ENGINEERING, MARINE AND WELDING EXHIBITION AT OLYMPIA,

INCORPORATING THE FOUNDRY TRADES' EXHIBITION.

(*Continued from page* 297.)

THE exhibition at Olympia closed yesterday. The exhibits generally were of a high standard, though few were particularly novel; indeed, novelty was more apparent in the stands, which were particularly attractive this year. In this article, we deal mainly with welding equipment.

The exhibits on the stand of Asea Electric, Limited, Fulbourne-road, Walthamstow, London, E.17, consisted of machines manufactured by Asea Svetsmaskiner A.B., of Stockholm. They included the welding head illustrated in Fig. 59, herewith, which is designed for longitudinal seam welding in a tube mill; it consists of a rotary transformer and adjustable pressure and supporting rollers. The electrode rollers are connected to the secondary of the transformer and they rotate together. The transformer can also be raised and lowered by a handwheel. An interesting point is that the machine is provided with a built-on lathe which, after the transformer and electrodes have been lifted a short distance from the tube to be welded, by a separate motor, can be used for grinding without disturbing the mill. The flying cut-off can be of the mechanical rotating or electrical tearing-off type.

The mills are manufactured in four sizes for welding tubes with external diameters from $\frac{1}{8}$ in. to 4 in., at maximum speeds of about 45 metres per minute. Such speeds can, however, only be used on light-gauge tubes and the frequency of the current supplied must be 150 cycles. Normally, the speed is limited to 36 metres per minute if a tight weld is to be secured. The electrical ratings of the four sizes of machine are 80 kVA, 150 kVA, 250 kVA and 350 kVA, respectively. All the main parts of the equipment, which includes the forming mill, welding machine and sizing and straightening mills, are mounted on the same bedplate, thus facilitating erection. The roller shafts on all the mills are carried in ball bearings and can be adjusted vertically.

The same firm also exhibited the bolt-blank heater illustrated in Fig. 60, herewith. This machine has been designed for heating the ends of blanks for bolts before the head is forged. It is pneumatically operated and although the blank is fed in and extracted by hand the heating sequence is automatic and operation can be effected by one man. The machine is made in five sizes with rated inputs of 35, 60, 80, 110 and 150 kVA, respectively, at 50 per cent. duty cycle, the range of bank sizes being from $\frac{1}{4}$ in. to $\frac{1}{2}$ in., $\frac{5}{8}$ in., $\frac{3}{4}$ in., $\frac{7}{8}$ in., and 1 in., on the five patterns, and the number of heatings per hour ranges from 1,200 to 300 according to the size of blank.

Messrs. Hancock and Company (Engineers), Limited, Progress-way, Croydon, Surrey, were showing a model of their latest oxygen profiling machine, which deals with the largest plates used in shipyards and has a cutting area of 10 ft. wide by any length in one setting. It is shown in Fig. 61, on Plate XXII. It consists of main and transverse carriages which are fabricated from steel plate and tubes. The main carriage runs on large-diameter hardened and ground wheels and the main 4-in. axle is of aluminium alloy, which is carried on ball bearings. The steel racks are precision finished, with a fabricated board stand to carry the tracer table. One or more burners can be fitted, their holders being mounted on a slide bar so that they can be set in any position within the cutting width by a handwheel which operates through a rack and pinion. The burners are of the coupled type with a control-valve box mounted on the vertical slide of the holder. They can all be operated simultaneously by a single lever with cam control, which is actuated from the control position at each end of the machine. The tracer is of the standard pattern. It can be raised or lowered from the two positions and can be used with steel, wood or strip templates or direct from the drawing or scrieve board.

The machine can be electronically controlled, for which purpose it is fitted with a photo-electric head that follows the lines on the drawing. Accurate profiles can thus be produced in the steel which is to be cut. A small tracing wheel projects from the head and engages with the surface of a cylinder which, in turn, drives the lower carriage of the machine through gearing. The wheel is driven by a variable-speed motor and is guided by a second motor, which steers it over the outline of the drawing. Both motors are housed in the head. When the axis of the tracing wheel is parallel to that of the cylinder, the lower carriage is driven forwards or backwards, but when it is at right angles to the cylinder axis, it runs along the latter and so causes the head and burner to move laterally without longitudinal travel. Between these two extremes, the resultant movements of the head and burner are combinations of the longitudinal and lateral travels. The path traced is therefore identical with that which would be produced if the tracing wheel were in direct contact with the drawing.

The movement of the head is controlled by a beam of light which is projected downwards and forms a small spot on the drawing. In this way, the head, and consequently the burner, is caused to follow the required profile, provided half the area of the spot remains over the drawing outline, which should be up to $\frac{1}{4}$ in. thick. Light from the spot is reflected on to the photo-electric control gear, so that if the spot tends to move away from the outline, the steering motor is caused by a bridge circuit to turn the spindle of the tracing wheel in the appropriate direction. When the spot is half over the outline and half over the white, or neutral, colour of the drawing paper, the reflected light has no effect on the steering motor, which, therefore, remains stationary. After the driving motor has been switched on, the head is guided by hand to bring

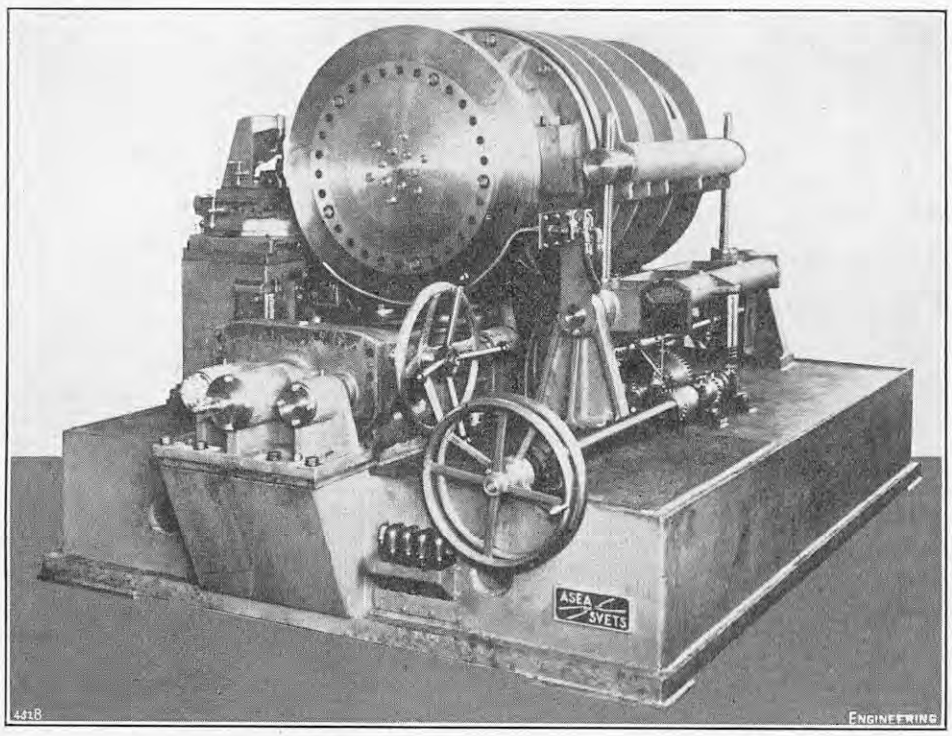

FIG. 59. WELDING HEAD FOR TUBE MILL; ASEA ELECTRIC, LIMITED.

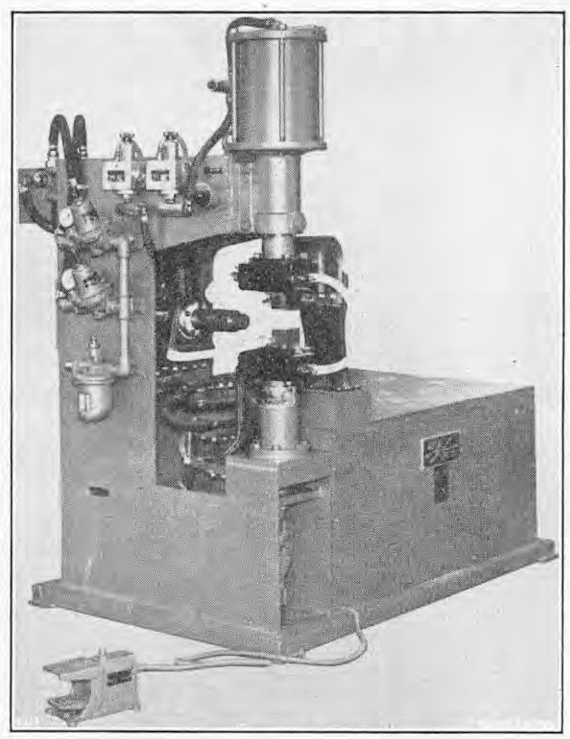

FIG. 60. BOLT-BLANK HEATER; ASEA ELECTRIC, LIMITED.

the spot over the outline of the drawing or pattern to be cut, the steering motor is started and the electronic control gear takes over automatically.

The principal exhibit on the stand of the Quasi-Arc Company, Limited, Bilston, Staffordshire, consisted of Unionmelt arc-welding equipment which, in addition to being fully automatic in operation, has recently been modified so that it can be used as a semi-automatic unit or as a manual tool which can be placed in position and guided by the operator. A welder of this type, which can be operated at currents up to 900 amperes, is illustrated in Fig. 62, on Plate XXII. It is designed for manual submerged-arc welding and is arranged so that the welding wire and Unionmelt powder are automatically fed through a flexible hose 20 ft. long. This hose terminates in the welding nozzle, which contains a small hole. The powder is fed round the wire automatically, and when sufficient has been deposited, the operator touches the wire on the workpiece, thus closing the electric circuit. As soon as the current flows, the nozzle is guided along the joint or over the area to be welded at a reasonably uniform distance above the workpiece. The rate at which the wire is supplied is automatically controlled so that the length of the arc is maintained. Starting and stopping are effected by a push-button, which operates a starter, the latter incorporating a switch so that the wire can be inched forward or backwards in the hose. The unit includes a motor for feeding the wire, a reel which carries 25 lb. of welding wire, a tank holding 75 lb. of powder, and an air-pressure regulator and safety valve. Either alternating or direct current can be used, the maximum value in either case being 900 amperes. Connection can be made to any type of arc welding transformer or generator.

The machine can stand on the shop floor with the operator at either floor level or higher. A lifting eye is fitted so that the unit can be slung over a welding area with the hose leading down to the operator, who is thus able to work freely within a radius of 15 ft. to 20 ft. Alternatively, the plant can be suspended from a wall-mounted jib crane, so that it can be operated over a still wider area.

The Unionmelt welding head, which is illustrated in Fig. 63, Plate XXII, allows a maximum current of 1,200 amperes. When wire from $\frac{3}{32}$ in. to $\frac{1}{4}$ in. in diameter is supplied down a 20-ft. flexible hose, one-pass butt welds can be made in material from No. 16 gauge to $\frac{3}{4}$ in. thick, as can plug and fillet welds of comparable size. Multi-pass welds can also be made in metal of any thickness. The head can be adjusted both vertically and horizontally and rotated through 360 deg., a single or double gear drive being used to obtain a wide current variation with the same diameter of wire. As shown in Fig. 63, the head can be supported on a self-propelled carriage, in which case a reel carrying 25 lb. of welding wire is provided. This can, however, be replaced by a reel carrying 150 lb. of wire when the machine is to be stationary. The welding voltage is kept constant by a series control unit which causes the motor to speed up or slow down when any variation in the arc length occurs, thus restoring the electrode to its correct position.

The same firm were showing a 300-ampere mobile welding unit, which is driven by a Diesel engine. Machines of this type were used for welding the Finnart pipeline through which crude oil is conveyed across Scotland. A 250-ampere petrol-driven welder exhibited was of interest from the fact that it could be separated into two parts for easy handling on site and that it was fitted with remote current regulation.

The wide range of alternating-current welding plant manufactured by the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, was represented at the exhibition by their twin-arc welding and portable single-phase sets. The twin-arc equipment is the result of experiments which were undertaken by the company with a view to producing alternating-current welders which would take a balanced three-phase supply from the mains at a high power factor without the expense of a correcting capacitor. Two parallel electrodes, which are insulated by their normal flux coating and are supplied from a three-phase to two-phase transformer, enable the whole of the energy to be concentrated alternately in each of the two arcs between the electrodes and the work-piece. Only a very small (single-phase) component of the current bridges the gap between the tips of the electrodes. Since ionisation, due to the arc burning at one electrode, assists in re-striking an arc at the other, and since temperature fluctuation in the arc zone is reduced, the open-circuit secondary voltage (normally about 80 volts) is only about 45 volts and a power factor of the order 0·55 is obtained.

Moreover, as a direct result of the improvement in stability, the arc is quieter and more easily controlled. Again, owing to the improved thermal efficiency of the two-phase arc and the fact that a larger cross-section of electrode can be used for a given size of weld, the rate of deposition is from 20 to 50 per cent. faster than in single-phase welding, depending upon the size and type of weld being produced. A further improvement in the welding speed is due to the fact that twin electrodes of standard length deposit about a 70 per cent. greater length of weld metal than equivalent single rods, with a consequent saving in the time taken to change the rods. Experience has, in fact, shown that on a $\frac{5}{16}$-in. fillet weld the total saving compared with single-arc welding is about 45 minutes for each 100 ft. of welding, 30 minutes being due to greater welding speed and 15 minutes to less frequent rod changing.

Although the equipment is intended primarily for service as a twin-arc set, it can also be used as a normal double-operator unit with independent control for each welder. For this purpose a voltage change-over switch is provided which gives 45 volts or 60 volts at the secondary terminals, the latter value being employed for single-arc welding. This facility is useful when special types of electrodes are necessary or when the equipment is used for tacking and intermittent welding in confined spaces.

During the exhibition, demonstrations were given to enable comparisons to be made between the twin plant and the more usual single-phase equipment. For this purpose, simultaneous welds were made by two operators using the two types of set, and the relative performances were continuously indicated on an instrument panel. As already announced, arrangements are now being made between the General Electric Company and the Quasi-Arc Company, whereby the latter will become sole concessionaires for this equipment.

Sciaky Electric Welding Machines, Limited, Slough, Buckinghamshire, were showing a full range of pedestal spot, portable spot, projection, seam and flash welding plant, including an air-operated machine which is capable of welding mild steel up to $\frac{1}{2}$ in. thick. This machine has a nominal rating of 25 kVA when the arms are arranged to give a throat depth of 24 in. The welding pressure is exerted by compressed air, which is supplied from a cylinder at a pressure of 785 lb. per square inch, and the duration of the weld current flow is governed by a resistance-capacitance timer. The machine is also capable of stitch-welding at speeds up to 150 spots per minute. Mention may also be made of the multiple cross-wire welding machine illustrated in Fig. 64. It has been developed so that a large number of welds can be completed simultaneously in wire mesh with a mains loading of 75 kVA. The welding transformer is located directly below the T-slotted platens, thereby reducing the secondary gap to a minimum, and considerably increasing the electrical efficiency of the machine. The provision of platens of this type also facilitates the mounting of welding fixtures. Working throat depths up to 36 in. are available and the maximum welding capacity is 120 welds per minute in No. 16 s.w.g. mild-steel wires. The cylinder is operated pneumatically at a pressure of 2,200 lb. per square inch.

Fig. 65 is an illustration of a bench-mounted spot welder which has been developed by the same firm for welding assemblies, such as radio-valve components. It has a capacity of two No. 16 gauge mild-steel sheets. Weld timing is usually effected by a resistance-capacitance timer, although a synchronous thyratron timer can also be fitted. The main operating cylinder is supplied with compressed air, the flow of which is adjusted by pressing a small pedal. A range of six heat tappings is available and the top and bottom electrodes can be adjusted both vertically and horizontally. In a second similar type of bench machine, the supply of air can be controlled either through a foot valve or through an electrically-operated valve, which is interlocked with the main electrical circuit.

Messrs. A. Reyrolle and Company, Limited, Hebburn, Co. Durham, were showing the 20/300-ampere dual-control single-operator welding set illustrated in Fig. 68, opposite. This is a composite unit of relatively small dimensions and light weight, which comprises an alternating-current motor, a welding generator and a control box containing the motor starter and generator controls. The rotor of the motor and the generator armature are mounted on a common shaft, which has been designed so that complete concentricity is maintained under all conditions. It is borne in either ball or roller bearings. The frame has been designed to facilitate inspection and maintenance and to afford maximum protection of the working parts. The motor is of the alternating-current squirrel-cage type with a normal synchronous speed of 1,500 r.p.m. Its windings are impregnated, so that it will withstand the most arduous working conditions, while protection against overheating is provided by a self-resetting switch which is in contact with the stator windings. Starting is effected by a push-button which switches the motor either directly on to the mains or through an air-break star-delta switch. The generator is of the direct-current drooping-characteristic type with a current range of 20 to 300 amperes at 20 to 30 arc volts, the striking voltage being 70 volts. Control is of the concentric dual type, a heavy-duty selector switch, with "make-before-break" contacts and definite settings being provided for adjusting the current and a wide-scale continuously-variable regulator for altering the voltage. This enables the most suitable setting for a particular welding run to be selected by means of the outer handwheel, after which an inner concentric knob can be used to regulate the welding conditions. Another single-operator set on view on this stand was rated at 400 amperes; it is driven by a Ford V8 petrol engine. Both the engine and the generator are housed in a common framework above which is a protective canopy, and they can be mounted on wheels for mobility.

The same firm exhibited a selection of their variable-speed alternating-current commutator motors with outputs from 5 to 35 h.p., as well as a number of squirrel-cage induction motors of various sizes and constructions. There was also an alternating-current commutator motor which has been designed for driving ring spinning frames. This motor, which is illustrated in Fig. 67, opposite, embodies a fully automatic speed-control unit for regulating the speed in accordance with the varying motion of the spinning frame. Switchgear was represented by a 33-kV metalclad horizontal draw-out circuit-breaker panel with a rupturing capacity of 1,500 MVA. The construction of this panel, which is illustrated in Fig. 66, is in general accordance with the firm's well-known equipment, but there are some modifications, including complete phase separation and three separate lifting rods, which are coupled above the top plate and are used for actuating the moving contacts. The operating mechanism is totally enclosed in dust-proof and vermin-proof covers and is fitted with external dashpots. It is nevertheless readily accessible through a simple front cover. Owing to the absence of projecting fittings on the front of the frame standards, and of wing panels on the covers of the mechanism, a switchboard built up of these panels has a particularly clean finish.

Fig. 69, on page 324, is an illustration of a 250-kVA flash butt-welder, which was shown by A.I. Electric Welding Machines, Limited, 68, Victoria-street, London, S.W.1. This machine has been designed as a general-purpose welder and combines the advantages of pre-heating for heavy solid sections with fully-automatic flash welding of lighter sections. A power forging unit also enables upset pressures up to 6 tons to be applied, thus ensuring correct weld consolidation. The welder is supplied from a 250-kVA single-phase transformer, the primary of which is wound for connection to the 400-volt mains. The secondary is water-cooled and, in connection with a regulator, supplies current at

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(*For Description, see Page* 321.)

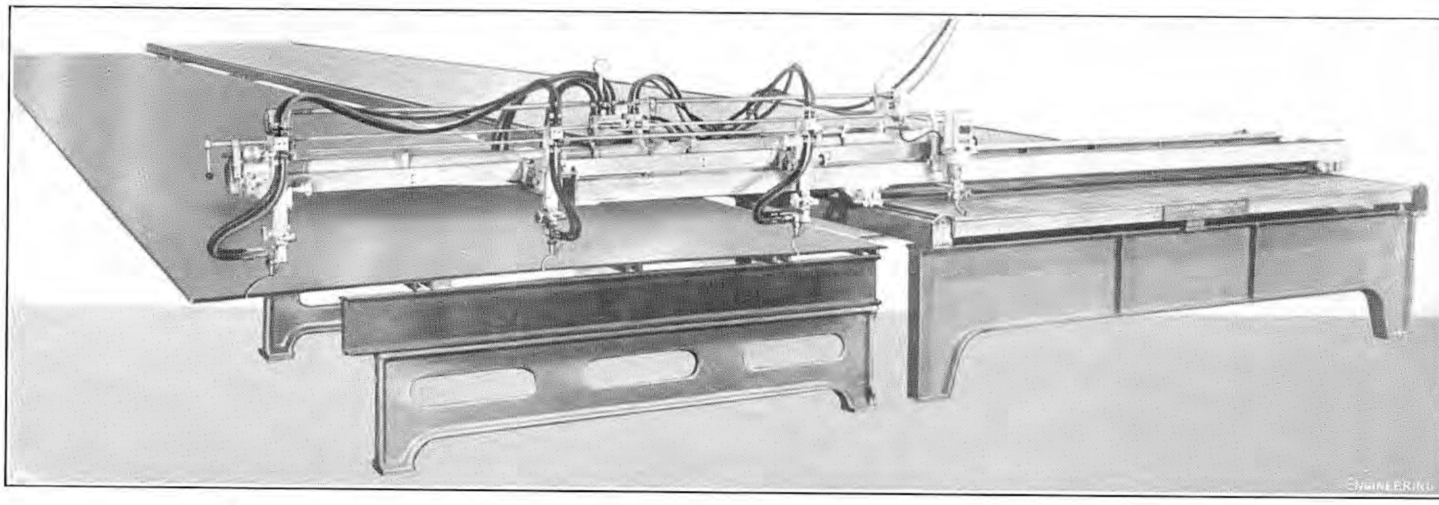

FIG. 61. LONGITUDINAL PROFILING MACHINE; HANCOCK AND COMPANY (ENGINEERS), LIMITED.

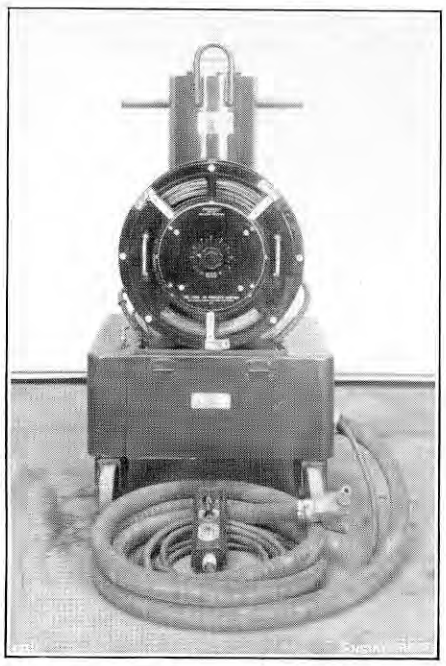

FIG. 62. 900-AMPERE "UNIONMELT" WELDING MACHINE; QUASI-ARC COMPANY, LIMITED.

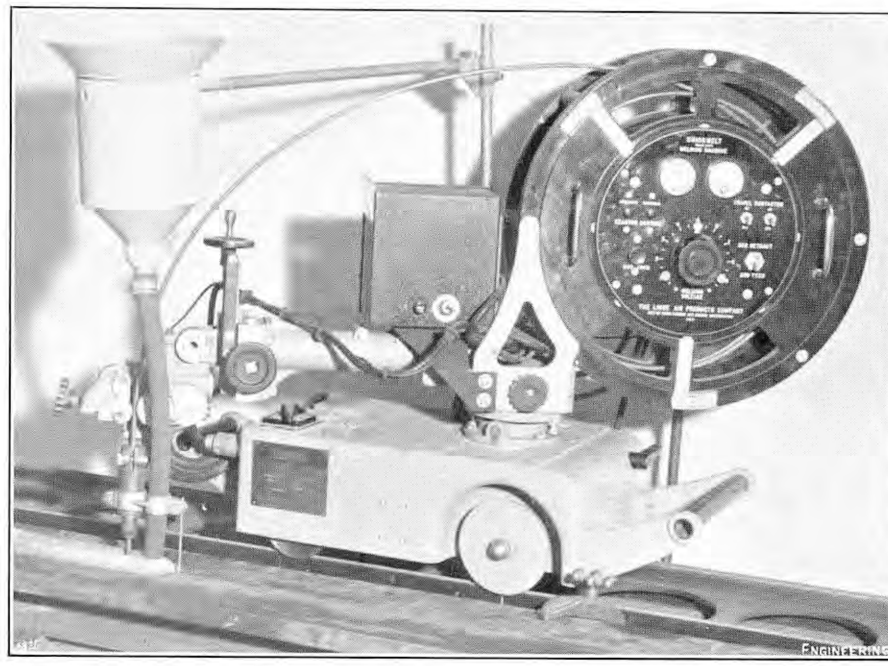

FIG. 63. 1.200-AMPERE "UNIONMELT" WELDING HEAD; QUASI-ARC COMPANY, LIMITED.

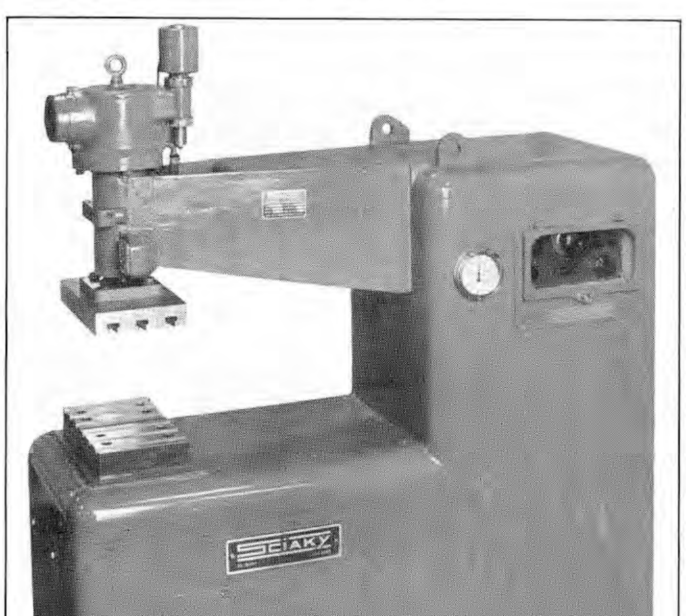

FIG. 64. MULTIPLE CROSS-WIRE WELDING MACHINE; SCIAKY ELECTRIC WELDING MACHINES, LIMITED.

FIG. 65. BENCH-MOUNTED SPOT WELDER; SCIAKY ELECTRIC WELDING MACHINES, LIMITED.

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FIG. 66. 1,500-MVA 33-KV METALCLAD SWITCHGEAR; A. REYROLLE AND COMPANY, LIMITED.

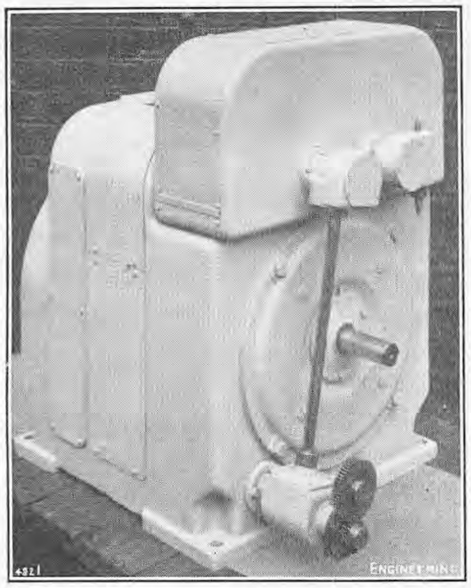

FIG. 67. MOTOR FOR RING SPINNING FRAMES; A. REYROLLE AND COMPANY, LIMITED.

FIG. 68. 20/300-AMPERE WELDING MACHINE; A. REYROLLE AND COMPANY, LIMITED.

voltages from 3 to 8. The clamps, which are either of the vertical or swivel type, are pneumatically operated and are controlled by foot-operated valves, the effective clamping pressure being 8 tons. The electrode blocks are of hard-wearing copper alloy and a water-cooling system is incorporated. As regards operation, the components to be welded are placed in position and clamped by depressing the pedals. The operating lever is moved to the "weld" position, thus initiating the flashing cycle and power forging and completing the weld. When pre-heating is necessary, current for this purpose is switched on, after the components have been clamped, by depressing a foot switch and operating the handwheel with a reciprocating action. This reciprocating movement is maintained until a temperature suitable for free flashing has been reached. The operating lever is then moved to the welding position so that automatic flashing and upsetting take place as before. The machine is capable of welding mild steel up to 5 sq. in.

The stand was provided with a series of display panels showing how flash butt-welding can be applied in a number of industries to increase production at a low cost. Actual examples of welding with production cost figures were exhibited to illustrate how simplified designs and reduction in weight can be achieved by planning the forging procedure in the shipbuilding, motor-car, mining, steel and general engineering industries.

The British Thomson-Houston Company, Limited, Rugby, exhibited on two stands at Olympia. The first was devoted to a display of the organisation's practice in electrical propulsion equipment, ships' electrical auxiliaries, marine radar and many kinds of electrical plant for dockyards and general industrial use. The exhibits ranged from a 12-ton gearwheel, as used on Diesel propulsion units and incorporating an electromagnetic coupling, to electric speed indicators and magnetos for marine engines. Developments in gas turbines, high breaking capacity switchgear for marine service, a new range of totally-enclosed fan-cooled motors with standardised dimensions, thrustors and sud pumps were also on view, and demonstrations were given of the firm's "Stacreep" system of crane control and of their "Clearcall" industrial communication equipment.

On the other stand, control panels for spot and seam welding machines were exhibited. These included the equipment illustrated in Fig. 70, on page 324, which has been designed to control both the periods of current flow (heat time) and of current interruption (cool time). The welding cycle, which is the sum of these two periods, is directly variable in one-cycle steps from two to 45 cycles, and the duty cycle (ratio of heat time to heat time plus cool time) can be varied from 10 to 90 per cent. The equipment consists of an insulated panel which is housed in a sheet-steel cubicle and on the lower part of which are mounted two ignitrons, two trigger thyratrons, fuses and a small contactor. The latter is used as a weld-initiating switch when seam welding or as a safety switch when spot welding. The transformers, rectifiers and other circuit components are mounted on the back of the panel. The upper part of the cubicle contains a timing tray on which a thermal time-delay switch, a rectifier valve and timing and control thyratrons are mounted. The tray is supported on metal runners so that it can easily be withdrawn for servicing. It is connected to the ignitron panel by two flexible cables, which terminate in plug-and-socket connections. All the controls are located in a small compartment on the front of the timing tray. Locks are provided to prevent access by unauthorised persons.

The ignitrons, which are water-cooled, are connected in inverse parallel and act as an electronic contactor which controls the current in the primary of the welding transformer. Up to 2,400 kVA can be controlled in this way, depending on the type of ignitron used. The thyratrons provided for timing and control purposes are of the mercury-vapour type, while those which act as triggers are of the xenon gas-filled shield-grid pattern. In both cases filament-type cathodes are used. The function of this equipment is to act as high-speed relays which control the duration of the current flow or vary the value of the current passed by the ignitrons. The synchronous timing circuit is supplied with direct-current at 400 volts from a rectifier.

The spot-welding equipment is provided with a rheostat which, in conjunction with its range switch, enables the welding time to be adjusted in two ranges from one to 30 cycles in one-cycle steps. It also has two heat-control rheostats for adjusting the welding current when operating on manual and automatic control, respectively; a change-over switch for altering the system of control; and a push-button for re-setting a protective circuit which prevents operation if the equipment is set up with an excessive control voltage. When the equipment is used for controlling seam welders the welding-time rheostat is replaced by welding-cycle and duty-cycle rheostats. The first of these allows the length of the welding cycle to be adjusted between 2 and 45 cycles in one-cycle steps, and the other the duty cycle between 10 and 90 per cent. The instruments include an ammeter for indicating the line current and a firing-angle indicator which shows the phase angle at which current flow commences. A time delay switch is incorporated in the equipment to prevent welding being started until the thyratrons have warmed up to their operating temperature. There is also a water-flow switch, which prevents welding being commenced or continued unless sufficient cooling water is flowing through the ignitron jackets. As regards the operation of the spot-welder equipment, after the main supply switch has been closed and the ignitron cooling water has been turned on, about one minute must be allowed to elapse for warming up. The safety contact is then operated and the weld-initiating circuit closed.

Another exhibit on the B.T.H. stand of which mention may be made was the high-speed counter illustrated in Fig. 71. This has been designed for industrial use and is capable of counting at speeds up to 25,000 counts per minute. It is operated from a 200/250-volt 50-cycle circuit, and the counting signal is normally received from a photo-electric scanning head, although other methods of detection can be provided. As will be seen, the counter is housed in a sheet-steel case, with the controls mounted on a sloping panel. These controls consist of a selector switch marked "auto reset," "manual reset," "count" and "test"; a push-button for indexing or resetting; an ejector selector switch; and a neon lamp which indicates when the equipment is operating. To the right of the control panel are two electronic counting tubes, which give visual indications of the units counted, while to the left is a six-figure electro-magnetic counter indicating hundreds.

When the counter is operating it closes the

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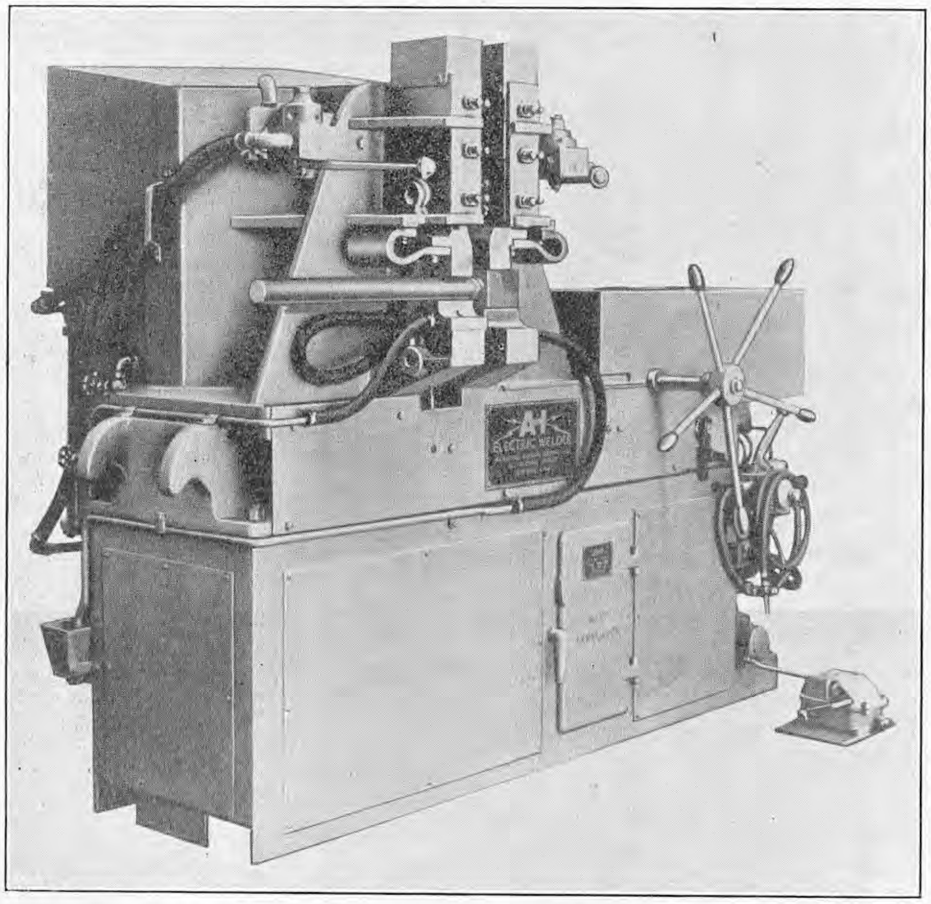

FIG. 69. 250-KVA FLASH BUTT-WELDING MACHINE; A.I. ELECTRIC WELDING MACHINES, LIMITED.

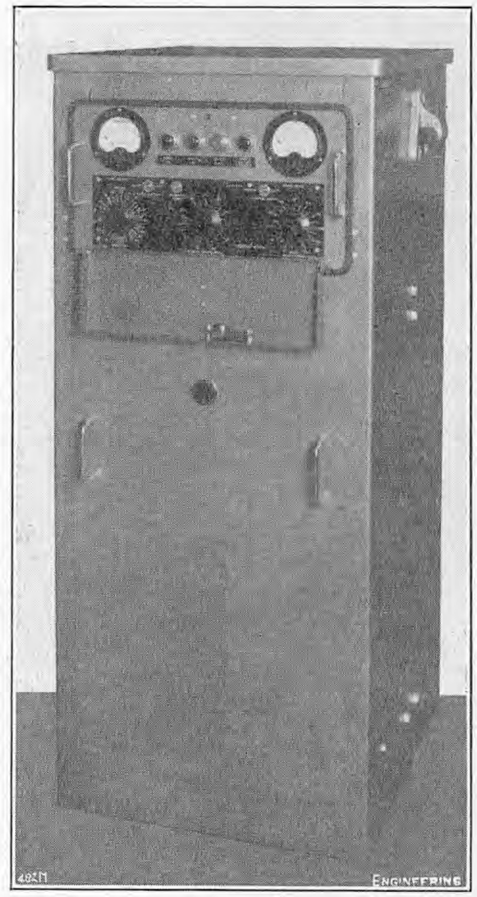

FIG. 70. SPOT-WELDING CONTROL EQUIPMENT; BRITISH THOMSON-HOUSTON COMPANY, LIMITED.

contacts of a relay at the 50th or 100th count, according to the position of the ejector selector switch; the former can be used up to speeds of 18,000 counts per minute and the latter up to the maximum counting speed When first switched on, the counting tubes set themselves automatically to zero; the electromagnetic counter remains at the previously-recorded count, though it can be set manually to zero. If it is desired to continue on a particular count after the machine has been shut down, the counter can be set to the appropriate figure using the "auto reset" and "manual reset"; and to show the previously-recorded count, two indicators, which can be set by hand, are provided. When the selector switch is in the "test" position, the tubes receive impulses, so that the whole equipment from the signal input to the electromagnetic counter can be readily checked.

Among the welding equipment which was exhibited by Murex Welding Processes, Limited, Waltham Cross, Hertfordshire, mention may be made of the 250/300-ampere transformer set illustrated in Fig. 73. It is of the single-operator self-contained oil-cooled type with an internal capacitor. It has three main current ranges, which can be selected by an appropriate switch, and within each range it is possible to obtain twelve values by the use of a second switch. Both these switches and the primary switch are installed inside the casing and are operated by crank handles on the top of the transformer. Two open-circuit voltages—80 volts and 100 volts—are available and are selected by means of a copper link. The ammeter is mounted on a desk-type fitting to facilitate reading, and the wheels on which the unit is carried are recessed into the equipment and fitted with solid rubber tyres. As will be seen from Fig. 73, the front wheel is provided with a drawbar for steering purposes.

The Elin-Murex automatic welding equipment, which is illustrated in Fig. 72, was shown for the first time at the exhibition. It consists of a mobile welding head which travels on a specially designed gantry girder, and which is provided with a 40-volt direct-current controller as well as with two dual-

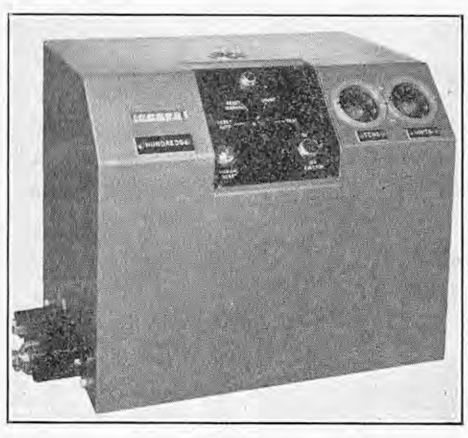

FIG. 71. HIGH-SPEED PHOTO-ELECTRIC COUNTER; BRITISH THOMSON-HOUSTON COMPANY, LIMITED.

control 400-ampere welding generators connected in parallel. One of the advantages claimed for this machine is its flexibility. For instance, the type shown normally makes use of a coil of bare wire, which is joined at the welding head by the two halves of a pre-formed strip of flux immediately before the weld is made. The result is an electrode which is similar to one of the extruded type with the difference that the wire and type of flux can be varied as required. Alternatively, the machine can be used for submerged-arc welding or for automatic welding with a new type of Murex electrode known as Coilex. Either alternating or direct-current can be used, according to the nature of the work; the maximum current on the model shown at Olympia was 600 amperes. The rate of travel of the welding head can be varied between 4 in. and 32 in. per minute.

Mention may also be made of the firm's latest low-voltage safety device which has been designed for use with alternating-current welding equipment. This "fails to safety" in the event of an internal fault, thus reducing the voltage at the electrode holder to a safe value within a fraction of a second after the arc has been broken and then restoring the full voltage and current for welding when the electrode is brought into contact with the work preparatory to striking the arc. The unit is housed in a sheet-metal container which is suitable for mounting on standard welding transformers. Both motor and engine driven welding sets were exhibited. The stand also included displays of the 70 different types of electrode made by the firm, and of arc-welding accessories.

Among the many examples of welders exhibited by the Lincoln Electric Company, Limited, Welwyn Garden City, Hertfordshire, was the petrol-engine set illustrated in Fig. 74. This consists of a Fordson Major tractor engine with cylinders $4\frac{1}{8}$ in. in diameter and 5 in. stroke, which is capable of developing 38 brake horse-power. The engine is of the side-valve type; the cylinders and the top half of the crankcase are a monobloc casting, and the cylinder head is detachable. The pistons which are of cast iron, are of the solid skirt type. The carburettor is of the Ford down-draught pattern, The engine is fitted with the firm's well-known system of throttle control, which allows it to idle at low speed when welding is not taking place and to be run up automatically to the speed set by the centrifugal ball-type governor when the arc is struck. When the arc is interrupted, the engine is again slowed down in a period which can be adjusted from 15 to 30 seconds.

The generator is mounted directly on the engine housing, its shaft being connected to the flywheel by a special coupling. It is of the single-operator variable-voltage type with a completely laminated magnetic circuit. Interpoles are provided so that no external reactance or stabiliser is required. In order to improve welding performance the exciter is a separate machine. The current range is from 40 to 300 amperes with an arc voltage of 40 volts. The open-circuit voltage can be adjusted in a sequence of fine steps by a shunt-field rheostat. The current can also be adjusted independently by altering the series field; a combination of the two

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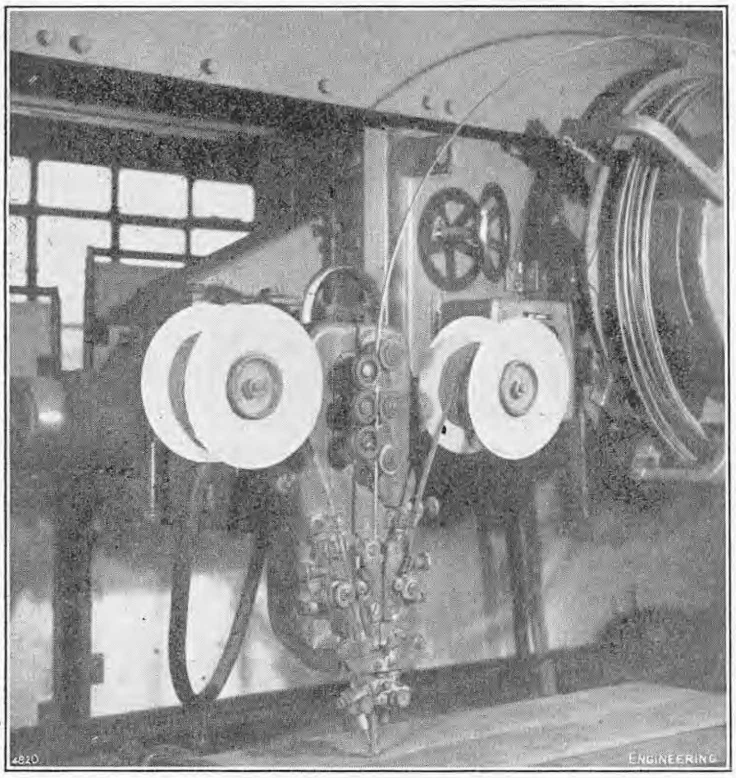

FIG. 72. AUTOMATIC WELDING EQUIPMENT; MUREX WELDING PROCESSES, LIMITED.

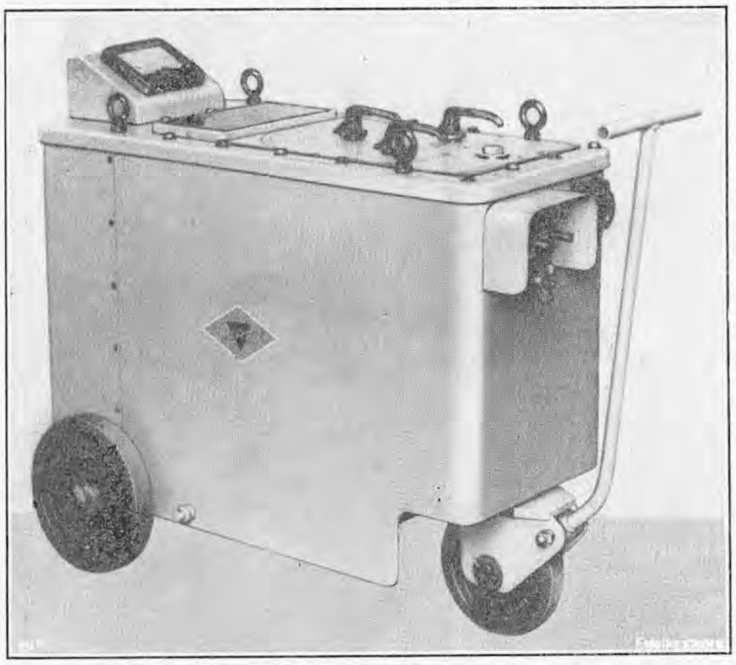

FIG. 73. 250/300-AMPERE ARC-WELDING TRANSFORMER SET; MUREX WELDING PROCESSES, LIMITED.

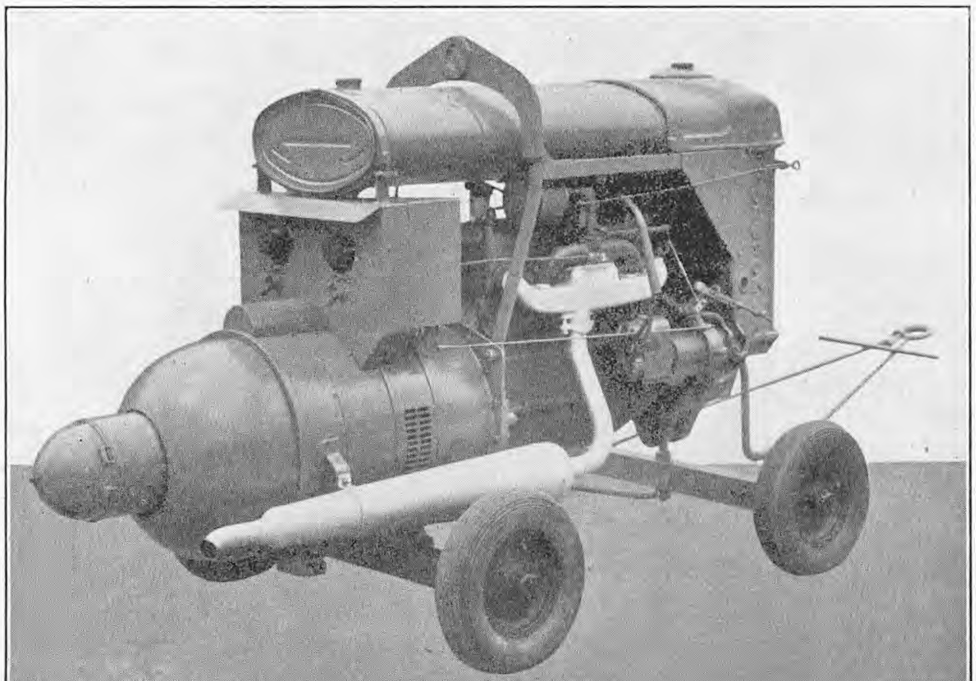

FIG. 74. PETROL-ENGINE WELDING SET; LINCOLN ELECTRIC COMPANY, LIMITED.

methods enables the operator to select the arc intensity best suited to the work.

The exhibits on this stand also included a number of electrically-driven welding machines and several recent developments in electrodes, among which were the Multiweld, Positionweld and Fleetwood 5, the last of which is used almost exclusively on pipe-lines and oil-refining work throughout the world.

Prominent features on the two stands of the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, were a number of models of the large types of equipment manufactured by them. These included a model of a 17,100-kVA 11·5-kV vertical alternator which was designed to be driven at a speed of 600 r.p.m. by a Boving water-turbine. Four of these alternators are being manufactured at Trafford Park for the Kiewa hydro-electric scheme of the Victoria State Commission, Australia. Another model was of a 9,000-h.p. Ward Leonard Ilgner winder, which was based on the design of equipment now in hand for the Mosley Common colliery in the North-Western Division of the National Coal Board. This will, it is believed, be the largest winder of this type in the world. A third model was of an 8,000-h.p. marine turbine now being built for two single-screw vessels; it illustrated modern tendencies in geared marine steam turbines, both in regard to operating conditions and construction. Finally, there were models of the Royal Iris, the Mersey dredger 26 and the Loch Fyne, all of which are fitted with Diesel-electric propulsion equipment.

Fig. 75, on page 326, is an illustration of an automatic arc welding machine which was shown at the exhibition to demonstrate the electronic control of weld-metal deposition. For this purpose, a short gantry had been erected to which a rail track for a standard travelling carriage was fixed. This carriage, which carried the automatic welding head, operator's control panel and a reel of coiled electrode, was of fabricated steel construction and was electrically driven on rollers by a motor The speed of the latter could be adjusted by a rheostat on the operator's panel and it could be declutched so that its position could be rapidly altered by hand. The welding head consisted of a pair of rollers which gripped the electrode, drew it through an adjustable roller-type straightener and passed it through a tubular nozzle into the arc. This nozzle was connected in the welding-current circuit which was coupled through the arc and an "earth" on the workpiece. The arm supporting the head was of a tubular section and had a flanged bracket which could be clamped in several positions between the shaped boss projections on the casing and a saddle.

To feed the electrode at a rate which ensured a constant arc length, the arc voltage on this machine was opposed to a voltage established by a potentiometer. These voltages were applied to the grids of a balance valve, the plate currents from which were passed to phase-shift transductors, so that the strength of the incoming current was translated into angle of phase displacement. This phase displacement was, in turn, connected to the grids of two thyratrons and used to regulate the amount of current passing through the armature of the feed motor. Since the field of this motor was permanently over-excited, its torque was proportional to the armature current and its speed therefore varied in such a way that the electrode was fed more quickly into a lengthening arc and more slowly into a shortening arc. This reaction was so rapid that in practice a constant arc length was maintained. This closeness of control made it possible to use a short arc, a high rate of deposition of weld metal and thus a high welding speed. The coiled electrode used in the demonstration was one of the Metromatic range and the welding current was supplied from a transformer with an output of 1,000 amperes.

The application of electronic control to the "take-up" or "let-off" drive of a reel of continuous material was also shown. This control is employed when constant tension is required and the material is fed on to or taken off the controlled reel by an uncontrolled motor drive. It provides a simple solution to a problem frequently encountered in the textile, paper-making and other industries,

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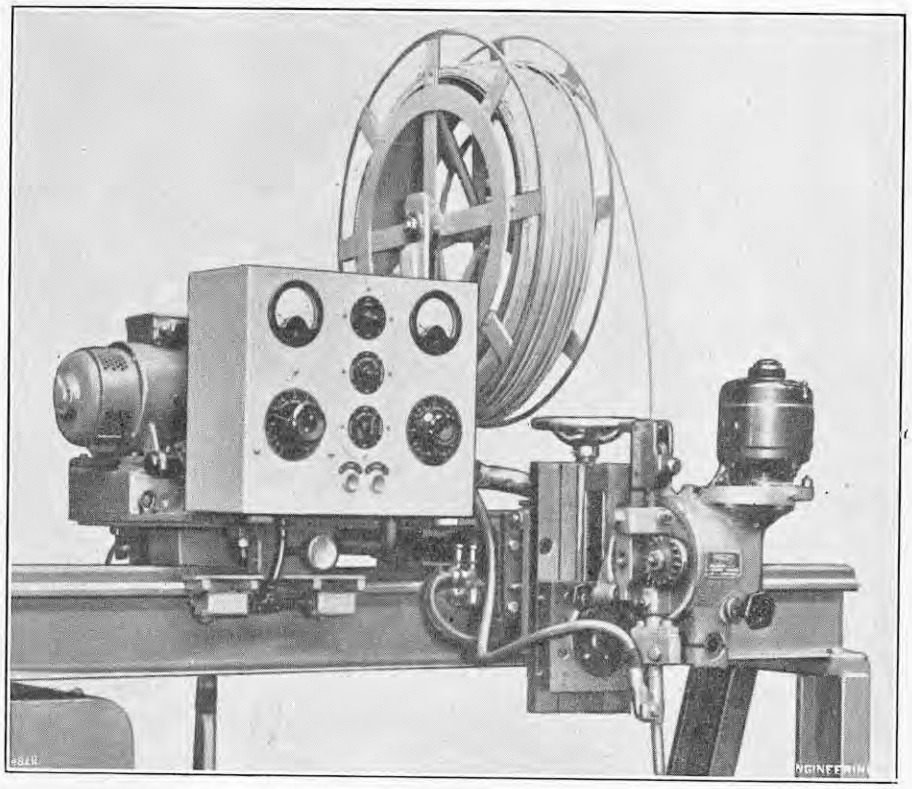

FIG. 75. AUTOMATIC ARC-WELDING EQUIPMENT; METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED.

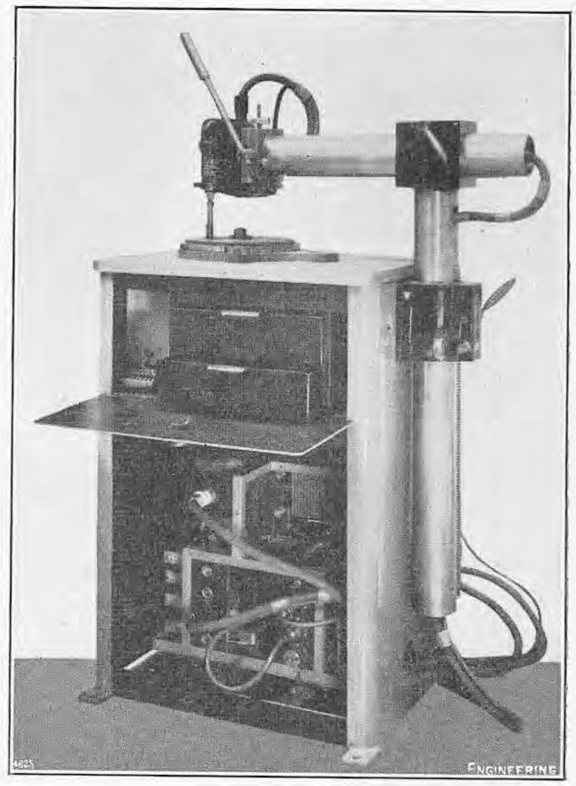

FIG. 76. STUD-WELDING MACHINE; CYC-ARC, LIMITED.

namely, how to control the speed of the reels to suit the linear speed of a continuous strip of material. In this system the reel is driven by a constant-speed reversible motor, so that the material can be run on or let off as required. A second similar reel is driven by a variable-speed motor which is electronically controlled by two thyratrons. The grid phase of the thyratrons is controlled by a magnetic amplifier and, in turn, controls the voltage applied to the motor armature. The reference voltage for the closed-loop control is obtained by a Mag-slip transmitter, which is driven by a "dancing" roller situated in a loop in the material between the two reels. This reference voltage is backed off against the armature voltage, any difference being fed into the magnetic amplifier and altering the grid phase of the thyratron. When controlling "take-up," a tendency for the length of the loop to increase increases the speed of the variable-speed motor, while a tendency in the opposite direction decreases the speed. For the "let-off" control the reverse takes place; the strip tension is maintained throughout both operations. As both motors drive their associated reels there is a progressive change in the linear speed of the strip as the diameter of the material on the constant-speed reel changes. The speed of the variable-speed reel must be altered to allow for these changes in linear speed and diameter, a condition which it would be very difficult to effect manually.

Among the exhibits on the stand of Cyc-Arc, Limited, 27, New North-road, London, N.1, was the stud-welding machine illustrated in Fig. 76, on this page. It is capable of welding studs and similar attachments of diameters ranging from ⅛ in. to ⅞ in. The welding head is fixed to a bracket which is free to move vertically on close-fitting V slides. These slides are carried on a horizontal tubular arm the length of which can be adjusted and which passes through a clamping device mounted on the top of a vertical pillar. The height of this pillar can, in turn, be adjusted by a rack and pinion. The welding head can be moved vertically by a lever-operated spindle to which a pinion engaging a spring-loaded rack on the bracket is fixed. All the welding and control cables are carried inside the tubular members so that they are protected from mechanical damage. The machined steel table to which the fixtures for locating the workpieces are clamped, is welded to a totally-enclosed steel-plate cabinet. Two steel drawers for tools, chucks, ferrules and accessories are contained in the upper half of this cabinet, while the bottom half houses the welding controller, the timing unit of which is mounted on the front. The welding head can be swung horizontally through 180 deg., so that steel welding can be carried out on any workpiece which is too large to be placed on the table but can be stood on the floor.

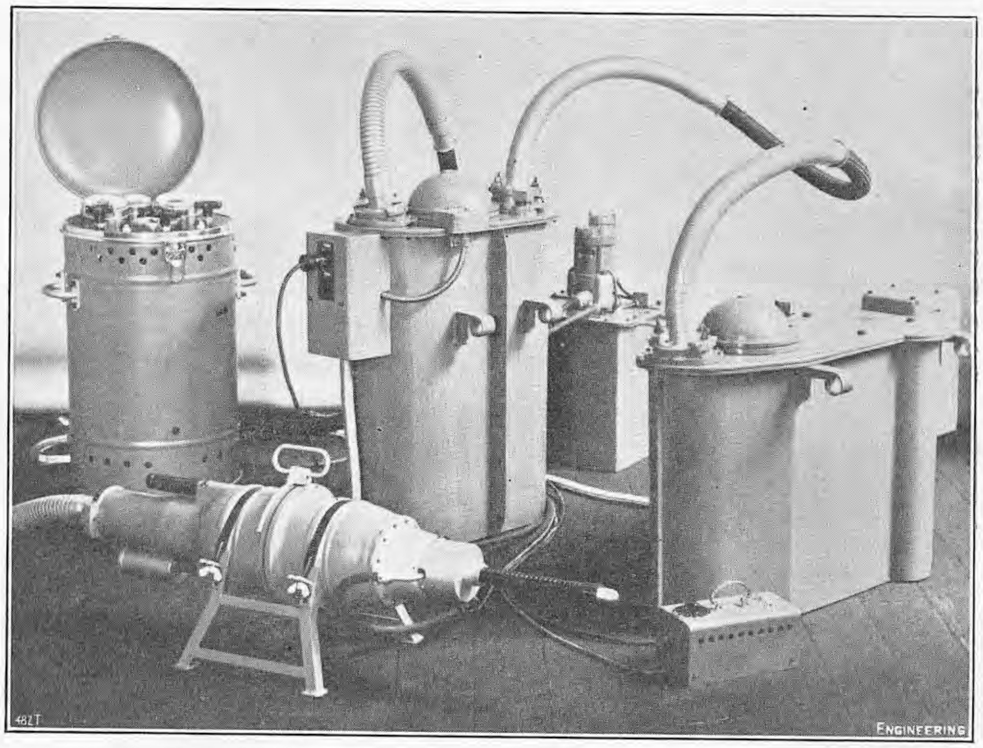

FIG. 77. 140-KV MOBILE X-RAY EQUIPMENT; SOLUS-SCHALL, LIMITED.

The exhibits on the stand of Messrs. Solus-Schall, Limited, 18, New Cavendish-street, London, W.1, included the mobile X-ray equipment illustrated in Fig. 77. This is designed to produce a peak tension of 140 kV and a current of 8·5 milliamperes when operating continuously. It is thus suitable for the examination of steel up to 1½ in. thick when fluorescent screens are used or up to ⅞-in. steel where lead screens are employed. The unit consists of an oil-immersed high-tension transformer, a control switchboard, the X-ray tube itself, and usually an oil pump for cooling purposes. In practice, the transformer is mounted on a trolley and above it is placed the X-ray tube, which rests on gimbals for transport. The control board is arranged in front of and on top of the oil pump. The trolley is provided with strong rubber-tyred wheels and there are long lengths of connecting cables, so that the radius of action of the equipment is wide and the handling of heavy parts is reduced to a minimum. Control is effected from a switchboard on which a compensating voltmeter and a kilovoltmeter are mounted, as well as a clock by which the time of the exposure

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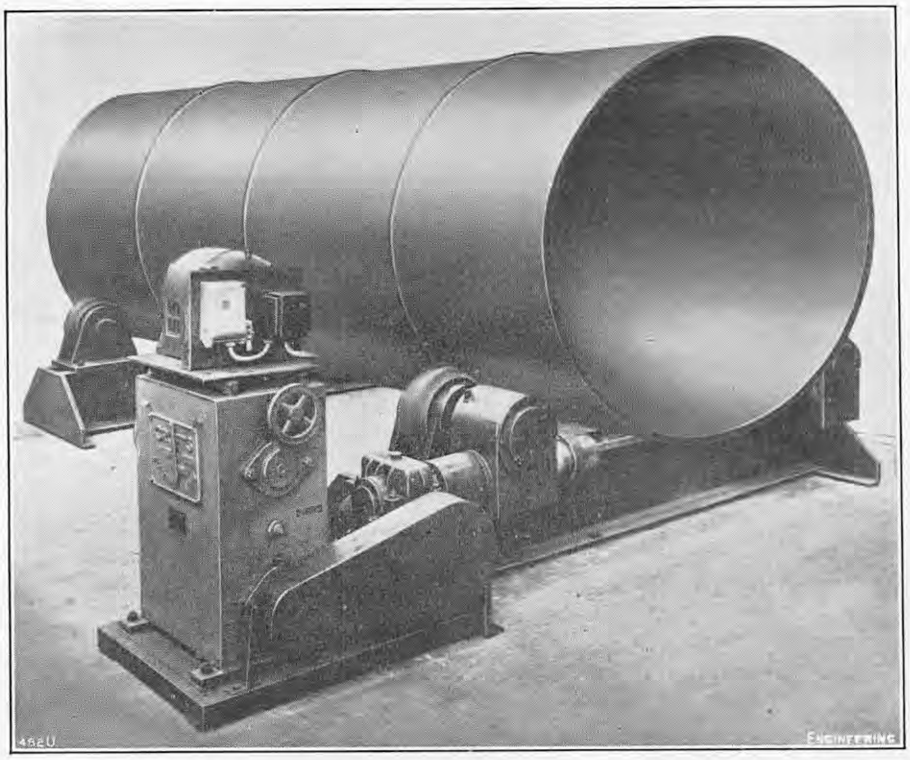

FIG. 78. TURNING ROLLS; DONALD ROSS AND PARTNERS, LIMITED.

FIG. 79. WELDING-FUME EXTRACTOR; SPENCER AND HALSTEAD, LIMITED.

can be regulated up to 12 minutes, the setting being effected by a knob. There is also a milli-ammeter, a current-control switch and the mains "on" and "off" switch. The kilovoltage can be adjusted by a handwheel.

A 300-kV X-ray equipment was also shown on the same stand. This, too, is mobile and has been specially designed for the examination of welded structures during erection on site. It is capable of radiographing sections up to $3\frac{1}{2}$ in. thick. One half of the apparatus can be used with a 150-kV extended-anode X-ray tube, which emits X rays to give a 360-deg. coverage. It is therefore particularly valuable for the radiography of circumferential welded seams or for simultaneous exposures on several specimens arranged in a circle. A fine-focus X-ray unit which was exhibited has been designed for the examination of light-alloy castings and small assemblies on a fluorescent screen. The use of a very small focal spot (0·2 mm.) allows the image to be magnified, thus increasing the sensitivity and revealing the finest defects.

Messrs. Donald Ross and Partners, Limited, 1-3, Arlington-road, London, N.W.1, showed for the first time their Twinner turning rolls for rotating large cylindrical workpieces of varying lengths and diameters at constant speeds ranging from 4 in. to 16 in. per minute at the periphery of the roller. The rolls, which are illustrated in Fig. 78, herewith, are intended primarily for use in connection with automatic or semi-automatic welding, but the possibilities of other applications are being investigated. The illustration shows a power-driven section and a separate idler section capable of supporting a total load of 5 tons. Additional idler sections, each capable of carrying $2\frac{1}{2}$ tons, can be added, at any suitable distance from the power-driven section, to increase the load-carrying capacity. Heavy-duty versions capable of carrying 5 tons and $7\frac{1}{2}$ tons are also available. The distance between the rollers in each section can be adjusted to suit the diameter of the workpiece.

Both the rolls in a power-driven section are driven, so that, in the case of a workpiece having an uneven diameter, there is no possibility of the drive transmission failing through lack of contact between roller and workpiece. A 2-h.p. or $2\frac{1}{2}$-h.p. 960-r.p.m. electric motor is coupled through triple V-belt, to the input shaft of a variable-speed gearbox; the output speed is infinitely variable from 920 to 250 r.p.m. From here the drive is transmitted by a Renold chain to a 40-to-1 reduction gearbox, and thence through a 30-to-1 worm gear mounted on the roller bracket. The output shaft of the wormwheel is coupled directly to the roller shaft. The adjustable outer roller is driven by a square shaft connected through a flexible coupling to the input shaft of the worm gear. The square shaft can slide through the centre of the worm gear which drives the adjustable roller, and is mounted on the roller bracket. The projecting end of the shaft is carried by a floating bearing. All the rollers are fitted with heavy rubber tyres, and are carried by heavy-duty bearings.

Messrs. Spencer and Halstead, Limited, Ossett, Yorkshire, showed blast-cleaning machines, dust-collecting units and fume extractors. The photograph reproduced in Fig. 79 illustrates the Spenstead portable welding-fume extractor, which was exhibited for the first time. The unit comprises a built-in fan with a capacity of 200 cub. ft. of air per minute, driven by a $\frac{1}{3}$-h.p. motor, and an inexpensive oiled-glass filter element which can be replaced. The complete unit weighs 80 lb., and is provided with carrying handles. Another machine shown for the first time was the Mark II dust-collecting unit, which consists of a cabinet housing a primary expansion chamber, a battery of filter screens agitated by a high-frequency agitator and a fan, directly coupled to an electric motor and provided with push-button starting. Four sizes of machine are available, in capacities ranging from 500 to 1,500 cub. ft. per minute; the filtering ratio can be varied to suit high or low dust concentrations.

The argon-arc welding plant exhibited by the Arc Manufacturing Company, Limited, Goldhawk-road, London, W.12, a typical example of which is illustrated in Fig. 81, Plate XXIII, has been designed to produce welds in light alloys by utilising the argon-arc fusion process. It consists mainly of a transformer, the primary of which is arranged with tappings for connection to the 380, 400, 420 and 440-volt mains, while two control wheels enable the secondary current to be adjusted between 25 and 300 amperes at a maximum of 110 volts. A direct-current suppressor, capable of carrying the full welding current, is connected in this circuit. The high-frequency ioniser consists of a spark oscillator with a specially-designed air-core high-frequency transformer, the output frequency of which is 3·5 megacycles. The plant is controlled by a main contactor, which is operated by a remote-controlled foot switch and isolates the set when it is not in use. This contactor is interlocked with a device in the cooling circuit so that the set is shut down automatically if the water supply fails. The gas supply can be turned off automatically when welding has been completed after sufficient time has elapsed to allow the tungsten electrode to cool in an inert atmosphere. The complete cycle of operations can also be controlled by a low-voltage circuit, and the ioniser is arranged so that it only operates until the arc is established and is then automatically cut off.

The same firm were exhibiting the Diesel engine-driven arc welder illustrated in Fig. 80, Plate XXIII. This consists of an air-cooled twin-cylinder Armstrong Siddeley engine with an output of 20 brake horse-power at a speed of 1,500 r.p.m. This engine, which is of the cold-starting solid-injection type, is fitted with a sensitive-speed governor. It is coupled to a self-stabilising drooping-characteristic direct-current generator, with a maximum current output of 300 amperes at 20 to 30 volts. The dynamo is controlled by a shunt-field regulator which is fitted with a rotary snap action selector switch with self-cleaning contacts, so that there is a definite location of each step. The regulator can, if desired, be remote controlled. The engine and dynamo are connected by a Hardy Spicer flexible coupling and the complete unit is enclosed in a sheet metal housing with a removable side cover and is arranged for mounting on a tractor.

Messrs. Cooper and Turner, Limited, Vulcan-road, Sheffield, were showing a range of their welding plant, among which mention may be made of a mobile Diesel engine-driven set. The engine embodies a new method of control so that it can be run at idling speed at all times, except when welding is actually in progress. A considerable saving in fuel is therefore possible. All the controls, both for the engine and the welding circuit, are concentrated on a sunk panel at the end of the casing. The electrically-operated sets included one with a maximum welding current output of 300 amperes, which can be driven either by an alternating or direct-current motor, and an equipment with a maximum output of 350 amperes, which is supplied from a heavy-duty oil-immersed transformer and choke. This set is contained in a welded steel-plate tank, which is mounted on wheels and can easily be slung. It is designed for connection to either a single or a three-phase supply.

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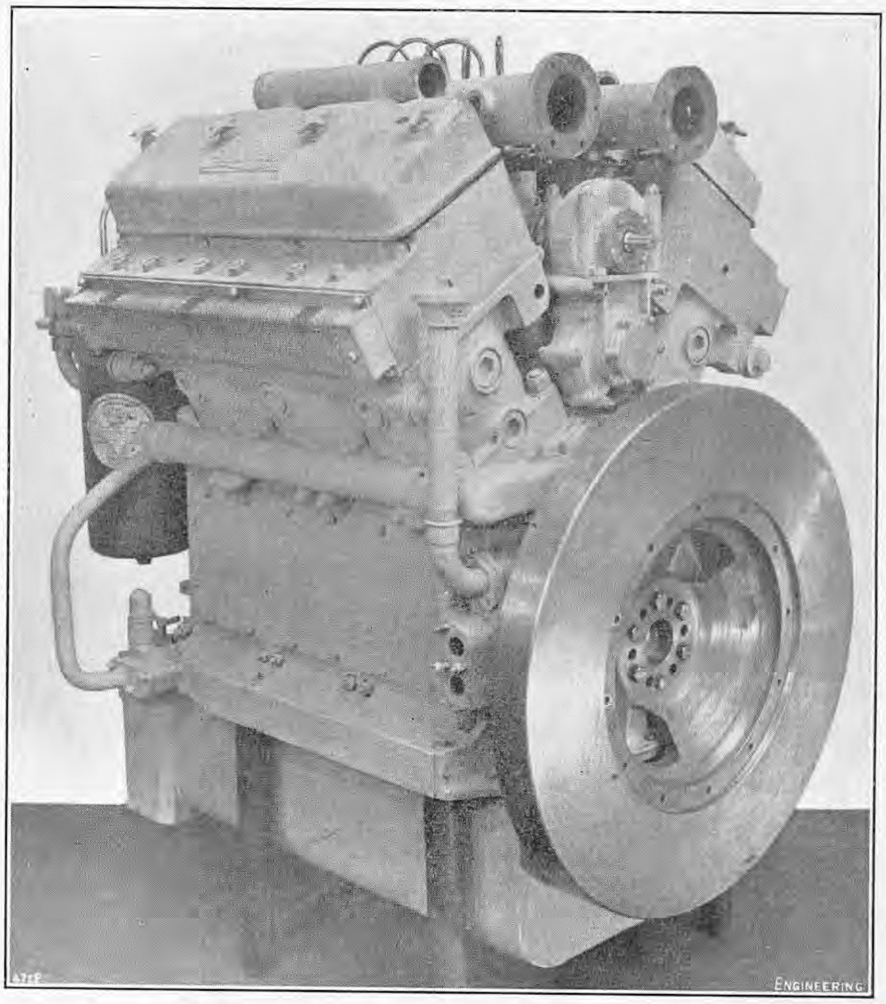

FIG. 84. MARINE DIESEL ENGINE; DAVEY, PAXMAN AND COMPANY, LIMITED.

The principal exhibit on the stand of Rockweld, Limited, Commerce-way, Croydon, Surrey, was a Diesel engine-driven welder consisting of an Armstrong-Siddeley air-cooled twin cylinder engine connected to a direct-current generator through a flexible coupling. The generator is self-excited and has a current output, which can be continuously adjusted from 40 to 300 amperes at the voltages prescribed in British Standard Specification 638, The absence of water cooling and a separate exciter, combined with the accessibility of all the controls, increases the simplicity of the unit and makes it easy to maintain. The generator is stabilised by a counter-compounding series winding and the characteristic is controlled by two independent shunt fields. A regulator in one of these fields provides stepless regulation within the current range mentioned above, while that in the second field enables the open-circuit voltage to be controlled between 55 and 80 volts. Both regulators are scaled so that the correct combination of open-circuit voltage and current can be obtained. The magnetic circuit is so designed that the dynamic characteristics ensure a quick response and a stable arc. A particular feature of the unit to which attention may be called is that there is no control gear in the main welding current circuit. The regulators are therefore of light construction and can, if required, be remotely controlled, a facility which is convenient when work is being carried out on scaffolding and other places that are difficult to reach. The equipment can be supplied for stationary use and is then provided with two lifting eyes. It is housed in a weatherproof enclosure and can be operated without the removal of covers or loose panels. Alternatively, it can be mounted on a carriage with steel or pneumatic-tyred wheels and arranged either for manual haulage or on a two-wheeled road towing tractor.

Another exhibit on this stand was an example of the firm's single-operator alternating-current welding plant, which actually comprises a range of four machines, with maximum welding currents of 160, 300, 400 and 600 amperes, respectively, all of which are of the oil-cooled industrial type. The set exhibited was fitted with a Perspex panel and illuminated interior. An example of the multi-arc plant made by Rockweld was a three-operator equipment consisting of a 57-kVA air-cooled three-phase transformer and three 350-ampere regulators. The latter are of the tapped reactor type and each is provided with 50 current settings within a range of 63 to 350 amperes. The open-circuit voltage for the range is 90 volts.

The English Electric Company, Limited, Queen's House, Kingsway, London, W.C.2, were occupying two stands, one confined to exhibits of the company's Diesel-engine division and the other to their electrical products. The outstanding exhibit on the former stand was undoubtedly the rail-traction unit illustrated in Fig. 83, Plate XXIII. It is of the four-stroke single-acting type and has 16 cylinders arranged in two banks of eight in V-formation at an included angle of 45 deg.; this type of engine, it will be recalled, was fitted to the Diesel-electric locomotives of the London Midland Region. The cylinder bore and stroke are 10 in. and 12 in., respectively, and the maximum traction rating 2,000 brake horse-power, this outstanding performance being obtained by employing exhaust-gas driven turbo-blowers and incorporating such refinements as four valves per cylinder. It has been designed specifically for Diesel-electric traction purposes and, as a consequence, is provided with a facing for bolting the generator directly to the crankcase and bedplate as shown in the illustration.

An interesting feature of the design is the incorporation of three-point suspension, an arrangement which ensures freedom from stresses brought about by distortion of the locomotive frame in service and permits the complete unit to be installed without the need for accurate lining up. The design of the mounting system is quite straightforward, one support being located under the front end of the engine and the two rear supports at the sides of the bedplate at the generator end. High-grade alloy cast iron is used for the bedplate, which is formed so that it accommodates the main bearings. These consist of steel shells lined with a copper-lead bearing material and located axially in the bedplate housings by means of flanges on the shells. The crankshaft is machined from an alloy-steel forging, the pins and journals being bored out and provided with oil ducts for lubrication of the big-end bearings. At one end of the shaft is a flange to which the flywheel and generator armature are coupled and at the other end there is a smaller flange for mounting a vibration damper. The crankcase is in two parts, joined at the centre of the engine, and contains the cylinder coolant spaces and camshaft compartments. Wet-type liners are located at the top by flanges and sealed at the bottom by oil-resistant rings in the normal manner.

The pistons are of aluminium alloy and each is fitted with four pressure rings and two oil-control rings, the latter being located one above and one below the gudgeon pin. Fully-floating gudgeon pins are employed and the piston crowns have simple bowl-shaped combustion chambers machined in them. The connecting rods are machined from I-section drop-forgings and are fitted with steel-backed copper-lead lined big-end bearings provided with flanges which, in addition to locating them, act as bearing surfaces between adjacent rods. Each cylinder has its own separate cast-iron head fitted with two inlet and two exhaust valves operated from the camshafts through rocking levers and push rods in the usual manner. There are two camshafts, one for each bank of cylinders, and they are driven from the crankshaft through a triplex chain and intermediate gearwheels. As previously mentioned, the engine is turbo-charged, there being four separate units arranged to serve four cylinders each, the pressure-charger bearings having their own lubricating system which is completely independent of the main system. Equipment installed on the engine includes a sensitive mechanical governor with hydraulic servo gear; two lubricating pumps, one of which circulates the oil through a cooler and the other through the main system; a separate priming pump; and two engine-driven centrifugal pumps for circulating the coolant through the engine and radiators. Normally, the engine is started by motoring the main generator, a notable feature being the provision of an oil-pressure switch in the electrical circuit which prevents the circuit from being energised until the priming pump has built up sufficient pressure.

Other engines displayed by the English Electric Company included a six-cylinder naturally-aspirated unit having an output of 200 h.p. at 1,300 r.p.m. This engine is illustrated in Fig. 82, Plate XXIII, where it is shown arranged for operating drilling rigs. The unit is of straightforward design, having a cast-iron bedplate arranged to support the main bearings. Cast iron is also used for the crankcase, which is a monobloc structure provided with transverse stiffening diaphragms and fitted with wet-type cylinder liners. The crankshaft is machined from a single steel forging and is supported by split-shell main bearings lined with copper-lead alloy. Separate castings are used for the cylinder heads, and, like the engine just described, each head is fitted with two inlet and two exhaust valves. Trunk-type pistons are employed; these are of heat-treated aluminium alloy and each is fitted with three pressure rings and two oil-control rings. Automobile-type connecting rods are fitted and each has a split-shell big-end bearing and a bush-type gudgeon-pin bearing. With the exception of the pistons and gudgeon pins, all moving parts are supplied with oil under pressure, a high-pressure system being used for the crankshaft main and big-end bearings and a low-pressure system for the camshaft bearings, chain drives, valve gear, etc.

As will be seen from the illustration, the engine, radiator and transmission assembly is mounted on skids so as to render the complete unit easily transportable. The radiator is designed to cool both the engine circulating water and the lubricating oil, the water being circulated through

(To face page 328.)

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(For Description, see Page 327.)

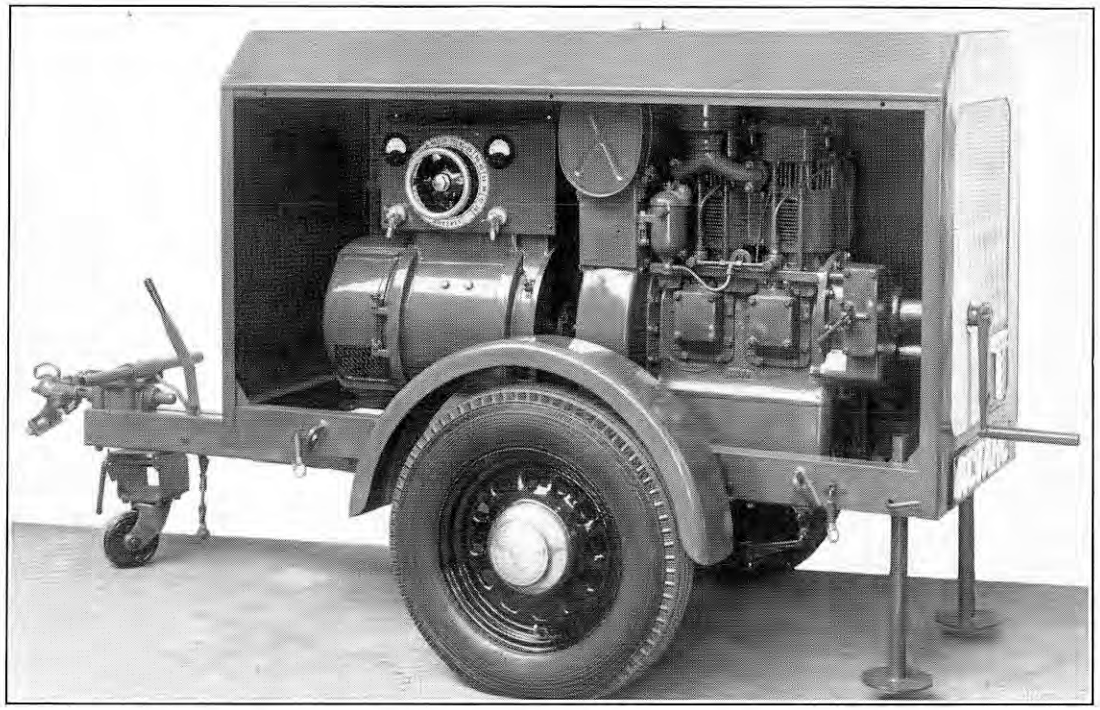


FIG. 80. DIESEL WELDING SET; ARC MANUFACTURING COMPANY, LIMITED.

FIG. 81. INERT-GAS WELDING PLANT: ARC MANUFACTURING COMPANY, LIMITED.

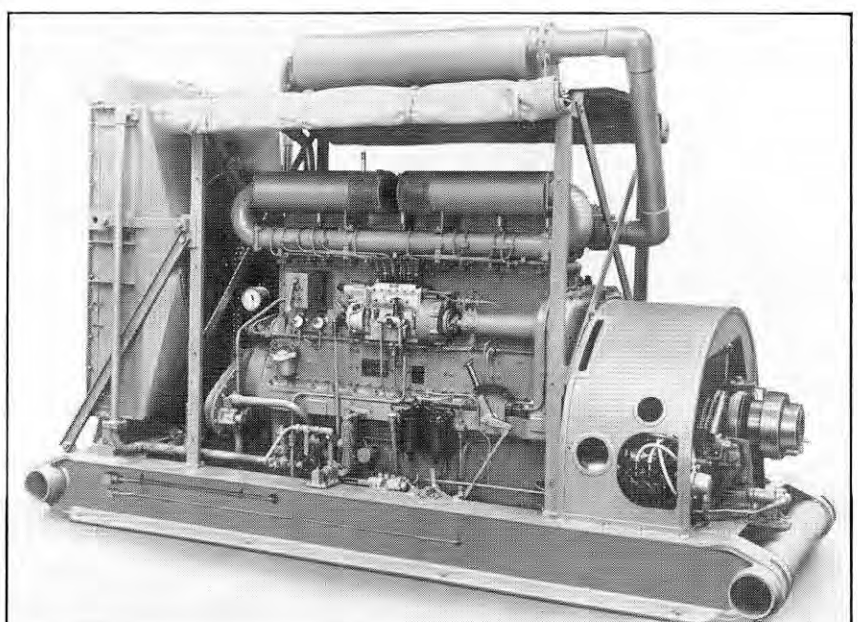


FIG. 82. DIESEL UNIT FOR OIL DRILLING RIG: ENGLISH ELECTRIC COMPANY, LIMITED.

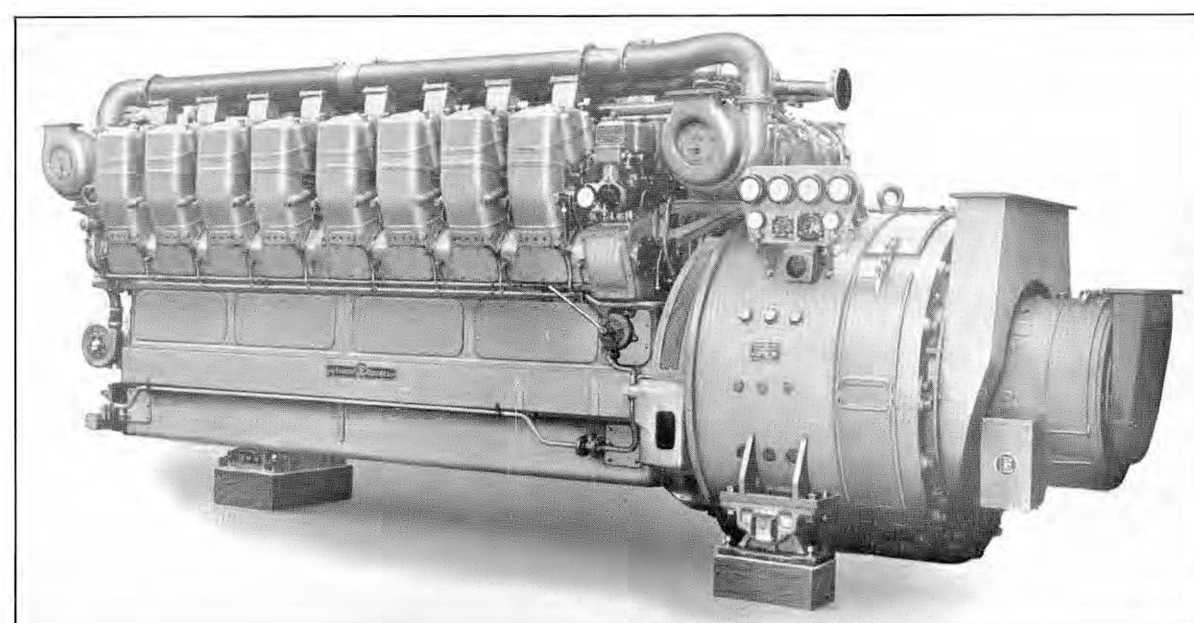


FIG. 83. 2,000-B.H.P. RAIL-TRACTION DIESEL ENGINE; ENGLISH ELECTRIC COMPANY, LIMITED.

the engine and radiator by a centrifugal pump with self-adjusting gland and cooling assisted by an engine-driven fan. Starting is accomplished by means of a compressed-air motor provided with a sliding pinion that automatically engages with the flywheel, the motor being controlled by an air valve on the control panel. The output from the engine is transmitted to a hydraulic coupling of the scoop-controlled type; this is provided with a water cooler for the oil, the cooler being located on the base at one side of the engine. The skid, or under-base, is constructed from heavy I-section girders welded together to form a rigid structure and the complete unit is protected from the elements by a metal canopy and heavy canvas side screens. Equipment provided as standard includes a tachometer, a hand-operated lubricating-oil priming pump, air silencers and filters, hand barring gear, fuel and lubricating-oil filters, and the usual range of pressure gauges, etc. In view of its output, the unit is particularly compact, the overall length, width and height being 12 ft., 4 ft. 11 in., and 6 ft. 11 in., respectively. The weight is 12,390 lb. and the fuel consumption at full load is stated by the manufacturers to being 0·37 lb. per brake horse-power per hour.

Messrs. Davey, Paxman and Company, Limited, Standard Ironworks, Colchester, exhibited a new six-cylinder marine Diesel engine in which the cylinders are arranged in two banks of three in V formation, a design in which this firm has had considerable experience. A photograph of the new engine, which has been designated the V6RPHM, is reproduced in Fig. 84, opposite. Naturally-aspirated and pressure-charged models are available, the former developing 250 brake horse-power and the latter 312 brake horse-power at 1,250 r.p.m. In general the design follows normal Davey, Paxman practice. An under-slung crankshaft is fitted and is supported by four main bearings comprising steel shells lined with copper-lead and housed in a simple cast-iron crankcase. Two faces machined on the upper side of the crankcase carry the separate cylinder blocks, which are cast in sets of three bores and arranged at an included angle of 60 deg. Cast-iron cylinder heads are used; they are fitted with the overhead valve gear and contain the spherical ante-chambers used in connection with the Ricardo combustion system. Aluminium Y-alloy pistons are fitted and are joined to the crank-throws by connecting rods machined from steel stampings. Blade-and-fork construction is employed for the bottom-end bearings, separate steel bearing blocks being bolted to the palm ends of the forked rods. Each block, in turn, is fitted with a shell-type copper-lead lined bearing which operates directly on the crankpin, while the outer surface of the block is chromium-plated to receive the copper-lead lined bearing of the blade rod. Special consideration has been given to the matter of obtaining good balancing, a built-in balance shaft driven at engine speed through gearing from the crankshaft being provided in addition to the usual counter-weights fitted to the crankshaft.

The camshaft, fuel pumps, governor, etc., are located centrally between the two banks of cylinders where they are readily accessible. An all-speed governor of the centrifugally-operated hydraulic-servo type is employed, the design being such that it can be adapted easily to remote control. Pressure lubrication is provided throughout by means of pumps located in the sump; two pumps of the valveless gear type are incorporated in the system, one being the pressure pump and the other the cooling pump. The cooling water is circulated by means of a centrifugal pump gear-driven from the crankshaft and an additional positive-displacement pump can be fitted for use when a heat exchanger for fresh-water cooling is installed. Normally, 24-volt electric-starting equipment is fitted but compressed-air starting can be incorporated if required. The engine exhibited was equipped with a reverse reduction gear of the oil-operated type and fitted with continuously-lubricated helical gears. A thrust-bearing is provided. The pressure-charged engine is fitted with a single-stage centrifugal clower driven by an exhaust-gas turbine.

(*To be continued.*)

DEVELOPMENTS IN GERMANIUM TRIODES.

ON page 630 of our 168th volume (1948) we gave a description of a device, known as the Transistor and consisting essentially of three electrodes and a pin-head of germanium which was soldered to a metal base. As a result of experiments made in the Bell Telephone Laboratories on the semi-conducting properties of the germanium, it was found possible to make this Transistor perform nearly all the functions of an ordinary thermionic valve. Its incorporation in a radio receiver would, therefore, have led to the elimination of filament heating and have the further advantages of securing greater compactness and robustness, as well as a longer life. Considerable interest, therefore, attaches to the further work on this metal which has been carried out by the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, as this has resulted in a radio receiver embodying this device, which, it is claimed, is stable, capable of withstanding severe mechanical shock and of producing a loudspeaker output with low power consumption.

Fig. 1.

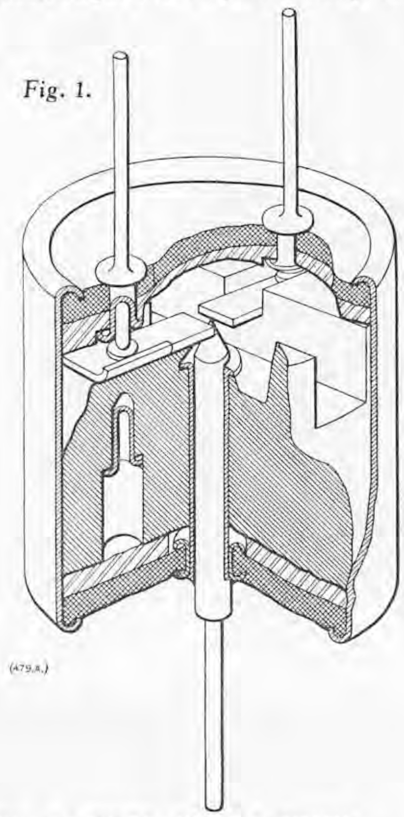
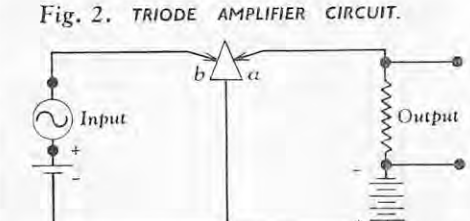


Fig. 2. TRIODE AMPLIFIER CIRCUIT.



This receiver consists essentially of the germanium triode, which is illustrated in Fig. 1. This incorporates two phosphor-bronze blades, 0·003 in. thick and 0·04 in. wide. The gap between these blades, which are supported on a moulded insulator, is very critical and during manufacture is obtained by placing a single strip of the metal in a channel in the moulding and then shearing a gap a few thousandths of an inch wide in it with a specially designed cutter. The germanium is soldered to the tip of a metal strip and is ground to a point with an angle of 60 deg. By inserting the resulting cone into the gap between the phosphor-bronze blades, the essential two-point contact between them and the germanium is made and can be controlled with great accuracy.

As pointed out in our previous article, the electrical operation of this triode depends on the fact that if a negative potential is applied to one of the blades, called the collector and shown at *a* in Fig. 2, then the current through it can be varied by altering the positive voltage applied to the other blade, called the emitter and shown at *b* in the same diagram. The emitter draws appreciable current when positive voltages are applied to it. It thus differs from a thermionic valve, in which the grid voltage is the important factor in securing control of the anode current, since the emitter current controls the collector current. The germanium triode is therefore a current-operated rather than a voltage-operated device.

The characteristics of the germanium triode are low input impedance (of the order of 500 ohms) and a relatively high output impedance (of the order of 30,000 ohms), conditions which influence the design of the associated circuits. For instance, typical operating conditions when the triode is used as an amplifier are 1·5 milliamperes at − 30 volts at the emitter and 0·5 milliampere at + 0·25 volt at the collector. With proper impedance matching such an amplifier stage would give a power gain of 20 to 30 decibels. Owing to limitations in the collector current, the power output of a single germanium triode of the present design is about 20 milliwatts for a tolerable degree of distortion. Oscillators may, however, be made with outputs up to about 100 milliwatts. There is also an inherent upper frequency limit for operating the germanium triode. This is due to transit time effects and is at present about 10 megacycles per second.

Although this triode is an extremely interesting development of the work which has been carried out by the General Electric Company on the germanium crystal diodes which are now used in television receivers and for other purposes, it must be pointed out that it is at present only in the experimental stage and is not likely immediately to replace thermionic valves in the ordinary radio receiver. In fact, its first application may be in electronic computing sets in which saving of space, weight and power are all important.

Germanium triodes capable of generating oscillations with a battery power of less than one microwatt are also being made by the British Thomson-Houston Company, Limited, Rugby, while at the other end of the scale this firm is manufacturing a water-cooled rectifier in which a current of about 100 amperes is carried in an area of 1 sq. cm.

CONFERENCE ON FUEL AND POWER SHORTAGE.

IN response to a number of requests prompted by the present shortage of fuel and power, the Combustion Engineering Association has arranged a two-day conference on "Meeting the Fuel and Power Shortage" to be held at the Dorchester Hotel, Park-lane, London, W.1. At the opening session, at 10.30 a.m. on Tuesday, October 9, the chairman will be the President of the Association, Mr. P. A. Sanders, C.B.E., and the delegates will be addressed by the Minister of Fuel and Power, the Rt. Hon. Philip Noel-Baker, M.P., and by Sir Herbert Houldsworth, Chairman of the National Coal Board. These addresses will be followed by an open discussion on the coal-supply position.

The session, which is due to conclude at 12.30 p.m., will be followed by another in the afternoon, lasting from 2.30 p.m. to 4.30 p.m., when Sir John Charrington, chairman of the Chamber of Coal Traders, will preside. After introductory remarks by the chairman, there will be two addresses on the supply and effective use of electricity and gas, respectively, to be given by speakers whose names have still to be announced. These will be followed by an address by Sir Archibald Forbes, President of the Federation of British Industries, on the subject of industry's fuel problems. The session will conclude with an open discussion.

On the second day, Wednesday, October 10, the chairman at the morning session, from 10 a.m. to 12.30 p.m., will be Sir Ernest W. Smith, chairman of the Industrial Coal Consumers' Council. Mr. B. E. A. Vigers will speak on "The Short Term Economy," and Mr. Oliver Lyle on "The Long Term Economy." These addresses will be followed by an open discussion. In the afternoon, at 2.30 p.m., the chair will be taken by Sir Ewart Smith, who will also speak on "The Requirements for a National Fuel Policy." Mr. W. L. Boon, O.B.E., will then review the salient points emerging from the conference, and an open discussion will follow at which Mr. George Schwartz, Dr. E. G. Ritchie, Mr. Lionel G. Locket, Mr. L. G. Northcroft, and a Parliamentary representative will be present to answer questions. The conference will conclude with remarks by Mr. P. A. Sanders.

THE LILLESHALL BLAST FURNACES.—Turbo-blowers are being installed at the blast furnaces of the Lilleshal Iron and Steel Company, Ltd., at Prior's Lee, near Oakengates, Shropshire. When the installation is completed, the present steam blowing engine will be placed in reserve. This is a vertical compound engine, with cylinders of 42 in. and 70 in. in diameter and a stroke of 5 ft. The engine has Corliss valve gear, and the two blowing cylinders, each 95 in. in diameter, are superimposed on the steam cylinders. It was built by the Lilleshall Company in 1900. The present reserve blowing equipment, a pair of beam engines coupled to a common flywheel and having cylinders 39 in. in diameter and a stroke of 8 ft., was built in 1851. It will be dismantled for scrap when the turbo-blowers are put into commission.

33-KV METALCLAD SWITCHGEAR FOR SUBSTATIONS.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, MANCHESTER.

(*For Description, see Opposite Page.*)

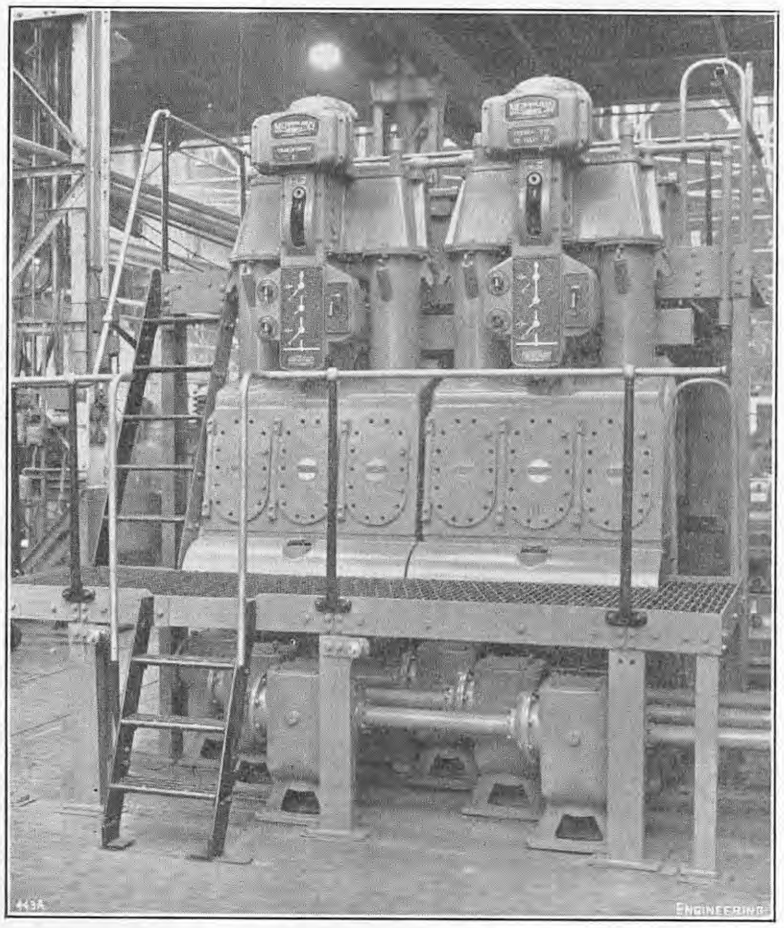


FIG. 1. FRONT VIEW OF 33-KV SWITCHGEAR.

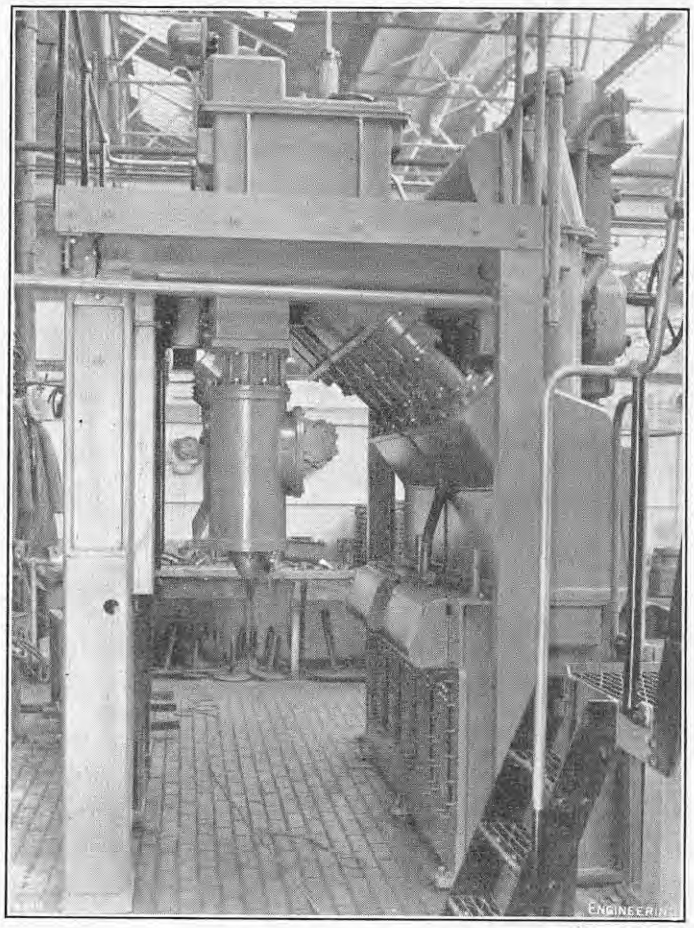


FIG. 2. SIDE VIEW OF SINGLE-BREAK CIRCUIT BREAKER.

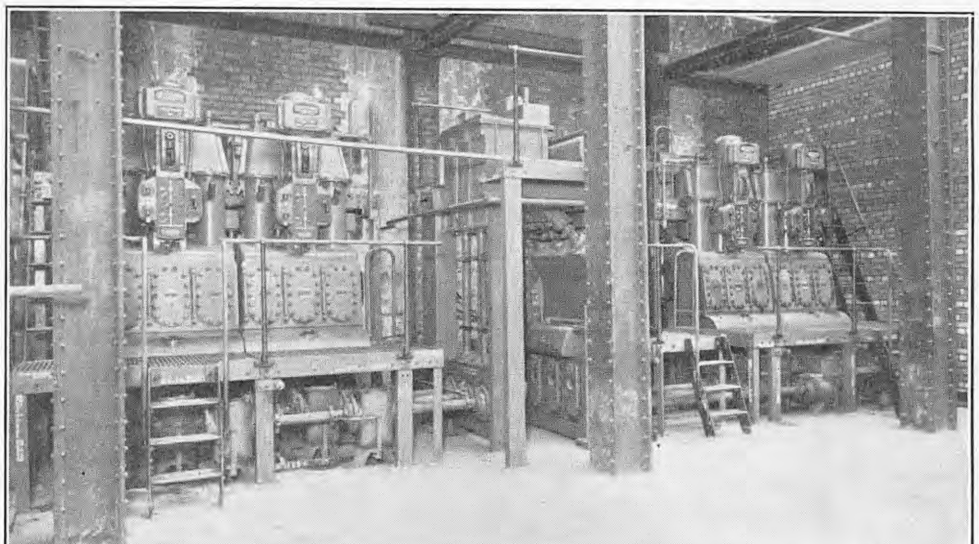


FIG. 3. 33-KV SWITCHGEAR AT SALFORD.

LAUNCHES AND TRIAL TRIPS.

M.S. "SENIORITY."—Single-screw cargo vessel, built by the Goole Shipbuilding & Repairing Co., Ltd., Goole, for F. T. Everard & Sons, Ltd., London, E.C.3. Main dimensions: 225 ft. by 37 ft. 10 in. by 16 ft.; deadweight capacity, 1,850 tons on a draught of 15 ft. 8 in. Sirron Diesel engine, developing 800 b.h.p. at 250 r.p.m., constructed by the Newbury Diesel Co., Ltd., Newbury, Berkshire. Speed, 10 knots. Launch, August 18.

M.S. "HOEGH EAGLE."—Single-screw oil tanker, built by Sir James Laing & Sons, Ltd., Sunderland, for A/S Leif Höegh & Co., Oslo, Norway. Second vessel of an order for two. Main dimensions: 565 ft. between perpendiculars by 74 ft. 9 in. by 41 ft. 6 in.; deadweight capacity, about 23,000 tons on a draught of 32 ft. Six-cylinder opposed-piston oil engine, developing 6,800 b.h.p. at 118 r.p.m., constructed by William Doxford & Sons, Ltd., Sunderland. Speed, 14½ knots. Trial trip, August 28.

M.S. "BOMI HILLS."—Single-screw cargo vessel, built and engined by the Fairfield Shipbuilding and Engineering Co., Ltd., Glasgow, for the Liberian Navigation Corporation, Monrovia, Liberia. First of a series of six. Main dimensions: 600 ft. by 80 ft. by 43 ft.; deadweight capacity, 22,500 tons. Fairfield-Doxford oil engine, developing 8,500 b.h.p. Launch, August 30.

M.S. "ANNO."—Single-screw cargo vessel, built by Hall, Russell & Co., Ltd., Aberdeen, for Mitchell & Rae, Ltd., Newburgh, Aberdeenshire, for service in the coal, grain and potato trade. Main dimensions: 120 ft. between perpendiculars by 24 ft. by 9 ft. 6 in. to upper deck. British Polar two-stroke direct-reversible Diesel engine, constructed by British Polar Engines, Ltd., Glasgow. Launch, September 3.

M.S. "WANDERER."—Single-screw cargo vessel, built and engined by William Doxford & Sons, Ltd., Sunderland, for Thos. & Jas. Harrison, Ltd., Liverpool. Third vessel of an order for four. Main dimensions: 460 ft. overall by 59 ft. 6 in. by 37 ft. 8 in.; deadweight capacity, about 10,000 tons on a draught of 26 ft. 6 in. Doxford four-cylinder opposed-piston oil engine, developing 3,300 b.h.p. at 108 r.p.m. Service speed, about 12½ knots. Trial trip, September 5.

M.S. "SYDENHAM."—Single-screw collier, built by the Burntisland Shipbuilding Co., Ltd., Burntisland, Fife, for the South Eastern Gas Board, Croydon, Surrey. Main dimensions: 265 ft. 10 in. between perpendiculars by 39 ft. 6 in. by 18 ft. 6 in.; deadweight capacity, 2,875 tons on a draught of 17 ft. 1¼ in.; gross tonnage, 1,871. British Polar eight-cylinder opposed-piston Diesel engine, developing 1,150 b.h.p. at 225 r.p.m., constructed by British Polar Engines, Ltd., Glasgow, and installed by the shipbuilders. Speed, 10¾ knots. Trial trip, September 6.

S.S. "POL XV."—Single-screw whale catcher, built and engined by Hall, Russell & Co., Ltd., Aberdeen, for the Hvalfangerselskapet "Polaris" A/S (managers: Melsom & Melsom), Nanset, near Larvik, Norway. Main dimensions: 147 ft. 8 in. between perpendiculars by 29 ft. 6 in. by 18 ft. Hall Russell-Fredriksstad four-cylinder steam motor and two Foster Wheeler marine boilers. Trial trip, September 6.

M.S. "CHAKDINA."—Single-screw refrigerated-cargo vessel, with accommodation for twelve passengers, built and engined by Swan, Hunter, and Wigham Richardson, Ltd., Newcastle-upon-Tyne, for the British India Steam Navigation Co., Ltd., London, E.C.3. Third vessel of a series of four for these owners. Main dimensions: 455 ft. between perpendiculars by 62 ft. 6 in. by 40 ft. 9 in. to shelter deck; deadweight capacity, 9,200 tons on a draught of 27 ft. 2¼ in.; gross tonnage, 7,150; cargo-carrying capacity, 94,000 cub. ft. Swan Hunter-Doxford six-cylinder opposed-piston heavy-oil engine, developing 6,800 b.h.p. at 116 r.p.m. Speed on trial, over 16½ knots. Trial trip, September 6.

33-KV METALCLAD SWITCHGEAR FOR SUBSTATIONS.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, MANCHESTER.

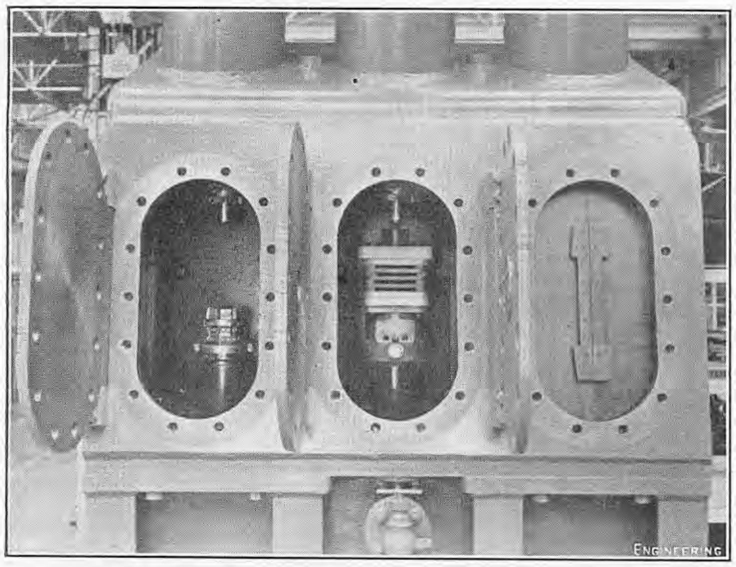


FIG. 4. CONTACTS AND CROSS-JET POTS.

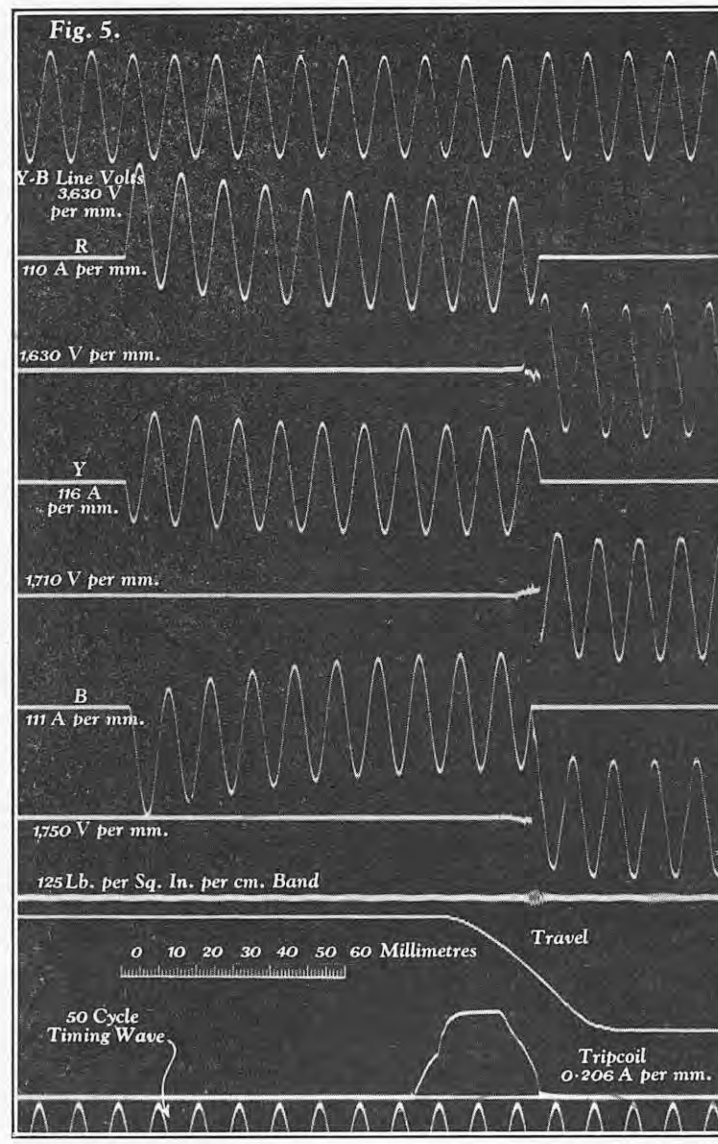


FIG. 5. 10-PER CENT. SYMMETRICAL BREAKING-CAPACITY TEST.

33-KV METALCLAD SWITCHGEAR FOR SUBSTATIONS.

IN 1933, the Metropolitan-Vickers Electrical Company Limited, Trafford Park, Manchester, 17, introduced a pattern of metalclad switchgear in which interruption was completed in a single break, while the circuit breaker, which was fixed, was isolated from the 'bus-bars and cables by oil-immersed switches. These modifications were rendered possible by the development of the cross-jet pot for controlling the arc, while, after exhaustive study, the oil-immersed isolators, which were incorporated, improved operation and made testing and maintenance easier. Further advantages were that a smaller floor area was required for the same power; the life of the bushings was increased, owing to the fact that their ends were completely immersed in oil in both the service and isolated positions. The number of bushings was reduced, thus simplifying the maintenance of the contacts. The facilities for circuit earthing, for the in-zone testing of the protective gear, for the high-voltage testing of the feeder cables and for the accommodation of current transformers were also better. Finally, where a double 'bus-bar arrangement was required, the 'bus-bars and their selectors could be housed in separate compartments.

Breakers of this type with a rupturing capacity of 1,500 MVA, were first used on the London Power Company's 66-kV system, and later units with rupturing capacities of 2,500 MVA at this voltage and of 1,500 MVA and 1,000 MVA at 33 kV were employed. The latest development is a unit with a smaller frame size than the existing range with a rupturing capacity of 750 MVA at 33 kV, a rating that is generally adequate to meet requirements on the distribution systems which are now being laid down in this country. The relative floor areas and cubic space occupied by the horizontal draw-out, vertical drop-down and the new fixed circuit breakers are shown in the accompanying table.

TABLE I.—*Comparative Space Requirements of Circuit Breakers.*

Type.	Unit Centres.	Phase Centres.	Building Details: Three-phase Circuit. Width.	Height.	Floor Area.	Volume.
	Ft.	In.	Ft.	Ft.	Sq. ft.	Cub. ft.
Horizontal draw-out	4·25	11	22·5	13	96	1,250
Vertical drop-down ..	4·25	11	18	17	76·5	1,300
Fixed	3·75	14	15	15	56·25	845

It will be noted that the smaller floor area occupied by the fixed breaker is not achieved by reducing the phase centres, and consequently the clearances in the tank. In fact, the reverse is true, since the elimination of the supporting side frames, which are required in draw-out circuit breakers, enables these centres in the fixed breaker to be reduced from 4 ft. 3 in. to 3 ft. 9 in. and the width of the tank to be increased from 2 ft. 10 in. to 3 ft. $7\frac{1}{2}$ in.

As the fixed circuit breaker incorporates oil-immersed isolators, it does not have to be withdrawn for isolation. Spout insulators are not therefore required and, as has been said, the ends of all the bushings are oil-immersed. It may be pointed out that most of the failures that have occurred in service with metalclad switchgear have been attributed to the deterioration of the Bakelite insulation in the spout, which, in turn, has been ascribed to some obscure chemical change or to age; it has therefore been regarded as inevitable. This theory is not, however, supported by the results of power-factor tests made by the Metropolitan-Vickers Company over a period of 20 years, as these indicate that the major cause of the increase in this quantity is moisture absorption. If, in fact, a varnish paper insulator is immersed in oil, and is thus prevented from absorbing moisture, it retains its original quality.

The new 33-kV equipment consists essentially of the circuit breaker and 'bus-bar isolator unit, the circuit isolator and current transformer chamber with the voltage transformer at the back and the terminal cubicle mounted against the wall. The 'bus-bars occupy an accessible position under the operating platform. The various chambers are of welded steel with independent compartments to provide phase separation. A front view of two such units is given in Fig. 1, on the opposite page, and a side view in Fig. 2, while an illustration of the 750-kVA metalclad switchboard in the Frederick-road substation, Salford, in which these circuit breakers are used, is given in Fig. 3. The arrangement of the contacts and cross-jet pots, which ensure the rapid and efficient interruption of short-circuit currents, is illustrated in Fig. 4, on this page.

A.S.T.A. certificates have been issued, which show that the complete series of tests laid down in British Standard Specification 116 : 1937 have been passed. The operating mechanism incorporates a multiple-lever trip to provide high-speed release and, as will be seen from Figs. 5, 6 and 7, on this page and on page 332, which show the results of a 10 per cent. symmetrical breaking capacity test, a 60 per cent. symmetrical breaking capacity test, and of a 100 per cent. asymmetrical breaking capacity test, respectively, the time from energising the trip coil to arc extinction is from 3 to $3\frac{1}{2}$ cycles. The maximum time at any current within the testing range does not exceed $3\frac{1}{2}$ cycles. Fig. 8, on page 333, is an oscillogram of a make-break test.

The circuit breaker can be supplied with solenoid or hand-charged spring closing mechanism. When the latter is employed, the springs are compressed by rotating a handwheel on the operating panel in front of the breaker. The spring mechanism is fitted with a reverse trip to prevent slow opening and an oil dash-pot which absorbs the shock of the spring if it is inadvertently released with the circuit breaker closed. When compressed the spring can be released by a lanyard or by a trip coil energised from a remote point. To remove the cross-jet pots and inspect the contacts, the oil is drained from the tank and the contacts are exposed by opening three hinged doors. No ancillary lifting equipment is required and the complete operation of opening the breaker, inspecting the contacts and making the breaker ready for service again takes less than one hour.

The 'bus-bar and feeder isolators each consist of three coupled oil-immersed hinged blades with definite "on," "off" and "earth" positions. They are operated by a handwheel on a panel on the front of the breaker, their positions being shown by an indicator. The panel also carries the interlocks between the isolator and the circuit breaker, which prevent the latter being closed unless the isolator blades are fully home in one or other of its three positions. The isolator blades cannot be moved when the circuit breaker is closed and the inspection door cannot be opened unless the isolators are earthed. As there is an isolator with an "earth" position on each side of the breaker, testing can be carried out easily and safely without the use of supplementary equipment. To earth the circuit the breaker is opened and the 'bus-bar isolator is moved to the "earth" position, where it can be seen through a window. The circuit isolator is next moved to the closed position and the circuit earthed by closing the breaker. Work is then possible

33-KV METALCLAD SWITCHGEAR FOR SUBSTATIONS.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, MANCHESTER.

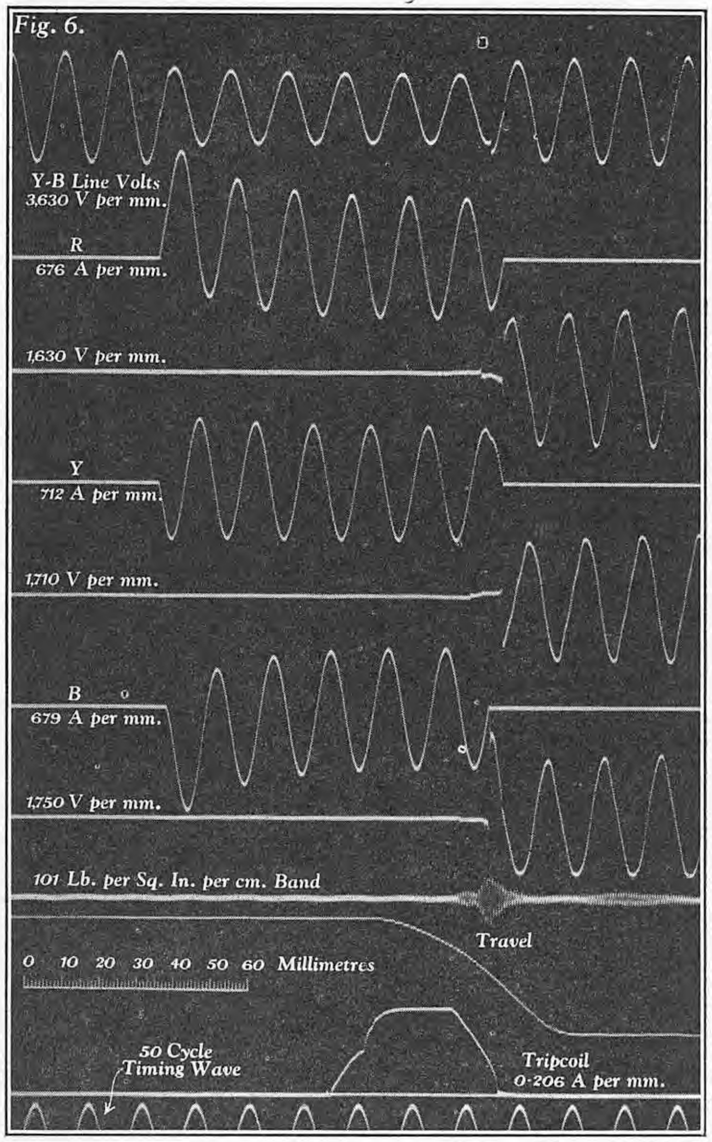


FIG. 6. 60-PER CENT. SYMMETRICAL BREAKING-CAPACITY TEST.

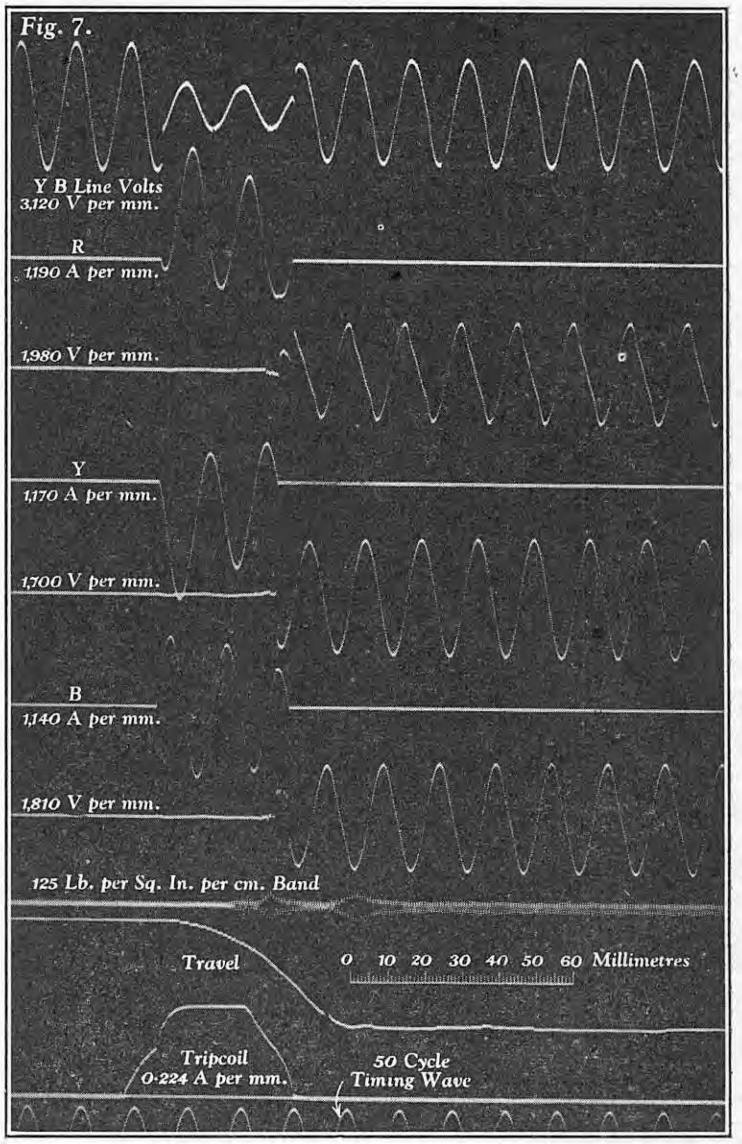


FIG. 7. 100-PER CENT. ASYMMETRICAL BREAKING-CAPACITY TEST.

in the zone between the circuit isolator and the 'bus-bar isolator earth contacts in complete safety. To apply a high voltage test to the outgoing cables, the circuit isolator is moved to the "off" position and telescopic test bushings are inserted through orifices in the top cover of the circuit isolator.

Current transformers can be accommodated on both sides of the circuit breaker so that the circuit and 'bus-bar protective zones overlap. To carry out the routine testing of the current transformer, the circuit and 'bus-bar isolators are both moved to the earth position and the circuit breaker is closed. One side of the test supply is then connected to the bushings mentioned above, the telescopic contacts of which are connected to the fixed contacts of the circuit isolator. The other side of the test supply is connected to terminals on the 'bus-bar isolator tank, access to which is obtained by removing a cover and disconnecting three earthing contacts.

The 'bus-bars consist of lengths of condenser bushings, the ends of which terminate in oil-filled T-boxes. These boxes also house the bushing type connections between the circuit breaker and the 'bus-bars. To give complete phase separation, the voltage transformers are single-phase units. Each winding is connected between line and neutral so that the three transformers are in star with the neutral point earthed. The fuses are mounted on carriers, which can be moved by a lever so that both they and the windings are disconnected from the line. At the same time, the fuses are lifted out of the oil into a dome-shaped cover in which they are accessible for inspection. The cover is interlocked with the lever, so that access cannot be obtained to the interior of the transformer while the latter is alive. This method of isolating and mounting the voltage transformers, enables spout insulators to be eliminated and avoids the exposure of insulation and live metal.

THE STRENGTH OF METALS.*

By PROFESSOR A. H. COTTRELL.

IN a ductile metal the yield strength and fracture strength both depend on the process of plastic deformation that takes place in its constituent crystals. It is well known that a metal crystal deforms plastically by the sliding of one piece of crystal past another on certain crystal planes (slip planes) and in certain crystal direction (slip directions). Because the slip direction is crystallographically determined, even when the maximum resolved shear stress acts in other directions in the slip plane, the material in the slip plane evidently remains crystalline when slip takes place.

The atoms in a slip plane cannot all slip simultaneously over their neighbours in the next plane; slip must begin at certain places and then spread throughout the rest of the plane. It is thus possible, in principle at least, for us to draw lines in an active slip plane, marking out the boundaries of regions where slip has occurred to the extent of 0, 1, 2 . . . etc., lattice spacings. We call these boundary lines "slip dislocations." The structure and properties of slip dislocations can be deduced from the theory of elasticity and from considerations of lattice geometry. Three properties are particularly important: (1) when a slip dislocation is moved in a slip plane the amount of plastic deformation in the crystal is altered; (2) the stress needed to move a dislocation through a slip plane of an otherwise perfect crystal is smaller than the lowest observed yield strength; (3) the stress needed to create a dislocation in a perfect lattice is larger than the highest observed strength.

This last property implies that slip dislocations must be present in the crystal before it is subjected to a plasticity experiment. Support for this idea is provided by a recent theory of crystal growth (theory of Frank), which shows that imperfect crystals, containing dislocations, will grow more quickly than perfect ones. This theory predicts that growth takes place by deposition along spiral terraces on crystal faces, the centre of each spiral being the point where a dislocation line emerges from the interior of the crystal. Recent observations of such growth spirals on inorganic crystals provide striking confirmation of this theory.

The dislocations formed during crystal growth are not constrained to lie in slip planes. Such a dislocation line may follow an arbitrary path through the crystal, some parts lying in slip planes, and so constituting slip dislocations, while other parts do not lie in slip planes and are immobile. A slip dislocation which is part of a more general dislocation line is anchored to the point (point of emergence) in its slip plane where the line turns out of the plane into some immobile orientation. It can therefore glide in its slip plane only by rotating about this point of emergence, rather as the hand of a clock glides in the plane of the clock face by rotating about the centre. The number of rotations which can occur is limited only by boundary conditions, and this is consistent with the observed fact that the amount of slip on active slip planes can be very large, of the order of 1,000 lattice spacings. The analogy with the hand of a clock is not perfect; the dislocation line will curl up into a spiral as it rotates, because, for a constant linear velocity of the dislocation, the angular velocity is greatest for those parts that are nearest to the point of emergence.

In certain circumstances this rotating dislocation may climb from one slip plane to the next as it rotates,

* Summary of paper delivered at a joint meeting of Section B (Chemistry) and Section G (Engineering) at the British Association meeting in Edinburgh on Tuesday, August 14, 1951.

33-KV METALCLAD SWITCHGEAR.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, MANCHESTER.

(*For Description, see Opposite Page.*)

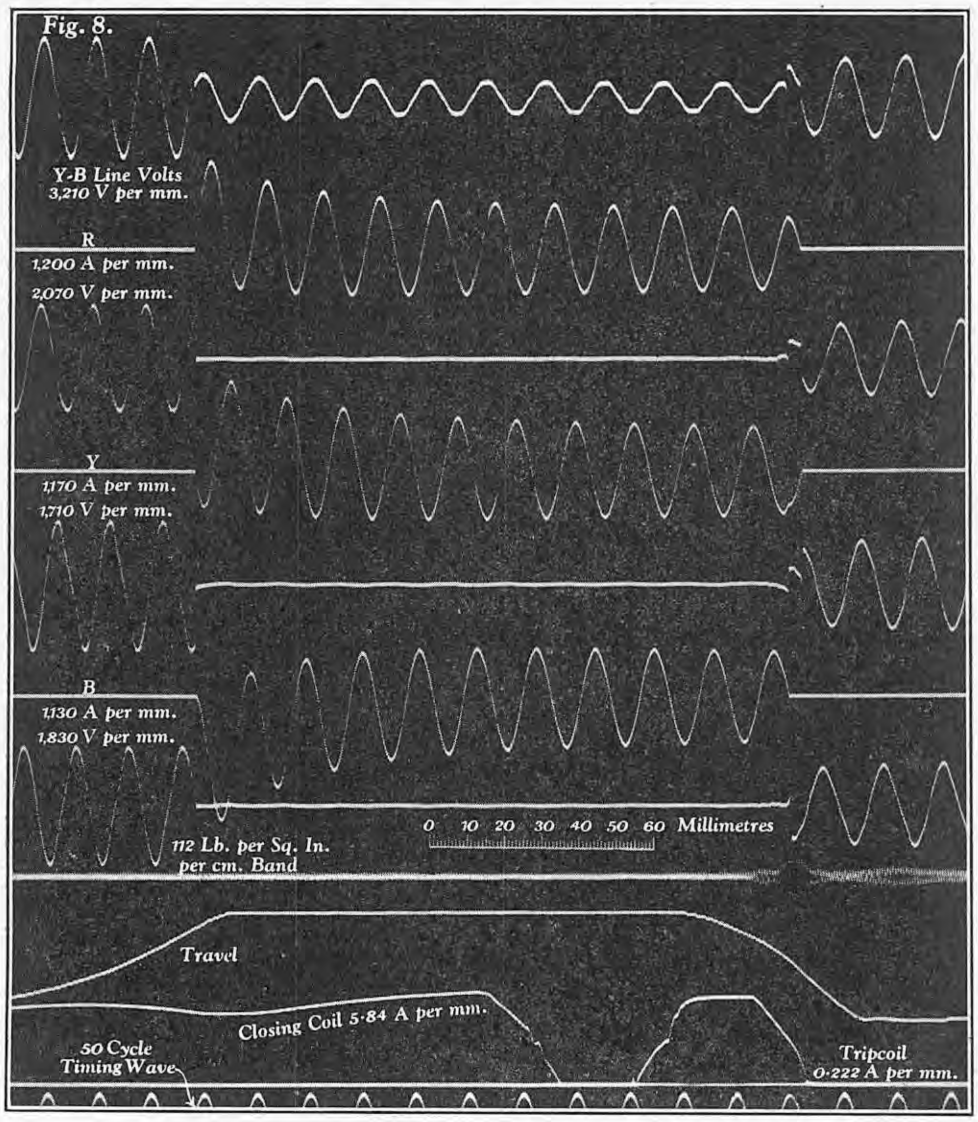


FIG. 8. 100-PER CENT. MAKE-BREAK TEST.

in which case the plastic deformation is not concentrated into a single active plane, but is spread homogeneously through a sequence of planes. This is most likely to occur when the slip dislocation produces a slip of less than one lattice spacing each time it moves through a plane. It may be the mechanism whereby deformation twins are formed.

Since a perfect lattice offers little resistance to the motion of a slip dislocation, the observed hardness of metals must be due to imperfections in the structure which obstruct the dislocations. Various kinds of obstacles may be encountered and affect dislocations in different ways. Mobile impurity atoms in solid solution may migrate to resting dislocations and anchor them firmly to their initial positions. A large stress is then needed to break the dislocations away from these positions, but once they have broken away they can be moved easily by smaller stresses. The material should therefore soften suddenly at the start of plastic deformation. This "yield phenomenon" is observed in soft iron which contains carbon and nitrogen.

Immobile solute atoms which are dispersed as individuals or clustered together into precipitates offer a resistance to a dislocation that is statistically independent of its position in the crystal. No yield phenomenon is observed, but the crystal is hardened because the dislocation has to be driven through the internal stress fields caused by these particles. A critical size of dispersion exists at which the hardening is a maximum. If the dispersion is too fine, the random stress fields acting on the dislocation practically cancel one another, and there is little hardening. If the particles are too far apart, the dislocation is able to curl between them and "by-pass" them, and again there is little hardening.

Grain boundaries form strong obstacles to the passage of dislocations. Slip can be transmitted from one grain to another, however, in the following way. If a sequence of dislocations, in an active slip plane, approaches a grain boundary, the pressure of the members of the sequence against their leader, which is obstructed by the boundary, causes a large intensification of stress in the neighbourhood of the obstruction. When the number of dislocations in the sequence is large (1,000 is a reasonable value) the stress is enlarged so much that slip is forced to take place in the crystal on the other side of the boundary. The number of dislocations that can be piled up in a slip plane increases both with the applied stress and with the length of that plane, that is, with the grain size. It follows that grain boundaries are less effective as obstacles when the grain size is large.

Strain hardening is proving to be one of the more intractable problems facing the theory. It depends upon the group behaviour of the large number of dislocations created during plastic flow. Recent experiments suggest that the initial dislocations tend to assemble into sheet-like arrays, roughly perpendicular to the slip direction, where they are firmly locked by their mutual interactions. These sheets act as barriers to the propagation of later dislocations, and as more dislocations gather up in them, they become observable under the microscope, where they are known as deformation bands. We do not as yet fully understand how these special arrays of dislocations are formed in the first place, or why they should be so stable mechanically, but there are strong reasons for believing that they are the main cause of strain hardening.

ROYAL AERONAUTICAL SOCIETY.—The seventh British Commonwealth and Empire Lecture of the Royal Aeronautical Society will be delivered at the Institution of Civil Engineers, Great George-street, London, S.W.1, on Thursday, October 4, commencing at 6 p.m. The lecturer will be Air Vice-Marshal Sir L. M. Isitt, K.B.E., who will take as his subject "Air Transport in New Zealand and the Southern Pacific."

ANNUALS AND REFERENCE BOOKS.

British Chemical Plant.—A 1951 edition of the illustrated directory of members of the British Chemical Plant Manufacturers' Association, 14, Suffolk-street, London, S.W.1, has been issued to replace the last edition dated 1947-48. It contains a list of members of the Association, a classified index of products and services, and an illustrated section provided by member firms. The list of members gives not only the addresses of the firm's head and London offices, but also the names and addresses of their overseas agents. The classified index of products and services is very detailed, and, forming a useful adjunct to this, is the illustrated section which occupies over 200 of the 300 odd pages of the directory and indicates the vast field covered by the Association. We understand that the directory, which is entitled *British Chemical Plant*, has been widely distributed to chemical and allied manufacturers at home and overseas, but a few copies are available gratis to chemical-plant users, who should apply to the secretary of the Association at the above address.

The Anglo-American Year Book.—The 39th edition, that for 1951, of the *Anglo-American Year Book* has been published by the American Chamber of Commerce in London, 7, York Buildings, Adelphi, London, W.C.2. Following well-established precedent the *Year Book* contains sections giving lists of the staffs of the American Embassy and Consulate General in London and the British Embassy in Washington and brief particulars of American institutions in Great Britain and British institutions in the United States. Legal and commercial information, including chapters on "American Law for Britons" and "English Law for Americans," again finds place in the book, but, to many, the directory portions will be found the most useful. These include a residential directory of American citizens in Great Britain; a list of members of the American Chamber of Commerce in London; a classified trades and professions list; and a commercial directory, consisting of an alphabetical list of British and United States firms, giving the representatives and agents of each in the other country. The *Year Book* is edited by Miss Phyllis Hamlin and the price is 25*s*. net.

Britannica Book of the Year 1951.—The events of the previous year are the subject of each *Britannica Book of the Year*; and they are most comprehensively surveyed. "Events" is perhaps too narrow in its implication, as the book covers developments in the thought and action, theory and practice, of politics, economics, industry, science, the arts, humanities, religion, law and sport. It can be regarded either as a supplement to the *Encyclopædia Britannica* or as a unique reference book standing independently on its own merits. The articles which should be mentioned here include those on docks and harbours, telegraphy, machinery and machine tools, rubber, railways, munitions of war, airports, aircraft, the motor industry, jet propulsion and gas turbines, shipbuilding and shipping, bridges, atomic energy, electrical industries, metallurgy, coal, tunnels, electronics, physics, mathematics, and light and heavy engineering. The treatment in the case of engineering, to take an example, is partly commercial and partly technical, a reasonable understanding of the subject being taken for granted. Facts are preferred to comment and opinion, though where the latter intervene they appear to be well founded. There is one small inconsistency which it might be possible to avoid: in the gas-turbine article the names of firms are freely given where necessary, but not so in the articles on light and heavy engineering. A list of editors and contributors (including some well-known names in this country and the United States) is given; also a diary of events, and biographies of persons prominent during 1950. The book contains 750,000 words, 370 photographs and 40 maps, charts and cartoons, and it is difficult to imagine its purpose being more admirably achieved than it has been under the direction of the London editor of the *Encyclopædia*, Mr. John Armitage. The *Britannica Book of the Year* is published at the price of 3*l*. by Encyclopædia Britannica, Limited, 102, Dean-street, London, W.1.

COURSE IN ENGINEERING METROLOGY.—The Royal Technical College, Glasgow, is offering a course of 12 lectures on engineering metrology at weekly intervals, commencing on Thursday, September 27, 1951, at 7.30 p.m. The inclusive fee for the course is 42*s*., and admission is by personal enrolment at the college between 7 p.m. and 9 p.m. on September 18, 19 and 20, or by post until September 22. The lectures will deal with the principles of measurement, gauges and gauging, gauge inspection, manufacture of gauges and measuring instruments, optical measuring instruments, quality control, control in medium quantity production, surface finish, interferometry, measurement and inspection of gears and gear cutters, and the metrology of machine tools. Further details may be obtained on application to the Director.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

TRANSPORT OF LARGE TANKS BY SEA.—Three tanks, each 16 ft. in diameter by 58 ft. long and weighing 33 tons, have been assembled as a sea-going raft in Queen's Dock, Glasgow, for towing to Swansea. They have been constructed by the Motherwell Bridge and Engineering Co., Ltd., Motherwell, Lanarkshire, and are to be used in connection with the oil refinery of the Anglo-Iranian Oil Company, Ltd., at Llandarcy, Glamorganshire.

THE NEED FOR INCENTIVES IN INDUSTRY.—A series of nine addresses, under the general heading of "Incentives from Achievement," has been arranged for delivery during the winter session luncheon meetings organised by the Glasgow branch of the Incorporated Sales Managers' Association. The series will be introduced by Lord Bilsland, M.C., D.L., chairman of Bilsland Brothers, Ltd., Glasgow, at the branch's luncheon on September 20, and speakers at the subsequent meetings will be drawn from leading firms in the West of Scotland.

TELEVISION RECEPTION IN SCOTLAND.—Test transmissions from the north of England television station at Holme Moss have been received in Edinburgh, according to a statement made by Mr. Aiden Thomson, B.B.C. assistant head of programmes for Scotland, at the Festival luncheon of the Scottish Music Merchants' Association, in Edinburgh, on September 5. The station is about 200 miles from the Scottish capital.

SCOTTISH GAS MANAGERS.—The formation of a new organisation, to be known as the Scottish Association of Gas Managers, by the amalgamation of the Waverley Association of Gas Managers and the North British Association of Gas Managers, was announced at the close of the annual general meeting of the North British Association, by the President, Mr. F. R. Mitchell. Sir Andrew Clow, chairman of the Scottish Gas Board, expressed the hope that, in adopting this new form, the organisations would continue the fine traditions which lay behind them. The annual meeting of the North British association was held in Ayr on September 6.

PRODUCTION DIFFICULTIES IN SCOTTISH STEEL INDUSTRY.—Local steelmakers have expressed their uneasiness at the extents of the cuts in ingot production imposed on them, having regard especially to the decreases in output imposed on other parts of Britain. They point out that, while output has been reduced by 20 per cent. in Scotland, it has been curtailed in Southern districts by only about 5 per cent. of their capacity. The shortage of scrap is a factor which weighs very heavily in Scotland, owing to the higher proportion of scrap in furnace charges. One sequel to the uneven apportionment of raw materials is that makers try to ensure that the manufactured steel is dispatched to local consumers rather than to those at a distance, in order that the scrap resulting from the finishing trades may remain in the district.

CLYDE NAVIGATION TRUST.—The revenue of the Clyde Navigation Trust, for the year ended June 30 last, was a record, it was stated at the meeting of the trustees held in Glasgow on September 4. The tonnage of vessels using the port increased, but revenue dues were down, largely on account of the greater number of vessels using the lower stages at reduced rates. Oil, petrol, and timber imports and exports were greater than last year, while 136,000 tons of American coal were imported, this being a new traffic. Imports of iron ore showed the greatest decrease compared with last year, while coke exports were trebled.

CLEVELAND AND THE NORTHERN COUNTIES.

TRADE ON TEES-SIDE.—Alderman B. G. Davies presided at the monthly meeting of the Tees Conservancy Commission held at Middlesbrough on September 3 and reviewed trade conditions on Tees-side during the past year. Traffic to and from the river during June, he pointed out, was at a low ebb. Imports in June were the lowest since the war, but there had been a considerable improvement in July, when the revenue had been only 4,000*l*. below the highest monthly record.

PRESSURE FOR MAXIMUM SUPPLIES OF IRON AND STEEL.—With no dearth of tonnage at ore ports abroad, imports of foreign ore are maintained on a substantial scale and consumers are building up stocks satisfactorily. North-East Coast buyers of iron and steel are pressing persistently for as big deliveries as possible before the control of tonnage distribution comes into force.

LANCASHIRE AND SOUTH YORKSHIRE.

MASTER CUTLER-ELECT.—Mr. Geoffrey M. Flather, joint managing director of W. T. Flather, Ltd., steelmakers, Sheffield, has been chosen by the Cutlers' Company of Hallamshire as Master Cutler-elect. The installation ceremony will take place later. Mr. Flather is a son of a former Master Cutler and has been prominent in the affairs of the Cutlers' Company and the Sheffield Chamber of Commerce. He is a member of the Council of the British Iron and Steel Federation and of the Council of the British Iron and Steel Research Association.

CUTLERY MANUFACTURERS' ASSOCIATION.—Mr. D. A. Palmer, managing director of Joseph Rodgers and Sons, Ltd., has been re-elected president of the Sheffield Cutlery Manufacturers' Association, an office he has held for 17 years.

RAILWAY PASSENGER TRANSPORT.—Many complaints having reached British Railways about the lack of a sleeping-car service between Yorkshire and London, an experimental service is to be inaugurated from October 1. A train will leave Leeds at 2.42 a.m. and Sheffield at 3.55 a.m. and is due to arrive at St. Pancras at 8.5 a.m. Sheffield industrialists are not wholly satisfied with the proposal, however, some considering that an earlier departure time would be convenient.

REVISED GAS CHARGES.—The East Midlands Gas Board hope to be able to issue, in October, revised tariffs which will make charges uniform over the whole area. At present, there are widely differing tariffs that were inherited from the privately-owned undertakings. The proposed standardised charges will lead to increases in some districts and lower charges in others.

WARNING OF ELECTRIC-POWER CUTS.—A demonstration has been given at the Cutlers' Hall, Sheffield, of a system of short-wave warnings of impending power cuts. A bell rings to give warning because it has not been clearly established whether the Post Office would permit verbal messages to be transmitted. Mr. F. Lloyd, former president of the Sheffield Chamber of Commerce, has stated that the proposed two-minutes warning is not enough; plant such as electric furnaces needed longer notice to avoid the risk of a steel melt being spoiled if the power were suddenly cut-off.

THE MIDLANDS.

TRADE AND LABOUR CONDITIONS.—The effects of the rearmament programme are becoming more marked in the Midlands, particularly in Birmingham and the Black Country, where there has been full employment and full order books for a considerable time; and rearmament orders are additional to normal work. There is a hope that the supply of raw materials may improve, if only in the iron- and steel-using trades, as a result of the increased prices for scrap which were authorised recently. These, together with an intensified drive for scrap recovery, should bring in more of this valuable material. The labour problem, however, remains urgent. There has been a small amount of redundancy, and there is said to be some concealed unemployment, particularly in the motor-vehicle industry, sections of which have had to introduce short-time working owing to the shortage of materials. This labour will be absorbed readily, as it is only a small proportion of the total need. Labour cannot be obtained from other districts, even supposing it is available, on account of the lack of housing accommodation.

REMOVAL OF REDDITCH FACTORY.—The entire equipment of the Index Automatic Machine Co., a subsidiary of B.S.A. Tools, Ltd., has been moved from Redditch to Cardiff, where increased space is available for expansion. Some 5,000 tons of machine tools were involved, and the whole removal has been undertaken by British Road Services. The Index Company's works at Redditch will be occupied by the B.S.A. Company, and a large number of the Index employees will be taken on by B.S.A. Tools. A number of key men will be taken to Cardiff to start operations at the new works.

THE CLOSING OF BRANCH RAILWAYS.—The West Midland Area Transport Users' Consultative Committee have met to consider the proposed closure of certain railway branches and stations in the Midlands. The railway branch lines involved are those between Craven Arms and Much Wenlock; Abbey Dore and Dorstone; Dollyhir and New Radnor; Blisworth and Stratford-upon-Avon; and Bromyard and Leominster. On other lines, between Crewe and Stafford; Malvern and Tewkesbury; and Wellington and Coalport, it is proposed to close certain stations only to passenger traffic, Brigadier F. Lane, chairman of the committee, has announced that special sub-committees have been set up to investigate, on the spot, the effects of the proposed closures. The committee have recommended that the British Transport Commission should hold public meetings in future when it is proposed to withdraw any services, in order that all complaints and views may have an opportunity of being presented.

EXTENSION OF RURAL WATER SUPPLIES.—The Rural District Council of Shipston-on-Stour, Warwickshire, have been informed by the Ministry of Local Government and Planning that their scheme for providing water to rural consumers in their area is likely to be approved. About 8,000 people live in the Council's administrative area and a large proportion of them go to make up the 2·6 per cent. of Warwickshire's population which have no piped water. The scheme, which will cost 315,000*l*., involves the purchase of water in bulk for the North Cotswold Rural Council.

NEW PLANT AT WILLENHALL.—New plant installed by the Willenhall Motor Radiator Co., Ltd., at Neachells-lane, Willenhall, Staffordshire, includes a British Clearing 500-ton press, a production line for an all-steel motor-lorry cab and another for a pick-up truck body designed for export to Australia.

NEW GAS COUNCIL RESEARCH CENTRE.—The Gas Council have now established a second research centre, which will be concerned mainly with the complete gasification of coal, at the Nechells gasworks, Birmingham. It will be administered by the West Midlands Gas Board on behalf of the Gas Council. Dr. F. J. Dent, the present assistant director of the Gas Research Board, has been appointed Director of the new centre. He has been closely associated with the experiments on complete gasification which have been conducted at the Poole research station.

SOUTH-WEST ENGLAND AND SOUTH WALES.

COAST-PROTECTION SCHEME.—A scheme to protect the Pembrokeshire village of Amroth from the coastal erosion, which, for a number of years, has caused considerable damage, is to cost 91,000*l*. At present, the first stage of the work, costing 7,850*l*., is being carried out. After grants, the Narberth Rural Council are expected to find 10,000*l*. of the cost.

SHIP-REPAIR WORK.—The South Wales ship-repairing industry, which has been carrying out a substantial amount of ship repairs for the Admiralty, is to have a larger share of this class of work. On a recent visit to Cardiff, Mr. James Callaghan, Parliamentary and Financial Secretary to the Admiralty, said there were at present 22 naval ships in South Wales ports for repair, and 500,000*l*. was being spent on ship-repairing in South Wales. Next year the value would be increased to 1,000,000*l*.

TIMBER IMPORTS.—The timber trade at Cardiff Docks is now more active than it has been for a long time. Recent imports have been at double the normal rate and have resulted in a heavy strain on the railway-wagon position.

OBSOLESCENT STEELWORKS.—The announcement by Mr. S. J. L. Hardie, chairman of the Iron and Steel Corporation, at the annual meeting of Richard Thomas & Baldwins, Ltd., that an investigation is to be made into the old hand-operated mills in West Wales has been welcomed in the area. The shortage of raw materials has already caused some of these old works to be closed down, and for some time there has been considerable concern for their future in view of the large-scale developments of the Steel Company of Wales.

SEVERN BARRAGE SCHEME.—When the electricity load-spreading arrangements for next winter were discussed by the London and South Eastern Regional Board for Industry at a meeting on September 5, it was urged that more stress should be placed on the provision of energy from sources other than coal. Further consideration of the Severn Barrage scheme was advocated.

BUSINESS EQUIPMENT EXHIBITION AT BRISTOL.—The first exhibition to be organised by the Office Appliance and Business Equipment Trades Association (the title of the Office Appliance Trades Association and the Association of British Business Equipment Manufacturers since their merger in July) will be held in the Victoria Rooms, Bristol, from September 25 to 28. It is entitled the South-Western Business Equipment and Management Exhibition, and will be opened by Mr. Reginald Verdon Smith, assistant managing director of the Bristol Aircraft Company.

NOTICES OF MEETINGS.

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

INSTITUTION OF PRODUCTION ENGINEERS.—*Derby Section:* Monday, September 17, 7 p.m., School of Art, Green-lane, Derby. "Materials Handling," by Mr. E. Williamson. *Coventry Graduate Section:* Tuesday, September 18, 7 p.m., Hare and Squirrel Hotel, Cow-lane, Coventry. Brains Trust Meeting on "Production Engineering." *Birmingham Section:* Wednesday, September 19, 7 p.m., James Watt Memorial Institute, Great Charles-street, Birmingham. "The Machine-Tool Industry," by Mr. W. J. Morgan.

INSTITUTION OF WORKS MANAGERS.—*Glasgow Branch:* Monday, September 17, 7.15 p.m., Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow, C.2. Annual General Meeting. "Job Evaluation," by Mr. R. Aston. *Merseyside Branch:* Tuesday, September 18, 6.30 p.m., Reece's Restaurant, Liverpool. Annual General Meeting. *Manchester Branch:* Monday, September 24, 6.30 p.m., Grand Hotel, Manchester. "The Task Ahead," by Mr. E. J. Holford Strevens.

INCORPORATED PLANT ENGINEERS.—*Edinburgh Branch:* Tuesday, September 18, 7 p.m., Edinburgh Chamber of Commerce, 25, Charlotte-square, Edinburgh. "The Construction of the Modern Oil Refinery," by Mr. W. M. Greenhorn. *Western Branch:* Wednesday, September 19, 7.15 p.m., Grand Hotel, Bristol. "Steam Peaks and Thermal Storage," by Dr. E. G. Ritchie. *Liverpool and North Wales Branch:* Thursday, September 20, 7.15 p.m., Radiant House, Bold-street, Liverpool. Discussion on "Industrial Lighting." *West and East Yorkshire Branch:* Monday, September 24, 7.30 p.m., The University, Leeds. Film Evening.

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—*Midlands Centre:* Tuesday, September 18, 7.30 p.m., Crown Inn, Broad-street, Birmingham, 1. "The Servicing of Brakes," by Mr. J. Kinchin. *North Western Centre:* Wednesday, September 19, 7.30 p.m., The Victoria Hotel, Wigan. "The Heating and Ventilating of Public-Service and Goods Vehicles," by Mr. F. Duncombe. *North Eastern Centre:* Thursday, September 20, 7.30 p.m., The Hotel Metropole, Leeds; and Tuesday, September 25, 7 p.m., Dunelm Hotel, Old Elvet-street, Durham City. "Garage Equipment and Service Tools," by Mr. R. M. Walker.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*Bournemouth and Portsmouth Branches:* Tuesday, September 18, 7.30 p.m., The Polygon Hotel, Southampton. Combined Lecture on "Electrical Protective Gear in Factories," by Mr. G. L. Leighton. *Manchester Branch:* Wednesday, September 19, 7.30 p.m., The Engineers' Club, Albert-square, Manchester. "Application and Development of Resistance Welding," by Mr. R. Bushell. *Kent Branch:* Thursday, September 20, 8 p.m., The County Hotel, Canterbury. "Electric Telemetering Systems," by Mr. F. C. Hill. *Oxford Branch:* Saturday, September 22, 2.30 p.m., Clarendon Laboratories, Pardis-road, Oxford. Discussion on "Electrical Apparatus Used in Nuclear Research," to be followed by an inspection of the cyclotron and other high-voltage apparatus.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—Wednesday, September 19, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, Westminster, S.W.1. "Dynamic Braking for Steam, Diesel and Gas-Turbine Locomotives," by Mr. J. Koffman.

INSTITUTE OF PETROLEUM.—Wednesday, September 19, 5.30 p.m., Manson House, 26, Portland-place, W.1. "Our Unproduced Reserves: What Are They?" by Dr. Morris Muskat.

BRITISH LIGHT STEAM POWER SOCIETY.—Saturday, September 22, 3 p.m., Waldorf Hotel, Aldwych, W.C.2. "The Problem of the Steam Car," by Mr. M. Harman Lewis.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—*Scottish Branch:* Tuesday, September 25, 6.30 p.m., Engineering Centre, 351, Sauchiehall-street, Glasgow, C.2. Annual General Meeting. "School Heating," by Dr. J. C. Weston. *Birmingham Branch:* Thursday, September 27, 6.30 p.m., Imperial Hotel, Birmingham. Annual General Meeting. "Heating and Hot-Water Service for Moderate Rental Flats," by Mr. A. F. Myers. *Manchester Branch:* Friday, September 28, 6.30 p.m., Engineers' Club, Albert-square, Manchester. Annual General Meeting.

INSTITUTION OF MECHANICAL ENGINEERS.—*Southern Branch:* Wednesday, September 26, 7 p.m., Technical College, Brighton. Discussion on "Britain—Liquid Fuel—Engineers," to be opened by Engineer-Captain H. Moy. *North Western Branch (Administration and Production Group):* Thursday, September 27, 6.45 p.m., Engineers' Club, Albert-square, Manchester. "Some Problems in the Manufacture of Experimental Gas Turbines," by Mr. L. H. Leedham. *East Midlands Branch (Provisional Graduates' Section):* Thursday, September 27, 7.15 p.m., Midland Hotel, Derby. "The Marine Gas Turbine from the Viewpoint of an Aeronautical Engineer," by Mr. A. H. Fletcher.

INSTITUTION OF MINING AND METALLURGY.—Thursday, September 27, 5 p.m., Geological Society's Apartments, Burlington House, Piccadilly, W.1. "Work in High Air Temperatures in a Fire in Mysore Mine, Kolar Gold Field," by Dr. W. B. Roantree.

ILLUMINATING ENGINEERING SOCIETY.—*Bradford Group:* Thursday, September 27, 7.30 p.m., Offices of the Yorkshire Electricity Board, 45-53, Sunbridge-road, Bradford. "Lighting of Trains and Public-Service Vehicles," by Mr. S. Anderson and Mr. C. Dykes Brown. *Leeds Centre:* Friday, September 28, 7 p.m., The Guildford Hotel, The Headrow, Leeds, 1. Chairman's Address, by Mr. J. Sewell.

CONTRACTS.

JOHN LAING AND SON, LTD., London, N.W.7, have been awarded a contract by the Air Ministry for the laying of high-quality concrete paving for the runways at the airfield of the National Aeronautical Establishment, near Bedford.

ALBION MOTORS, LTD., South-street, Glasgow, W.4, an associated firm of Leyland Motors, Ltd., have obtained a contract to construct 200 six-wheeled motor lorries for the War Office. This contract will provide the firm with work for about six months. The lorries have been developed from a type widely used in South Africa and in countries with similar terrain, and are intended for field work generally. Albion Motors will supply the chassis, bodywork and engines.

During August, the British Electricity Authority placed contracts for equipment for power stations, transforming stations and transmission lines amounting, in the aggregate, to 4,203,375*l*. The principal contracts include orders for the painting of buildings and plant at Poole power station, with R. P. SINGLETON; generator, station and unit transformers at Acton-lane "B" power station, with FERRANTI, LTD.; 11-kV, 6-kV and low-tension power and control cables and accessories, for Littlebrook "C" power station, with W. T. HENLEY'S TELEGRAPH WORKS CO., LTD.; foundations for the second half of the main building at East Yelland power station, Barnstaple, with TAYLOR WOODROW CONSTRUCTION, LTD.; coal-handling plant at Bold power station, St. Helens, Lancashire, with NAYLOR BROTHERS, LTD.; civil-engineering works at Doncaster power station, with HIGGS AND HILL, LTD.; extension of boiler-house foundations and ancillary works at Skelton Grange power station, Leeds, with HAROLD, ARNOLD AND SON, LTD.; site clearance and preliminary works at Stella North power station, Blaydon-on-Tyne, with SIR ROBERT MCALPINE (NEWCASTLE-UPON-TYNE), LTD.; brick chimney at Chadderton power station, with P. C. RICHARDSON CO. (MIDDLESBROUGH), LTD.; three 360,000 lb. per hour boilers for Carrington power station, Manchester, with JOHN BROWN & CO., LTD.; generator and unit transformers for Fleetwood power station, with the ENGLISH ELECTRIC CO., LTD.; boiler-house buildings for Roosecote power station, Barrow, with DORMAN, LONG & CO., LTD.; 132-kV 2,500-MVA switchgear for Ince power station, Capenhurst, with the ENGLISH ELECTRIC CO., LTD.; 33-kV and 11-kV static condensers for Llanelly substation, Carmarthen, with BRITISH INSULATED CALLENDER'S CABLES, LTD.; 132-kV switchgear for Bonnybridge substation, Stirling, with the BRITISH THOMSON-HOUSTON CO., LTD.; 132-kV and 33-kV cables for laying on the Longstone-Gorgie-Telford road, south-east Scotland, with PIRELLI-GENERAL CABLE WORKS, LTD.; and 132-kV overhead-line equipment for erection between Kilmarnock and Kendon, with WATSHAM'S, LTD.

COAL PRODUCTION IN GREAT BRITAIN.—The output of deep-mined coal in Great Britain, according to statistics issued by the Ministry of Fuel and Power, amounted to 143,597,000 tons for the 36 weeks ended September 8, 1951, compared with 138,964,000 tons for the corresponding period in 1950. The output of opencast coal declined during the same corresponding periods from 8,865,700 tons in 1950, to 7,690,500 tons in 1951.

ELECTRICITY SUPPLY STATISTICS.—The official returns issued by the Ministry of Fuel and Power show that during the first seven months of 1951 34,848 million kWh of electricity were generated in the power stations of the British Electricity Authority, the North of Scotland Hydro-Electric Board and the Lochaber Power Company, compared with 30,885 million kWh during the corresponding period of 1950. At the end of July, the installed capacity of the generating plant was 15,364 MW, compared with 15,099 MW at the beginning of the year.

PERSONAL.

The annual awards of the Royal Aeronautical Society, presented on September 10 by the President, Major F. B. Halford, C.B.E., are as follows: the Society's gold medal, awarded posthumously, to MR. W. G. A. PERRING, C.B.; the Society's silver medal, to MR. S. B. GATES, O.B.E., F.R.S.; the British gold medal to MR. A. E. RUSSELL, B.Sc.; the British silver medal to GROUP CAPTAIN JOHN CUNNINGHAM, D.S.O., D.F.C.; the R. P. Alston Memorial Prize to WING COMMANDER R. J. FALK, A.F.C.; the George Taylor of Australia Gold Medal to MR. R. E. BISHOP, C.B.E.; the Sims Gold Medal to DR. G. S. HISLOP, Ph.D., B.Sc.; the bronze medal to MR. H. J. POLLARD, Wh.Ex.; the Herbert Akroyd Stuart Memorial Prize to MR. A. V. CLEAVER; and the Edward Busk Memorial Prize to MR. R. HILLS, B.A. Three honorary fellows have been elected, namely, PROFESSOR SIR BENNETT MELVILL JONES, C.B.E., A.F.C., F.R.S., SIR HENRY THOMAS TIZARD, G.C.B., A.F.C., F.R.S., and MR. C. C. WALKER, C.B.E.

MR. DAVID D. WALKER, M.A., M.I.E.E., was elected President, and MR. H. S. BROOM, M.B.E., B.Sc., M.I.Mech.E., was re-elected vice-president, of the British Engineers' Association, 32, Victoria-street, London, S.W.1, for the session 1951-52, at the meeting of the Association's Council on September 6. Mr. Walker is a joint managing director of Evershed and Vignoles, Ltd., and Mr. Broom occupies a similar position with Broom and Wade, Ltd.

MISS E. M. COLLIN, Ph.D., D.Sc., F.R.I.C., was installed as President of the Women's Engineering Society, 35, Grosvenor-place, Westminster, London, S.W.1, at the Society's annual general meeting, on September 8, in succession to MISS SHEILA LEATHER.

MR. GILBERT ROBERTS, B.Sc. (Eng.), M.I.C.E., MR. IAN COX, M.A. (Hons.), MR. CECIL COOKE, F.R.S.A., and MR. F. R. BELL have been awarded the honorary membership of the Institution of Engineering Draughtsmen and Designers, Grand Buildings, Trafalgar-square, London, W.C.2.

MR. R. W. TAYLOR, A.M.I.E.E., who recently resigned his position as sales manager to Cyc-Arc, Ltd., has been appointed product sales manager of the Nelson stud-welding service of Crompton Parkinson, Ltd., Aldwych, London, W.C.2, in succession to MR. R. V. POWDITCH, O.B.E., T.D., A.M.I.E.E., who, as announced on page 143, *ante*, has been appointed product sales manager for Crompton Parkinson F.H.P. motors. These appointments take effect from October 1.

MR. H. C. REEVES, B.Sc. (Eng.), A.M.I.C.E., D.I.C., has been appointed chief fan designer of Air Control Installations, Ltd., Ruislip, Middlesex.

MR. C. L. FISHER has been promoted to the position of manager of the British sales division of the Consolidated Pneumatic Tool Co., Ltd., 232, Dawes-road, London, S.W.6, with effect from August 29. He has spent nearly 38 years in the company's service.

MR. D. E. DAVIS, A.M.I.Mech.E., has been appointed chief development engineer of Berger Equipment, Ltd., Moor-lane, Staines, Middlesex. MR. J. A. CORNISH-BOWDEN, M.I.Mar.E., has been appointed sales manager in succession to MR. W. GRAHAM.

MR. G. B. HAYWARD, A.M.I.E.E., has been appointed manager of the Plymouth sub-office of Metropolitan-Vickers Electrical Co., Ltd., with effect from August 1. He has succeeded MR. W. S. LIVSEY, who has transferred to the Metropolitan-Vickers Export Co., Ltd.

MR. R. H. PENNEY has been elected chairman of Council of the Incorporated Sales Managers' Association, 4, Holborn-place, High Holborn, London, W.C.1. He will take over that office from MR. W. E. WHEATLEY in November.

HIGH DUTY ALLOYS, LTD., 89, Buckingham-avenue, Slough, Buckinghamshire, have changed their telephone number to Slough 23901. Their telegraphic address, "Alloys, Slough," remains unaltered.

A new firm, BESTWOOD, FRASER AND WEIR, LTD., has been formed as a private company, registered in Great Britain, to provide consulting and mining engineering services in this country, South Africa, the United States and elsewhere. It is an association of the BESTWOOD CO., LTD., Nottingham; H. H. FRASER AND ASSOCIATES (PTY.), LTD., Johannesburg; and the PAUL WEIR CO., INC., Chicago, U.S.A. The directors of the new company are MR. R. C. LANCASTER (chairman), MR. HUGH FRASER, MR. PAUL WEIR and SIR ERIC YOUNG, and its registered office is at 22, Ryder-street, St. James's, London, S.W.1. Offices are also being opened shortly at Johannesburg.

BELL'S ASBESTOS AND ENGINEERING, LTD., 157, Queen Victoria-street, London, E.C.4, have acquired the entire ordinary share capital of the MILLER INSULATION CO., LTD., thermal and acoustic insulation contractors, of Glasgow. MR. A. J. M. MILLER, the chairman and joint managing director of the Miller Insulation Company, has been appointed to the board of Bell's Asbestos and Engineering, Ltd. It is intended that the Miller Insulation Company shall retain its separate identity.

ELECTRIC-FURNACE MODEL FOR ROYAL SCOTTISH MUSEUM, EDINBURGH.

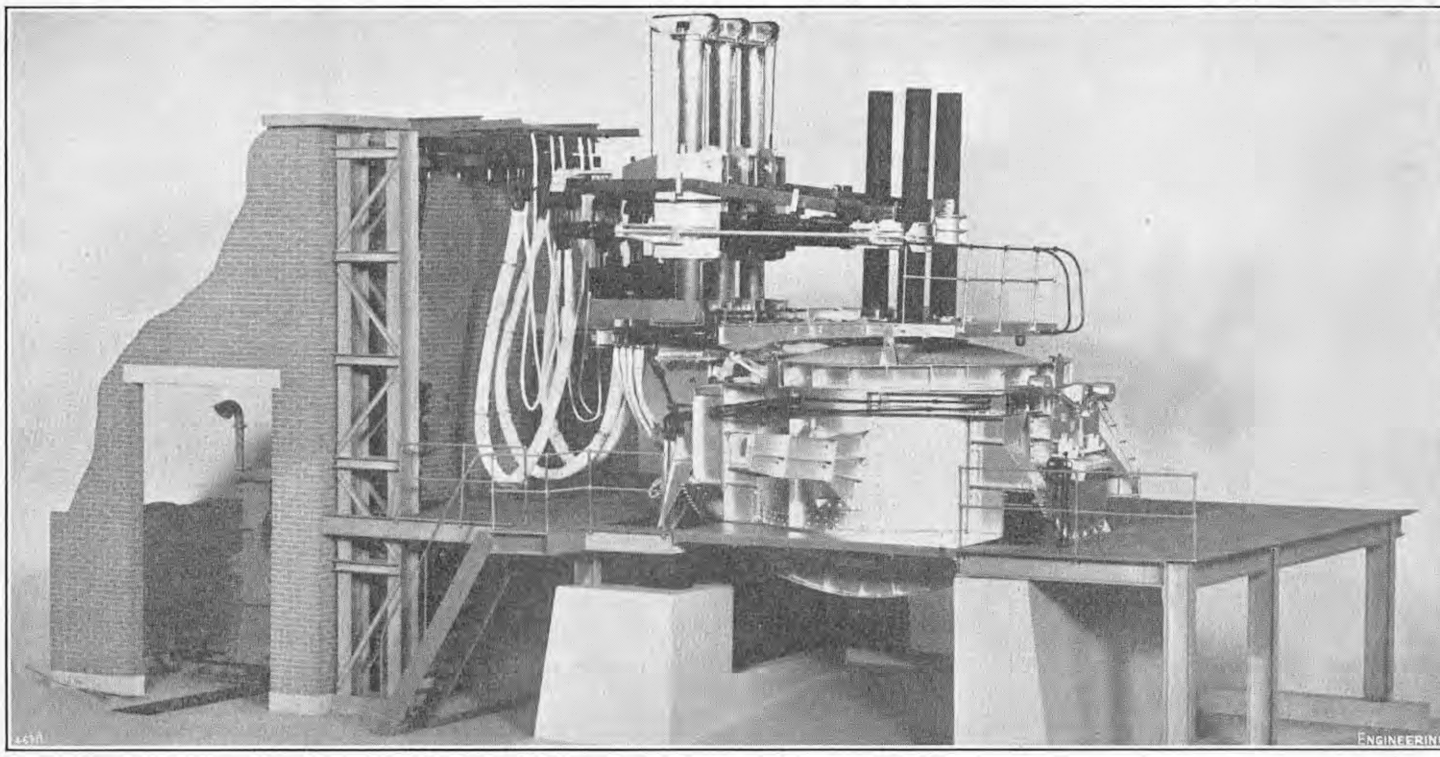


FIG. 1. GENERAL VIEW OF MODEL.

ELECTRIC-FURNACE MODEL FOR ROYAL SCOTTISH MUSEUM.

THE Royal Scottish Museum at Edinburgh has acquired recently, for inclusion in its permanent collection, a model of a Heroult electric steel-melting furnace, to the scale of ¾ in. to a foot. It is illustrated in Figs. 1 and 2, herewith, and Fig. 3 shows, for comparison, the actual furnace of which the model is a copy, as erected in the works of William Shaw and Company, Limited, at Middlesbrough, by the makers, the Electric Furnace Company, Limited, Weybridge, Surrey. It is of the direct-arc tilting type, with three electrodes, and has a capacity of 12 tons. The diameter of the original is 11 ft. 6 in., the overall height 27 ft. 6 in., and the weight 31 tons. It is fitted with a swing roof for rapid charging; the roof ring with its steelwork and brick lining, and the electrodes and their carriages, are raised mechanically about 6 in. and swung to the side. The adjustment of the electrodes is automatic. In the model, which was made by Mr. C. A. Mills, 18, Manor-road, Ruislip, Middlesex, the furnace is partly sectioned to show the electrodes and the refractory lining. The tilting mechanism, which rocks the furnace on its two tracks, is of the hydraulic type in the model, but electro-mechanical tilting is often used. Special efforts were made to complete the model in time for it to be placed on exhibition a few days before the opening of the recent British Association meetings in Edinburgh.

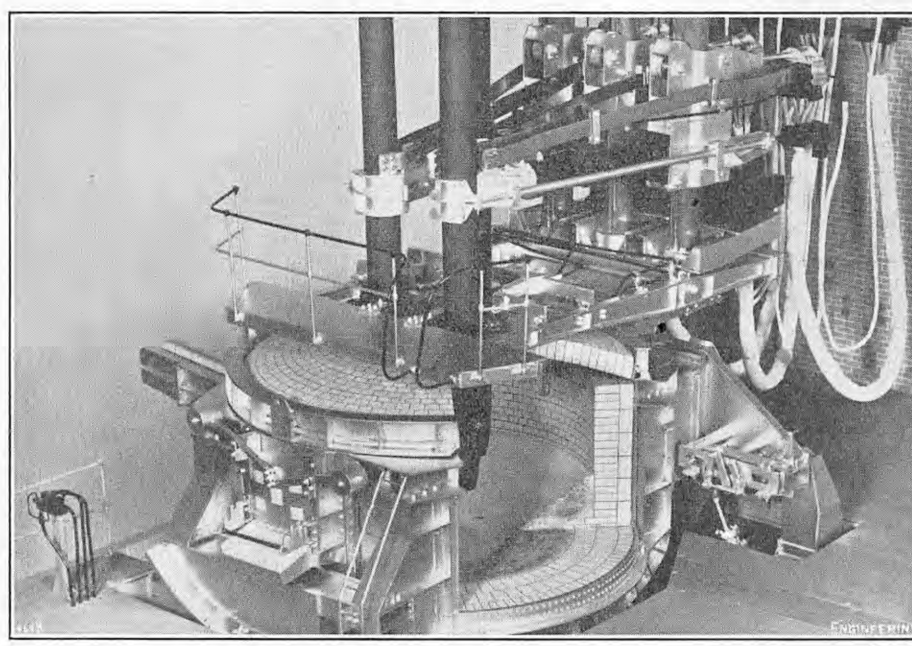


FIG. 2. REAR OF MODEL, SHOWING ELECTRODES.

PHOTOGRAPHIC EXHIBITION.

THE 96th Annual Exhibition of the Royal Photographic Society was opened at 16, Princes Gate, London, S.W.7, by Lord Brabazon of Tara, on Thursday, September 13, and will remain open until Sunday, October 14. In addition, scientific films, including one on "Sound Steel" and another on "Magnetism," will be shown in the Lecture Theatre of the Victoria and Albert Museum, Exhibition-road, London, S.W.7, at 7 p.m. on Thursday, October 4, and tickets for these can be obtained, without charge, from the Secretary of the Society. Although the majority of the photographs at Princes Gate are of a non-technical character, we may remark on their high quality, especially of those in the stereoscopic section, which include examples both in monochrome and in colour. Among these mention may be made of some photographs showing the products of Messrs. J. Bigwood and Son, Limited, Wolverhampton. These comprise close ups of a slideway and connecting rod in a horizontal boring machine, of a bending machine for heavy steel plate and of a double reduction gearbox to show the quality obtainable without special lighting and the advantages of stereoscopic photography. There are a number of normal photographs of engineering subjects, although these are of pictorial rather than technical interest.

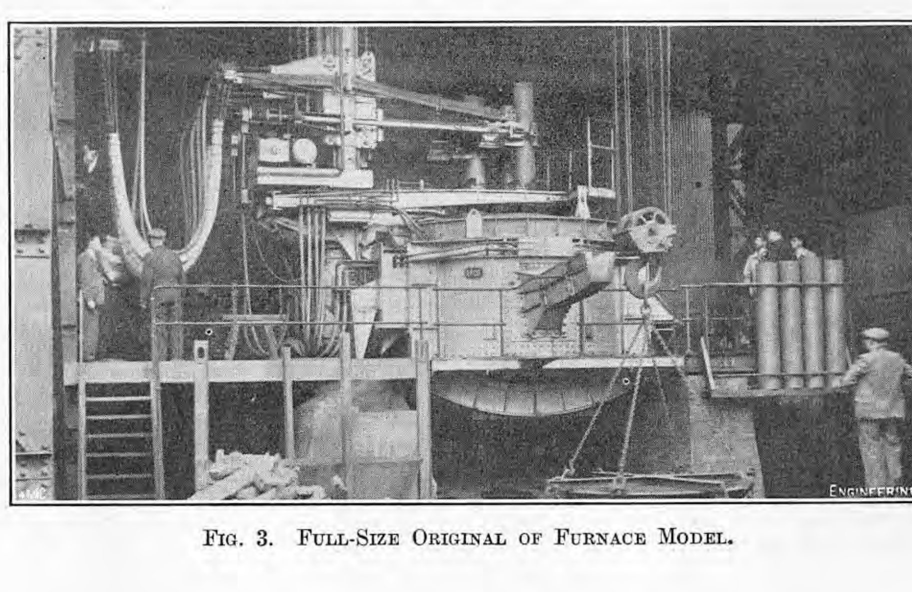


FIG. 3. FULL-SIZE ORIGINAL OF FURNACE MODEL.

ENGINEERING,

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Two One-Page Plates.—ENGINEERING, MARINE AND WELDING EXHIBITION AT OLYMPIA.

ENGINEERING

FRIDAY, SEPTEMBER 14, 1951.

VOL. 172. No. 4468.

WELDING PRACTICE.

THERE can be but few branches of engineering in which welding in some form or other is not practised. For this reason, any general report on the subject should be of interest to a very wide circle. For the same reason, however, a general report cannot be expected to deal with every detail problem of every industry. This point is illustrated by the fact that the British welding team which visited the United States in October and November, 1950, under the auspices of the Anglo-American Council on Productivity, although it visited 29 works and attended the Annual Convention of the American Welding Society, yet in its report has nothing to say about the use of welding in the manufacture of aeroplanes and aero-engines. It is also indicated in the report* that it was not possible for the team to investigate the use of welding in the construction of buildings and bridges to the extent which would have been desirable. The mention of these matters is not intended to suggest that the report may not be of value to users of welding in some types of industry ; its purpose is to illustrate the extent of present-day welding interests. Many welding problems and practices are common to many industries and the report may profitably be studied by anyone engaged in welding in any sphere.

The report deals with some welding processes in considerable detail and contains 25 sketches showing plant or welding procedure ; 25 photographs illustrating machines and plant are also reproduced. In broad terms, the team came to the conclusion that American productivity in welding is higher than British productivity, although the difference might not be very great. As has been the case with other productivity reports, stress is laid on shop methods and labour procedure rather than on technical processes. In the "findings" which summarise the contents of the report, attention is drawn to only two technical methods. The first is the Aircomatic torch in which a consumable electrode is shielded by argon or helium ; it is stated that this device shows great promise of increasing the range and reducing the cost of welding non-ferrous metals. The second is the low-hydrogen electrode for use with a chromium-molybdenum steel for high-pressure steam pipes. Other American welding electrodes and gas welding rods in general are not considered to be superior to British.

The statement that welding productivity in America is somewhat greater than in this country is apparently based on a general impression rather than on specific figures. The matter really turns on the meaning attached to the term "productivity." In a broad sense, it might be taken to indicate output per man-hour, but with a process of such very varied application output may itself be difficult to define. A matter which should be capable of specific measurement is the arcing time factor for manual welding. This is the ratio of arcing time to the total time the supply is available for the arc. Actually there proved to be little information available on this subject ; the same thing applies to this country. Among the few firms having any figures, a shipyard gave a time factor varying between 0·45 and 0·72 for piecework manual welders, but it is stated that statistics were not available to prove that these time factors were obtained in practice.

The proportion of his time during which a man engaged on arc welding is actually welding, clearly depends on the amount of time he spends on setting up and ancillary operations, and it is particularly owing to the attention paid to these matters that high outputs are obtained in America. A valuable example of this attention is furnished by the extensive use of manipulators which enable work pieces easily to be swung into the most convenient position for working. A further example is the provision of local lifting equipment so that welders are not dependent on the main shop cranes. Even if a shop is well equipped with overhead cranes, considerable time may be lost at busy periods, waiting until one of them is free. In American shops, as a rule, the number of overhead cranes appeared to be low compared with British practice, but this was made up for by the liberal provision of subsidiary lifting apparatus in the form of jibs attached to machines, wall jibs and mobile cranes.

A matter of the first importance, which is one of the main lessons of this report, is that this auxiliary lifting apparatus is operated by the welders themselves ; they do not wait for some one else to come and do it for them. Very few slingers are employed and anyone available is quite ready to assist in handling, pushing bogies or any other job requiring little time. The fact that a craftsman undertakes labouring jobs in connection with his own work does not mean that his output is reduced ; on the contrary, it is probably increased, as no time is lost in waiting for outside assistance. The whole procedure illustrates the absence of that extreme demarcation from which British industry suffers. In the United States, assemblers carry out their own flame cutting, tack welding, chipping and grinding when necessary, and do their own slinging and handling.

The low percentage of helpers and labourers in the shops means that more men are available for production. A released labourer is, of course, not a craftsman, but a very large part of the work is done by semi-skilled men, and great attention is paid to the lay-out and arrangement of work so that their tasks will not be beyond their skill. An example of this is furnished by the fact that "the management is prepared to go to almost any lengths

* *Productivity Report on Welding.* The Anglo-American Council on Productivity. U.K. Section. 21, Tothill-street, London, S.W.1. [Price 3*s*. 6*d*. post free.]

to arrange that all welds can be made in the down-hand position." This practice also relieves fatigue and permits the use of large-gauge electrodes and heavy currents. Both these factors increase production. It is not suggested that all work can be arranged in this way, nor that there are no skilled craftsmen, but there is not a sufficient supply of the latter to enable work to be confined to them. There is, incidentally, a feature of American labour relations of which the visiting team did not approve. This is the seniority rule, under which, in slack times, the latest comers must be stood-off before those who joined the firm earlier. This rule may force a firm to get rid of a first-class man and retain an indifferent one in his place.

Piece work is apparently not very common, but men on time work do everything they can to help production and to increase it. As has been emphasised in other productivity reports, they welcome new methods and new machines and are prepared to employ them fully. As explanation of this, it is pointed out that the American workman has clearly in mind the relationship between productivity and the standard of living. He enjoys high wages but spends much on amenities such as motor cars and refrigerators. Many appliances are bought on hire purchase and the necessity for paying instalments makes him chary of doing anything likely to lose him his job and, industry being highly competitive, he does his best towards keeping the firm with which he is employed in a position to get business.

One of the recommendations made in the report, is that unsparing efforts should be made to provide more goods, and particularly foodstuffs, and that retail shops should provide more convenient times to enable workmen to shop in reasonable comfort. The object of this is clearly to create conditions in which it is manifest that hard-earned money is worth the effort to get it. It will, no doubt, be said that measures of this kind are impossible in this country, but the real trouble is that a welfare-state attitude of mind has been created here. The fundamental reason why the productivity of the American workman is greater than that of his British counterpart is that his standard of living and his prosperity both depend essentially on his own efforts.

The fact that men may be made redundant by the introduction of new machines or methods is not looked upon as a serious matter in America, since, as there is little trade demarcation, a man may turn to some other type of employment without difficulty. The productivity team evidently hope that some approach to this order of freedom may be made in this country, as they recommend "that union rules be so framed as to permit more ready entry into alternative forms of employment." They also consider that managements should "devote serious thought to economic planning and the more generous introduction of mechanical handling devices." To this suggestion, it is added that unions should "accept freely all labour saving devices with a realistic approach to any redundancy of man-power involved." There are, no doubt, some managements, possibly many, to which the criticism implied in the first of these recommendations might fairly be directed, but it is doubtful if there are any unions to which the strictures implicit in the second do not apply.

It is to be hoped that both employers and employed will heed the words of the Chancellor of the Exchequer, Mr. H. Gaitskell, when he addressed the Trades Union Congress last week. Fear, he said, was to be found in both sides of industry—fear of the machinery and the proper use of it, fear of the lost job, fear of letting unwanted men go, fear of letting who were needed come in, fear of better methods, fear of letting someone else share in the work, fear of learning "know-how" from one another or from the Americans.

MECHANICAL ENGINEERING RESEARCH.

ORGANISING research is in many ways a larger problem than actually undertaking research work, and the difficulty is greatest when the research is basic rather than applied and when the objectives are not readily defined. Such were the circumstances which faced the Mechanical Engineering Research Board when it was appointed in December, 1946, "to advise generally on the research to be undertaken by the Mechanical Engineering Research Organisation of the Department of Scientific and Industrial Research." The report* which the board, under the chairmanship of Sir Henry Guy, C.B.E., F.R.S., have recently presented to the Committee of the Privy Council for Scientific and Industrial Research, reviews the whole period of their activities up to the end of 1950, and the ramifications of the researches which it covers are sufficient evidence—if evidence were needed—that "it is not an easy matter to determine how best the resources at the disposal of the Organisation should be applied."

The Board, surveying the potentialities of a rapidly expanding team of workers, for whom the new laboratories at East Kilbride are being built and equipped, concluded that the chief services that can be rendered to the mechanical-engineering industry are to carry out work designed to fortify and give deeper meaning to what is being done already, and to provide basic knowledge which will help the industry to conceive and achieve new possibilities for development. Stress is being laid on original work of a basic and generic character, and on the need for codifying and tabulating data in a form which can be readily used by industry. The work is planned in seven main divisions, namely, properties and strength of materials; mechanics of solids, stress analysis, and vibration; mechanics of fluids, including hydraulic machinery; lubrication, wear and corrosion; mechanisms and engineering metrology; mechanics of formation and machine shaping of materials; and heat transfer and applied thermodynamics. It was apparent to the Board that the progress of research in these fields varied considerably. In some—for example, properties of materials—it was well developed and a programme for the future followed readily from past work; but in others basic work was almost unknown, little work having been done on the kinematics of machinery, and work on hydraulic machinery and heat-transfer apparatus having lagged.

To appraise the situation authoritatively and to advise the Board on the tasks which should be undertaken by the Organisation, several committees were appointed, though they do not correspond exactly to the seven main divisions mentioned above, there being, for example, two separate committees for heat transfer and thermodynamics. In addition, some correlation of previous work was carried out by members of the laboratory staff, so as to clarify the conception of future work, and, in that connection, some members of the staff visited the United States to consult with fellow-workers in the same fields. Concurrently with these detail surveys the design and construction of the laboratories have been proceeding, and, in the interim, work on the M.E.R.O. programme, has been continued at the National Physical Laboratory.

The staff at the East Kilbride Laboratory will eventually be about 600, including 100 scientific officers of all grades, but at the end of 1950 it numbered 123. In their work they will often be giving a lead in the advancement of mechanical-engineering science in this country, in spite of the fact that many of their researches will be undertaken because industrial firms have not found the need to embark on the work themselves. The long-term value of such researches is inestimable, but it will certainly exceed the estimated annual expenditure of between 250,000*l.* and 350,000*l.*

The report constitutes a valuable record, probably more embracing than any other published, of the general state of mechanical-engineering research in this country, and gives a hopeful indication of the content and quality of future papers on the results of research. In the Properties and Strength of Materials Division, for example, the main items in the programme for future work are: the examination of the properties of metallic materials under static-loading, high-speed loading, and repetition of loading (fatigue); the behaviour of metallic materials at high and low temperatures; physics of the solid state in relation to the strength of materials; and the behaviour under load of various non-metallic materials. Specific matters of research in this Division include the effect of size on fatigue strength, the strength of riveted and welded joints in a high-strength magnesium alloy, and the fatigue strength of sheet material. Investigations are also being undertaken at Leeds University on material for springs and at Bristol University on the fundamental mechanism of fatigu failure of metals. In the Divisions dealing with the mechanics of solids, etc., for which a team had still to be built up, the main objects of research will be the development of new and improved methods, both analytical and experimental, for the determination of stress distributions in mechanical-engineering components and structures. In particular, work which should have immediate practical value is being carried out on the strength of screwed and bolted connections, and a mobile strain-gauge laboratory is being equipped to assist industry. At Cambridge University, under the direction of Professor J. F. Baker, the stresses in gear teeth under running conditions are being investigated by photo-elasticity.

A well-equipped laboratory, designed primarily to meet the requirements of the hydraulic-machinery industry, will be an outstanding feature of the East Kilbride station. Meanwhile, extra-departmental research is being undertaken at Cambridge on the reduction of losses through pipe bends—it has been found that sheet-metal turning vanes are advantageous—on the swirling flow of water through a nozzle, on scavenging flow in two-stroke engines, and on flow conditions in the runner of a centrifugal pump. Imperial College are working on axial-flow fans, introducing ammonia gas into the air stream so as to record flow patterns on sensitised paper.

The programme of work in the Division dealing with lubrication, wear and corrosion is in four sections, namely hydrodynamic lubrication, boundary friction, wear, and a special study of the lubrication of such mechanisms as ball and roller bearings. The subject of wear is receiving greater attention than had been possible at the National Physical Laboratory. The report states that, hitherto, advances in the development and use of mechanisms have been mainly due to the ingenuity of designers in relation to particular problems; there has been no recognised school or group responsible for the basic study of the subject as a branch of engineering science. A team is to be formed for this purpose, however, and the starting point for research will be a study of particular mechanisms, such as cams.

The sixth Division's programme will consist or four main groups dealing with crystal plasticity, plastic properties of materials, mechanics of the formation of materials, and mechanics of machine shaping of materials. Some of the work, on cold impact extrusion, is being carried out at Sheffield University under Professor H. W. Swift, and the behaviour of the material in screw-thread rolling is being investigated at Edinburgh University under Professor R. N. Arnold.

* *Mechanical Engineering Research*, 1947–1950. Department of Scientific and Industrial Research. [Price 2*s*. 6*d*. net.]

NOTES.

THE JAMES CLAYTON LECTURE.

AT a meeting held at the Institution of Mechanical Engineers, Storey's Gate, London, S.W.1, on Wednesday, September 12, Professor A. P. Colburn, head of the division of chemical engineering at the University of Delaware, Newark, Delaware, U.S.A., delivered the eighth James Clayton lecture on the subject "Problems in Design and Research on Condensers of Vapours and Vapour Mixtures." The chair was taken by the President of the Institution, Mr. A. C. Hartley, C.B.E., who formally welcomed the lecturer as a specialist in the field of heat transfer and distillation and the author of numerous publications on these subjects. On this occasion, the James Clayton Lecture formed one of a series of papers presented during the course of a three-day conference on heat transfer, arranged jointly by the Institution of Mechanical Engineers and the American Society of Mechanical Engineers, in co-operation with kindred bodies, which was held in London from September 11 to September 13, and mentioned previously in our columns, on page 96, *ante*. Professor Colburn referred to himself as one who was interested mainly in problems of design. It was important to be able to design condensers accurately and to be able to predict their performance with reasonable certainty. Practical engineers were more interested in research which gave answers than research for its own sake, and quick methods of obtaining reliable estimates were of great value. Professor Colburn then dealt with his subject under two headings, namely, pure-vapour condensers and mixed-vapour condensers. Dealing with condensers having vertical tubes, he pointed out how the original heat-transfer theory of Nusselt, which assumed laminar viscous flow in the layer of condensate, had to be modified to take account of turbulence and the effect of the friction of the vapour current on the surface of the condensate. Although the mathematical theory was somewhat approximate, certain types of condenser could be designed with fair success. In the case of condensers of mixed vapours, there were many factors to be considered, but reasonable results could again be obtained by approximate methods. It was difficult to ensure that optimum results were achieved, but, frequently, economic considerations ruled out possible refinements. Although considerable research on heat transfer was in progress, more was required, and the greatest service to designers would be done if a number of large condensers were designed carefully using the most accurate theory available and their actual performance compared with theoretical estimates. A vote of thanks to the lecturer was proposed by Professor O. A. Saunders, seconded by Professor E. A. Allcut, and carried with acclamation.

THE ROYAL AERONAUTICAL SOCIETY.

The Wilbur Wright Memorial Lecture, which is read before the Royal Aeronautical Society each year alternately by an Englishman or an American, usually takes place in May, bringing to a close the winter season of lectures. This year it was postponed until September 10 so that members of the American Institute of Aeronautical Sciences attending the Anglo-American Aeronautical Conference—which concluded on Friday, September 7, with a highly successful dinner and dance—could attend the lecture presented by one of their own members, Mr. A. E. Raymond. The lecture was preceded by the presentation of the Society's awards, as detailed on page 335. The subject of the 39th Wilbur Wright Memorial Lecture was "The Well Tempered Aircraft." The production of an operationally useful aircraft, said Mr. Raymond, depended upon certain essential elements: an environment conducive to efficiency, a good initial choice based on sound specifications, excellent detail design, thorough development, assisting the operators when the aircraft entered service, exploring all the ways it could usefully be employed, the properly-timed introduction of new aircraft, and adaptability of the design to cope with unforeseen elements. A good environment for the work implied the enthusiasm of the backers of the project and adequate financing, and satisfactory relations with the customer, in addition to good working facilities and organisation. A successful initial choice of design depended upon the balanced assessment of what was really needed and what it was possible to build. With a conservative approach based on past design it was possible to start production earlier, but, carried to extremes, such an attitude stifled progress. The simplest design which fulfilled the requirements was likely to be the lightest, with the best performance, and the highest reliability in service. From the general arrangement of the aircraft to the detail design of its components, it was important to allow for future requirements—the installation of different engines and propellers, the carriage of different types of payload, etc. It should be possible to produce the aircraft using comparatively simple tools, which could be duplicated if production had to be increased and thrown away when the design was changed. Adopting standard components ensured the utilisation of the best previous experience. A new design must be commenced several years before the existing aircraft showed signs of obsolescence; this was particularly true of military aircraft. "The country that rests on its oars too long," said Mr. Raymond, "is overwhelmed by the enemy." The lecture was followed by a reception by the President, Major Frank Halford, and Mrs. Halford, at the Society's headquarters in 4, Hamilton-place, London, W.1. Some 600 people were present, and the Society is to be congratulated on the excellent organisation of this occasion and of the past week in Brighton.

INCOME TAX: DEDUCTION OF ENTERTAINMENT EXPENSES.

It is the fate of everyone liable to pay income tax to receive a form to fill up, in order that an assessment can be made. This form is usually accompanied by a closely printed circular, which sets forth, *inter alia*, the permissible "deductions." Here, however, is to be found a warning to the effect that "no deduction can be made of any disbursements or expenses, not being money wholly and exclusively laid out or expended for the purposes of the trade, profession, employment or vocation." This enactment, which is to be found in the Income Tax Act, 1918, has probably given rise to more cases in the Revenue Court than any other section of the statute. Income tax being a tax upon income, it is obvious that, if it is earned income, the taxpayer must be allowed to deduct his normal expenses. There have been many hair-splitting decisions as to what is "money wholly and exclusively laid out for the purposes of a trade, etc.," and it is probably true to say that the tendency has always been to decide against the taxpayer. For instance, it was long since held by the Courts that the expense which a taxpayer incurs in travelling between his home and his place of business cannot be deducted; it is as if the legislature desired everyone to "live over the shop." There are, however, many expenses incurred by a man of business as to which it is by no means easy to say, offhand, whether they can be deducted or not. An example of a decision in favour of the taxpayer and against the Revenue authorities is to be found in a recent case which came before Mr. Justice Roxburgh (*Bentley, Stokes and Lowless* v. *Beeson, Inspector of Taxes*: (1951) 2 All England Reports, 667). While primarily affecting solicitors, it is of general interest to all taxpayers who, being in business, show hospitality to their customers and clients. The facts were these. A firm of solicitors made a practice of entertaining existing clients to luncheon at a social club and at various restaurants. During lunch, business was discussed. The legal advice then given was charged for in the ordinary way, but the expense of the meals was charged to the firm. This practice was adopted by the partners both for their own convenience, so that they could devote the remainder of the day to office work, and for the convenience of clients. An inspector of taxes refused to allow these "entertainment expenses" and the Commissioners of Income Tax confirmed his decision, holding that they could not come to the conclusion that the moneys expended on entertainment were expended solely for the purposes of the profession, and were entirely divorced from the element of hospitality and the relationship of host and guest. They stated a case for the opinion of the Court. Having heard argument, Mr. Justice Roxburgh held that there was no evidence to support this finding. He said: "It seems to me on the evidence that this transaction (the entertainment of a client) was one single transaction embarked on for business or professional purposes solely and exclusively. The partner who attended the luncheon was an essential element in the transaction. Legal advice could not have been given and the fee could not have been earned if the partner had not attended, and, obviously, if the partner has to attend and the client is to be given a lunch, business would not be promoted if the partner should sit by eating and drinking nothing." He relied on a passage from an opinion of a former Lord Chancellor (Lord Cave) who said (in the case of *British Insulated and Helsby Cables* v. *Atherton*: (1926) A.C. 211): "It is clear that a sum of money expended, not of necessity and with a view to advice and immediate benefit to the trade, but voluntarily and on the grounds of commercial expediency, and in order indirectly to facilitate the carrying on of the business, may yet be expended wholly and exclusively for the purposes of the trade." So the solicitors were held entitled to make the deduction, one form of "entertainment tax," at any rate, being thus declared inexigible. It is a curious circumstance that, in the course of the argument before Mr. Justice Roxburgh, no case was referred to in which the right of a commercial firm to make a deduction for the entertainment of customers was called in question or even discussed. The inference is that no inspector of taxes has ever yet asserted that the taxpayer is not entitled to this measure of relief. It is, of course, not unknown for engineering firms to spend considerable sums per annum on extending hospitality to customers, and, indeed, to employ responsible men to see that customers—particularly foreign customers—are suitably entertained. If any attempt were made to prevent those firms making a deduction when preparing the income tax return, the decision in the case of the solicitors would be very apposite.

ELECTRICITY SUPPLY FAILURE IN NORTH-WEST ENGLAND.

That shortage of generating plant is not the only difficulty which the British Electricity Authority have to face at the present time is illustrated by the failure which occurred over a large part of north-west England on Monday, September 3. As a result, Liverpool was deprived of power for three hours during the evening rush hours; steam trains being delayed, electric trains and trams stopped, work at the docks brought to a standstill, telephones put out of action, and general inconvenience being caused. At Blackpool, Southport, Birkenhead, Chester and as far away as Colwyn Bay conditions were similar. According to a statement made by the Parliamentary Secretary to the Ministry of Fuel (Mr. H. Neal) in a letter to one of the local Members of Parliament this failure was principally due to the fact that the grid lines between Blackburn and Quernmore and between Percival-lane (Runcorn) and Crewe were out of action for maintenance. Shortly before 5 p.m. the protective equipment cut out the lines from Percival-lane to Bromborough and Chester, with the result that three other lines became overloaded and were also tripped; Scotland and the Carlisle area thus being cut off from the rest of the network. The local generating plant therefore became overloaded and had to be shut down. The means of preventing the repetition of such an occurrence, and repetitions are, we fear, likely to take place in the near future, is, of course, to strengthen the transmission system. The grid is now being used to transmit supplies in bulk from one part of the country to another, a purpose for which it was not originally intended and, in consequence, is frequently overloaded. The protective apparatus, therefore, often performs the function for which it was installed and, if it does so when lines are out of action for maintenance or other reasons, trouble is certain. Given every facility, however, that strengthening cannot take place at once. In the mean time, "staggering," load shedding and occasional blackouts will be our lot. The only advantage of these drawbacks is that they may lead the public to insist on the application of the real remedy without more delay.

The Women's Engineering Society.

The 29th annual conference of the Women's Engineering Society was held in London on Friday, Saturday and Sunday, September 7, 8 and 9, the headquarters of the conference being established at Nutford House, Brown-street, W.1. The afternoon of the Friday was occupied in a tour of the Science Museum, South Kensington, and in a lantern lecture by Mr. G. Tilgham Richards, M.I.Mech.E., on "Man and the Machine." On Saturday morning, a visit was paid to the Engineering, Marine and Welding Exhibition at Olympia, and the annual general meeting of the Society was held in the afternoon. In the evening, Miss Sheila Leather, the retiring President, delivered her presidential address on "Training in and for Industry." The principal business on the closing day of the conference was a discussion on "The Women's Engineering Society and Its Future," which was opened by Dame Caroline Haslett. The annual dinner of the Society was held at Nutford House on September 7, in conjunction with the conference. The toast of the Society and its President was proposed by Colonel B. H. Leeson, O.B.E., T.D., vice-president of the Institution of Electrical Engineers, who traced the growth of the Society from the early days of its foundation, with the assistance of Lady Parsons, to the present time. Its first years, Col. Leeson recalled, were coincident with the difficult times following the 1914-18 war. In spite of the troubles raised by the economic depression of that period, the Society persevered in its efforts and had performed useful work in opening the doors leading to education, training, and employment, to those women desiring to become engineers. In her response, Miss Leather referred to the substantial increase in the Society's membership which has taken place during 1950. She stated that a generous gift had been made to the Society by the British Electrical and Allied Manufacturers' Association, and mentioned that the electrical industry was always in the forefront in its recognition of women engineers. Miss E. M. Collin, Ph.D., D.Sc., F.R.I.C., as President-elect, proposed the toast of the guests, to which Mr. F. H. Perkins, B.Sc., M.I.Mech.E., M.I.E.E., replied.

OBITUARY.

SIR HOLBERRY MENSFORTH, K.C.B.

It is often alleged that engineers do not take a sufficiently prominent part in the administration of engineering businesses, but a notable exception is provided by the career of Sir Holberry Mensforth, whose death on September 5, at his home in Hazlemere, Buckinghamshire, we regret to record. Sir Holberry, who was 80 years of age, distinguished himself at a comparatively early age as a thoroughly practical engineering designer and constructor, and was in his middle forties when he came to the front as an administrator, a role in which he left his mark on many branches of heavy engineering.

Holberry Mensforth was a native of Bradford, where he was born on May 1, 1871. His home was a modest one and he received only an elementary-school education; but he possessed great determination and force of character, coupled with a natural ability as an engineer, so that, even as an apprentice in the small local engineering firm of S. Clayton and Company, Limited, Bradford, he showed qualities of leadership which made him a foreman in all but name. It had been his parents' wish that he should study law, but there is no doubt that he was justified in following his own preference for mechanical engineering. His training was mainly on blowing-engines for blast furnaces, using blast-furnace gas, and in this field he rapidly became expert, acquiring at the same time a knowledge of steelworks plant that was to prove valuable in later years.

In 1904, after several years as assistant to Mr. B. H. Thwaite, Great George-street, Westminster, he went to Manchester as a draughtsman with the then British Westinghouse Company, at first mainly on gas-engine work, and in the short space of six years had progressed to the position of head of the engine department of the works. In this capacity, he was largely instrumental in developing the design and production of steam turbines, mainly for power-station and industrial applications. He held this position for seven years and then, in 1917, was appointed general manager of the works, which at that time, of course, was operating at high pressure on a variety of munitions production outside the firm's usual range. This brought him into more direct contact with Government departments, especially the Ministry of Munitions, and resulted in his appointment as chairman of the Manchester and District Armaments Output Committee, and the award of a C.B.E. in 1918. It had the further effect, however, of making him known on Ministerial levels, so that when the re-organisation committee under Sir Eric Geddes, who applied the "Geddes axe" to the Government departments after the war, required a man to put the munitions establishments on an economical peace-time basis, Mensforth was entrusted with the task, with the title of Director-General of Factories.

This was an appointment after his own heart, unhampered by precedent—though he found himself entangled in much red tape at the outset—and requiring both initiative and determination. In the course of some five years he closed down the redundant factories put others on a care and maintenance basis, and completely re-organised the accounting systems at Woolwich Arsenal and the other establishments that were retained. He relinquished the appointment in 1926, receiving a K.C.B. in recognition of his work, and was immediately engaged as managing director of Bolckow, Vaughan and Company, to carry out a somewhat similar re-organisation in their group of collieries, steelworks, ironstone mines, etc., on the North-East Coast. This occupied him until 1931, when, largely at his instigation, the Bolckow, Vaughan interests were merged with those of Dorman, Long and Company, and he joined the board of the combined undertaking. Shortly afterwards, he became chairman of the English Electric Company, again with the task of modernising their plant and methods; and then of Edmundson's Electricity Corporation, a holding company controlling about 60 electricity supply undertakings in the Midlands and west of England. In 1931, also, he joined the board of John Brown and Company, and remained with them and their associates—Thos. Firth and John Brown, Limited, Westland Aircraft, Limited, Markham and Company, Limited, Craven Brothers (Manchester), Limited, and the Tredegar Coal and Iron Company—until he retired, in 1945, from all except the last-named, of which he was still a director at the time of his death.

Sir Holberry was a member of the Institution of Civil Engineers and the Institution of Mechanical Engineers, and a vice-president of the British Electrical and Allied Manufacturers' Association, and had served as President of the Manchester Engineering Employers' Association. He had few interests of other than those of an engineering character, but devoted much of what leisure he had to a well-equipped private workshop, and, in earlier days, to motoring, in which he was almost a pioneer. Many with whom he came in contact found him a hard taskmaster, ruthless when he had made up his mind on a particular course of action, and he could, on occasion, express himself with a gruffness which lent some colour to the belief; but he was quick to appreciate the need for teamwork in any large organisation, and had initiated the equivalent of a "joint production committee" of management and employees many years before that term was adopted in official circles. He was a great believer in providing opportunities for young men, and in the advantages of improving engineering education—in 1919 he was made a M.Sc. (Tech.), *honoris causa*, of Manchester University, for his work in connection with education. In this, and in many other directions, his strong individualism is likely to be long remembered.

MR. G. H. HUMPHREYS.

We regret to record the death of Mr. G. H. Humphreys, which occurred suddenly on Sunday, August 19, at the age of 55, as the result of a stroke.

Guy Howard Humphreys was born at Wembley on March 31, 1896. He was educated at Westminster and Trinity College, Cambridge, where he obtained a first class in the Natural Science Tripos of 1915. For the next three years he underwent practical training with Messrs. Chance and Hunt, Limited, Oldbury, and in 1918 began practising consulting engineering as an assistant to his father. Among the work on which he was engaged was the design of the Crumpsall Vale Railway, Manchester, for the British Dyestuffs Corporation, for which he later acted as resident engineer. He also assisted in the design of sewerage schemes for Georgetown, Demerara; St. George's, Granada; and Bridgetown, Barbados, and drafted a complete set of by-laws for the municipality of St. George's, besides organising and supervising a survey of the house property of the city. In 1926 the firm, of which he had by then become a partner, was appointed consulting experts by the Postmaster-General on questions relating to the damage of roads; and also carried out the survey and supervision of a new road at Axmouth. Among other work with which he was subsequently connected mention may be made of a water-supply scheme for Jinta, Uganda, a main-drainage scheme for Lagos, Nigeria, and a water-supply scheme for Kaduna in the same colony. He was also partly, or entirely, responsible for many outfall works, pumping stations, water-supply schemes and bridge reconstructions in this country, as well as for the repair of the West Pier of Shoreham Harbour. At the request of the Secretary of State for the Colonies, he prepared a number of sewerage, irrigation, water-supply and road-construction schemes for St. Kilts, Dominica and Antigua.

Humphreys was elected an associate member of the Institution of Civil Engineers in 1922 and was transferred to the class of member in 1931. He became a Member of Council in 1946 and was serving at the time of his death. He was awarded a Miller Prize in 1920 and received a Telford Premium in 1933 for his paper on the "Main Drainage of Georgetown, British Guiana." He was also chairman of the Engineers' Guild, a past-president of the Institution of Sanitary Engineers and a past-chairman of the Association of Consulting Engineers. He was a member of the Westminster City Council and had served as chairman of the Works and Traffic Committee of that body. He was the author of a book on the *Training of a Civil Engineer*.

COMMANDER F. G. LORING, O.B.E.

The death of Commander F. G. Loring occurred at Foot's Cray, Kent, on Friday, September 7, at the age of 82.

Frederick George Loring was born in the Isle of Wight on March 11, 1869, being the eldest son of Admiral Sir William Loring, K.C.B. He entered the Royal Navy in 1882 and, after serving in the Royal Yacht as sub-lieutenant, was one of the lieutenants on H.M.S. Victoria when she was rammed by H.M.S. Camperdown off Tripoli on June 22, 1893. He took an active part in the rescue work in connection with this disaster and was awarded the bronze medal of the Royal Humane Society for saving two lives. After qualifying in torpedo work, he was in charge of the Admiralty shore wireless stations from 1902 to 1908, and in the latter year was appointed Inspector of Wireless Telegraphy in the Post Office, a position he held until his retirement in 1930. He was Admiralty delegate to the International Conference of Wireless Telegraphy at Berlin in 1906, and during his time at the Post Office was the delegate of that department to the conferences in London in 1912 and in Washington in 1927. After his retirement he represented the International Marine Radio Company at the International Radio Conferences at Copenhagen in 1931, at Madrid in 1932, at Lisbon in 1934, at Bucharest in 1937, at Cairo in 1938, and at Stockholm in 1948. He was also Assessor, Wireless Telegraphy, for the Board at the Safety of Life at Sea Conference in London in 1914 and also in 1929.

Loring was appointed an Officer of the Order of the British Empire for his services at the Post Office. He was elected a member of the Institution of Electrical Engineers in 1906.

THE ANGLO-AMERICAN AERONAUTICAL CONFERENCE.

(*Continued from page* 298.)

LAST week we published summaries of the papers dealing with aircraft structures and materials which were read before the Anglo-American Aeronautical Conference held at Brighton from September 3 to 7. We continue our report on the Conference this week with summaries on certain aspects of aircraft design, propulsion, and airline operation.

TRAINING IN DESIGN FOR SAFETY.

On Tuesday, September 4, Mr. Jerome Lederer presented a paper on "Infusion of Safety into Aeronautical Engineering Curricula."

He proposed five broad principles of safety:—(i) The failure of any aircraft component should not create an additional hazard; for example, if a propeller blade should fracture and whip into the fuselage it should not be able to sever any system essential for the control of the aircraft. (ii) The structure and its components should be able to withstand the impact of objects and the effects of natural phenomena, such as hailstorms, and rough handling by personnel. (iii) Procedures for adequate maintenance and operating practices should be consistent with the average human effort, ability and attitude, which might be different from that of the mechanic who serviced the aircraft on its trial runs or for sales demonstrations. The designer must also guard against irresponsible behaviour by the passengers. (iv) The aircraft and its components should be protected against the effects of human errors or carelessness, for instance, it should not be possible for bolts dropped by mechanics to jam the aircraft controls. (v) Aircraft should be designed to give reasonable protection in accidents that are considered to be survivable; safety-belt attachments, for instance, should have adequate strength, and loose equipment should be adequately restrained.

Examples of good safety practice should, he thought, be woven into existing engineering courses and text-books. A good grounding in statistics was important for evaluating the chances of several things going wrong simultaneously to create an emergency. Teaching safety by infusion, however, could not deal adequately with the study of the average man in relation to the design of the machine which he had to operate. The human mechanism had been designed to operate in the Stone Age, within narrow tolerances, and had not improved since. He considered that all students of aeronautical engineering should be given a course in human engineering—a study of those factors which helped a man to do his job with speed, accuracy, comfort and safety.

TRANSONIC AND SUPERSONIC PROPELLERS.

On Wednesday, September 5, Mr. George W. Brady read a paper on "Propellers for High Powers and Transonic Speeds." The gas turbine, said Mr. Brady, had made possible horse-powers up to 10,000 or more, and supersonic speeds. Although propellers had been operating with supersonic tip speeds for a long time, it had been recognised that their efficiency was below the maximum possible, and several new forms of propeller design, such as swept-back blades, blades of necked-down plan form, low aspect-ratio blades, etc., had been tried in the past few years. They showed no outstanding aerodynamic advantage, however, over the straight blade of very thin section, which was superior structurally.

Another method for improving the propeller efficiency at high speed was to keep the wind angle below 45 deg. (i.e. the angle between the relative wind and the plane of rotation). This could be done by increasing the rotational speed. For transonic forward speeds, this resulted in supersonic propeller-section speeds along almost all the radius. If the individual section efficiencies could be kept high under these conditions, by the use of low-thickness/chord ratios, the overall efficiency would be good. Fortunately, high solidities made it possible to achieve satisfactory structures of suitably thin section. It was expected that the "transonic" propeller, designed with thin sections to give high efficiencies at high subsonic and low transonic forward speeds, would have an efficiency of 80 per cent. at Mach numbers from 0·75 to 0·85. The "supersonic" propeller, with thin sections and high revolutions per minute, would not have quite such high efficiencies below Mach numbers of 0·8 to 0·85, but would maintain its efficiency well into the supersonic region.

The most important factors in the structural design of transonic and supersonic propellers were flutter and the "$1 \times P$" forced vibration due to inclined flow through the propeller disc, or to a variable velocity distribution due to fuselage or nacelle interference, in which each blade experienced a sinusoidal variation of lift once each propeller revolution. Resonance could be prevented by proper selection of the plan-form and thickness-ratio distribution. Flutter in the fundamental torsional mode about the radial axis of the blade could arise under high-power static conditions; it normally disappeared as air speed increased. The tip sections of supersonic propellers required to have thickness ratios between 2 per cent. and 3 per cent.; structural rigidity must be obtained either by thick wall plates or by solid sections, using a high-modulus material. The shank thickness was determined by the $1 \times P$ conditions.

A four-blade transonic propeller with a centrifugal twisting moment of about 125,000 lb.-in. per blade required a 30-h.p. pitch-changing mechanism for a rate of pitch change of 20 deg. per second. Engine power could be used to change pitch, through electrically-actuated clutches and worm gearing. Variable rates of pitch change could be obtained by a control system supplying energy to the clutch in a series of pulses of variable length or frequency. High-speed propellers would be of hollow or solid steel, depending on the size. A lighter alloy would be desirable; titanium alloy had good characteristics, except that its elastic modulus was low compared with steel, which meant that for equal torsional rigidity, titanium-alloy blades would have to be thicker, and therefore of lower efficiency. For structural testing of supersonic propellers a high-speed wind tunnel was desirable in order to excite high vibrating stresses.

The take-off thrust of transonic and supersonic propellers was good, and the specific fuel consumption of the propeller-turbine unit was low. The reverse thrust, for braking, of transonic propellers was also good. The supersonic propeller of small diameter had a lower unit negative thrust, but since it would be used on a large engine, the actual negative thrust available for aerodynamic braking would be quite high. Either fixed negative-angle reversing or constant-speed reversing could be used. Using reverse pitch in flight, controlled rates of descent of about 10,000 ft. per minute had been obtained at indicated airspeeds of the order of 200 m.p.h. The supersonic propellers would probably not be more noisy than existing high-power propulsion systems.

HIGH-SPEED HYDRODYNAMIC DEVELOPMENT.

Mr. Ernest G. Stout presented "A Review of High-Speed Hydrodynamic Development" also on Wednesday, September 5. By means of free-body dynamically similar model tests developed by the Consolidated Vultee Aircraft Corporation, hull-loading and form criteria had been established that allowed the seaplane designer a wide choice of optimum hull size and layout for minimum aerodynamic drag, so that the seaplane performance would be equal to that of the landplane designed for the same duty. The Convair XP5Y-1, a high-speed propeller-turbine seaplane, was based on these criteria, and incorporated a multi-cellular watertight structure below the cargo floor, giving a cargo space free from bulkheads. It was possible to design transonic and supersonic seaplanes without compromising hydrodynamics, seaworthiness or stability, by using a blended wing-hull layout, in conjunction with "spray dams" for suppressing spray.

HEAT TRANSFER IN ROCKET POWER PLANTS.

On Thursday, September 6, Messrs. Louis G. Dunn, Walter B. Powell and Howard S. Seifert, presented a survey of "Heat Transfer Studies Relating to Rocket Power-Plant Development," undertaken in the Jet Propulsion Laboratory of the California Institute of Technology. In the first part of the paper, the lecturers described the processes of convective and radiative heat-transfer in rocket combustion chambers, reviewed methods for measuring rates of heat flow, and discussed the various techniques for protecting rocket chambers against heat. The only alternative to providing cooling, they said, was to use refractory materials as liners or for the structure of rocket-motor combustion chambers and nozzles. Refractory liners, such as stabilised zirconium oxide, zirconium silicate, graphite, molybdenum, and silicon carbide with silica, were used. A stabilised zirconium-oxide tube inserted in a cylindrical combustion chamber could reduce the net heat flow which must be absorbed by the outside coolant to 20 per cent. of that required without a refractory liner. For some systems, and for operating periods not greatly exceeding 60 sec., external cooling could be dispensed with completely, but this type of lined chamber was usually heavier. These liners were, however, susceptible to thermal shock, cracking, and spalling, and could not be used for more than 3 or 4 minutes. To withstand the higher rates of heat transfer in exhaust nozzles, and to resist erosion by the high-velocity gases, refractories such as silicon carbide, graphite with a protective coating of silicon carbide and chromium, and molybdenum with a protective coating of molybdenum silicide were required. Molybdenum metal had been used for rocket nozzles, without fluid cooling, for periods of 60 sec.

External cooling was widely used; the coolant fluid, which might be one of the propellants, was circulated through a jacket surrounding the combustion chamber and nozzle. With internal cooling, a gaseous or liquid coolant could be introduced into the combustion chamber through a porous inner shell; or liquid could be injected as a sheet through a slot or as jets through a number of holes in the combustion-chamber wall. The internal-cooling techniques—of which the bulk-injection of liquid was preferred to the porous-shell method—had several disadvantages; the coolant was introduced into the chamber in addition to the propellants, causing an increased specific consumption and a decreased performance. If one of the propellants was used as an internal coolant, it might take part in the reaction and liberate extra heat near the walls. Internal cooling should therefore be used only when external cooling was inadequate.

In the second part of the paper, the lecturers dealt with convection to liquids at high heat-transfer intensities, discussing in detail the boiling process and the influence of fluid pressure, and describing studies of bubble dynamics. They reviewed theoretical and experimental work on transpiration and film cooling, and, finally, presented a new relationship for the heat-transfer coefficient for turbulent fluid flow which, they said, could take into account the variation of the physical properties in the boundary layer of the coolant.

AIRLINE ENGINEERING.

On Friday, September 7, Mr. B. S. Shenstone gave a paper describing some of the "Engineering Problems of Aircraft Operation" that had been encountered by British European Airways (B.E.A.). A highly qualified development and project group was necessary, said Mr. Shenstone, to correct the mistakes and omissions made by the aircraft designer, to assess the capabilities of the aircraft and provide operating data, and to investigate future requirements. In B.E.A., both present and future problems were considered by the same technical group, and it was intended to carry out practically all development and project work in the new engineering base at London Airport, near the aircraft. Before an aircraft was ordered, the development group had to draw up requirements, obtain from the constructor an outline specification of the aircraft, and assist with the technical aspects of the contract. After it was ordered, a detailed specification had to be worked out with the constructor, and progress had to be watched, in order to foresee delays, to ensure interchangeability of components and equipment, to eliminate defects that had occurred on current aircraft, to compile data for the operating, maintenance and repair manual and the parts catalogue, and to keep a check on the weight and, consequently, the performance.

The maintenance and overhaul department made it possible for the aircraft to function continuously. Maintenance was essentially carried out by replacement of worn or life-expired parts. Some operators carried out minor overhauls at out-stations and only performed major overhaul at base, whereas others carried out both minor maintenance and major overhauls at base; it depended mainly on the geography of the routes. An airline should have as few bases as possible, to avoid duplication of management and equipment and overstocking of space, and to ensure consistent maintenance standard. Modern production methods should be applied; aircraft should be fed into the base on a planned and controlled schedule. There should be well-planned tools and jigs, and the shops should work in liaison with the development department so that improvements could be phased properly. In B.E.A.. a premium bonus-incentive scheme had been adopted successfully. On the whole, it appeared more satisfactory for the airline, which had direct access to the development group, to carry out overhaul rather than to contract it out to the manufacturer.

The new overhaul base at London airport consisted of five bays each comprising a shallow hangar with a 150-ft. door on one long side; the hangar had a clear height, below a 5-ton overhead crane, of 30 ft., and a clear depth of 110 ft. There were no permanent internal partitions in the resulting 900-ft. long structure; it would thus be easy to modify the layout as new aircraft were adopted.

(To be continued.)

AIRCRAFT AT FARNBOROUGH DISPLAY.

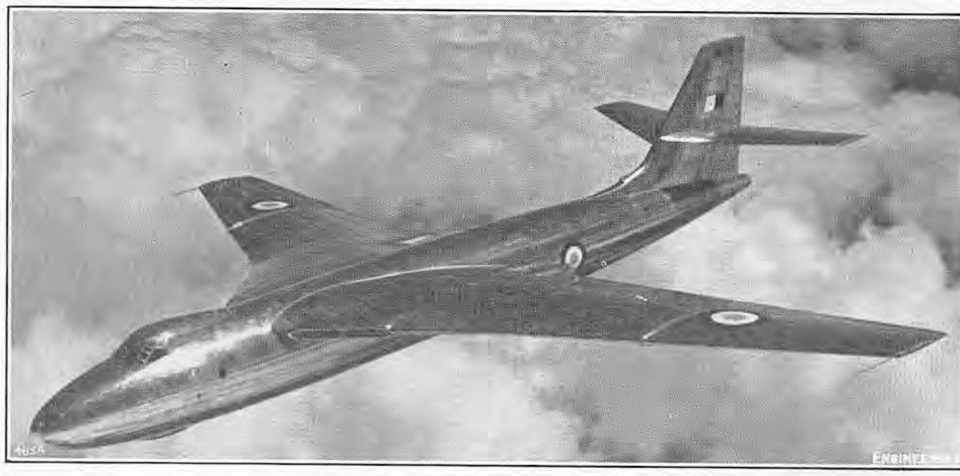


FIG. 1. "VALIANT" BOMBER AIRCRAFT; VICKERS-ARMSTRONGS LIMITED.

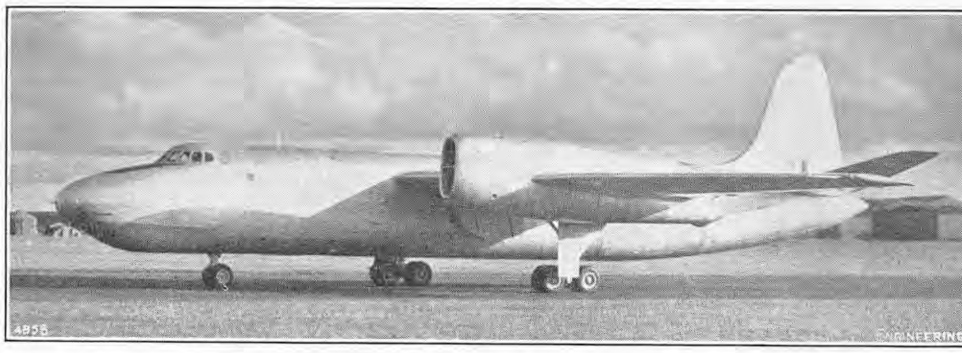


FIG. 2. SA-4 BOMBER AIRCRAFT; SHORT BROTHERS AND HARLAND, LIMITED.

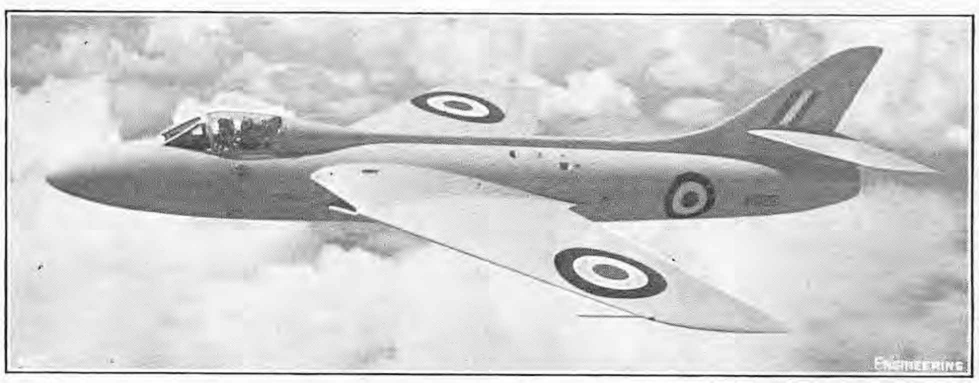


FIG. 3. P.1067 FIGHTER AIRCRAFT; HAWKER AIRCRAFT, LIMITED.

FLYING DISPLAY OF BRITISH AIRCRAFT.

DURING this week the Society of British Aircraft Constructors have been holding their 12th annual flying display and static exhibition of aircraft, engines, and equipment at Farnborough aerodrome, Hampshire. The display this year has been arranged to coincide with the annual general meeting in London of the International Air Transport Association which is being held from September 10 to 14; and to follow the third Anglo-American Aeronautical Conference, which concluded at Brighton last Friday. As usual, a preview was held on Tuesday, September 11, for technicians and the press. On Wednesday, Thursday, and to-day, the display is open only to invited guests of the Society. Members of the public will be able to attend on Saturday and Sunday, the last day, and on these two days there will be an additional attraction in the shape of a formation flight of Royal Air Force jet-propelled fighter aircraft, which is being organised as part of the Battle of Britain celebrations.

An outstanding feature is the growing trend to order new aircraft in quantity "off the drawing board." Apart from the aircraft specially designed for research purposes, only four of the new machines displayed are not in production. This year there are some notable new aircraft for the Royal Air Force, and there is gratifying evidence of intense research activity in the transonic region. In civil transport there is, naturally, little that is new; the air liners that have been developed over the past few years, including the world's first turbine-powered and jet-propelled air liners, are soon to enter service with the British airways corporation and they will be expected to operate for some years before the question of replacements arises. On account of the predominantly military character, therefore, it is possible to give only a bare outline of some of the most interesting new exhibits, since no comment is allowed on the construction (other than what can be seen from outside the aircraft) and the performance.

For most people, the greatest interest this year centres around the new four-engined jet-propelled heavy bomber aircraft. Fig. 1 shows the Valiant, perhaps the most shapely bomber aircraft that has yet been built. It is designed and constructed by Messrs. Vickers-Armstrongs Limited, Weybridge, Surrey, and is already ordered in quantity for the Royal Air Force. It is said to be faster than the Canberra light bomber and has, naturally, a considerably greater disposable load. It is powered by four Rolls-Royce Avon axial-jet engines buried completely within the wing and set close to the fuselage; each pair of engines shares a common air intake. It will be observed that a high-wing layout has been adopted, and that both wings and tailplane have a medium degree of sweepback, the tailplane being set high on the single fin, as has now become fairly common practice. Boundary-layer fences, for avoiding premature tipstall, may be observed on the wing forward of the inboard end of the ailerons. The aircraft has a tricycle undercarriage, with a twin nosewheel, folding backwards, and four mainwheels arranged in tandem and retracting outwards into the wing.

The SA4 prototype bomber aeroplane, illustrated in Fig. 2, presents an interesting contrast to the Valiant. It is designed and constructed by Messrs. Short Brothers and Harland, Limited, Queen's Island, Belfast, Northern Ireland. Like the Valiant, it has a high-wing layout and is propelled by four Rolls-Royce Avon jet engines; but the latter are installed, in pairs, one above the other, in massive nacelles. Whereas the Valiant fuselage is of streamline shape, the SA4 fuselage has, over the middle section, a straight roof and floor line; it may be suggested tentatively that the designers appear to have sacrificed elegance and speed to greater load-carrying capacity and ease of manufacture. The wing, which is very thin, is straight, with only a slight sweepback on the leading edge; it has a span of 109 ft. The overall length of the aircraft is over 102 ft. The dihedral tailplane is in this case cantilevered from the fuselage. The SA-4 has a tricycle undercarriage with a twin nose wheel and main-wheel units of bogie type retracting sideways into the wing. A crew of five is carried.

Although new prototype fighter aircraft have appeared regularly each year at the display, and the Navy have had on order carrier-borne fighter aircraft of high performance and have recently formed the first squadron of Vickers-Armstrongs Attackers, until this year there has been no mention of re-equipping the fighter squadrons of the Royal Air Force. They are still using aircraft conceived during the second World War. It is therefore good news that two new single-seat fighter aeroplanes of outstanding performance have been ordered "off the drawing board" for the Royal Air Force. Fig. 3 shows the P.1067, designed and constructed by Messrs. Hawker Aircraft, Limited, Canbury Park-road, Kingston-on-Thames, Surrey. It is propelled by a Rolls-Royce Avon axial-jet engine; if the appearance of the P.1067 is compared with that

AIRCRAFT AT FARNBOROUGH DISPLAY.

FIG. 4. SUPERMARINE "SWIFT" FIGHTER AIRCRAFT; VICKERS-ARMSTRONGS LIMITED.

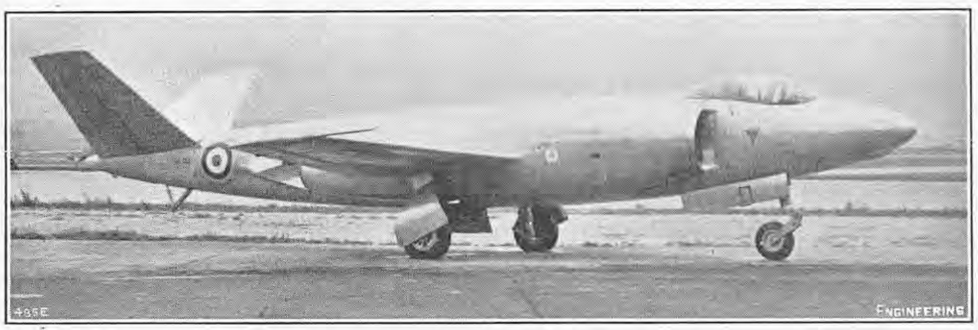


FIG. 5. SUPERMARINE 508 NAVAL FIGHTER AIRCRAFT; VICKERS-ARMSTRONGS LIMITED.

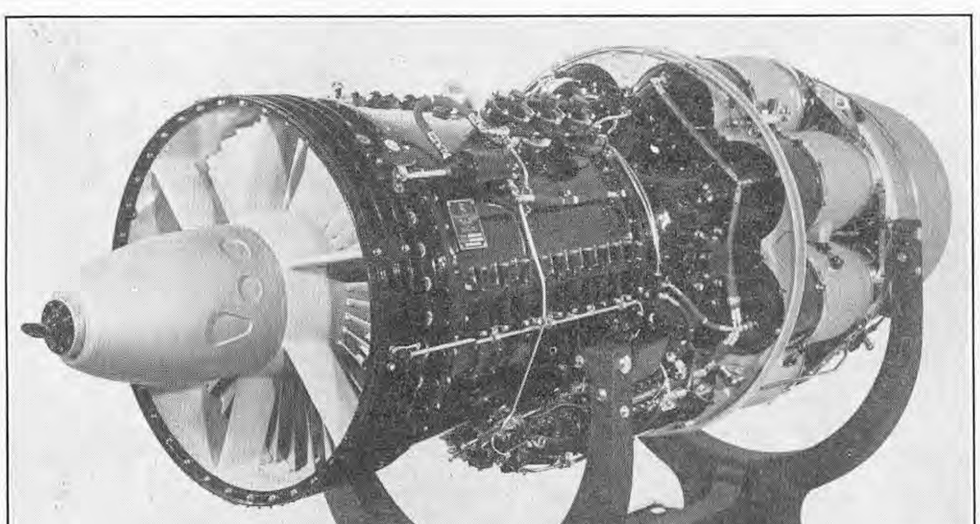


FIG. 6. "AVON" AXIAL JET ENGINE; ROLLS-ROYCE, LIMITED.

of the Hawker P.1081 (illustrated on page 224 of our 170th volume, 1950), which was powered by a Rolls-Royce Nene centrifugal turbojet, it will be observed that the axial-jet installation has enhanced the slenderness-ratio of the fuselage. As in the P.1081, which flew for the first time last year, the air intakes for the engine are in the wing roots and the exhaust nozzle is in the tail. A conventional tricycle undercarriage is fitted, the nosewheel retracting forwards and the mainwheels inwards. The Hawker P.1067 is known to have a speed in excess of 661 m.p.h. (the world speed record), and is believed to be one of the fastest fighter aircraft yet built. On its first high-speed run across the aerodrome on Tuesday afternoon, it certainly appeared to travel much faster than anything that has hitherto been seen at Farnborough. It has, moreover, a high rate of roll and generally appears to have excellent handling qualities.

As we go to press, it is doubtful whether the Supermarine Swift, the other single-seat fighter on order for the Royal Air Force, will appear in the display, as orginally intended. We are, however, including here such details as have been released, for comparison with the Hawker aeroplane. The Swift, which is illustrated in Fig. 4, is designed and constructed by Messrs. Vickers-Armstrongs Limited, Supermarine Works, Hursley Park, Winchester, Hampshire, and has been developed from the Supermarine 535, which has a Rolls-Royce Nene engine. As in the Hawker P.1067, a Rolls-Royce Avon jet engine is fitted in the fuselage of the Swift, ejecting at the tail end. The air intakes, however, are just forward of the wing root on either side of the fuselage. Whereas the Hawker P.1067 is based on a mid-wing layout, the Swift is a low-wing monoplane with a sharper sweepback than the Hawker fighter, and the tailplane is supported by the fuselage structure. The aircraft has a span of 31 ft. $8\frac{1}{2}$ in., a wing area of 295 sq. ft., an overall length of 42 ft. 11 in., and a maximum height of 12 ft. 6 in.

The Vickers Supermarine 508 twin-engine naval fighter, which is illustrated in Fig. 5, has many interesting features. The aircraft is constructed by Messrs. Vickers-Armstrongs Limited, Supermarine Works, Hursley Park, Winchester. It is said to be the fastest and most powerful aeroplane yet built for operating from an aircraft carrier. The wing loading of the Supermarine 508 would appear to be considerably higher than has been customary in naval fighters designed in this country. The thin wings are of very small area and are straight. The landing speed, we are told, is kept within the limit required for carrier-operation by special high-lift devices on the wing. Two Rolls-Royce Avon jet engines are installed side by side within the fuselage, the exhaust nozzles being located aft of the wing roots but well forward of the tail. The dihedral stabilising surfaces, which combine the functions of tailplane and fin, have not, it is believed, been seen hitherto on British military aircraft. A conventional tricycle undercarriage is fitted, the main wheels folding sideways into the fuselage and the nosewheel retracting backwards.

It may have been observed that every one of the new aircraft described is powered by the Avon axial turbo-jet engine, as are also the various versions of the English Electric Canberra aircraft in production in this country. Information on the Avon engine, which is illustrated in Fig. 6, is still very limited, but it is known to have a high power-to-weight ratio and a low specific fuel consumption. It has an axial compressor and a two-stage turbine. The Mark I Avon has a sea-level static thrust of 6,500 lb., and the dry weight is approximately 2,240 lb. The specific fuel consumption at the maximum continuous rating is 0·865 lb. per pound-thrust per hour under sea-level static conditions. The overall length of the engine is 119 in. and the diameter is 42·4 in. The Avon engine is designed and constructed by Messrs. Rolls-Royce, Limited, Derby, and is also to be produced at their two factories in West Scotland—Hillington and East Kilbride; at a new factory to be opened by Messrs. D. Napier and Son, Limited, at Bootle, Lancashire; at the works of the Bristol Aeroplane Company, Limited, Filton, Bristol; and at the factory of the Standard Motor Company, Coventry. It is also being built in Australia for installing in Australian-built Canberra and F-86 Sabre aircraft.

(To be continued.)

RECENT METALS AND ALLOYS.*

By PROFESSOR A. G. QUARRELL.

MANY operations in the production and working of metals are only possible because the engineer provides the metallurgist with the powerful and sometimes elaborate machines that are required. It is equally true that many of the achievements of modern engineering would not have been possible had not the metallurgist developed new and improved alloys with properties suitable for the particular application. Whereas engineers at first based their designs upon the alloys that happened to be available, in recent years they have developed the habit of telling the metallurgist what combination of properties is required to permit optimum, or at least efficient, performance of a given machine. The metalluriqst is by now quite familiar with the technique and knows only too well that as soon as he has provided what he was asked for, more exacting demands will be made.

For most of the five or six thousand years that metals have been used by man, metallurgy has been an art rather than a science and new alloys have resulted from chance observation rather than from deliberate effort. The last few years have seen vast strides in our understanding of the theory of alloys, but unfortunately the alloys that are most important technically are extremely complex and industrial practice still outstrips theoretical understanding. As a result, alloy development is still largely empirical and the rapidity with which existing alloys are improved and new alloys developed is due mainly to the magnitude of the effort being made and to the skill of the metallurgist in exploiting to the full any beneficial effects he observes as a result of changes in composition or in heat treatment.

The needs of the aircraft industry for alloys of high strength-to-weight ratio suitable for air-frames, and for alloys capable of withstanding high stresses at elevated temperatures in aero engines, have provided the incentives for the steady improvement of light alloys on the one hand and of the special alloy steels on the other. High-strength aluminium alloys of the alu-

* Paper read at a joint session of Section B (Chemistry) and Section G (Engineering) of the British Association at Edinburgh, on Tuesday, August 14, 1951.

minium-zinc-magnesium-copper type are the most recent in the line of descent from Wilm's Duralumin and are used extensively in the form of extrusions and rolled sheet in modern aircraft. Such alloys frequently contain 6·5 to 7·0 per cent. zinc., 1·5 to 2·0 per cent. magnesium with 1·5 per cent. copper and, in the extruded form, possess a 0·1 per cent. proof stress of 36 tons per square inch, an ultimate tensile strength of 40 to 41 tons per square inch, and an elongation of 9 to 11 per cent.* Rather better strength properties can be obtained in sheet material, but with some sacrifice of ductility, if the artificially-aged alloy is cold rolled and then given a short secondary hardening treatment at 125 deg. C. Ageing within the range 125 deg. to 130 deg. C. is found to give the optimum combination of tensile properties and corrosion resistance. There is reason to believe† that below 125 deg. C. copper-bearing phases Al_2Cu and Al_2CuMg precipitate, whereas above this temperature, $MgZn_2$ is the main age-hardening constituent.

Magnesium-base alloys with greatly improved properties have become available commercially in the last five years owing to the introduction of the magnesium-zirconium-zinc alloys.‡ German workers discovered the beneficial effects of zirconium, but British metallurgists exploited the discovery on an industrial scale by developing a method of introducing zirconium into the alloys without leaving flux residues that had an adverse effect upon the corrosion resistance. Zirconium exerts a powerful grain refining effect upon magnesium and greatly reduces the microporosity that was such an undesirable feature of some of the earlier alloys; it also facilitates both hot and cold working.

Considerable interest is being shown both here and in the United States in the ultra-light magnesium-lithium alloys. In 1945, Hume-Rothery, Raynor and Butchers§ studied the properties of the magnesium-lithium and magnesium-silver-lithium alloys. In the discussion of their results they said "It is also interesting to note that alloys in the homogeneous β-phase area, containing 26 to 30 atomic per cent. of lithium (about 10 to 12 per cent. by weight) have a melting point of over 580 deg. C. and a body-centred cubic structure, and consequently they offer the possibility of a ductile alloy considerably lighter than magnesium. From the purely structural point of view, therefore, these alloys appear of interest." Practical development of the alloys has not been without difficulty. Lithium is found to have the predicted effect of making the alloys more workable because of the change in structure from hexagonal to body-centred cubic, but even traces of sodium are sufficient to cause serious embrittlement and high-purity lithium must therefore be used in making up the alloys. Again, some of the precipitation hardening alloys based on magnesium-lithium and having otherwise attractive mechanical properties are found to be unstable at 65 deg. to 100 deg. C. because they over-age and become brittle. Stability can be improved by increasing the proportion of other alloying elements such as zinc, but this increases the density. One of the more stable alloys contains 9 per cent. lithium, 5 per cent. aluminium and 8 per cent. zinc; typical mechanical properties obtained on rolled sheet of this composition quenched from 425 deg. C. are ultimate tensile strength 24·1 tons per square inch before ageing dropping to 21·6 tons per square inch after ageing for 1,000 hours at 95 deg. C.‖, while corresponding values of elongation are 6·5 per cent. and 2·5 per cent., respectively. The specific gravity of this alloy is 1·65.

The gas turbine has made great demands upon the metallurgist and the improvements that have been made in creep-resistant alloys for use at elevated temperatures during the last seven or eight years has been truly astonishing. The subject has been discussed in detail recently at a Symposium organised by the Iron and Steel Institute, and on the whole the tale is one of steady improvement of known alloys rather than of the discovery of alloys of quite new types. Steels for high temperature use can be divided into two main classes: (i) ferritic steels the structures of which at the operating temperatures are based on the body-centred cubic α-iron, and (ii) austenitic steels in which the matrix is face-centred cubic. Once the practicability of the jet engine had been demonstrated in 1943, working stresses as high as 3 tons per square inch at 750 deg. C. and 12 tons per square inch at 650 deg. C. were envisaged in the rotor disc. As there seemed little chance that ferritic steels could be developed to satisfy these requirements, effort was concentrated on the improvement of the austenitic steels.

(*To be continued.*)

* M. Cook, R. Chadwick and N. B. Muir, *Jl. Inst Metals*, vol. 79, page 293, July, 1951.

† A. Saulnier, *Compt. rend.*, vol. 226, page 181 (1948).

‡ C. J. P. Ball, *Metallurgia*, vol. 35, pages 206-7, Jan. and Feb., 1947.

§ W. Hume-Rothery, G. V. Raynor, and E. Butchers, *Jl. Inst Metals*, vol. 71, pages 579 to 601 (1945).

‖ P. D. Frost, J. G. Kura and L. W. Eastwood, *Trans. A.I.M.E.*, vol. 188, page 1277 (1950).

LABOUR NOTES.

The wide range of activities undertaken by the Ministry of Labour and National Service may not be generally realised. They include, to mention but a few of the more important, employment services, training schemes, vocational guidance, the re-settlement of disabled persons and ex-regular members of H.M. Forces, industrial relationships, international labour relations, the compilation of much useful statistical information, and the publication of the *Ministry of Labour Gazette*. Many aspects of welfare work also come within the scope of the Department. Its duties include the keeping of a register of technical and scientific personnel available for employment. In this connection, although 3,026 vacancies were filled by the Department during the past year, there were 5,254 persons on the register on December 11 last, of whom 1,417 were unemployed and 3,837 were in employment, but seeking a change of work. A summary of the work accomplished by the Ministry during the twelve months ended December 31 last, is contained in its annual report for 1950 (Cmd. 8338, H.M. Stationery Office, price 6*s*. net.)

It is estimated by the Ministry that the total working population in Great Britain at the end of 1950 was 23,180,000, being an increase during the year of 218,000, of whom 91,000 were men and boys, and 127,000 women and girls. The tendency of the past few years for more women to return to, or remain in, employment continued. The working population at the end of November, 1950, was the highest ever attained in peace-time. The Ministry records that the entry of young persons into employment in 1950 was affected by the low birth rate during the 1930's, and forecasts that the effects of the higher birth rate attained during 1942 and the succeeding years will not become noticeable until about 1957. The size of the Armed Forces showed a net increase during 1950 for the first time since 1945. The total strength of the Forces at the end of 1950 was approximately 752,000, or about 3 per cent. of the total working population.

Unemployment during 1950 remained at a low level and the number of unemployed persons registered with the Ministry did not, at any time, exceed 1·8 per cent. of the total working population. At mid-January, 1950, the number of registered unemployed persons was 372,300. It rose slightly, to a peak figure of 372,800 in mid-February, and thereafter declined steadily to 272,000 in mid-July. This was the lowest figure for the year. There was a seasonal increase in the autumn, but, by December, the number had dropped again, to 301,800. An analysis of persons unemployed in December showed that almost 60 per cent. of the men were 41 years old or over and that 34 per cent. were aged between 21 and 41 years old. In the case of women, the proportion aged 41 or over was 38 per cent. Vocational guidance was given by the Ministry to some 485,000 young persons, on their leaving school. It may be regarded in some quarters as encouraging that the staff of the Ministry declined in number to 28,466 at the end of the year under review, a reduction of 2,861, or about 9·1 per cent., on the total for 1949.

Now that the eighty-third Trades Union Congress has ended, the importance of the need for the exercise of much caution in the presentation of new wage claims is beginning to be more fully recognised. In his address to the Congress at Blackpool on September 4, Mr. Hugh Gaitskell, the Chancellor of the Exchequer, urged that the need for such caution would be especially necessary during the next few months. At the same time, it is becoming increasingly apparent that the implications of the Chancellor's plea will be largely ignored by the trade-union movement. The next round of wage claims is already in full swing and some demands have, in fact, already been conceded. Another suggestion made by Mr. Gaitskell, in his address, was that some form of partnership might be conferred on employees in individual firms or industries, through the distribution to them of bonus shares in proportion to the increase of undistributed profits in the firms or industries concerned.

Profit sharing has not been popular with trade unions in the past and there has been little evidence to show that the opinions of these bodies has altered, but the idea seems to have been fairly fully discussed behind the scenes, perhaps a little unfavourably, during the closing stages of the Congress. One result of Mr. Gaitskell's suggestion will probably be a renewal of the criticism levelled at the Government for its action in cancelling a number of profit-sharing schemes, after the nationalisation of the gas industry. Many privately-owned gas companies had operated such schemes over long periods for the benefit of their employees, and the schemes had been very largely successful.

The meetings of the Congress on September 5 were mainly concerned with a series of debates on re-armament, peace, and international affairs, from which little emerged that was fresh or novel. A motion demanding the ending of American interference with Britain's trading policies, and the substitution of a policy for an equal exchange of products between the Commonwealth and other nations, both east and west, was overwhelmingly defeated on a card vote. Thursday, September 6, was largely devoted to the consideration of wages, prices and profits. It had been expected that this section of the General Council's report would be introduced at some length by Sir Vincent Tewson, the T.U.C. general secretary, but, instead, the report was presented formally, in a few words, by the chairman, in order to save time.

Mr. Tom Williamson, the general secretary of the National Union of General and Municipal Workers, moved a composite motion suggesting five measures which the Government should take to check the rising cost of living. These were a wider control of the prices of home-produced goods, reconsideration of the limitation of food subsidies, more effective control of profits, with a limitation on the issue of bonus shares, and the removal of purchase tax from household necessities. Mr. Williamson advocated that, instead of fixed subsidies, a sum of money should be set aside by the Government for application in a flexible manner for the "temporary cushioning of vicious rises in prices." The General Council approved this motion and, after some discussion, it was passed by a large majority.

Also on Thursday, a debate on production in industry was introduced by Mr. Jack Tanner, the President of the Amalgamated Engineering Union. He issued a warning that, although the miners were doing their best, the fuel and power problems confronting the country were threatening to limit industrial development. Serious questions of equity and priority were likely to arise during the coming, winter when a fuel crisis might become imminent. If coal imports were likely to be necessary, as seemed to be the case, a decision to that effect should be taken by the Government promptly. Mr. Ernest Jones, vice-president of the National Union of Mineworkers, considered that it would be impossible to get through the coming winter without coal imports. Although the miners had produced another four million tons of deep-mined coal in 1951, consumption had been increased by five million tons, and the output of open-cast coal had declined by more than one million tons. Moreover, men were now leaving the mines at the rate of over 15,000 a year. The final sessions of the Congress were marked by the number and variety of the subjects which the delegates considered.

Several classes of unskilled employees have benefited from recent wage increases. Manual workers in the employment of those local authorities in England and Wales which are represented on the manual workers' section of the National Joint Council for Local Authorities' Service have been granted an increase of 2*d*. an hour in their basic wage rates, under the terms of an award by the National Arbitration Tribunal. The award, which was announced on Monday last, does not apply to local authority employees in civic restaurants or in the school-meals service. The increase will be payable from September 3. It was also announced on Monday last that unskilled labourers in Government industrial establishments in the London area have secured a wage increase of 6*s*. a week, as the result of an industrial court award. This increase, which will date from August 25, will advance the basic wage rate of the men concerned to 5*l*. 14*s*. a week. An increase in their wages, bringing the basic rate to 5*l*. 8*s*., a week, was conceded as recently as April last.

Farm workers in England and Wales are to benefit in various ways from an agreement reached by the Agricultural Wages Board at a meeting in London on Tuesday last. Its terms provide for an increase of 8*s*. a week for men employees, which will bring their new minimum rate to 5*l*. 8*s*. a week. The rate for women will be advanced by 6*s*. a week, to a new weekly minimum of 4*l*. 2*s*. Payment for overtime is to be raised in proportion, and juveniles and casual employees will also receive higher wages. All these increases are due to become effective on October 10. Other benefits to be derived from the agreement will include an additional five days annual holiday, bringing the total to twelve days a year. It is estimated that some 700,000 farm workers will be affected by the agreement.

HEAT-TREATED CONCRETE.

Fig. 1.

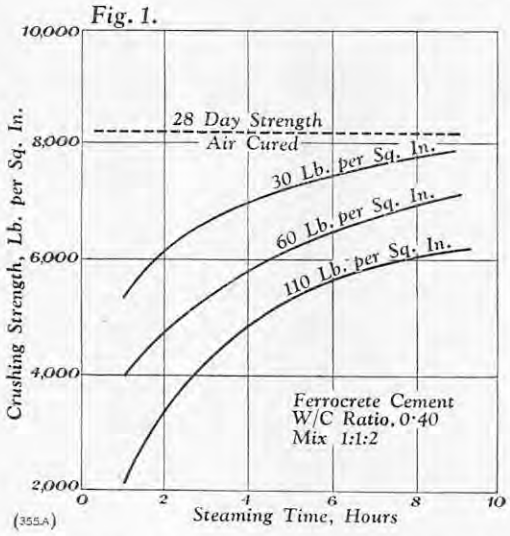


Fig. 2.

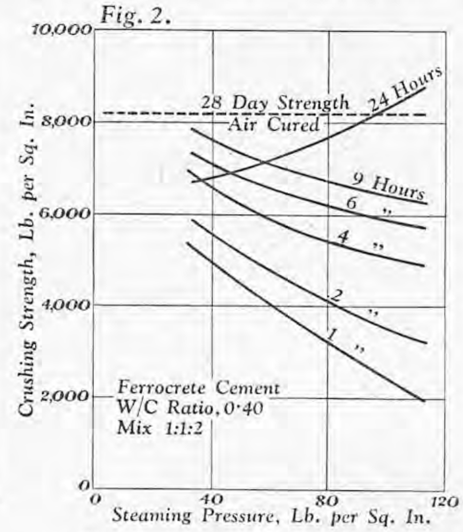


Fig. 3.

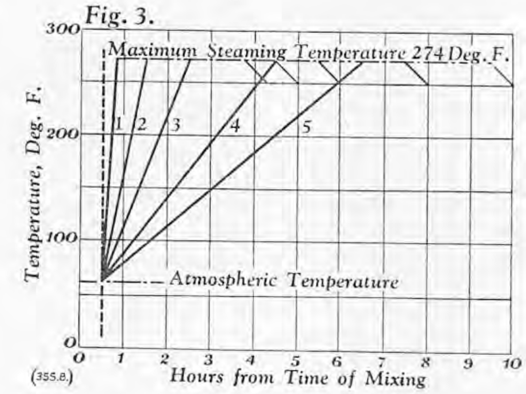
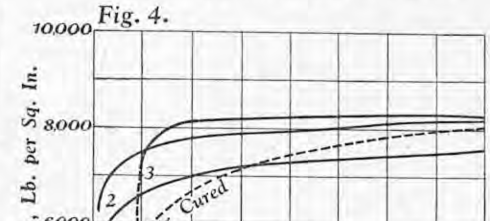


Fig. 4.



HEAT-TREATED CONCRETE.*

By P. Clarkson, B.Sc., Stud.I.C.E.

The advancement made in reinforced-concrete construction and the increasing popularity of pre-cast reinforced-concrete products have brought a growing demand for more effective and economical methods of production. One way in which this can be done is to reduce the time required for the concrete to set and harden, so that the moulds can be released as soon as possible and the need for large storage facilities obviated. The first investigation into the possibility of using heat treatment to hasten the curing process of concrete was probably the result of coupling two well-known facts. Firstly, when the mixing water is added to the dry ingredients of a concrete mix a fairly complicated chemical reaction between the water and the cement is started, which results in the hardening of the concrete. Secondly, if heat is added to almost any chemical reaction the rate of the reaction is accelerated.

Several different methods of applying heat treatment to concrete have been advanced. (1) Electrical heating of the concrete by passing an electric current through either the steel reinforcement or the concrete itself. (2) Passing hot saturated air over the concrete surface. (3) Curing of the concrete products in high-pressure saturated steam, atmospheric steam or very hot water. The electrical methods lend themselves very readily to the treatment of individual members, but, like method (2), they are comparatively wasteful and mild in action. Hot-water curing is inconvenient to use and time is lost in waiting for the concrete to set before the members can be immersed in the hot-water bath. Steam-curing is therefore the most effective method, for it is economical to produce and easy to handle.

The main advantages to be gained from heat treatment, according to workers in the past, are a more rapid increase in early strength, a reduction in final drying shrinkage, an increased resistance to attack by sulphate solution and, in some cases, a greater final strength after prolonged treatment. Steam treatment in industry has been restricted mainly to mass-produced products such as concrete building blocks, drainage tiles and fence posts, where steam at atmospheric pressure is used to accelerate the hardening. However, there is considerable scope for its use in the manufacture of prestressed floor joists and railway sleepers, where it is necessary to allow several days to elapse for the concrete to mature before releasing the pre-tensioned reinforcing wires. If the rate of curing can be accelerated to cut down this time interval, it would result in an effective reduction in moulds, prestressing apparatus and floor space.

The following tests were therefore carried out to investigate the possibility of obtaining a concrete of satisfactory working strength in as short a time as possible, using normal materials. Many factors contribute to the crushing strength and other properties of concrete, the most important being: (a) mix, (b) water-cement ratio, (c) curing conditions, and (d) age. When the concrete is subjected to steam-curing several additional factors are introduced, namely: (e) age before steaming, (f) rate of increase of temperature, (g) constant steaming temperature, (h) duration of steaming, (i) rate of decrease of temperature, (j) dryness fraction of steam and (k) curing conditions after steaming. The influence on the crushing and tensile strength of the most important of these factors has been studied by varying each one in turn while the rest remained fixed. Using a 1 : 1 : 2 mix (by weight) with a water-cement ratio of 0·40 to give a concrete of normal workability, 4 in. cubes and standard briquettes were cast and steam-cured under differing conditions. In addition, from each different concrete, a similar set of control specimens was cast and cured in air for 28 days before testing, thus enabling a direct comparison to be drawn between the relative effects of steam-curing and air-curing on the strength of a given mass of concrete. The effect of varying the water-cement ratio and the mix has also been investigated. In all cases, Earle's Ferrocrete rapid-hardening Portland cement was used.

The steam-curing chamber is designed to serve for both atmospheric and high-pressure curing processes. It consists of a mild-steel tube, 30 in. in internal diameter and $\frac{5}{16}$ in. thick, one end of which is permanently sealed by a welded steel flange, the other being fitted with a hinged door for access. The overall length is 6 ft. The tube is completely lagged with fitted asbestos mats to reduce heat losses, and the fittings include a thermometer pocket, a blow-off cock and a pressure gauge. Steam is supplied at a working pressure of 110 to 140 lb. per square inch (gauge pressure) and can be admitted either directly to the chamber or passed through a reducing valve for work at lower pressures. Entering at the sealed end the steam is dispersed round the tube by a baffle plate and then finally led away through a steam trap. When curing at atmospheric pressure, a uniform flow of steam is passed through the tube to maintain a constant temperature, and a large board is placed at the open end to act as a baffle. In the case of pressure curing, the hinged door is securely clamped by twelve $\frac{7}{8}$-in. diameter bolts spaced round the circumference.

The two most notable workers on high-pressure steam curing are Carl Menzel* of the United States and T. Thorvaldson† of Canada. Menzel carried out work on small specimens of neat cement or cement mortar, and later applied the tests to concrete products of commercial size. He concluded that the optimum steaming temperature was 177 deg. C. (corresponding to a pressure of 136 lb. per square inch for saturated steam), the strength increasing with duration of steaming up to three days. The steaming procedure consisted of a period during which the temperature was gradually increased to a maximum, followed by a period of steaming at constant temperature or pressure, and finally by a gradual release of temperature and pressure, after which the moulds were removed. Menzel allowed 10 to 12 hours for gradual heating and cooling and between eight hours and three days for constant steaming. In this way he stated that concrete could be obtained within one or two days after moulding having a strength of 40 per cent. to 60 per cent. of that at 28 days with moist curing. He also showed that, by adding optimum proportions of finely-divided silica, strengths equalling or exceeding 28-days moist-cured concrete could be obtained.

However, experimental work carried out in the civil engineering department of Leeds University, under the supervision of Professor R. H. Evans, D.Sc., shows that the optimum pressure for short steaming periods of one to four hours is 30 lb. per square inch. The cycle used is much more rapid than that of Menzel, only 30 minutes being allowed for heating and cooling with one to four hours constant steaming. Curing under these conditions produces a concrete of satisfactory strength for high-grade work, although it is somewhat weaker than a similar air-cured concrete. Tests were made at steaming pressures of 30, 60, and 110 lb. per square inch for durations of steaming from one to ten hours, and Figs. 1 and 2 show the relationships obtained between crushing strength, steaming pressure and steaming time, together with the 28-day air-cured strength for comparison. Lower steaming pressures of 5 lb. and 15 lb. per square inch were used in later tests, but both gave inferior results to those obtained at 30 lb. per square inch. When steaming is prolonged to 24 hours and over it is found that the greatest strength is then given at the higher pressures.

To study the effect of the rate of increase of temperature, a series of steaming cycles were applied in turn, using the optimum pressure of 30 lb. per square inch for short durations. The time taken to raise the curing temperature from atmospheric to the maximum steaming temperature was varied from a quarter hour to six hours. This was followed by a short period of steaming at constant temperature and pressure. These cycles, illustrated in Fig. 3, thus gave a range of conditions varying from a very rapid to a very gradual application of heat, and the complete cycle took from one to ten hours. Comparing these figures with those given by Menzel, it will be appreciated that they were designed to obtain an economical steaming cycle which could be used in practice to give a sound concrete of satisfactory strength as quickly as possible. Menzel states that the temperature should be raised gradually over a period of five to twelve hours to prevent surface cracks. Although this period depends to some extent on the working pressure, all the cycles shown in Fig. 3 have a much more rapid initial temperature rise than suggested by Menzel, and yet it is possible to obtain a sound concrete with all of them. Indeed, the strength given by using cycle (1) is comparable with that of cycle (5) (the strengths are shown in Fig. 4 by curves 1 and 2, respectively), although the time of the complete cycle is reduced by half.

Nevertheless, many cases did contain surface cracks, but it is significant to note that they occurred mostly when cycles (2) and (3) were used, i.e., when the maximum temperature was reached from $1\frac{1}{2}$ to $2\frac{1}{2}$ hours after moulding. B.S.S. tests on R.H. Portland cement show the initial and final setting times to be

* Paper read before Section G of the British Association at Edinburgh on Tuesday, August 14, 1951. Abridged.

* Carl Menzel, "Strength and Volume Changes of Steam-cured Portland Cement Mortars and Concrete," *Journal Am. Concrete Inst.*, vol. 6, pages 125-148 (1934); "Studies of High-Pressure Steam-Curing of Concrete Slabs and Beams," *Journal Am. Concrete Inst.*, vol. 7, pages 621-640 (1936).

† T. Thorvaldson and V. A. Vigfusson, *Eng. Journal*, vol. 11, pages 174-180 (1928).

HEAT-TREATED CONCRETE.

Fig. 5.

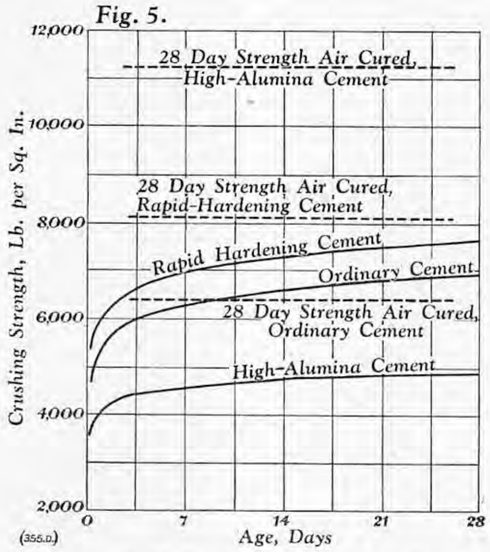
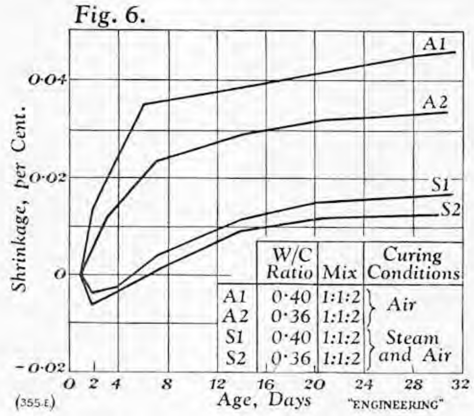


Fig. 6.



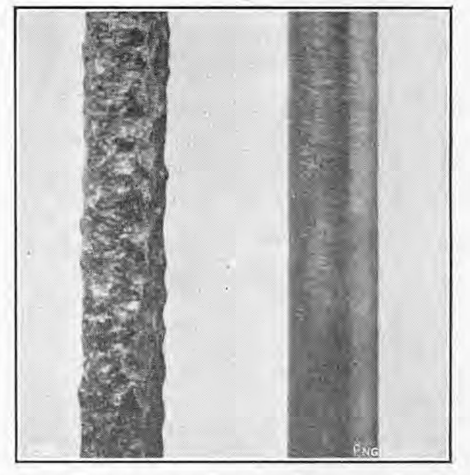


FIG. 7. PITTED WIRE AND SMOOTH WIRE.

1½ hours and 2¾ hours, respectively. Expansion occurring at these critical times may therefore prevent the concrete binding together and be the reason for these cracks. By delaying the heat treatment from four to 48 hours after moulding, all possibility of surface cracks can be eliminated, as the final set of the concrete will already have taken place when the heat is applied. The strength of the concrete is increased even if the steaming is not applied until seven days after casting, but naturally the longer the delay the lower is the percentage gain over air-cured concrete of equal age.

Heat-treated concrete continues to gain strength after steaming in a similar manner to that cured in normal conditions. Fig. 4 shows the increase in strength with age of concrete cured under differing conditions. Curves 1 and 2 compare the effect of applying the heat rapidly and gradually, steaming cycles (1) and (5) (see Fig. 3) being used, respectively. It will be seen that by using a more gradual increase in temperature a gain in immediate strength of over 16 per cent. is obtained, which is maintained as the concrete matures. Curve (3) shows that although the steaming treatment has been delayed for three days the immediate strength is 18 per cent. more than air-cured concrete of the same age. In each case the increase in strength of steam-cured concrete occurs mostly in the first few days, after which it is much more gradual. The crushing strength : age graph (dotted line) of air-cured concrete is shown for comparison.

The different factors enumerated and discussed for high-pressure curing again apply in the case of atmospheric-pressure steam curing, but the critical factor is the steaming temperature since the process is carried out at atmospheric pressure by simply passing a constant flow of steam through the chamber containing the specimens. The process is much milder in action than pressure curing, so that longer steaming periods are necessary to produce a concrete of equal strength. It is found that the strength of concrete cured under atmospheric-pressure conditions increases as the maximum temperature of curing and as the duration of steaming increase. The concrete continues to gain strength with the lapse of time after steaming and attains the 28-day air-cured strength after about ten days.

The data in Table I give a comparison of the crushing strength of concrete for various intervals of time at atmospheric pressure and at different steam pressures, the figures in brackets denoting the strength as a percentage of the 28-day air-cured cube strength. The initial temperature rise is again an important factor and must be carefully controlled to avoid surface cracks. Rapid application of heat in the initial stages invariably causes severe cracking, the critical temperature being about 120 deg. F. Therefore, to produce a sound concrete of high strength, a period of four to six hours should be allowed for gradual heating, or, alternatively, the temperature should be raised to the maximum in stages at various intervals of time.

Further tests have shown that the mix and water-cement ratio influence steam-cured concrete in much the same way as normal air-cured concrete. A richer mix or a drier mix will give higher strength for the same steaming conditions. In addition, the concrete strength is affected by the curing conditions after completion of the steaming process, according to whether moist or air-curing is used. It is, therefore, true to say that steam-cured concrete exhibits characteristics similar to those of normally cured concrete specimens, the steam heat-treatment merely accelerating the hardening process to give high early strength. Aluminous cement is unsuitable for steam-curing as the chemical reaction between the cement and water breaks down above a certain temperature so that the concrete fails to harden properly. Fig. 5 compares the strengths obtained for steam-cured concrete using different cements, the corresponding 28-day air-cured strength being given for comparison.

The modulus of rupture and Young's Modulus, E, are also affected by all the above factors and show a similar relationship with steaming time and pressure to that of crushing strength. The tensile strength of concrete steamed for short durations, however, seems to increase with the pressure and length of treatment. Two other properties on which steam-curing has considerable effect are shrinkage and bond resistance.

An important feature of steam-cured concrete is the reduction in the volume change in comparison with air-cured concrete, as illustrated by the shrinkage curves shown in Fig. 6. Steam-cured concrete is found to expand slightly during the first few days but the net change results in shrinkage, which is always less than that of air-cured concrete. Although the first measurements for the shrinkage curves shown in Fig. 6 were not taken until the columns were 24 hours old, attempts have been made to measure any change in length which takes place during the steaming period in the autoclave. Conflicting results have been obtained by different methods, however, so that it is too early to give precise figures.

This aspect of heat-treated concrete may affect the bond between the steel and concrete in reinforced and pre-tensioned prestressed concrete. Indeed, Menzel states that the bond resistance of concrete to steel is reduced by 50 per cent. or even more by steam-curing. Some of the results of a series of pull-out tests designed to investigate this are listed in Table II. High-tensile steel wire, 0·2 in. diameter, was used, having an ultimate strength of about 100 tons per square inch and a value of E of approximately 26×10^6 lb. per square inch. All the steam-cured specimens were treated for three hours at 30 lb. per square inch. The figures in the table show that, with plain polished wire, steam-curing reduces the bond resistance by about 55 per cent., but better strength can be obtained by first weathering the wires to give a pitted surface. Fig. 7 shows the difference in the surface condition of the polished and badly pitted wires, the slightly pitted surface representing an intermediate condition. Clearly, then, in order to get satisfactory bond strength with steam-cured concrete, mechanical bond must be used, either by weathering or by notching, crimping or twisting the wires.

The following conclusions may be drawn from the work outlined and discussed above. Concrete made from ordinary materials may be successfully cured in steam at atmospheric or higher pressure, immediately after casting for short durations of one to four hours, to produce satisfactory strength for high-grade work. The optimum steaming pressure for short steaming periods lies around 30 lb. per square inch. To prevent undue cracking and to obtain higher strengths, the rate of the initial temperature rise must be carefully controlled. Steam-cured concrete continues to gain strength with age after steaming, in a similar way to that of air-cured concrete. The different strengths of steam-cured concrete vary with water content in the same manner as those of normal air-cured concrete. Aluminous cement is unsuitable for steam-curing. The ultimate shrinkage of concrete is considerably reduced by steam-curing, but, for several days after casting, steam-cured concrete actually expands. The bond strength developed between steel and concrete is reduced by steam-curing and should be supplemented by mechanical bond to obtain satisfactory results. Steam-cured concrete is white in colour, sound in appearance and possesses the same flexibility as normal air-cured concrete.

TABLE I.

		15 lb. per sq. in.			30 lb. per sq. in.			
Pressure above atmospheric	Curing conditions.	1 hr.	2 hr.	3 hr.	1 hr.	2 hr.	3 hr.	—
	Immediate cube strength, lb. per sq. in.	3,700 (49)	4,400 (59)	4,700 (63)	4,300 (57)	4,800 (64)	5,100 (68)	—
		Maximum temperature, deg. F.						
Atmospheric pressure	Curing conditions.	160 (2 hr.)	200 (2 hr.)	160 (3 hr.)	180 (3 hr.)	190 (3 hr.)	205 (3 hr.)	205 (4 hr.)
	Immediate cube strength	2,200 (29)	2,900 (38)	2,800 (37)	2,400 (34)	3,000 (40)	3,600 (48)	5,000 (67)
	Cube strength after 24 hr.	4,800 (64)	5,000 (57)	4,900 (65)	5,100 (68)	6,000 (80)	6,500 (87)	6,900 (92)

TABLE II.

Description of Wire and Condition of Surface.	Bond Length. (In.)	Average Bond Strength, lb. per sq. in.				
		Air-cured.		Steam-cured.		
		3 days.	7 days.	Immediate.	24 hr.	7 days.
1. Plain wire, smooth and polished	10	286	414	120	143	189
2. ,, ,, slightly pitted	10	656	956	478	510	590
3. ,, ,, badly pitted	10	> 1,156*		> 1,156*		
4. ,, ,, badly pitted	4	—	1,500	—	900	—
5. Notched wire	4	—	1,280	—	1,120	—

* Steel failed before the concrete.

PROPERTIES OF GASES OF COMBUSTION.

Fig. 1.

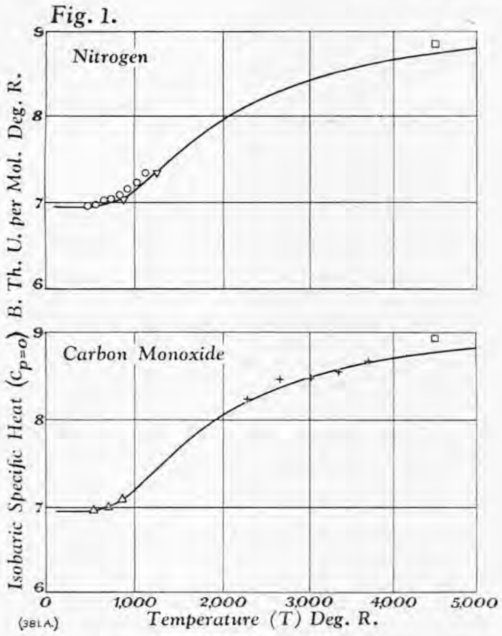


Fig. 2.

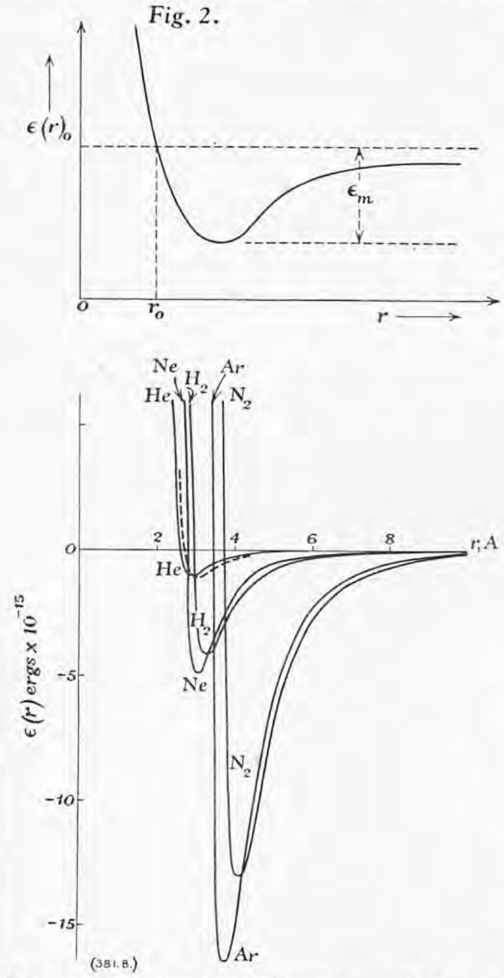
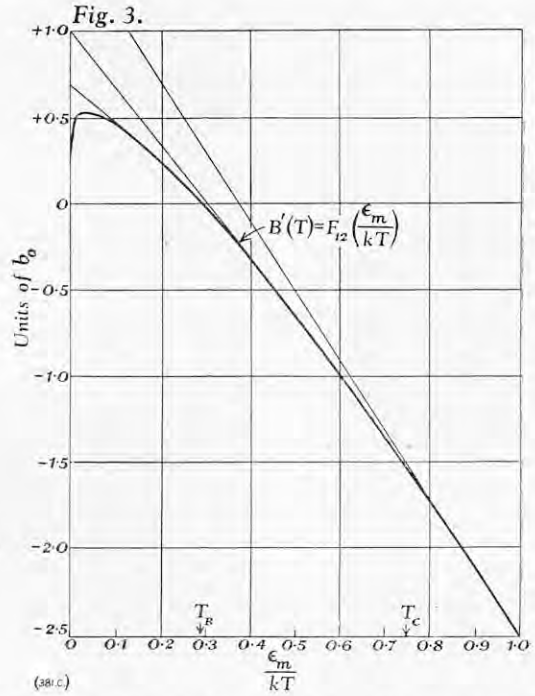


Fig. 3.



PROPERTIES OF THE GASES OF COMBUSTION PROCESSES.*

By PROFESSOR JOSEPH H. KEENAN.†

THE advance of technology from its early contributions to highways for transport and catapults for warfare to modern aeroplanes and atomic weapons has been dependent primarily upon the production of power from the combustion of fuels. The courage, steadfastness and unflagging energy of Herbert Akroyd Stuart, and of others like him in various quarters of the world, have provided the engines which have produced the power which, in turn, has created this great era of technology. It is doubtful that Herbert Akroyd Stuart ever fully comprehended the import of his work in either its technological or social consequences. Even to-day, from a vantage point farther along in time, we often stand aghast at the revolutionary thing we have created. At times it seems that only a profound faith in man, his spirit and his intellect, can make us believe that it is good. But there is no turning back. The survival of the good that we have depends upon the vigorous pursuit of technology. The development of the heavy-oil engines of Herbert Akroyd Stuart has led to the gas turbine and jet propulsion, and these, in turn, to the ram jet and the rocket.

For the accomplishment of these things the engineer must have as working material a knowledge of the nature of the fluids that he employs. This knowledge takes the form of data on the thermodynamic properties like energy and entropy and the transport properties like viscosity and thermal conductivity. Unless these things are known the engineer cannot design an oil engine, a gas turbine, or a rocket to the ultimate of its possibilities; and nothing short of the ultimate can suffice as an objective.

For these reasons it is proposed to devote this Herbert Akroyd Stuart lecture to a consideration of the present state of our knowledge of the properties of gases employed in the production of power. Since the products of combustion of hydrocarbons in air include most of the important power-plant fluids, consideration will be limited almost exclusively to these products and their constituent gases. Even within this limitation the task is a formidable one. The literature of the subject is so voluminous that no single lecture could possibly encompass it. It follows that selection must be made, and selection inevitably reflects the prejudices and limitations of the one who selects. If the emphasis here lies heavily upon American research it is partly owing to the provincialism of the lecturer and partly to a deliberate intent to bring a report from abroad.

The most notable extension of our knowledge of thermodynamic properties in the last quarter of a century is attributable to the development of the science of interpreting band spectra of gases. The band spectrum yields information about the behaviour of individual molecules each uninfluenced by the presence of any other. Thus, the information obtained is applicable to extremely rarefied states of the gas; that is, to states at zero pressure. From measurements of the spectrum, therefore, it becomes possible to compute the specific heat, the energy, the enthalpy, and the so-called reduced entropy of the gas over a wide range of temperatures at zero pressure.

* Herbert Akroyd Stuart Memorial Lecture; delivered at Nottingham University on May 10, 1951. Abridged.

† Of Massachusetts Institute of Technology.

Analysis of the spectrum yields the so-called energy levels of vibration of the nucleus and rotation of the molecule which, when introduced into the relations of statistical quantum mechanics, yield the energy of the molecules as a function of temperature. Professor Herzberg of the University of Chicago has explained the contribution of the spectrum in these words:* "The spectra of molecules correspond to transitions between these energy levels. The transitions between different vibrational levels give rise to 'bands' each of which has a fine structure which is determined by the different possible transitions between the various rotational levels belonging to the two given vibrational levels. Broadly speaking, it may be said that the separations of bands give the separations of the vibrational levels and therefore the vibrational constants. . . . Similarly, the separations of appropriate fine structure lines give the separations of the rotational levels and therefore the rotational constants . . . or the moments of inertia of the molecule."

As to the precision attainable, Professor Herzberg has the following to say: "For the monatomic gases and vapours, He, A, and Hg, the energy levels are so accurately known from the spectrum that the thermodynamic functions can be calculated with an accuracy which is limited only by the accuracy of the fundamental constants. In the case of the diatomic molecules H_2, O_2, N_2, and CO, the rotational and vibrational constants are known with sufficient accuracy to obtain the thermodynamic functions with an accuracy of 0·1 per cent., or better, to fairly high temperatures. . . For the polyatomic molecules CO_2, H_2O, NH_3, CH_4, and C_2H_4 the rotational and vibrational constants as yet are not known with as high a precision as those of the diatomic molecules just discussed. Nevertheless, except for the case of C_2H_4 . . . the available spectroscopic data are sufficient to calculate thermodynamic functions up to 1,000 deg. K. with an accuracy of, say, 5 per cent."

From spectroscopic observations the thermodynamic properties of N_2, O_2, H_2O, CO_2, H_2 and CO were calculated over a wide range of temperature during the years 1933 to 1935 by Johnston, Giauque, Gordon, and Kassel. In 1945, Wagman, *et al*,† of the National Bureau of Standards reviewed these data in view of revision of the fundamental constants and of newer spectroscopic data. Even more recently, at the thermodynamics research laboratory of the University of Pennsylvania, Professors Goff and Gratch have brought into good order the thermodynamic properties derived from spectroscopic data of twelve monatomic gases,* the diatomic gases CO and N_2,† and the triatomic CO_2.‡ The monatomic gases which they cover include argon, helium, carbon, and mercury, and monatomic oxygen, nitrogen and hydrogen. The range of temperature is from 100 to 5,000 deg. F. absolute and values of properties are tabulated to seven significant figures, four or five of which are in most instances justified by the precision attained.

* *A.S.M.E. Trans.* vol. 70, page 623 (1948).

† Wagman, Kilpatrick, Taylor, Pitzer and Rossini. *Jl. Res. N.B.S.*, vol. 34, pages 143-161 (1945).

Similar tabulations are given for carbon monoxide and nitrogen. Fig. 1 shows comparisons of the spectroscopic values of the isobaric specific heat at zero pressure with the best values obtained from thermodynamic experiments. The triangles in Fig. 1 represent the adiabatic-expansion measurements of Eücken and Lüde and of Eücken and Mücke which have an estimated precision of 0·1 per cent. The spectroscopic values are doubtless of still higher precision. Fig. 1 shows how at low temperatures the magnitude of the specific heat of CO and N_2 conforms to the classical kinetic-theory value of $\frac{7R}{2}$ for a molecule with five degrees of freedom, three translational and two rotational. The increase in specific heat at high temperatures is evidence of the failure of the kinetic theory as new modes of behaviour, vibrational and rotational, come into play.

It appears that the study of band spectra has resolved the problem of thermodynamic properties at zero pressure of the molecularly simple gases. The corresponding properties of the more complex molecules, and in particular those having permanent dipoles or magnetic moments, are in a less satisfactory state. Among these is water, about which more will be said subsequently. Professor Herzberg, however, is hopeful regarding these substances. He states that "there is no question, however, that an intensive study of the spectra of CO_2, H_2O, NH_3, CH_4, and C_2H_4 will make it possible to derive molecular constants and therefore thermodynamic functions of these molecules comparable in accuracy to those now available for the diatomic molecules . . ."

The determination of thermodynamic properties at finite pressures has not yet yielded in the same degree as at zero pressure to the analysis of non-thermodynamic data. Nevertheless, some notable progress has been made in this direction, which is based on the construction of a theory of the effects of interaction between molecules from assumptions concerning the force field surrounding the molecule. Recently, Professor Hirshfelder and his colleagues of the Naval

* Goff, Gratch and Van Voorhis, *Trans. A.S.M.E.*, vol. 72, pages 725-740 (1950).

† Goff and Gratch, *Trans. A.S.M.E.*, vol. 72, pages 741-750 (1950).

‡ Gratch, *Trans. A.S.M.E.*, vol. 71, pages 897-902 (1949).

Research Laboratory of the University of Wisconsin* have attempted to bring into a form useful to engineers the present state of the science of molecular interaction. Their methods are based on the work of Professor J. E. Lennard-Jones, of Cambridge University, of David Enskog, of the Royal Institute of Technology in Stockholm, and of Chapman and Cowling, respectively of the Imperial College of Science and Technology and of Manchester University. Fundamental to it all is the Lennard-Jones potential which may be written in the form

$$\epsilon\,(r) = 4\,\epsilon_m \left[\left(\frac{r_0}{r}\right)^{12} - \left(\frac{r_0}{r}\right)^{6}\right] \quad . \; . \; . \quad (1)$$

where $\epsilon\,(r)$ denotes the energy of separation of two simple molecules, the centres of which are separated by the distance r, ϵ_m the minimum value of this energy, and r_0 the separation corresponding to zero energy. These quantities are shown in the upper part of Fig. 2, page 347, the lower part of which compares the energy of separation for certain molecules. The significance of r_0 might be explained by noting that a mass starting from rest at $r = \infty$ and accelerating under the influence of the force field of the single molecule in question will attain a maximum velocity towards the molecule at the distance r, corresponding to ϵ_m and will return to zero velocity at r_0 before it starts its return journey.

The authors of this paper, subsequently referred to as H. B. and S., state that "the inverse sixth-power energy of attraction . . . can be justified rigorously on the basis of an instantaneous dipole moment in one molecule inducing a dipole in a second molecule and the two dipoles . . . attracting one another. The inverse twelfth-power energy of repulsion . . . has no good theoretical foundation. Lennard-Jones and others have shown that it suffices to explain all of the available experimental second-virial-coefficient data. If the experimental data were accurate to 0·1 per cent. rather than to 1 per cent., it is clear that a more accurate form for the energy of repulsion would be desired." The impression obtained from this statement, that this choice of exponents in entirely satisfactory in view of all available data on compressibility near zero pressure, is probably unwarranted. Nevertheless, these simple assumptions yield an astonishing amount of useful data for many substances for which only meagre data were previously at hand.

In Fig. 3, page 347, is shown the variation of the second virial coefficient corresponding to the assumed force field with reciprocal temperature. It will be recalled that the second virial coefficient is the temperature function B (T) in the equation of state

$$\frac{p\,v}{\mathrm{R\,T}} = 1 + \frac{\mathrm{B\,(T)}}{v} + \frac{\mathrm{C\,(T)}}{v^2} + \; . \; . \; .$$

The departure of the curve of Fig. 3 from a straight line is a measure of the departure of the assumed force field from that of the van der Waals model. The two constants ϵ_m and r_0 in the equation of the force potential may be determined from experimental values of the second virial coefficient. For example, a curve of measured values of B (T) plotted against $\frac{1}{\mathrm{T}}$ for any gas should resemble in character the curve of Fig. 3. The multipliers of ordinate and abscissa which will make this curve most nearly superimpose upon that of Fig. 3 determine respectively the values of r_0 and ϵ_m.

It is possible, however, to determine these constants quite independently of the second virial coefficient from the measured viscosity of the gas and its variation with temperature. This procedure involves a more complicated analysis of molecular interaction for the non-symmetrical distribution of molecules found in a velocity gradient. Here H. B. and S. followed the methods of Enskog, Chapman, Cowling, and others in the analysis of collisions of various types. They improved upon the work of their predecessors by analysing the behaviour of pairs of molecules surrounded by the force field of equation (1). They determined the angle of deflection χ of the molecule A interacting with molecule B, as shown in Fig. 4, for 500 different combinations of the relative kinetic energy and the perpendicular distance b between the molecule B and the undisturbed line of motion of molecule A. Fig. 5 illustrates a type of orbital encounter which was included in these calculations. Table I lists the constants of equation (1) for a number of gases as found from viscosity data on the one hand and from pressure-volume-temperature data on the other. The agreement between the values from the two sources is quite striking.

It appears, therefore, that a knowledge of the second virial coefficient is sufficient to determine the variation of viscosity with temperature at zero pressure; or, conversely, a knowledge of the variation of viscosity with temperature at low pressures is sufficient to determine the second virial coefficient. In either case, the precision would seem to be good compared with the meagre direct experimental knowledge available for many substances.

* Hirshfelder, Bird, and Spotz, *Trans. A.S.M.E.*, vol. 71, pages 921-937 (1949).

H. B. and S. are careful to point out that the simple potential function of equation (1) is not a satisfactory representation of the force fields around molecules having permanent dipoles or molecules departing radically from the spherical form. They apply the more complex Stockmayer potential to the polar molecules H_2O and NH_3 and tabulate the corresponding constants. They propose rules of combination of the constants ϵ_m and r_0 in equation (1) which will yield the second virial coefficients for binary mixtures of both non-polar and polar gases. The validity of these rules, it seems, has not yet been tested by comparison of calculated with measured second virial coefficients.

TABLE I.—*Force Constants Between Like Molecules.*

	Force Constants Determined from Viscosity Data.		Force Constants Determined from 2nd Virial Coefficient.	
Gas.	ϵ/k (deg. K.)	r (Å)0	ϵ/k (deg. K.)	r (Å)0
Air	97·0	3·617	99·2	3·522
H_2	33·3	2·968	37·02	2·92
N_2	91·46	3·681	95·9	3·72
CO_2	190·0	3·996	185·0	4·57
N_2O	220·0	3·879	189·0	4·59
NO	119·0	3·470	131·0	3·17
CH_4	136·5	3·882	142·7	3·81
O_2	113·2	3·433	117·5	3·58
CO	110·3	3·590	95·33	3·65
A	124·0	3·418	119·5	3·41
Ne	35·7	2·80	35·7	2·74
He	6·03	2·70	6·03	2·63

Fig. 4.

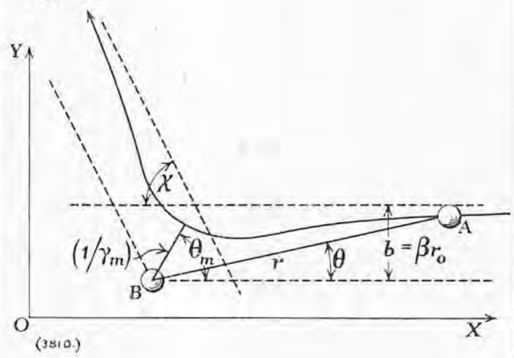
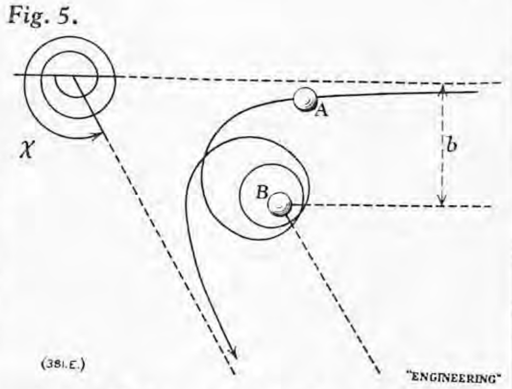


Fig. 5.



Perhaps the least satisfactory aspect of the science of thermodynamic properties of gases is the paucity of direct experiment of the thermodynamic type presently being pursued. It is true that precise experimentation is costly and that the numbers of gases of engineering importance waiting to be investigated is discouragingly large. These considerations, however, serve only to emphasise the value of analytical studies like those based on spectroscopic data and on assumed molecular force fields in generalising our knowledge of gases. Nevertheless, the need for precise experiments of the thermodynamic type is very great and is being filled only inadequately.

Johnston and White* have given an interesting survey of the contributions to our knowledge of gases through throttling experiments. Beginning with the work of Joule and Thomson in the decade 1852 to 1862 they trace the improvements in technique, through attention to the reduction of heat leakage along the temperature gradient of the expansion, up to the present day. Regnault introduced the cup-shaped plug with radially-inward flow. More recently, Professor Johnston and his colleagues at Ohio State University have perfected the simpler valve-type of throttling device with good results down to 64 deg. K. on hydrogen and deuterium.

**Trans. A.S.M.E.*, vol. 70, pages 651-654 (1948).

Buckingham, in 1910, was the first to employ isothermal throttling in which heat is added at a sufficient rate to maintain temperatures equal before and after the throttle. This yields the very important derivative $\left[\frac{\partial h}{\partial p}\right]_{\mathrm{T}}$ which is also equal to

$$v - \mathrm{T}\left(\frac{\partial v}{\partial \mathrm{T}}\right)_p = \left[\frac{\partial\,(v\,\tau)}{\partial \tau}\right]_p$$

where h denotes enthalpy and τ the reciprocal of the absolute temperature T. This method has recently been perfected by Collins and Keyes at the Massachusetts Institute of Technology, and Eücken, Clusius, and Berger of Göttingen. To throttling measurements we owe a considerable body of data on air and its constituent gases, on H_2O, CO_2, NH_3 and other substances. Joule-Thomson coefficients have been measured for water vapour by Kleinschmidt, at Harvard University, whose measurements extended to 600 lb. per square inch absolute and 600 deg. F., for a number of gases by Roebuck, at the University of Wisconsin, whose measurements extended to 3,000 lb. per square inch absolute and 570 deg. F., and for hydrocarbons and binary mixtures of hydrocarbons by Sage and Lacey at the California Institute of Technology.

(*To be continued.*)

HIGHER TECHNICAL AND SCIENTIFIC MANPOWER.*

By THE RT. HON. LORD HANKEY.

(*Concluded from page 299.*)

JUST as technical and scientific training and education developed during the war from pre-war preparations, so post-war developments originated in demobilisation and reconstruction plans made during the war. From visits as chairman of the Technical Personnel Committee to radar units and other technical establishments, I had encountered among the personnel—especially the Hankey Bursars—a good deal of anxiety about their post-war future. I therefore accepted an invitation from Mr. Ernest Bevin, early in 1943, to preside over two bodies, one known as the Committee of Further Education and Training, the other as the Higher Appointments Committee, both intended to look after the future of those who had been torn from the careers of their choice. Sir Clement Jones was again my vice-chairman. Both reports were completed by January, 1945.

The main result of the Committee on Further Education and Training was to enable the Government to advise the universities and technical colleges what to prepare for, and, to make known in detail to interested personnel in the Services and war workers what scientific and technical occupations were open to them in civilian life and how they should proceed in order to obtain the necessary training and education. The value of the scheme is shown by the fact that up to June 30, 1951, over 150,000 awards for further training and education, out of 217,500 applications, were granted. Of these 150,000 awards, more than 18,000 were for study of engineering, about 3,000 for general science, 5,000 for chemistry and physics, 7,500 for medicine and some 30,000 for teaching.

The principal result of the Higher Appointments Report was the re-organisation of the Higher Appointments Department of the Ministry of Labour and National Service and of the Technical and Scientific Register. The main functions of the latter are now to act as a voluntary employment agency; to carry out surveys of manpower in the fields of technology and science, and to watch trends of supply and demand; and to distribute between the Services the young scientists and engineers leaving the universities who become liable for call-up under the National Service Act.

The Register deals with both unemployed and employed persons seeking alternative employment. It operates centrally from London, with a staff of professionally qualified members of the professions concerned, who visit the universities to distribute scientific and engineering graduates between the Services, and take the opportunity also to give advice and assistance to ex-Service men and women and other graduates not liable for military service. Many graduates also visit the Register in London and receive similar assistance. Apart from their direct contacts with the universities and with the University Appointments Boards, the Register is in touch with Government departments, industrial establishments and employers generally, and such professional agencies as the Professional Engineers Appointments Board—thus continuing and expanding contacts built up during the war. A measure of its success is, perhaps, the filling of

* Lecture delivered at the Home Office Industrial Museum, London, S.W.1, under the auspices of the Ministry of Labour and National Service, on August 29, 1951. Abridged.

over 65,000 higher posts since 1939. In addition, since 1949, the Register has included a special unit to handle requests for technical experts from overseas Governments.

Since the war, the universities have made gallant efforts to increase their output of technical and scientific graduates. They have more than achieved the overall increase of 50 per cent. above the pre-war number of students—the greater part in scientific and technical subjects—envisaged by the Committee on Further Education and Training in 1944. The immediate aim recommended by the Barlow Committee on Scientific Manpower of 1946, "to double the present output so as to yield roughly 5,000 newly-qualified scientists at the earliest possible moment," has been approximately attained. That is a very remarkable achievement, on which both the universities and the University Grants Committee are to be congratulated.

In the technical colleges also there have been notable advances since the Education Act of 1944, which, among other things, made the provision of technical education a duty of the local education authorities. Eleven Regional Advisory Councils now advise on the needs of their regions, both for university and technical college provision, thus ensuring adequacy of educational facilities without unnecessary duplication and overlapping. Another notable advance is the establishment of National Colleges for such varied subjects as aeronautics in all aspects, horology, foundry technology, heating and ventilating engineering and refrigeration, rubber technology and food technology: more are envisaged. A sound feature is that each industry concerned is associated with the government of the college and usually with its finance. It can be said with certainty that at no time has the country's provision for scientific and technical education been under such close and continuous review, not only by the Government, but by the professional and associated bodies.

An important new factor is the reconstitution of the Technical Personnel Committee with wider terms of reference, as announced by Mr. Alfred Robens, the Minister of Labour and National Service, in the House of Commons on July 26. The Committee will, in future, deal, in collaboration with the Advisory Committee on Scientific Policy, with questions relating to the overseas, as well as the home demand for scientific and technical personnel of professional or approximately professional standards.

One of the most important and most controversial questions now is that of higher education in technology, which raises big issues. I understand that the Government have had the matter under consideration for some time and that an announcement of policy may be expected before long. Another subject of special interest to young people bent on a scientific or technological career, to their parents, and to those responsible for laying out the facilities of universities and technical colleges, is the extent of the prospective demand for qualified personnel in industry, the fighting Services and Government at home and abroad, and the capacity of the nation's educational resources to meet the demand.

Yet another question for the future is the introduction of the "humanities" in the curriculum for students of science and technology, which many industrialists in Britain and America favour. It is a formidable problem for the student. A high standard in science at his secondary school is required as a condition of his acceptance by a university as a scientific student, and at the university itself he becomes so absorbed in his scientific work that he finds little time for anything else and is liable to become self-centred and narrow in outlook. At least one famous university prescribes a qualification in one "humane" subject as necessary for a scientific degree. Possibly, however, the same object might be achieved in other ways, e.g., by laying a foundation in early life, and by bringing home to every scholar that the object of education is not so much the acquisition of knowledge as an introduction to a treasure house of reading and self-education, including the humanities, that will last a life time.

In conclusion, I would draw attention to a new high level development in recent years resulting from the huge expansion of science and technology since the outbreak of World War II, which should not only give a fillip to the study of the humanities by the budding scientist and technologist, but should also open even wider vistas than in the past to those seeking a scientific or technological career. I refer to the growth of great blocks of science and technology, grouped sometimes by professions, sometimes geographically, sometimes under Government, sometimes in private industries or groups of industries, and whose higher direction and co-ordination call for a very special type of scientific and technological administrator, which is not always easy to find.

Such great groups are to be found in the area of defence under the Ministry of Supply, the three Service departments, and the Home Office (Civil Defence). On the civil side of Government also there are the three huge groups of Scientific and Industrial Research, Medical Research and Agricultural Research, which report to the Lord President of the Council, the new Colonial Research Service covering many branches of research and technology and extending over the whole Colonial Empire, as well as smaller research units, in other Government departments and outlying organisations. In the Government, these blocks of science are usually run by a highly qualified Chief Scientist, often with a high-powered advisory board or council to assist him and the department. The survey and co-ordination of the two main branches of Government researches is entrusted to two committees known, respectively, as (for defence research) the Defence Research Policy Committee, associated with the Ministry of Defence, and, for civilian research, the Advisory Council on Scientific Policy to advise the Lord President of the Council, who is responsible for the formulation and execution of Government scientific policy. At the top of the pyramid are the Prime Minister and the Cabinet. Outside the Government there are large autonomous blocks of science maintained by universities, the larger private industries and joint research associations, supported by smaller industries, which usually collaborate with the Department of Scientific and Industrial Research.

Many experts of exceptional experience and knowledge are now required for higher direction. The director of each block or group of blocks must have a wide knowledge of several sciences, what can and what cannot be done, the personal and professional qualities of individual scientists and technologists of all kinds, and where they are to be found. He must have initiative, drive and ingenuity, and the gift of leadership, with vision to sense the wider implications of the epoch-making discoveries taking shape in so many fields. He must have a flair to appreciate how they affect national and international life and politics, as well as human relations and indeed nature itself, not only within the narrow range of our own senses, but far beyond towards the infinite.

To close, I will throw into the arena a new idea for consideration on the top level. Would not science and technology do well to study the experience of the Committee of Imperial Defence in setting up the Imperial Defence College, with a view to the possible adaptation of the same system, *mutatis mutandis*, to the study of science and art of higher scientific and technological administration? For 25 years, selected officers of the middle ranks, drawn from all branches of the fighting Services and civil service of Great Britain and other parts of the Commonwealth and Empire, have under experienced direction, been studying together the broadest aspects of imperial strategy. From this pooling of varied experience a common doctrine of co-operation in all fields and higher direction of war has gradually emerged and has permeated the Services and the civil administration, with great advantage to all concerned. The system has also crossed the Atlantic.

In science and technology there may not be so definite an objective, but there are many problems to be solved, and there is the same need in science and technology as in the Services for a cadre of persons qualified for higher direction and top-level co-ordination. Should not aspirants to such posts have some establishment comparable to the Imperial Defence College, where they would not only obtain a more intimate knowledge of sciences and technologies other than their own, but also meet people with totally different experience in various branches of government and administration, finance, economics, humanities, and international affairs? By these means there would be a double advantage: the scientists and technologists would broaden their outlook, and in doing so, would pass back a much needed knowledge of science to government, administration, the humanities and other branches of national life.

CORROSION OF BURIED PIPES.—Inquiry into the corrosion of buried pipes will be greatly facilitated if water engineers, gas engineers and others concerned will co-operate with the British Iron and Steel Research Association's sub-committee on the corrosion of buried metals to the extent of completing, in all cases of corrosion failure, a standard data form which has been prepared by the sub-committee. Copies of the form are available from Mr. E. E. White, B.I.S.R.A., 140, Battersea Park-road, London, S.W.11, and are to be returned to the Chemical Research Laboratory (Department of Scientific and Industrial Research), Teddington, Middlesex. The sub-committee have taken over this work from the research co-ordination committee of the Institution of Water Engineers, and the chairman is Mr. L. C. Whiskin, of the Metropolitan Water Board. Underground corrosion has been estimated to cost the country 5,000,000*l*. a year. The seriousness of the problem was recognised in the report of the Ministry of Health's departmental committee last year, which emphasised the importance of full and accurate records of all cases.

BOILER AND TURBINE TESTING.*

By CAPTAIN (E) L. F. INGRAM, R.N., and CAPTAIN (E) L. A. B. PEILE, D.S.O., M.V.O., R.N.

(*Continued from page* 300.)

Turbine Testing.—Until the testing facilities of Pametrada came into operation, the testing of marine propulsion turbines had necessarily to be carried out afloat. It was not possible accurately to separate the turbine water rate from the total water rate, or to instrument adequately for other than steady steaming runs. The Admiralty normally specified, for cruisers and above, a series of six-hour consumption trials at perhaps eight or more different powers, with two 12-hour trials at particularly important points, and an 8-hour full-power trial; for smaller ships the consumption trials were reduced to four hours' duration and the full-power trial to six hours. The Daring trials at Pametrada constitute the first occasion on which the designer can compare design data with recorded evidence of performance.

There are three designs of turbine fitted in the Daring class of destroyers, all of which are being tested at Pametrada. At the time of writing, full results and reports of the first series only are available, so that, unless otherwise stated, remarks apply to the reaction design of high-pressure and low-pressure turbines. In this design, known as Daring I, the high-pressure turbine comprises a Curtis wheel followed by reaction stages, with a by-pass from the wheel chamber to one of the lower stages, and the low-pressure turbine is a double-flow reaction turbine with an astern Curtis wheel at each end. Double-helical double-reduction locked-train gearing is employed. Daring II is identical except that the high-pressure turbine is of all-impulse design. In Daring III, both the high-pressure and low-pressure are impulse designs, the latter being a double-flow turbine with an astern Curtis wheel at each end. All three variations were designed to have very similar steam consumptions over the whole working range.

Daring I turbines and gearing, together with the associated auxiliaries and the boiler, were erected at Pametrada by the Wallsend Slipway and Engineering Company. Special care was taken to reproduce important features of the ultimate ship arrangement, such as the relative positions of the extraction pump and the condenser, and the boiler-room air intake and uptake arrangements. The trials comprised, in addition to preliminary proving tests, consumption trials of six hours duration at one-fifth, two-fifths and three-fifths power, full power, and overload, with one-hour check readings at intermediate powers, a series of manœuvring trials, and a series of astern trials. The trials were very fully instrumented, no less than 525 separate quantities being measured during some of the runs, and an accuracy of $\pm \frac{1}{4}$ per cent. was achieved, with reproducible results on repeat trials. So consistent were the results that the duration of the consumption trial could be reduced without loss of accuracy. At the design points, the designer's figures for water rate were achieved to within less than 1 per cent. and, even at lower powers, where turbine clearances play such a significant part, the greatest departure from expectation was only 4 per cent.

In all, the machinery was run for 407 hours, including 23 hours astern trials. This occupied 34 weeks, which included considerable periods for examination of machinery, including three halts each of four weeks duration, some modifications, and the eradication of teething troubles; moreover, this was the first occasion on which this extensive testing equipment had been used. Some important associated researches were carried out at the same time, and, since security forbids the publication of the main performance data, it is proposed to deal with some of these other tests.

The object of the astern trials was to determine the behaviour of the turbines during prolonged astern running. Trouble has been experienced in the past on account of distortion and overheating, necessitating, in some cases, restrictions of astern power and running periods. The two chief problems requiring investigation were the rate of increase of temperature in the high-pressure turbine and the ahead blading of the low-pressure turbine, due to "windage" losses, and the distortion of the low-pressure turbine casing due to the presence in the casing of high-temperature exhaust steam discharged from the astern turbines. It was not found possible to measure turbine blade temperatures, but it was considered that these temperatures would approximate very closely to the steam temperature, provided conditions were not altering too rapidly.

The first trial was carried out with steam at 650 deg. F., which is the temperature that will normally be employed at sea when manœuvring. The machinery

* Paper presented to the International Conference of Naval Architects and Marine Engineers at a meeting held in London on June 27, 1951. Abridged.

BOILER AND TURBINE TESTING.

Fig. 1. ASTERN TRIAL WITH 825 DEG. F. STEAM. VARIATION TIME AND TEMPERATURE IN TURBINES

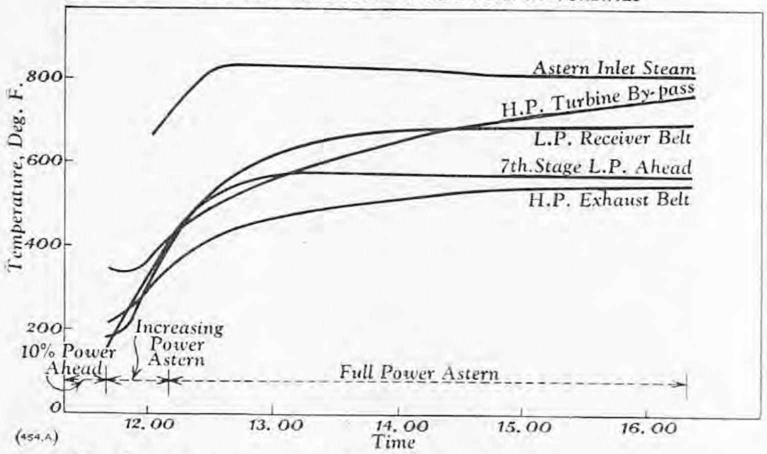


Fig. 2. L.P. TURBINE DISTORTION

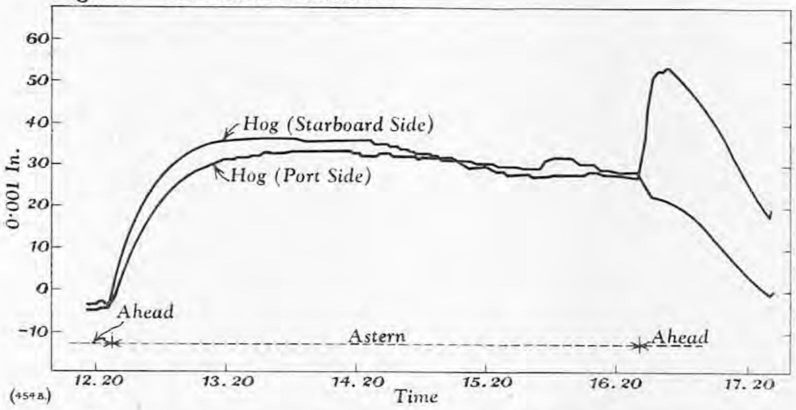


Fig. 3. ASTERN TRIAL TEMPERATURE AND TIME

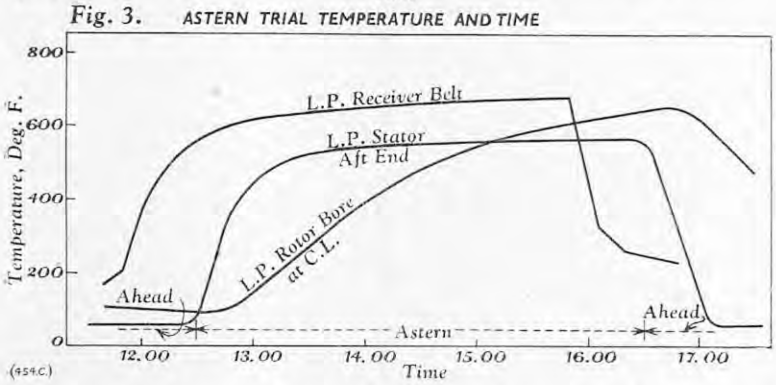
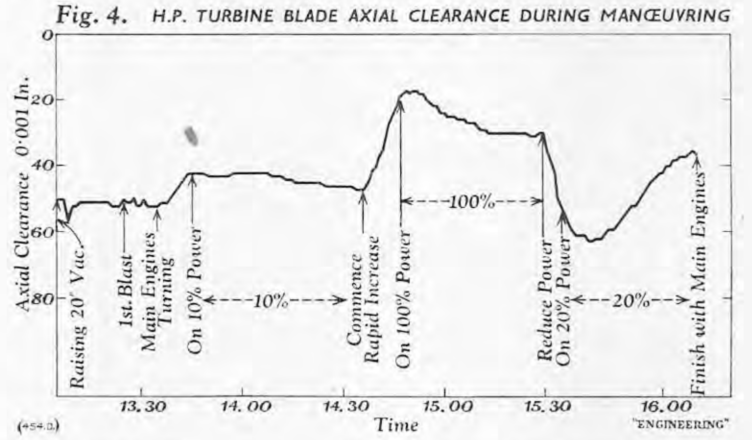


Fig. 4. H.P. TURBINE BLADE AXIAL CLEARANCE DURING MANŒUVRING



was first run at 10 per cent. power ahead to get the engines properly warmed through, and was then worked up to full astern power in half an hour. After three hours' running, temperatures in the ahead turbines had, in the main, become steady. The highest temperature in the L.P. turbine was 550 deg. F. at the receiver belt, and in the H.P. turbine 565 deg. F. at the by-pass belt.

A second trial was then carried out with steam at 825 deg. F., as there can be no certainty that, when on service, the engine room staff will always reduce the steam temperature when manœuvring. Again, the engines were warmed through at 10 per cent. power ahead and then reversed, half an hour being allowed to work up to full astern power.

The results, which are illustrated in Fig. 1, herewith, showed that there was a rapid increase in temperature in the L.P. turbine during the first ¾-hour, approximate figures being, L.P. ahead (7th stage) from 160 deg. F. to 550 deg. F., and L.P. receiver belt, from 160 deg. F. to 580 deg. F. The L.P. casing temperature rose to a range of 400 to 500 deg. F. under these conditions. After 2½ hours' running, the L.P. turbine temperature became steady, when the maximum reached was 710 deg. F. in the receiver belt. The H.P. turbine temperatures were, however, still increasing after 4½ hours of astern running when 770 deg. F. had been reached in the by-pass belt.

Maximum acceptable blade temperatures had been fixed at 800 deg. F. for the L.P. and 900 deg. F. for the H.P. and it can be assumed that these temperatures will never be reached, even under the most arduous astern running conditions. It is worth noting that, in the Daring II trials, with an all-impulse H.P. turbine, the H.P. wheel chamber reached the permitted maximum temperature of 900 deg. F. after three hours at full astern power, with steam at 825 deg. F. With this design of turbine, therefore, it is imperative to reduce the steam temperature at the boilers during prolonged astern running.

Reverting to the Daring I trials, hog gauges were fitted to the L.P. turbine casing to measure the deflection during prolonged astern running. Fig. 2, herewith, gives the readings of these gauges. During the first ¾-hour the hog at both sides of the casing increased rapidly to a value of about 0·030 in. This rapid increase period corresponds to the temperature increase mentioned above. After reaching a maximum of 0·035 in. hog in about one hour, it fell off very slowly, until after four hours' astern running it had reached a value of 0·028 in.

Fig. 3, on this page, shows the temperatures at the L.P. receiver belt, at the turbine casing, and at the rotor bore in approximately corresponding positions. Over the period of the first ¾-hour the receiver-belt temperature, and therefore presumably the blade temperature, rose rapidly, but the rotor and casing temperatures lagged far behind. This must evidently cause a reduction in the radial clearances. The designed minimum radial clearance was 0·050 in. and, as can be seen from Fig. 2, the casing hog will absorb 0·035 in. The remaining margin was clearly too small for safety, and it was decided to increase the minimum radial clearance to 0·070 in. The estimated effect upon steam consumption of this modification was less than 1 per cent.

Fig. 5. ROTOR-BORE TEMPERATURES AT VARIOUS POWERS

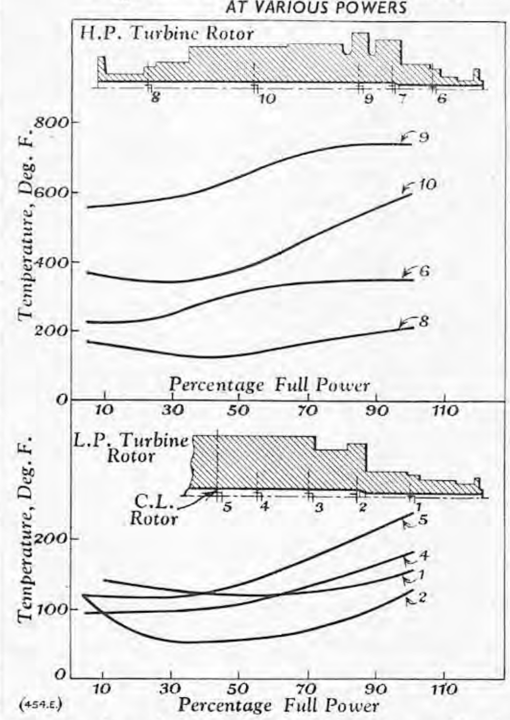
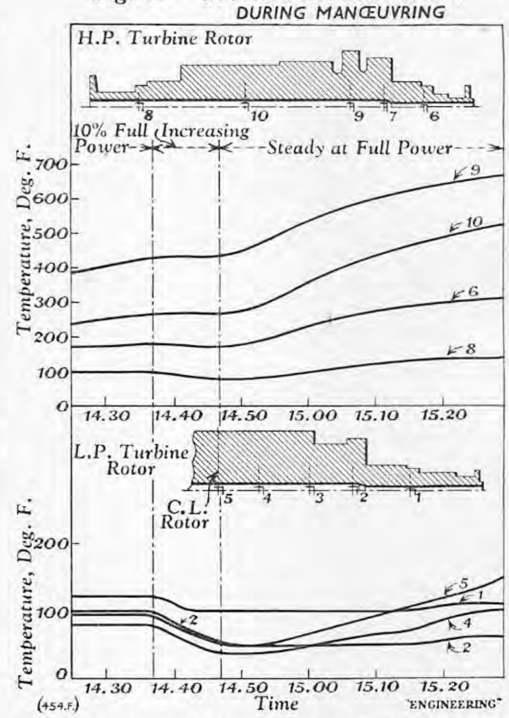


Fig. 6. ROTOR-BORE TEMPERATURES DURING MANŒUVRING



An attempt was made to correlate mathematically the hog experienced and the measured temperatures in the turbine casing. It was estimated that a temperature gradient in a vertical plane of 29 deg. F. per foot would be required to produce a hog of 0·030 in. but, while a gradient of this order could be found during the early stages of the astern run, the gradient became very much less as the trial proceeded, though the hog was but little reduced. The possibility that the hog was due to jamming of the L.P. turbine sliding foot, or to a temperature gradient in the condenser shell, was disproved by practical experiment. The H.P. turbine casing never exceeded a hog of 0·010 in. during the astern running. Axial clearances decreased slowly through the astern run from 0·035 in. to 0·020 in. after 4½ hours.

The method of measuring axial clearances is interesting. Three methods were tried, namely, an electronic capacitance intrument, which suffered from condensation of water vapour; a telescope measuring the axial clearances between fixed and moving blades in one of the later expansions, in which trouble occurred due to fouling of the observation window; and a third instrument, which comprised a gauge acting against the face of the after gland thrower ring. This gauge took the form of a box with one open side, so arranged that the gland thrower face completed the sixth side, but with a clearance, which varied with the relative movement of rotor and casing. The box was supplied with compressed air through an orifice, on the upstream side of which the pressure was maintained constant. The pressure in the box itself was led to a manometer, calibrated in terms of axial clearance. After the

BOILER AND TURBINE TESTING.

Fig. 7. H.P. TURBINE TEMPERATURES DURING MANŒUVRING

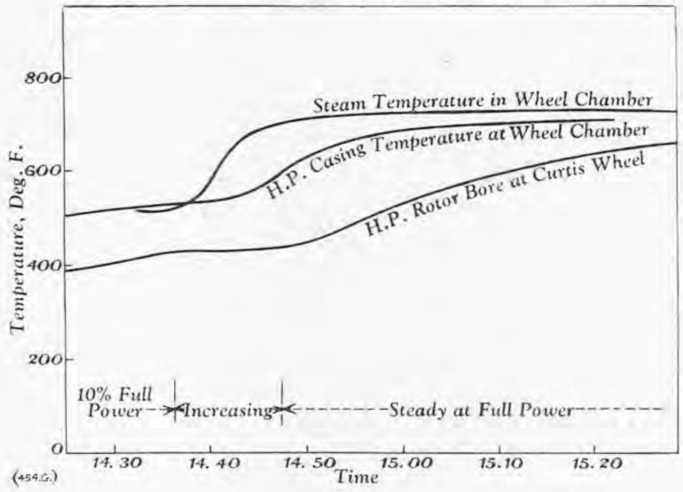
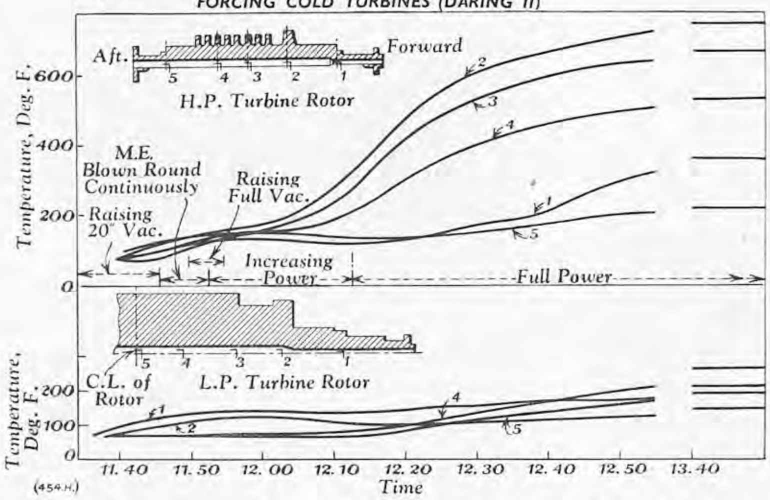


Fig. 8. ROTOR-BORE TEMPERATURES WHEN FORCING COLD TURBINES (DARING II)



technique had been mastered, this gauge was found capable of accurate and consistent calibration. It worked well under all conditions, and enabled an extremely useful record to be made of relative rotor and casing expansion.

The astern trials were at the time chiefly remarkable for troubles that arose when subsequently going ahead. After the astern run with 650 deg. F. steam, the turbines were run at about 10 per cent. power ahead for some 25 minutes while the soot-blowers were used, and no difficulties were encountered. The high-temperature astern run was also followed by a period at 10 per cent. ahead, but after some 20 minutes the turbine started vibrating and the engine was shut down. Turning gear was engaged, but the current taken by the turning-gear motor, normally 7 amperes, was 10 amperes, rising to 30 amperes every half minute. Shortly afterwards, it became impossible to turn the engines. An hour later, the engines were found to be free and the turning-motor current normal.

Subsequent opening up of the L.P. turbine revealed the fact that a blade rub had occurred in the lower half of the cylinder, evidently caused by hogging of the L.P. turbine casing, and the measurements of casing distortion showed that the hogging had taken place almost entirely on the starboard side of the casing. (See Fig. 2.) In addition to the turbine-casing distortion, records of L.P. turbine rotor-bore temperatures showed a very slow decline, whereas the casing was cooled rapidly by the low-temperature steam. At about the time when the rub took place, the casing temperature was 300 deg. F., while the rotor-bore temperature was 600 deg. F. (See Fig. 3.) If the mean rotor temperature were 450 deg. F., there would be a reduction of blade clearance of some 0·014 in., so that a hog of only 0·036 in. would cause a rub.

The suggestion was made that differential cooling of the starboard side was caused by the cool exhaust steam, which left the last row of blades with a considerable amount of whirl, impinging on the lower part of that side of the casing. To reduce the differential cooling effect, a system of light metal shields was fitted to the lower half of the casing and to the stiffening grid in the lower half of the casing. In a subsequent trial, it was found that the hog of the outer casing when the engine was going ahead was considerably reduced and it was possible to carry out a trial of four hours full astern, followed by one hour at 10 per cent. full power ahead, without recurrence of the rubbing. Fig. 2 actually refers to this trial.

The metal shields had somewhat reduced the asymmetrical hog, but they were by no means the complete answer. Later trials revealed that the real cause of the trouble was the air ejector re-circulating water. The re-circulating water pipe, which connected the main condensate line downstream of the air ejector to the condenser, was led to the forward side of the condenser shell almost in line with the starboard side of the L.P. turbine casing, and the water was sprayed into the condenser over an arc extending from about 60 deg. above to 60 deg. below the horizontal. The water therefore sprayed on to the lower part of the starboard side of the turbine casing. When going from full astern to 10 per cent. full power ahead, the re-circulating valve was always opened, to maintain a sufficient flow of condensate through the air ejector, and the effect of the water spraying on the casing was to cause differential cooling in the starboard side of the casing. A minor modification to the re-circulating water pipe effected a complete cure of the trouble.

The object of the manœuvring trials was to determine the ability of the engines to stand up to the most severe handling that might conceivably be encountered on service. Only with the full instrumentation that was available was it possible to determine whether an operation was risky, and yet be able to stop before serious damage was inflicted. Before commencing these trials, the H.P. turbine axial clearance was increased from 0·030 in. to 0·045 in. cold.

For the first trial, it was decided to start with cold turbines, allow half an hour for warming through and raising vacuum, and then work up to full power in 20 minutes. Gland steam was put on and vacuum raised to 20 in. Hg., the time taken being 15 minutes; the engines were then turned by bursts of steam at ¾-minute intervals for 5 minutes; full vacuum was then raised in a further 10 minutes and the engines started, 20 per cent., 40 per cent. and 60 per cent. power being achieved in 1, 4½ and 9½ minutes, respectively, and full power in 20 minutes. The axial clearances in the H.P. turbine decreased rapidly in the first ten minutes of running from 0·045 in. to 0·017 in., after which they increased gradually to 0·030 in; at this point they became steady.

Negligible distortion occurred in the L.P. turbine casing, but a hog amounting to 0·010 in. to 0·015 in. was recorded in the H.P. turbine casing. These results were roughly in agreement with those obtained for steady running, and it appears that no serious distortion is induced by the transient conditions. No unusual temperature increases were recorded apart from the rapid rise during the period of power increase, which reached a maximum after approximately 15 minutes of steady running. During the period of warming through, prior to the trial, turning the engine by bursts of steam made no appreciable difference to the H.P. turbine casing temperatures and could have been omitted. Condensation is most severe during the first few minutes from starting, when almost all stages are operating with saturated steam and casing temperatures are considerably below the steam temperature. It is difficult to assess the importance of this factor, and probably the only reliable guide is that the trial was completed without damage to the machinery.

The above trial showed that the H.P. axial clearance was the only factor which might be critical during violent increases in power, so it was decided to try an even more rapid rate of increase to see if this factor became limiting. In the next trial, the engines were increased from 10 per cent. to 100 per cent. power in ten minutes. The results of this trial were comparable to the previous one. The casing temperature curves became almost flat within 15 minutes of reaching full power. The decrease in axial clearance indicated very clearly the effect of differential expansion between the rotor and the casing when power is increased rapidly. This is illustrated in Fig. 4, opposite. It appears, therefore, that the principal limitation on the rate of increase in power, so far as the turbines are concerned, is that imposed by the reduction of the H.P. turbine axial clearances.

The next trial simulated conditions when, owing to sudden deterioration in weather, it becomes necessary to get under way in the shortest possible time. No attempt was made to warm the engines. Gland steam was put on and vacuum raised. When vacuum had reached 25 in. Hg. (8 minutes from putting on gland steam) the engine was started and the power increased to 10 per cent. in 12 minutes. Full vacuum was attained approximately 8 minutes after starting the engine. The results were similar to those obtained from previous warming-through trials. There was no serious distortion of either H.P. or L.P. turbine casing and no reduction in H.P. axial clearance. It was noticeable that putting on gland steam had an appreciable effect in raising the temperature at the ends of the H.P. turbine casing and the top half of the L.P. turbine casing.

Finally, the effects of a sudden call to stop the ship at sea were investigated. After a period of steady steaming at 20 per cent. power, the ahead throttle was shut off rapidly and the astern throttle opened to give 10 per cent. astern power, this being the maximum power that can be absorbed by the brake when running reversed. This trial was repeated from 60 per cent. and again from 100 per cent. ahead power. The most noticeable effect was that these reversals show no sudden change of temperature in the H.P. turbine casing. In the 100 per cent. trial, the maximum H.P. casing temperature dropped approximately 120 deg. F., and in the other two trials it remained sensibly constant. H.P. turbine hog tended to decrease slightly after the reversals. There was a sudden slight decrease in H.P. turbine axial clearance after reversals, which was probably due to the thrust collar centring itself between thrust pads when the thrust came off the blading.

On the other hand, the L.P. turbine casing temperature increased rapidly after the reversal due to the presence of high-temperature exhaust from the astern turbines. Temperature curves flattened out after about 15 minutes of astern running, by which time the L.P. turbine casing hog had increased by about 0·005 in. to 0·010 in. It was clear from these trials that the speed at which the reversal was effected was not, in itself, important, and that any effects which did occur were caused by the normal astern-running conditions.

Investigations were also made of various methods of warming through the turbines, and of conditions obtaining when the engines are stopped, but available at immediate notice. In all these tests, there was no evidence of untoward distortion or expansion and the machinery had thus been proven as being adequately robust for all conditions of service. From the record of relative movement of the H.P. turbine rotor and casing, taken over the whole series of manœuvring trials, it was decided to maintain the coarse axial clearance of 0·045 in. for normal service, though 0·040 in. would just provide a safety margin, even at the most rapid rate of increase of power.

It is known from the results of the consumption trials that an increase of axial clearance from 0·030 in. to 0·045 in. raises the steam rate by 2 per cent. at full power. This has given rise to the suggestion that it might be worth considering the fitting of a form of pulling-up gear, such as is used in land turbines of this type, to allow a smaller axial clearance to be used under steady conditions than when manœuvring. From the operational point of view, large increases in power can normally only be made over a period of several minutes, owing to the limitation of boiler output, and therefore, during an increase of power, sufficient time should be available for increasing the clearances by means of the adjusting gear. On the other hand, a rapid decrease in load, which might be carried out in a matter of seconds, would involve no danger, as such changes cause the clearances to open up. Before such a device could be accepted for naval service, it would need to be both simple and also proof against mis-handling by semi-trained watchkeepers.

Reference is made above to rotor-bore temperatures. The apparatus used to record these temperatures consisted of five thermocouples, located axially in the rotor bore. At each thermocouple position a split copper cylinder with three tongues was attached to the locating pipe, and the thermocouple was brazed into the centre of one of these tongues The clearance between the copper cylinder and the bore is such that, when rotating, the centrifugal load presses the tongue against the rotor wall so that good thermal contact is obtained. The leads from the thermo-couple were then led down the locating pipe to an axial-type six-way slip ring, and the results recorded on a Speedomax automatic recorder.

Readings were taken at various powers and the steady temperatures attained are shown in Fig. 5, page 350. As was expected, the highest temperature recorded when going ahead was under the first-stage Curtis wheel; 740 deg. F. was reached at this point at full power, falling to 550 deg. F. at very low power. The highest temperature in the L.P. was 270 deg. F., under the inlet belt.

Fig. 6, on page 350, shows the rate of increase of rotor-bore temperatures during the most rapid manœuvring trial, when power was increased from 10 per cent. ahead to 100 per cent. ahead in ten minutes; and Fig. 7, on page 351, shows the simultaneous records of rotor-bore, casing and steam temperatures in way of the H.P. turbine Curtis wheel during the same trial. The temperature at the surface of the turbine rotor will presumably approximate to the steam temperature, so that radial temperature gradients across the rotor of the order of 260 deg. F. must have been experienced during this trial.

Working up to full power with a cold turbine may produce even steeper radial temperature gradients in the H.P. rotor. Fig. 8, on page 351, shows rotor-bore temperatures taken in the "0 to 100 per cent. ahead in 20 minutes" trial with the Daring II machinery. Generally, the rotor-bore temperature records in Daring II gave very similar records to those of Daring I, the temperatures differing only by a few degrees; though, in the case of the increasing-power trial, the response of the rotor-bore temperatures was naturally quicker, owing to the lesser thickness of metal. The initial temperatures were from 70 to 100 deg. F., and had increased to about 150 deg. F. when the engines were started. Since the wheelcase temperature at the lower power is about 500 to 550 deg. F., increasing to 750 deg. F. at full power, it appears that a temperature difference of some 400 deg. F. may exist between the outside and the inside of the rotor in these circumstances.

Generally speaking, the rotor-bore temperatures attained after a reasonable period of running are very close to the steam temperature at that position, and, in these circumstances, little in the way of temperature stress is to be expected. Conditions at the glands and journals may be somewhat complex, but, as the rotational stresses here are small, it is unlikely that any undue stressing will arise in a rotor under steady conditions. The conditions on first admitting steam, however, are much more complex, and work has been carried out on the rate of heating of a section of a rotor, similar to that on which the first series of rotor-bore temperatures were taken. From the temperatures observed during the initial warming, it has been possible to compute the stresses due to the temperature differentials. This investigation has not yet been completed, but it would appear that considerable stresses may be caused by temperature alone, particularly at the reduced diameter between the Curtis wheel and the dummy, and at the bore. It may well be proved on further investigation that the rate of working up a cold turbine may be limited from this consideration, though the gashed impulse type of turbine is better off in this sense than the solid-rotor reaction turbine.

(*To be continued.*)

NOTES ON NEW BOOKS.

Principles of Mechanism.

By F. DYSON, B.Sc., A.M.I.Mech.E. Fourth edition. Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4. [Price 16s. net.]

AFTER careful consideration of the desirability of enlarging the previous edition of this book to cover more advanced work, the author decided to restrict the fourth edition approximately to meet the requirements of students taking the first part of the final examinations for a university degree in engineering. Thus the present text is substantially the same as that of the third edition, though the appendix has been revised and enlarged so as to include an improved system of notation adopted for the Coriolis component of acceleration. For those unacquainted with the earlier editions of the book, it may be remarked that Mr. Dyson has succeeded in presenting in a comprehensive manner the large amount of subject-matter which is sometimes called the theory of machines. The chapters on mechanisms and velocity diagrams and on acceleration diagrams together exhibit a nice balance between graphical and analytical methods, which facilitates the study of later chapters dealing with the slider crank chain, and toothed gearwheels and gearing. Another characteristic is an excellent treatment of the dynamics of machinery, under the separate chapter headings of friction, flywheels and turning-moment diagrams, governors, and balancing. In preparing the work it has not been overlooked that, while there is a large number of students who can grasp bookwork readily, there seems to be a general weakness in applying the results of theory to specific problems and exercises. The author evidently believes that this special faculty may be cultivated by solving numerous exercises, for a large section, drawn from university and other sources, is given at the end of each chapter, and the answers are to be found at the end of the text.

Technology of the Machine Shop.

By H. C. TOWN, M.I.Mech.E. Longmans, Green and Company, Limited, 6 and 7, Clifford-street, London, W.1. [Price 21s. net.]

THERE is no shortage of books on machine tools, jigs and fixtures, but Mr. Town's work differs from most of them in that it keeps a proper balance between descriptions of machines and devices, the investigation of cutting actions, and the economics of book production, so that it covers the wide field indicated by the title in one volume of about 360 pages. It is addressed to advanced engineering students, and, therefore, the numerous illustrations are, to a great extent, of a diagrammatic nature. The descriptions and illustrations present the latest practice in mechanical, electrical and hydraulic operation of all types of machine tools. The book deals with recent developments in cutting tools, and gives much new information on diamond tools. After considering the layout of motorised workshops, and methods of metal removal, the author turns to the general features of machine-tool design and construction, together with geared and hydraulic drives. One chapter is devoted to planing, shaping and slotting machines, with their construction and control and the cutting tools used with them; another, on similar lines, to lathes. Capstan, turret and automatic lathes; drilling and boring machines, including jig borers; and the various types of milling machines with their attachments, are all given due attention. It may be said, in fact, that practically all types of machine tool, and methods of metal forming and removing, receive attention in some part or another of the book, usually with illustrative examples from the current practice of well-known machine tool firms; though it should be emphasised that the book is not merely a series of paraphrases from catalogues. The concluding chapter points to the need for further experimental work and research on machine tools, and describes the equipment required for these purposes. General guidance is also given on inspection tests.

Konstruieren im Maschinen- und Gerätebau. Vol. I. Das Gestalten der Form.

Edited by DR.-ING. H. RÖGNITZ. B. G. Teubner Verlagsgesellschaft, Poststrasse 3, Leipzig, C.1. [Price 3·07 dols. net.]

THIS is the first volume of a series of text-books on the design of machines and engineering devices, and deals mainly with the shape of components. Just, however, as studying a book on harmony does not guarantee that the reader will become a composer the designer can only expect to be guided; only those who have experience of design work, and have made typical mistakes, can really appreciate the value of this guidance. A prominent feature of the book is the comparison of illustrations of appropriate and inappropriate designs, with captions explaining what principle has been violated. After introductory sections dealing with the significance of standards, and with the basic geometrical shapes, the forms, sizes, and properties of available rolled-steel sections, as well as of semi-finished other materials, are discussed. The main section of the book deals first with dimensions, tolerances and allowances, and the proper way of indicating them on a drawing. The various processes in engineering manufacture—casting, forging, pressing, extruding, welding, brazing, stamping, bending, drawing, and the various machining processes—are then considered, design rules being given, based on their respective characteristics and requirements. The book continues with the various fits of mating parts, and shows how assembling is simplified if the respective requirements have already been observed in designing the components. The subsequent sections deal with safety and ease of control, glands and packings, causes of and remedies for excessive noise, and the text concludes with considerations of æsthetics. The style of the book is somewhat pedantic, and many uncommon terms are used, but readers sufficiently familiar with the German language should find in it useful material.

BOOKS RECEIVED.

The Torsion of Aluminium-Alloy Structural Members. By DR. M. S. G. CULLIMORE and PROFESSOR A. G. PUGSLEY. Research Report No. 9. The Aluminium Development Association, 33, Grosvenor-street, London, W.1. [Price 7s. 6d.]

Lloyd's Register of Shipping. Register Book 1951-52. Volume I. A-L. Volume II. M-Z. Offices of the Register, 71, Fenchurch-street, London, E.C.3.

BEAMA Guide to British Electrodes Covering Arc Welding Electrodes for Welding Mild Steel. Prepared by the Arc Welding Electrode Section. The British Electrical and Allied Manufacturers' Association, 36 and 38, Kingsway, London, W.C.2. [Price 2s. net.]

National Physical Laboratory. Notes on Applied Science No. 1. *Gauging and Measuring Screw Threads.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 5s. net.]

Theoretical Physics. By PROFESSOR GEORG JOOS, with the collaboration of PROFESSOR IRA M. FREEMAN. Second edition. Blackie and Son, Limited, 16-18, William IV-street, London, W.C.2. [Price 50s. net.]

The Hardness of Metals. By D. TABOR. Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4. [Price 15s. net.]

Applied Electricity. By PROFESSOR H. COTTON. Cleaver-Hume Press, Limited, 42A, South Audley-street, London, W.1. [Price 17s. 6d. net.]

Tacheometry. By PROFESSOR F. A. REDMOND. The Technical Press, Limited, Gloucester-road, Kingston Hill, Surrey. [Price 21s. net.]

The London Tramcar 1861-1951. By R. W. KIDNER. Locomotion Papers No. 7. The Oakwood Press, Tanglewood, South Godstone, Surrey. [Price 5s. 6d.]

Metallurgy for Engineers. By PROFESSOR G. K. OGALE. United Book Corporation, Poona. [Price 10.8 Rupees.]

Cornish Engineers. By BERNARD HOLLOWOOD. Holman Brothers, Limited, Camborne, Cornwall. [For private circulation.]

Locomotive and Train Working in the Latter Part of the Nineteenth Century. By E. L. AHRONS. Volume I. W. Heffer and Sons, Limited, Cambridge. [Price 15s. net.]

The Great Western Railway. By O. S. NOCK. W. Heffer and Sons, Limited, Cambridge. [Price 18s. net.]

TRADE PUBLICATIONS.

Fluorescent Lighting Lamps.—Concise descriptions of a new range of fluorescent lighting fittings are given in a pamphlet received from Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, 17.

Machine Tool Drives.—A leaflet issued by Lancashire Dynamo & Crypto (Mfg.), Ltd., 25, Shaftesbury-avenue, London, W.1, deals with the various applications of that company's electrical equipment to the driving of machine tools.

Electronics in Industry.—A pamphlet recently received from British Electronic Products (1948), Ltd., Rugeley, Staffordshire, describes the work of that firm and gives a general picture of their specialised activities in the electronic field.

Direct-reading Air-Velocity Instruments.—The construction and applications of the direct-reading air-velocity instruments, known as Velometers, are dealt with in a brochure recently issued by Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, 17.

Automatic Control of Alternator Excitation.—The extensions to power systems which are being carried out on an increasing scale add considerably to the problems of control. Interest, therefore, attaches to the discussion of modern practice in the automatic excitation of large alternators, which is contained in a leaflet prepared by Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, 17.

Resistance Thermometers.—Bailey Meters and Controls, Ltd., Progress Way, Croydon, Surrey, have issued a catalogue, No. E.230, which gives details of their range of "Calortron" electronic resistance-thermometers. Up to four temperatures can be recorded simultaneously on one 12-in. diameter chart, a separate electronic amplifier and driving motor, mounted in the case, being employed for each recording pen. Combined recorders and indicators can also be supplied.

Twelve-Channel Carrier Telephone System.—A pamphlet, received from Automatic Telephone and Electric Co., Ltd., Strowger Works, Liverpool, 7, contains an account of a 12-channel carrier telephone system which has been designed to meet the requirements of both large and small territories. It is applicable in areas where a heavy traffic warrants the installation of coaxial cables or where a lighter traffic can be dealt with by a basic group of four channels. A system of this kind, comprising six 12-channel groups, is being commissioned on a quad-type carrier cable between Liverpool and Manchester, which is 35 miles long and is "repeatered" at Walton, Old Boston and Swinton.