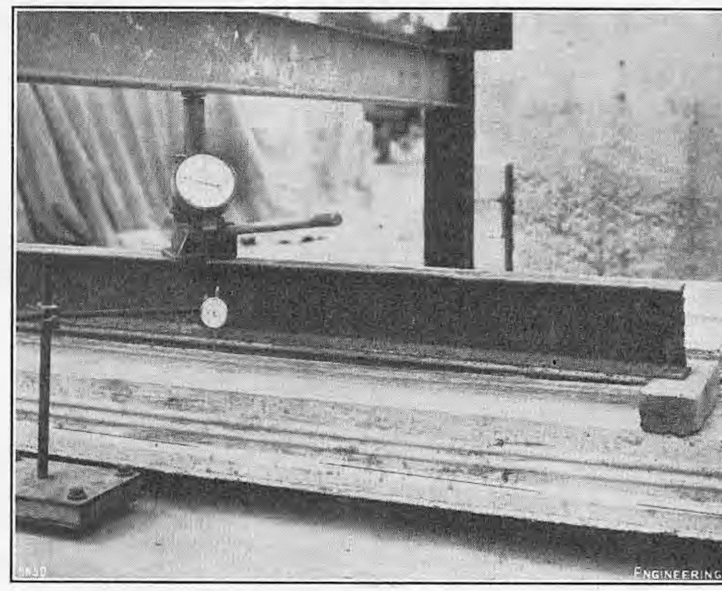


FIG. 4. BEAM DEFLECTED 3 IN.

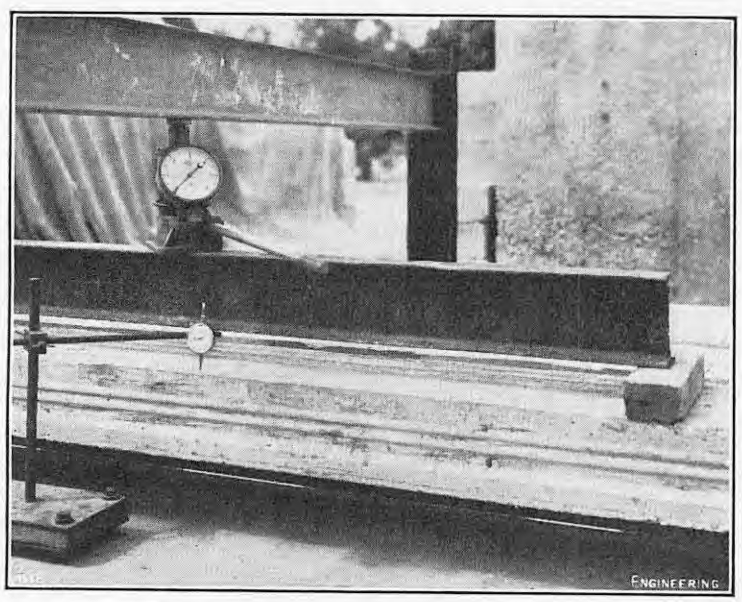


FIG. 5. LOAD REMOVED; DEFLECTION 0·260 IN.

bed is illustrated by the photograph reproduced in Fig. 1. The loading is continued until the beam cracks, this point being indicated by an increase in the rate of deflection as compared with the rate of loading; in this way the cracking point is obvious before visible cracks appear. The load is then removed and the permanent deflection noted. If this is less than 15 per cent. of the maximum deflection, recovery is considered to be complete.

Figs. 3 to 5 illustrate the various stages of a routine test. The four beams shown in position for testing in Fig. 1 are 20 ft. in length and $6\frac{1}{4}$ in. deep, the testing load, of course, being applied to one beam only. A tightly stretched horizontal cord, partly black and partly white, can be distinguished near the lower edge of the foremost beam in Fig. 1, indicating that a camber of about $\frac{3}{4}$ in. is provided. Fig. 3 shows the beam loaded to 1·5 times the designed resistance moment, which is three times the superficial load the beam is designed to support. The deflection in this case is 0·452 in. In Fig. 4, the load has been increased to give 2·25 times the designed resistance moment, or five times the designed superficial load. The deflection with this load is 3 in., and in the original photograph numerous cracks can be seen in the lower edge, although they are hardly visible in the reproduction. The load had been removed before the photograph reproduced in Fig. 5 was taken and the beam had recovered to a deflection of 0·260 in. The cracks had closed up completely. The stretched cord was not moved throughout the test, so that its position relatively to the lower edge of the beam is an indication of the deflection.

A total of 1,030 beams were tested in this way and none was found to crack before the designed safe load had been applied. Only 24 did not recover completely and of these nine failed on cracking and 15 recovered partially. It should be noted, however, that the 24 beams which did not show a satisfactory recovery had all been condemned before testing for obvious faults, such as holes in the vertical sides. The results of the complete series of tests may be summed up as follows. Taking R as the ratio of the bending moment at which cracking occurred, as defined above, to the design resistance moment, no cracking occurred at values of R of less than unity, as previously mentioned; 45 beams cracked at values of R between 1·00 and 1·25; 179 at values between 1·25 and 1·50; 500 at values between 1·50 and 1·75; 220, at values between 1·75 and 2·00, and 86 at values of R exceeding 2·00. The makers particularly emphasise that a prestressed beam is not harmed by being cracked and is only destroyed by very greatly increased loading.

This will be apparent from the results of a series of tests carried out on 50 beams, all over one year old and some up to three years old. These beams were surplus to contract requirements and had been left in the open exposed to the weather from the time they were made until they were tested. Most of them were tested to failure, but some which had not failed when the limit of the stroke of the jack had been reached were regarded as having failed at the maximum load reading obtained. These beams ranged from 8 ft. to 45 ft. in length and the designed floor loads varied from 20 lb. to 600 lb. per square foot. In these tests, 27 beams failed at values of R ranging from 2·00 to over 3·00, the failures being: three at values of R between 2·00 and 2·25; four between 2·25 and 2·50; ten between 2·50 and 2·75; three between 2·75 and 3·00; and seven at over 3·00.

An analysis of the causes of failure showed that 10 were due to the wires breaking, nine were caused by crushing of the concrete, two were due to slipping between the wires and the concrete, two as a result of shear at the point of application of the load, and four were caused by the walls splitting horizontally; the remaining 23 did not fail with a deflection of 6 in. The makers point out, however, that shear at the point of loading and horizontal splitting of the walls would not be likely to occur in a complete floor carrying a uniformly distributed load. It is clear that of these two causes of failure in the tests, the first is due mainly to the fact that the maximum bending moment and maximum shear occur at the same point and the second would be prevented by the grouting between the joints.

The conclusions which the makers draw from the test results recorded above, which were carried out under the direction of Mr. K. M. Wood, managing director of the firm, are that, at maturity, the prestressed beams have about the same factor of safety as normal reinforced-concrete or steel beams; and that the deflections recorded up to the cracking point are less than for equivalent reinforced-concrete or steel beams. There is no risk of cracking when the safe load is applied and there is a substantial warning period between cracking and failure when considerable deflection and cracking are visible without permanent damage to the beam. It is also considered that the provision for losses due to shrinkage, creep, etc., is adequate, and that the special treatment of the reinforcing wires effectively prevents bond slip. Finally, it is stated that some of the beams that had been stored in the open for two or three years showed no sign of rusting of the reinforcement when broken open.

FLEXIBLE CURVED WOOD PANELLING.—A range of machine-made decorative flexible wood panelling, which can be curved, has been introduced by H. Morris and Co. Ltd., 147, Milton-street, Glasgow, C.4. It is available in thicknesses of $\frac{3}{8}$ in., $\frac{1}{4}$ in. or $\frac{1}{16}$ in., and can be supplied with oak, mahogany or walnut veneers, plain or with a choice of four surface designs. A fire-proofed and tropicalised version is available for use in ships.

CLOSING OF RAILWAY BRANCH LINES IN WALES.—In a written answer to a Parliamentary question on July 24, Mr. Alan Lennox-Boyd, Minister of Transport, stated that the British Transport Commission had authorised the closing of 12 railway branch lines for passenger services in Wales and Monmouthshire since the end of 1949. The Transport Users' Consultative Committee for Wales had heard objections in respect of six of these proposals, and, in all these cases, had endorsed the Railway Executive's suggestions.

MECHANISMS FOR INTERMITTENT MOTION.

By O. Lichtwitz, M.I.Mech.E.

(Concluded from page 125.)

Intermittent Gears for Crossing Shafts.

Crossing shafts, that is, shafts which are inclined to each other, but do not intersect, can be connected by intermittently working gears, though designed on other principles than those for parallel shafts. The driving member of the gear shown in Figs. 59 and 60, herewith, is virtually a cylindrical or drum cam which drives the followers mounted on the disc of the driven member. The drum has a ridge which extends round more than the circumference, and which engages the rollers. Part of the ridge is in a plane perpendicular to the axis of the drum. Its width is equal to the distance between the rollers, and it serves for locking the driven disc. The two ends of the ridge are curved outwards, and the distance between the two branches there is equal to the diameter of the rollers, or slightly more. The driven gear is rotated by the interaction of the curved portion of the ridge with the rollers. As the ridge thus serves both for moving and for locking, it ensures a positive movement of the driven member. The rollers should really be conical, with the apex on the axis of the drum. Cylindrical rollers are simpler, however, and do not noticeably increase wear if they are kept short.

In the case of Geneva mechanisms, the course of the movement is determined merely by the choice of the partial movement, that is, by the choice of n. In the case of star-wheel mechanisms, either the ratio μ or the ratio ε can be chosen in addition to the partial movement. Intermittent gears for crossing shafts allow the still greater freedom of choosing the course of the movement. The lay-out of such gears is, therefore, based on kinematical considerations. There are two approved methods in cam design, one of imparting to the follower a uniformly accelerated and retarded motion, and the other of imparting a harmonic motion. The cams for the purpose under consideration can also be laid out as cycloidal cams, a form which has been dealt with in the literature in recent years. In this case, the maximum acceleration exceeds that of the two groups discussed here; however, in contrast to the cams of these two groups, the acceleration at the start and at the end of the motion is zero, and the course of the acceleration is continuous throughout. Further characteristics to be outlined here only for the uniform acceleration and the harmonic forms can also be applied, with the necessary modifications for the cycloidal.

If the proportion of motion in one revolution of the driving gear is ν, the motion occupies the angle $2\pi\nu$ radians of the driving gear. With n rollers, one partial movement of the driven gear is $\frac{2\pi}{n}$ radians. Figs. 61 to 63, herewith, show the characteristics of the two motions for the same angle $2\pi\nu$ of the driving cam, and for the same angular displacement $\frac{2\pi}{n}$ of the driven disc. The full line for the angle β consists of two parabolic arcs and represents the uniformly accelerated and retarded motion. The dotted line for the angle β is part of a sine-curve, and represents the harmonic motion.

In both cases, the angular velocity $\frac{d\beta}{d\alpha}$ has a maximum at the central position, the value for the sine-curve being the lower one.

The angular acceleration $\frac{d^2\beta}{d\alpha^2}$, in the case of uniformly accelerated and retarded motion, has a constant value which changes abruptly at the central position into a constant angular retardation of the same amount. In the case of the harmonic motion, the angular acceleration is a continuous curve, with a gradual transition from positive to negative values. The extreme values, however, are higher than the constant values in the uniformly accelerated and retarded motion. Both types of motion thus have merits.

If the left-hand ends of the graphs in Figs. 61 to 63 are taken as the origins, the equation of the left-hand parabola is $\beta = c\,\alpha^2$, and the constant c is obtained by associating the value $\pi\nu$ of α at the central position with $\beta = \frac{\pi}{n}$. Hence

$$\beta = \frac{1}{\pi n \nu^2}\alpha^2. \quad . \quad . \quad . \quad (54)$$

If unit angular velocity of the driving cam is assumed, the numerical value of the angular velocity of the driven disc is

$$\frac{d\beta}{d\alpha} = \frac{2}{\pi n \nu^2}\alpha, \quad . \quad . \quad . \quad (55)$$

and the angular velocity in the central position $\alpha = \pi\nu$ is

$$\left(\frac{d\beta}{d\alpha}\right)_0 = \frac{2}{n\nu}. \quad . \quad . \quad . \quad (56)$$

The angular acceleration and retardation have the constant value

$$\frac{d^2\beta}{d\alpha^2} = \frac{2}{\pi n \nu^2}. \quad . \quad . \quad . \quad (57)$$

Again, with the left-hand end of the graph as origin, the sine-curve is $\beta = c\,(1 - \cos c'\,\alpha)$, wherein c and c' are constants to be determined. At the end of motion, $\alpha = 2\pi\nu$ and $c'\alpha = \pi$, so that $c' = \frac{1}{2\nu}$. Since at the same instant $\beta = \frac{2\pi}{n}$, $c\,(1 - \cos\pi) = 2c = \frac{2\pi}{n}$, or $c = \frac{\pi}{n}$. The relation between β and α is, therefore,

$$\beta = \frac{\pi}{n}\left(1 - \cos\frac{\alpha}{2\nu}\right) \quad . \quad . \quad (58)$$

The angular velocity is

$$\frac{d\beta}{d\alpha} = \frac{\pi}{2n\nu}\sin\frac{\alpha}{2\nu}, \quad . \quad . \quad (59)$$

and its amount in the central position is

$$\left(\frac{d\beta}{d\alpha}\right)_0 = \frac{\pi}{2n\nu}. \quad . \quad . \quad (60)$$

The angular acceleration is

$$\frac{d^2\beta}{d\alpha^2} = \frac{\pi}{4n\nu^2}\cos\frac{\alpha}{2\nu}, \quad . \quad . \quad (61)$$

and its maximum, at $\alpha = 0$, is

$$\left(\frac{d^2\beta}{d\alpha^2}\right)_{\max.} = \frac{\pi}{4n\nu^2}. \quad . \quad . \quad (62)$$

A comparison between (56) and (60) shows that the ratio of the maximum angular velocities for harmonic, and uniformly accelerated and retarded motion is $\frac{\pi}{4} \simeq 0{\cdot}7854$. A comparison between (57) and (62) shows that the ratio of the maximum angular accelerations for harmonic, and uniformly accelerated and retarded motion is $\frac{\pi^2}{8} \simeq 1{\cdot}2337$. As an example, we may investigate the kinematic properties of intermittent gears for crossing shafts, with $n = 6$ rollers, and $\nu = \frac{1}{2}$, assuming the angular velocity of the driving gear to be $\omega = 1$ radian per sec.

Considering first uniformly accelerated and retarded motion, the maximum angular velocity (56) is $= 0{\cdot}667$ radians per sec. The angular acceleration and retardation (57) are $= 0{\cdot}424$ radians per sec.². For harmonic motion, the maximum angular velocity (60) is $0{\cdot}524$ radians per sec. and the maximum angular acceleration (62) is $0{\cdot}524$ radians per sec.².

If there is a large number of rollers, the developed curve along which the centres of the rollers are moving relatively to the driving cam resembles the two parabolas or the sine-curve, and the developed contours of the ridge are obtained from the envelope of all circles which have their centres on the curve and their diameter equal to that of the rollers. The method of constructing the parabolas or the sine-curve will be assumed known. When the number of rollers is small, it is advisable to construct the developed centre line of the groove more exactly, as indicated in Figs. 64 and 65, herewith.

If the motion is intended to be uniformly accelerated and retarded, the arc 1-9, in Fig. 64, along which the rollers travel in one partial movement, is divided into, for instance, 32 (or in general $2x^2$) equal parts; the arcs 1-2 and 9-8 are made equal to one of these parts, the arcs 2-3 and 8-7 equal to three parts, the arcs 3-4 and 7-6 five parts, and the arcs 4-5 and 6-5 seven parts. The distance 1′-9′ is made equal to the developed circumference of the part of the driving cam during which motion takes place, and it is divided into 8 (or in general $2x$) equal parts. A circle of radius equal to the pitch radius of the rollers and having its centre at the

MECHANISMS FOR INTERMITTENT MOTION.

Fig. 59.

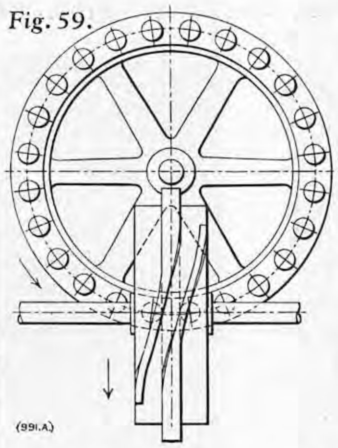


Fig. 60.

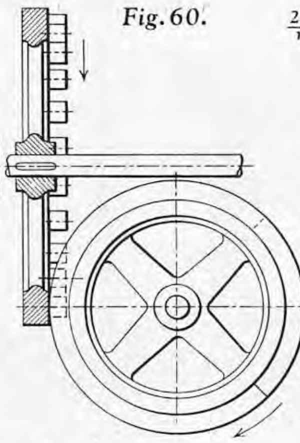
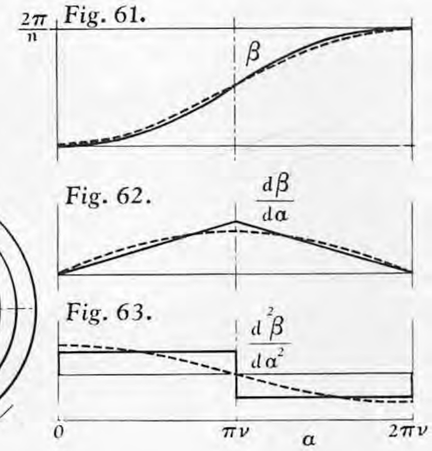


Fig. 61. Fig. 62. Fig. 63.



(991.A)

Fig. 64.

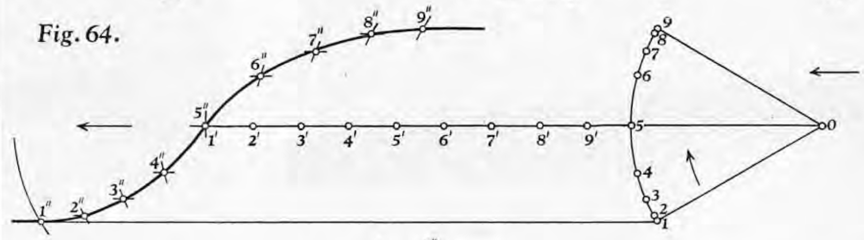
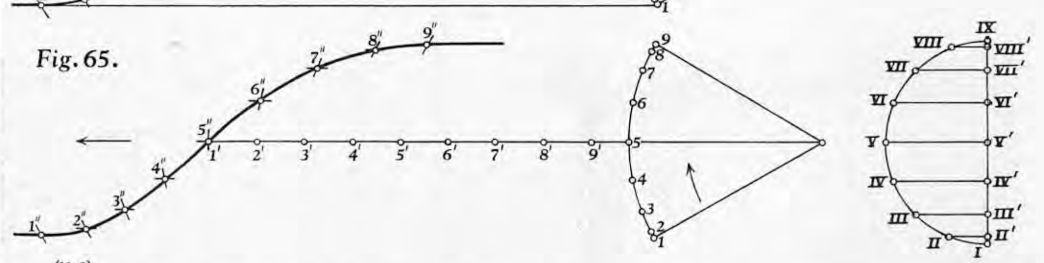


Fig. 65.



(991.C)

MECHANISMS FOR INTERMITTENT MOTION.

Fig. 66.

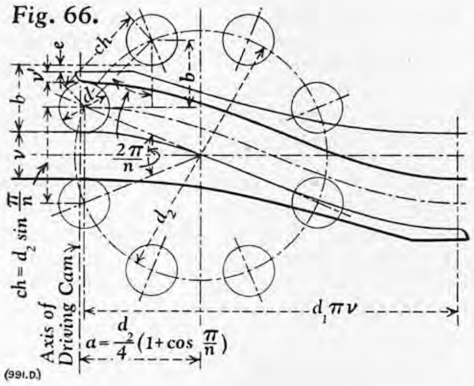


Fig. 67.

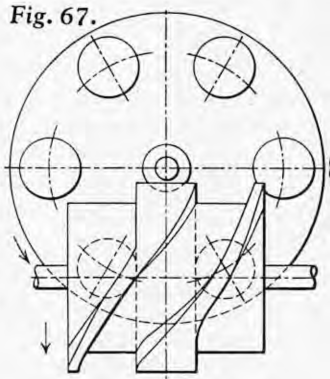


Fig. 68.

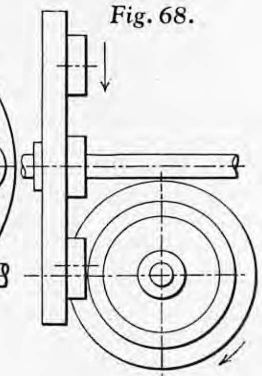


Fig. 69.

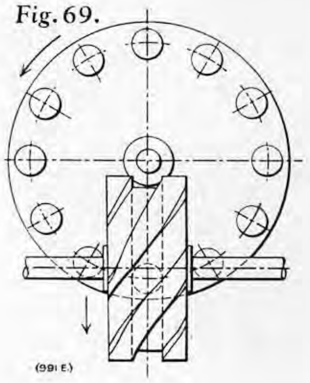


Fig. 70.

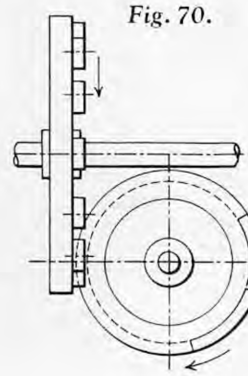


Fig. 72.

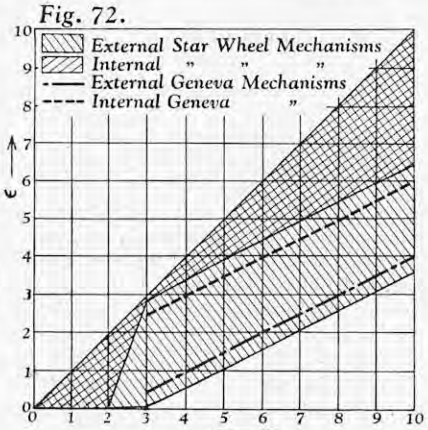
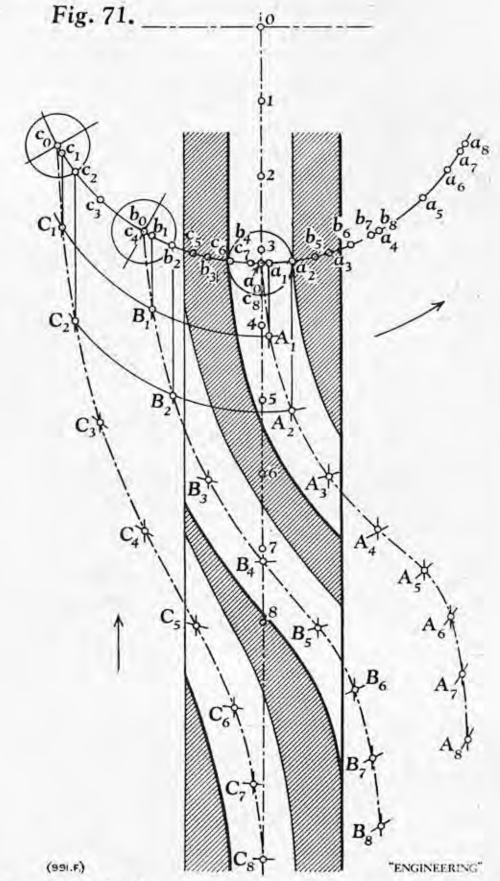


Fig. 71.



point 1′, and a straight line parallel to 1′-9′ through the point 1 intersect in the point 1″. This and other points similarly constructed determine the developed centre line of the groove.

If a harmonic motion is required, a circle is described the diameter, I-IX, of which equals the length of the arc 1-9, in Fig. 65, along which the rollers travel in one partial movement. Half of the circle is divided into 8 equal parts, and the points II, III, etc., are projected on to the diameter I-IX. The arc 1-9 is now divided into 8 parts by making the arc 1-2 equal to I-II′, the arc 2-3 equal to II′-III′, etc. In other respects, the construction of the centre line of the groove is the same as described above.

The formulæ obtained earlier show that the kinematic properties are independent of the diameter d_1 of the driving cam, the pitch diameter d_2 of the driven disc, and the diameter d of the rollers. These dimensions can be chosen arbitrarily, and the following observations may be of assistance in design work. A large diameter d_1 reduces the inclination of the ridge, and since the inclination has a similar significance to the angle of a wedge, or the helix angle of a screw thread, the pressure between the cam and the followers decreases with increasing diameter d_1.

The length of the curved portion of the ridge in Fig. 66, herewith, is $d_1\pi\nu$ (corresponding to the angle $2\pi\nu$ in the graphs of Figs. 61 to 63). The lift of the cam is $d_2 \sin\frac{\pi}{n}$, corresponding to the angle $\frac{2\pi}{n}$ in the same figures. If $\frac{d_1\pi\nu}{d_2\sin\frac{\pi}{n}}$ is approximately 4 in the case of the sine-curve, and approximately 5 in the case of the two parabolic branches, the maximum inclination, that is, the inclination in the central position, is less than 22 deg. in both cases. From this point of view, the sine-curve is preferable if space is limited. The advantage of a large diameter d_1, which has been mentioned above, is counterbalanced in some cases by disadvantages. For instance, if d_1 exceeds d_2, the driven shaft cannot be extended beyond the driving gear. In many cases of small values for ν and n, it is necessary to make a compromise by reducing the values of $\frac{d_1\pi\nu}{d_2\sin\frac{\pi}{n}}$ recommended above.

As the rollers move along an arc, their axes cannot point continuously towards the axis of the driving cam. The effect of this is minimised if the axis of the driving shaft lies midway between the extreme positions of the rollers. As Fig. 66 shows, the distance between the driving and driven shafts, in this case, is

$$a = \tfrac{1}{2}\left(\frac{d_2}{2} + \frac{d_2}{2}\cos\frac{\pi}{n}\right) = \frac{d_2}{4}\left(1 + \cos\frac{\pi}{n}\right). \quad (63)$$

Fig. 66 also shows that the chord ch is

$$c\,h = d_2 \sin\frac{\pi}{n} = d + r.$$

If the diameter d of the rollers, and the thickness r of the ridge are assumed to be equal,

$$2\,d = 2\,r = d_2 \sin\frac{\pi}{n},$$

or

$$\frac{d}{d_2} = \frac{r}{d_2} = \tfrac{1}{2}\sin\frac{\pi}{n}. \quad (64)$$

The thickness r' at the ends of the ridge must be small enough for there to be no interference between the outer contour of the ridge and the roller behind the one being moved by the ridge. As a guide to design, r' may be equal to $\frac{d}{4}$. Fig. 66 shows that $\frac{b}{c\,h}$ equals $\cos\frac{2\pi}{n}$. The distance e is zero if $b = d + r'$. With $r' = \frac{d}{4}$, or $b = 1{\cdot}25\,d$, and $ch = d + r = 2d$, $\cos\frac{2\pi}{n} = \frac{b}{c\,h} = \frac{1{\cdot}25}{2} = 0{\cdot}625$, so that n is approximately 7.

To prevent interference when there is a small number of stations, r' may be reduced to less than $\frac{d}{4}$, the diameter of the rollers may be reduced and the thickness r of the ridge correspondingly increased, or the height of the rollers may be reduced. Figs. 67 and 68, herewith, show that mechanisms with six rollers are possible, but this number is best regarded as the lower limit. Mechanisms with one or two rollers are excluded altogether.

As an example, we may consider the design of intermittent gears for crossing shafts for the case $n = 24$, $\nu = \frac{1}{4}$ shown in Figs. 59 and 60. The driven shaft is to be of $1\frac{1}{2}$ in. diameter, and is to cross the driving cam. The diameter of the rollers is to be $d = 1\frac{1}{4}$ in.

By (64), the pitch diameter of the rollers is $d_2 = \frac{2 \times 1{\cdot}25}{\sin 7\frac{1}{2}\text{ deg.}} = 19{\cdot}153$ in. As the ridge may be thinner than $1\frac{1}{4}$ in., d_2 may be assumed somewhat smaller, for instance, 18 in. The chord, therefore, is $ch = 18 \sin 7\frac{1}{2}$ deg. $= 2{\cdot}350$ in., and the thickness of the ridge is $r = 2{\cdot}350 - 1{\cdot}250 = 1{\cdot}100$ in. By (63), the distance between the driving and driven shafts is $a = \frac{18}{4}\,(1 + \cos 7\frac{1}{2}\text{ deg.}) = 8{\cdot}961$ in. There is no objection to making it 9 in.; the axis of the driving shaft then does not lie midway between the extreme positions of the rollers but, instead, touches the pitch circle of the rollers.

The diameter of the driving cam must be smaller than $2a - 1{\cdot}5 = 16{\cdot}5$ in., in order to let the driven shaft pass; it may be made 16 in. The ratio $\frac{d_1\pi\nu}{d_2\sin\frac{\pi}{n}}$ is $5{\cdot}349$, which indicates that either a uniformly accelerated and retarded motion or a harmonic motion can be used. With the lift of the cam equal to $2{\cdot}350$ in., and the developed length $\frac{16\pi}{4} = 12{\cdot}566$ in., the maximum wedge angle, in the case of a uniformly accelerated and retarded motion, is 20 deg. 30 min, because $2 \times \frac{2{\cdot}350}{12{\cdot}566}$ is the tangent of this angle. In the case of harmonic motion, it is 16 deg. 22 min, since $2 \times \frac{2{\cdot}350}{16}$ is the tangent of this angle.

The proportion of motion in one revolution of the driving gear can be chosen to suit any requirements between $\nu_{max.} = 1$ and $\nu_{min.} = 0$, corresponding to $\varepsilon_{max.} = n$ and $\varepsilon_{min.} = 0$. In the former case, the ridge of the driving cam is curved throughout, and the driven gear is slowed down periodically to zero velocity, without remaining at rest. In the other extreme case, the driving gear is straight, and works like a rack.

The basic principle of the mechanisms considered previously can be modified in several ways. For instance, the cam can be designed in such a way that the ridge has more than one straight and one curved portion, so that the driven gear makes more than one partial movement during one revolution of the driving gear. The duration of the partial movements can be varied in this case. To some extent, also, it is possible to obtain varying partial movements. In what has been said previously, it has been assumed that one roller is guided between the flanks of two branches of the ridge, and that the straight part of the ridge acts as a locking device while running between two rollers. The arrangement can be inverted, without departing from the essentials of the mechanism, in such a way that two rollers are guided by the curved ridge, and two straight branches of the ridge serve for locking.

A modification which has no analogy in intermittent gears for connecting parallel shafts is shown in Figs. 69 and 70, on page 157. This mechanism is equivalent to that shown in Figs. 67 and 68, since $n = 6$, and $\nu = \frac{1}{2}$. The kinematic conditions of these mechanisms have already been investigated. The pitch of the rollers in Figs. 67 and 68 is rather coarse, and the whole mechanism is somewhat bulky.

In worm gearing, multi-start worms are used to reduce the pitch. The driven gear of Figs. 69 and 70 is equipped, similarly, with $2 \times 6 = 12$ rollers, and the driven gear is advanced two pitches during each partial movement. A duplication of the ridge with its two branches would be inconvenient. Instead, the driving gear is designed with a groove in the central position which locks a roller there. At the commencement of motion, this roller is moved first, and the two following rollers enter the grooves of the cam successively. At the conclusion of the motion, the first two active rollers have left the cam, and the third roller is in the central position, ready to be locked. The construction of the developed contour of the cam is made clear in Fig. 71, on page 157.

The rectified part of the circumference of the driving cam, which corresponds to the period of motion, is divided into, for example, 8 equal parts, marked 0, 1, 2, . . . 8. The pitch circle of the driven disc is described about the centre 0, and the centres of the three active rollers are drawn at the positions a_0, b_0, and c_0, at the commencement of motion. The arc $a_0\,a_8$, equal to two pitches of the rollers, is divided into 8 unequal parts marked a_1, a_2, etc., obtained in the way shown in Figs. 64 and 65. The path of the second roller $b_0\,b_8$, and of the third roller $c_0\,c_8$, is divided in the same way. Straight lines are drawn through the points a_1, b_1 and c_1, parallel to the direction of motion of the driving cam, and the pitch circle of the driven rollers is described about the centre 1. The points of intersection are marked A_1, B_1 and C_1. The procedure is repeated for the points 2 to 8. The lines connecting the points A, B and C, are the centres of the grooves.

Only the roller in the central position is supposed to be guided in the period of standstill, and the driving gear, therefore, is assumed to be of such a width that the two neighbouring rollers are not touched in that period. The roller B comes in contact with the cam between the positions 2 and 3, when the roller A is still in the groove. The roller C reaches the cam between the positions 4 and 5, when the roller B is still guided. In the meantime, roller A has left its slot. The continuity of motion is thus guaranteed, in spite of the comparatively narrow cam. The contours of the cam are obtained in the usual way as curves which envelop the positions of the rollers. The shape of the cam is unsymmetrical. The cam has two grooves, one for guiding the roller B, and one for guiding the rollers A and C.

Intermittent gears for crossing shafts have several features in common with worm or spiral gears. Just as right-hand and left-hand threads are used in these gears to obtain the required direction of motion, so also the inclination of the ridge of the driving cam can be varied to achieve the same result. As in worm gearing, the driving shaft can be arranged horizontally independently of whether a horizontal or a vertical shaft is to be driven. As in the case of worm or spiral gearing, adequate measures must be taken for taking up the axial thrust of the gears.

Comparison of Intermittent-Motion Mechanisms.

By way of conclusion, the various types of intermittent gears will now be compared. The movement of an intermittently rotating shaft is specified by the partial movement or by the number of stations n, and the ratio of the angles through which the driving and driven gears rotate during the period of motion. Formulæ (3) and (3a), on pages 453 and 485, of the previous volume, express, for external and internal Geneva mechanisms, linear relations between ϵ and n. The values of ϵ in Tables II and III, on the same pages, plotted against n, in the graph of Fig. 72, on page 157, lie on two straight lines, starting at the smallest possible number of stations, namely, three. Fractional values of n, relevant to some modified mechanisms, are disregarded.

Formulæ (28) and (28a), on pages 741 of the previous volume and page 91, *ante*, indicate that, for external and internal star-wheel mechanisms, ϵ depends on n and on μ, so that, for any value of n, there is a multitude of values ϵ. According to formulæ (30) and (30a), on page 742 of the previous volume and page 91, *ante*, the upper limit of ϵ is n, and that limit appears in Fig. 72 as a straight line at 45 deg. to the axes. The lower limits of ϵ are determined by formulæ (32) and (32a), on page 742 of the previous volume and page 92, *ante*. The values of $\epsilon_{\text{min.}}$ in Tables IV and VII, on the same pages, are plotted in Fig. 72, and the lines connecting these points are the lower limits of ϵ.

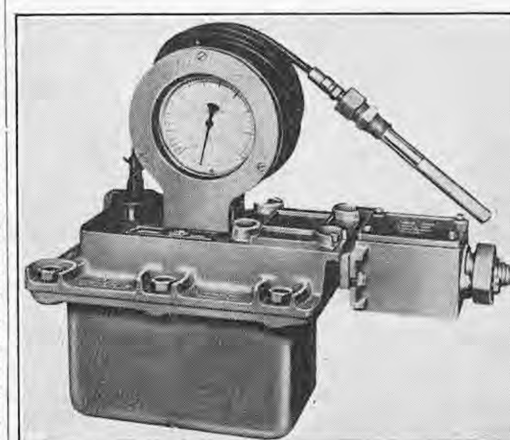
Fig. 72 shows that the external star-wheel mechanism is the most versatile, as its range includes those of the three other mechanisms considered. External Geneva mechanisms, internal Geneva mechanisms, and internal star-wheel mechanisms cover different ranges, and are not interchangeable. External star-wheel mechanisms, therefore, can be regarded as a universal means for imparting intermittent motion between two parallel shafts. Internal star-wheel mechanisms are not only useful where an internal drive is essential, but are often simpler than equivalent external star-wheel mechanisms, as there is a greater possibility of dispensing with special elements for imparting the uniform motion. External Geneva mechanisms are simple, and are to be used where the only value of ε for any particular number of stations is suitable. Internal Geneva mechanisms have a rather limited field of application, because the high values of ε can be reconciled with practical requirements only in a restricted number of cases.

The driving member of intermittent gears for crossing shafts can be designed for any value of ε between 0 and n. Intermittent gears for crossing shafts have, therefore, an even wider range of application than star-wheel mechanisms, and can be designed to have the best possible kinematic properties. Nevertheless, they cannot compete with Geneva or star-wheel mechanisms, because the number of driven rollers cannot be smaller than 3, and, in practice, not less than 6. Star-wheel mechanisms, on the other hand, with one or two locking shoes, are comparatively simple, but the difficulties and costs rise as the number of stations is increased. This remark also applies to Geneva-mechanisms. Provided that the arrangement of the shafts is not the decisive factor, therefore, the choice between gears connecting parallel and crossing shafts depends mainly on the number of stations, and the two groups of mechanisms are complementary. Although there is no hard and fast rule, the following scheme may serve as a guide. If the number of stations lies between 1 and 3, star-wheel mechanisms are suitable. For 4 to 6 stations, Geneva-mechanisms may be used. In the case of 6 or more stations, mechanisms for crossed shafts are advantageous. The bevel gears which have been considered should be used only if intersecting shafts cannot be avoided.

Regulations for the Electrical Equipment of Buildings.—The Wiring Regulations Committee of the Institution of Electrical Engineers frequently receive inquiries regarding the interpretation of certain of the rules. A digest of their replies to some of these inquiries has been issued and indicates not only the wide interest that is being taken in the conditions laid down, but the concern which exists that the installations should be safe. These interpretations, it may be pointed out, are of a general nature only, since the Institution naturally cannot undertake to comment on particular installations or upon types of equipment and material. Neither can it deal with differences of opinion between supply authorities and consumers. The answers reveal that, in general, the regulations have been wisely drafted, although in some cases clarification may be desirable.

FLAMEPROOF THERMOSTAT.

To protect air compressors employed in coal mines against excessive rises in temperature which may result from the ingress of dirt or from mechanical defects, the flameproof thermostat shown in the accompanying illustration has been developed by the Electrical Apparatus Company, Limited, St. Albans, Hertfordshire. The thermostat switch is enclosed in a flameproof housing which can be secured to a wall or a bracket. The switch is operated, through a 10-ft. length of armoured capillary tubing, by a temperature-sensitive phial inserted in the supply line, as close as possible to the compressor outlet.



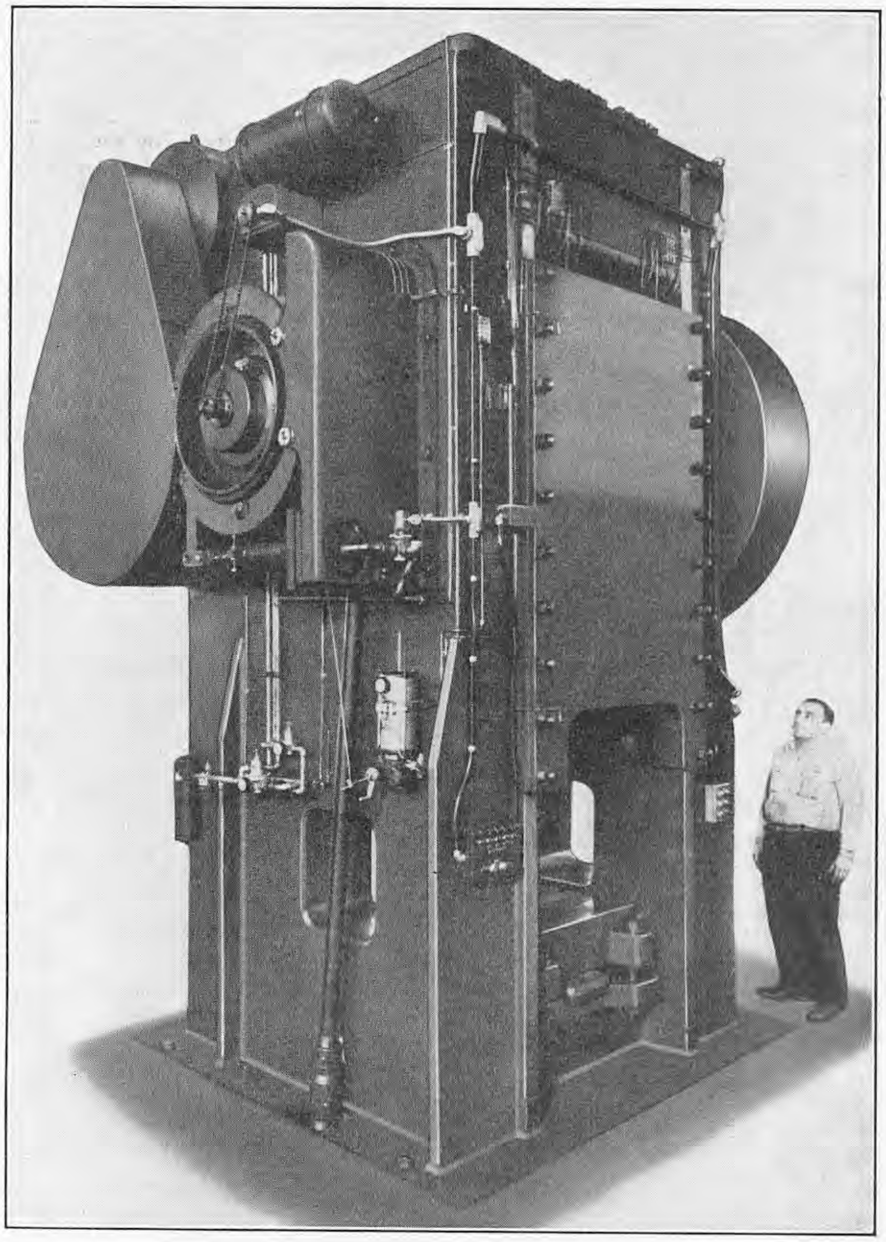
The thermostat switch comprises an air-break butt-contact switch, normally closed, and magnetically assisted to give a "snap" action. The switch opens when the pre-set temperature at the discharge point has been reached. The actual value of the discharge air temperature is indicated on a dial thermometer mounted on the thermostat housing. The thermostat setting is adjustable after removing the main cover. When installing the thermostat, the only external wiring required is a twin cable connection between the switch and the compressor-motor control gear. The unit weighs about 50 lb.

Institute of Metals Students' Essay Prize Competition.—The Council of the Institute of Metals are offering two students' prizes, each of 20 guineas, for the best essays submitted in English, not later than January 1, 1953, on a metallurgical subject but excluding extraction and ferrous metallurgy. The competition is open to student members and associate members of local sections of the Institute who are eligible for student membership, the age limits being from 17 to 25 years. Essays should be from 2,500 to 3,500 words in length and must not exceed 3,500 words. A students' essay prize for 1952 has been awarded to Mr. J. C. Wright, laboratory assistant, development and research department of the Mond Nickel Co. Ltd., Birmingham, for an essay on "The Metallographic Investigation of Failed High-Temperature Components." The prize of 20 guineas will be given in the form of 10 guineas in money and 10 guineas in books to be selected by the prize winner. Mr. Wright's essay will be printed in the September issue of the Institute's *Bulletin*.

Fatigue-Testing Laboratory: Errata.—Our attention has been drawn to two errors, which we regret, in the article on the fatigue-testing laboratory of the British Welding Research Association, which appeared on pages 12 and 13 of our issue of July 4. In the third paragraph, on page 12, it was incorrectly stated that jigs were used in the construction work. In fact, the connecting members were designed to be "self-jigging," were secured initially by single bolts and were later welded to the main members, the bolts then being removed. The reference, in the fourth paragraph, to bolted side connections should read "bolted site connections." We are also asked to mention that the gantry girders were designed after a strength analysis in which plastic deformation was assumed to occur under a factored load. It was found, however, that elastic instability would occur at a lower load. In connection with the account of the method of supporting the Losenhausen machine, it has been stated that this method was first employed in a similar instance by Mr. T. S. Robertson at the Naval Constructors Research Establishment, Rosyth.

HIGH-SPEED FORGING PRESS.

E. W. BLISS (ENGLAND) LIMITED, DERBY.



HIGH-SPEED FORGING PRESS.

THE high-speed forging press illustrated herewith is one of a new series of presses made by the E. W. Bliss Company, Canton, Ohio, U.S.A., which have capacities varying from 300 tons to 4,000 tons and are designed to work at maximum rates of 100 to 45 strokes per minute, respectively. The machine illustrated, which has a capacity of 1,600 tons and operates at rates up to 70 strokes per minute, is driven by a 100-h.p. electric motor. The die seating measures 38 in. by 46 in. The main drive is transmitted through an air-controlled clutch that permits high press speeds with only small clutch wear; the drive is provided with an air-release which is applied by a spring. Both the clutch and the brake are mounted on the main eccentric shaft. The welded-steel frame is designed with the main upright members located immediately on each side of the die seat and extending from the bottom of the bed to the top of the crown; these members have an exceptionally liberal cross-section to prevent undue elongation of the frame when the load is applied. A heavy front plate, integral with the front guides, is bolted to the main members and, together with side-to-side braces at the back, opposes distortion of the frame and retains the correct alignment of the slide-ways. The front of the slide has long continuous guides extending up to the crown to maintain the dies in true alignment when off-centre loads are applied.

The die seat is a self-contained unit, provided with an easily-operated wedge adjusting mechanism, so arranged that the die seat can be bumped to the correct front-to-back alignment without disturbing the adjusting mechanism. Wedges are inserted between the die seat and the uprights of the press frame to locate the seat in the transverse direction. To give smooth operation at the relatively high speeds at which these presses work, there is a buffer cylinder in the crown to assist the brake in stopping the slide at the top of the stroke and to provide an additional accelerating force when re-starting the slide on its downward motion, thereby easing the load on the clutch. A load indicator, which registers the actual load on the press by measuring the strain in the frame uprights, is mounted on the front of the machine. The weight of the press illustrated is 96 tons. The new range is being built in England by E. W. Bliss (England), Limited, City-road, Derby.

SMALL MINES LOCOMOTIVE.—A 15-h.p. Diesel locomotive, for gold mines and other mines where space is restricted, is being produced by Hunslet Africa (Pty.), Ltd. It can go in the small cages of Rand gold mines since, with couplings off, it is only 4 ft. 9 in. in length, 3 ft. 8 in. high, and 3 ft. wide. The weight is 2¼ tons. The locomotive is fitted with an air-cooled engine, to avoid risk of accident through the radiator being left unfilled, and with a suspension system which enables it to hold the track even if one wheel is lifted 2 in. off the rail. A conditioner is fitted to deal with the engine exhaust gas.

CONTRACTS.

THE NATIONAL GAS AND OIL ENGINE CO. LTD., Ashton-under-Lyne, one of the Brush ABOE group of companies, have received orders for 41 Diesel engines for railway applications. Thirty-two of these are for use on the New Zealand Government Railways; 21 are engines developing 260 b.h.p., at 1,250 r.p.m. for use in railcars now under construction by the DREWRY CAR CO. LTD., London, E.C.2. The remaining 11 engines, which will develop 250 b.h.p. at 1,400 r.p.m., are to be fitted in shunting locomotives now being built by the HUNSLET ENGINE CO. LTD., Leeds, 10.

THE GENERAL ELECTRIC CO. LTD., Magnet House, Kingsway, London, W.C.2, are to supply three 30-MW, 11-kV turbo-alternators, to run at 3,000 r.p.m., for installation in the new Kelvin power station, Johannesburg. The steam-raising plant, which is being supplied by BABCOCK AND WILCOX LTD., will consist of six stoker-fired boilers, each having an evaporative capacity at the maximum continuous rating of 187,500 lb. per hour, at a pressure of 625 lb. per square inch, and a steam temperature of 865 deg. F.

JOHNSON IRETON LTD., 7, Victoria-street, London, S.W.1, are to supply, deliver and erect the steelwork for re-roofing platforms 4 and 5 at Preston station, on the London Midland Region of British Railways.

The British Tanker Company, the shipping subsidiary of the Anglo-Iranian Oil Co. Ltd., have placed orders for seven more oil-tank ships, each of about 32,000 tons deadweight, at a total cost of upwards of 12,000,000*l*. Two of the seven will be built by JOHN BROWN & CO., LTD., Clydebank; one by CAMMELL LAIRD & CO. LTD., Birkenhead; one by HARLAND & WOLFF LTD., Belfast; one by HAWTHORN, LESLIE & CO. LTD., Hebburn-on-Tyne; one by SWAN, HUNTER, AND WIGHAM RICHARDSON LTD., Wallsend-on-Tyne; and one by VICKERS-ARMSTRONGS LTD., Barrow-in-Furness. The hulls will be similar to those of six 32,000-ton ships already on order, but the double-reduction geared steam turbines of the new vessels will be somewhat more powerful, developing 14,000 s.h.p. and giving an average service speed of 15½ knots with full cargo. The vessels will be 675 ft. in length and will have a beam of 86 ft., and a draught of 35 ft.

LAUNCHES AND TRIAL TRIPS.

M.S. "STYLEHURST."—Single-screw cargo vessel, built and engined by Swan, Hunter, and Wigham Richardson, Ltd., Newcastle-upon-Tyne, for the Grenehurst Shipping Co., Ltd., London, E.C.3. Main dimensions: 435 ft. between perpendiculars by 60 ft. by 39 ft. to shelter deck; gross tonnage, 5,750. Swan Hunter-Doxford four-cylinder opposed-piston heavy-oil engine, developing 4,400 b.h.p. at 115 r.p.m. Launch, July 8.

M.S. "JANOVA."—Single-screw oil tanker, built and engined by Harland and Wolff, Ltd., Belfast, for Anders Jahre & Co., Sandefjord, Norway. Main dimensions: 540 ft. between perpendiculars by 73 ft. by 39 ft. 3 in. to upper deck; deadweight capacity, 18,500 tons; gross tonnage, 12,800. Harland-B. and W. six-cylinder two-stroke single-acting oil engine. Launch, July 8.

M.S. "DIPLOMAT."—Single-screw cargo vessel, built and engined by William Doxford and Sons, Ltd., Sunderland, for the Charente Steam Ship Co., Ltd. (Managers: Thos. and Jas. Harrison, Ltd.), Liverpool. Main dimensions: 460 ft. overall by 59 ft. 6 in. by 37 ft. 8 in.; deadweight capacity, 9,850 tons on a draught of about 26 ft. 6 in. Four-cylinder opposed-piston oil engine developing 3,300 b.h.p. at 108 r.p.m. Service speed, 13½ knots. Launch, July 9.

M.S. "PRINCE CHARLES."—Single-screw trawler, built by Cochrane & Sons, Ltd., Selby, Yorkshire, for St. Andrew's Steam Fishing Co., Ltd., Hull. Second of two sister ships. Main dimensions: 160 ft. 6 in. by 29 ft. by 14 ft. 6 in. Crossley eight-cylinder Diesel engine, developing a maximum of 1,500 b.h.p., constructed by Crossley Brothers, Ltd., Manchester, and installed by Amos and Smith, Ltd., Hull. Launch, July 9.

M.S. "LONDON SPIRIT."—Single-screw oil tanker, built by Sir James Laing & Sons, Ltd., Sunderland, for London and Overseas Freighters, Ltd., London, W.1. Last vessel of a series of three for these owners. Main dimensions: 506 ft. overall by 67 ft. 4½ in. by 37 ft. 4 in.; deadweight capacity, about 15,300 tons on a summer draught of 29 ft. 1 in. Four-cylinder opposed-piston oil engine, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Service speed, 12½ knots. Trial trip, July 14 and 15.

M.S. "AFRICA PALM."—Single-screw cargo vessel, built by Short Brothers, Ltd., Sunderland, for the West African trade of the Palm Line, Ltd., London, E.C.4. Main dimensions: 425 ft. between perpendiculars by 57 ft. 9 in. by 37 ft. 2 in. to upper deck; deadweight capacity, about 8,600 tons on a summer draught of 23 ft. 9 in. N.E.M.-Doxford four-cylinder opposed-piston oil engine, developing 3,000 b.h.p. at 122 r.p.m. constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Launch, July 22.

NOTES ON NEW BOOKS.

Handbook of Heating, Ventilating, and Air Conditioning.

By John Porges, M.I.Mech.E., M.Inst.F. Third edition. George Newnes, Limited, Tower House, Southampton-street, Strand, London, W.C.2. [Price 25s. net.]

This book, the first edition of which we reviewed on page 203 of our 155th volume (1943), has now been revised and brought up to date by the addition of new material. The format has been changed from loose-leaf to ordinary binding, which is a good move, but the general scheme of the work remains unaltered. It is a compilation of the formulæ, data, tables and charts which are required in everyday practice by the heating and ventilating engineer. Little explanation or theoretical treatment is given, but this is not necessary in a work of this character, and, in any case, a sectionalised bibliography is now included. The book brings together a large amount of information which otherwise would have to be sought from a wide variety of sources. When so much is given, it is perhaps invidious to mention deficiencies, but more extended data for use in the design of panel heating and high-pressure hot-water systems would be welcome; also, it may be remarked that some values given for thermal conductivities and transmittances do not agree with those recommended by the Institution of Heating and Ventilating Engineers, and the table of intensities of solar radiation relates to latitude 45 deg., and is inapplicable in this country. In some of the formulæ, the indices and suffixes require a magnifying glass for their identification. The original loose-leaf pagination has been retained, and this possibly accounts for some scattering of related data. Thus, tables of circular areas are given on pages I.8 and II.17, heat transmissions from radiators on IV.15 and IV.26, thermal conductivities on IV.21 and VI.18, and velocity heads for air on VI.16 and X.7. These points, however, detract but little from the value of a comprehensive work of reference, which should be of particular value in the drawing office.

An Engineer's Approach to Corrosion.

By C. F. Trigg, M.Sc., A.M.I.C.E., A.M.I.Mech.E., Sir Isaac Pitman and Sons, Limited, Parker Street, Kingsway, London, W.C.2. [Price 15s. net.]

The cynic might say, in response to the challenge implied in the title of this book, that the engineer has no business to "approach" corrosion; if he is worth his salt, he should be looking far enough ahead to prevent it, either by the selection of non-corrodible materials or by suitable protective measures. In practice, however, as every engineer knows to his own or someone else's cost, the problems of corrosion are not so simply settled; a fact which Mr. Trigg emphasises at the outset by listing 20 distinct "reactions and influences" which are significant in the study of this phenomenon. He quotes Dr. F. N. Speller, of Pittsburgh, U.S.A., as having estimated that there are about 1,200 million tons of steel in use in the world, three-quarters of which requires to be protected against corrosion; we recall that the late Mr. J. L. Hodgson made a similar calculation, arriving at approximately the same result, though he was not, at the time, concerning himself with corrosion. In a nutshell, however, as Mr. Trigg remarks, man takes the iron ore—a relatively stable substance—and puts it through numerous complicated and expensive processes, only to produce a readily corrodible material which, unless regularly subjected to processes of protection (also expensive) will speedily revert to something that is "approximately identical, both chemically and mechanically, to the iron ore from which it originated." No argument is needed, therefore, to support the thesis that corrosion is every man's problem and that he owes a duty to himself and his fellow men to reduce by all possible means the waste for which it is responsible. The first step in that direction is to acquire some dependable knowledge about it, and this Mr. Trigg's book provides. It may be commended, especially, to those who wish to establish for themselves a basis for more extended studies.

DIESEL-ENGINED INDUSTRIAL TRACTOR.

LANSING BAGNALL, LIMITED, BASINGSTOKE.

DIESEL-ENGINED INDUSTRIAL TRACTOR.

The accompanying illustration shows a heavy-duty industrial tractor, fitted with a Diesel engine, which has been introduced by Lansing Bagnall, Limited, Kingsclere-road, Basingstoke, Hampshire, and was shown for the first time at the recent Mechanical Handling Exhibition at Olympia. The tractor, known as the AP4, has a maximum draw-bar pull of 4,500 lb., and can tow a 45-ton load on a level concrete surface. Power is supplied by a four-cylinder Perkins P4 Diesel engine developing 42 b.h.p. at 2,000 r.p.m., and a maximum torque of 1,440 lb.-in. at 1,220 r.p.m. A single-plate clutch is fitted, with a ball-bearing thrust pad, and the gear-box provides four forward speeds and one reverse speed. The maximum road speeds are 14·5 miles per hour in top gear, 8·6 miles per hour in third, 4·7 miles per hour in second, 2·3 miles per hour in first, and 1·9 miles per hour in reverse. The drive is taken, through a Layrub universal coupling, to a worm reduction gear and a fully-floating differential, running in an oil bath.

The rear-axle unit is rigidly mounted on the chassis frame, which is a welded-steel structure, with slinging points provided by holes formed in the steel bumper plates at the front and rear of the vehicle. A towing eye, with a quickly-removable towing pin, is bolted to the rear of the frame. The front axle is of the "wishbone" type, connected to the frame by a universally-pivoted trunnion. The wheel hubs are carried on taper-roller bearings on forged-steel stub axles. Suspension is by a transverse leaf spring, rubber bushes being fitted in the shackles. The steering mechanism is a Marles double-roller and cam steering box. Girling hydraulic foot-operated brakes are fitted, and a mechanically-operated hand-brake is provided for parking. The bonnet swings upwards about a rear hinge and is held open at 45 deg. by a pivoted stay. The two 6-volt batteries and the tool kit are stowed beneath the driver's seat. Chassis lubrication is effected by a Tecalemit high-pressure grease system. The overall dimensions are 7 ft. in length, 5 ft. in width, and 4 ft. 6 in. in height. The wheelbase is 46½ in. and the minimum clearance is 7 in. The vehicle has a turning radius of 140 in.; and the weight is 44 cwt.

Helicopter Tests on the South Bank.—The Helicopter Experimental Unit of British European Airways are carrying out approach, landing and take-off tests, and noise measurements, on the South Bank fairway, with Bristol 171 and Westland Sikorsky S 51 helicopters, to ascertain the suitability of this site in the centre of London for possible regular helicopter services.

BOOKS RECEIVED.

Transactions of the Institution of Naval Architects. Edited by Captain (S) A. D. Duckworth, R.N. (ret.). Vol. 93. Obtainable from the Institution, 10, Upper Belgrave-street, London, S.W.1; and from Henry Sotheran, Ltd., 2, Sackville-street, London, W.1.

Les Machines Thermiques. By Dr. Paul Chambadal. Librairie Armand Colin, 103, Boulevard Saint-Michel, Paris (5e). [Price 260 francs.]

Bayernwerk Aktiengesellschaft. Bayerische Landeselektrizitätsversorgung. Geschäftsbericht uber das einundreissigste Geschäftsjahr vom 1 Oktober 1950 bis, 30 September, 1951. Bayernwerk A.G., Bayerische Landeselektrizitätversorgung, Munich, Germany.

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