THE BRITISH INDUSTRIES FAIR AT BIRMINGHAM—II.

WE continue in this article descriptions of further exhibits at the Castle Bromwich section of the British Industries Fair which is open until Friday, May 8.

55-In. Universal Cutting Machine.

The exhibits of the British Oxygen Company, Limited, Bridgewater House, Cleveland-row, St. James's, London, S.W.1, include demonstrations of various welding processes, in particular the Argonaut process for all-position welding of heavy-gauge aluminium plates, a process that was described recently in ENGINEERING, March 27, page 397, *ante*. The new Argonarc spot-welding process will also be demonstrated, this being particularly suitable for spot-welding stainless and bright mild steel; access to one side of the joint only is required and material up to $\frac{1}{16}$ in. thick may be joined to any greater thickness or to sections of any shape. For continuous, heavy-duty work the company are exhibiting their water-cooled shield that has been designed for use on the standard Mark III torch. The wide range of cutting and welding blow-pipes shown on the stand is representative of industry's requirements in this field and includes a complete range of Cutogen blow-pipes that are capable of cutting mild steel up to 20 in. in thickness and cast iron up to 15 in. thick.

For profile or shape cutting, two stationary types of machine are on show, the 55-in. and the smaller 36-in. universal flame cutting machines, each of which is fitted with a Cutogen one-piece nozzle. The larger, 55-in. machine is illustrated in Fig. 1, on this page. These two machines are suitable for precision work and are both capable of producing an infinite variety of complex shapes by following the contour of a steel template. This is achieved by using a motor-driven magnetic roller to trace round the edge of the template. The machine comprises a massive base supporting a vertical column which carries two balanced arms. The upper arm has a machined slide on its underside to which the template holder and the radius bar for circle-cutting are fixed. The lower arm is articulated and, due to its form, is termed the folding-gate arm; this arm, with a maximum reach of either 55 in. or 36 in., carries the cutter and the magnetic tracing roller, which is driven round the template by an electric motor that is coupled to the tracer by a suitable driving shaft and variable-speed mechanism. The height of the cutter can also be adjusted during work to allow for unevenness in the surface of the material being cut. Using a standard cutter, the maximum thickness of material which can be cut is between 10 in. and 15 in., but extra heavy duty, cutters can be supplied with the necessary auxiliary equipment for profile cutting up to 48 in. thick. Mild steels containing 0·25 per cent. carbon or less can be cut cold; steels richer in carbon require preheating to reduce internal stressing and consequent surface cracking on cooling.

Where large numbers of similar parts have to be produced in relatively thin plate, stack cutting may be adopted, but the plates must be tightly clamped together so that air pockets between successive plates are avoided. The company's stand is completed by the range of publications that are on sale and information booklets that are available for distribution.

"Rotocube" Mixing Machine.

The exhibits of Foster, Yates and Thom, Limited, Blackburn, are the "Rotocube" mixing machine and their "Lancastrian" 50-ton fully-automatic moulding press. The Rotocube mixing machine is illustrated below in its laboratory form; in its production form it was described in ENGINEERING, vol. 169, page 558 (1950). These machines are notable for obtaining a consistently accurate dry mix when the ingredients vary widely in both characteristics and proportions, and they achieve this in a short space of time even when one of the ingredients represents only a minute percentage of the whole mix. As will be seen from the illustration, the principle of the machine is that of a cube rotated on trunnions and mounted diagonally at a compound angle, the effect of which is to give a gentle overturning action to the ingredients, which action may be enhanced by the introduction of removable impellers to give an additional interweaving motion. The "Lancastrian" 50-ton moulding press was the first of its kind to be produced in England, and the new Model 2 exhibited is of advanced design; this new model is fully automatic, with a time cycle of 15 seconds plus the curing time, which naturally varies with the type of work being moulded and the powder used. The powder feed gives a maxi-

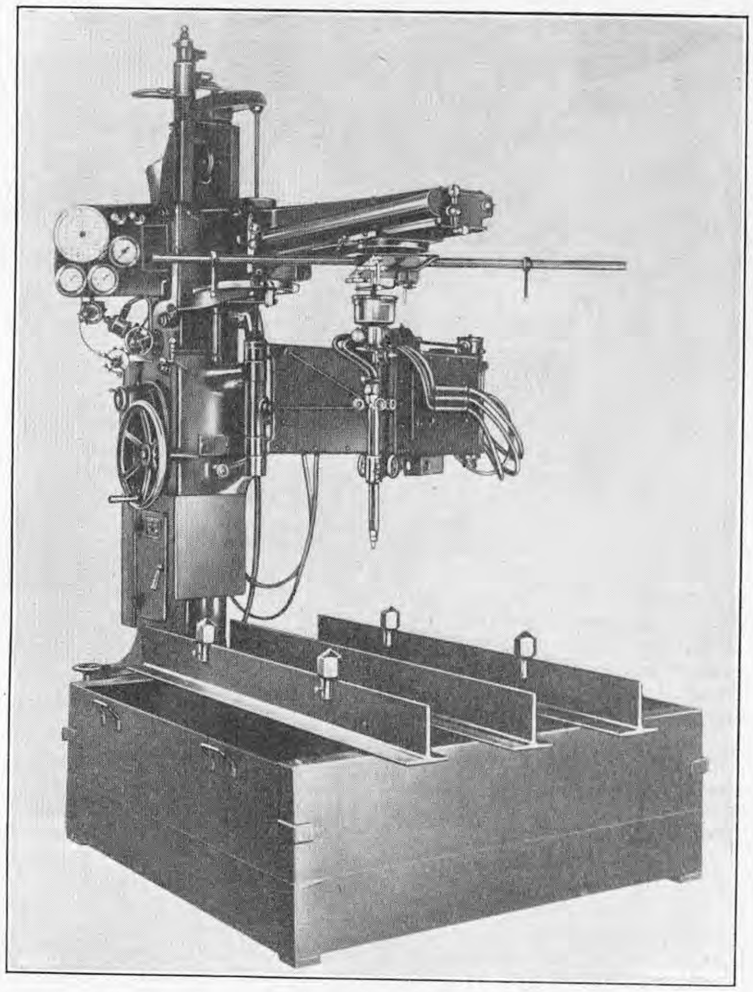


Fig. 7. 55-in. Universal Cutting Machine; British Oxygen Co., Ltd.

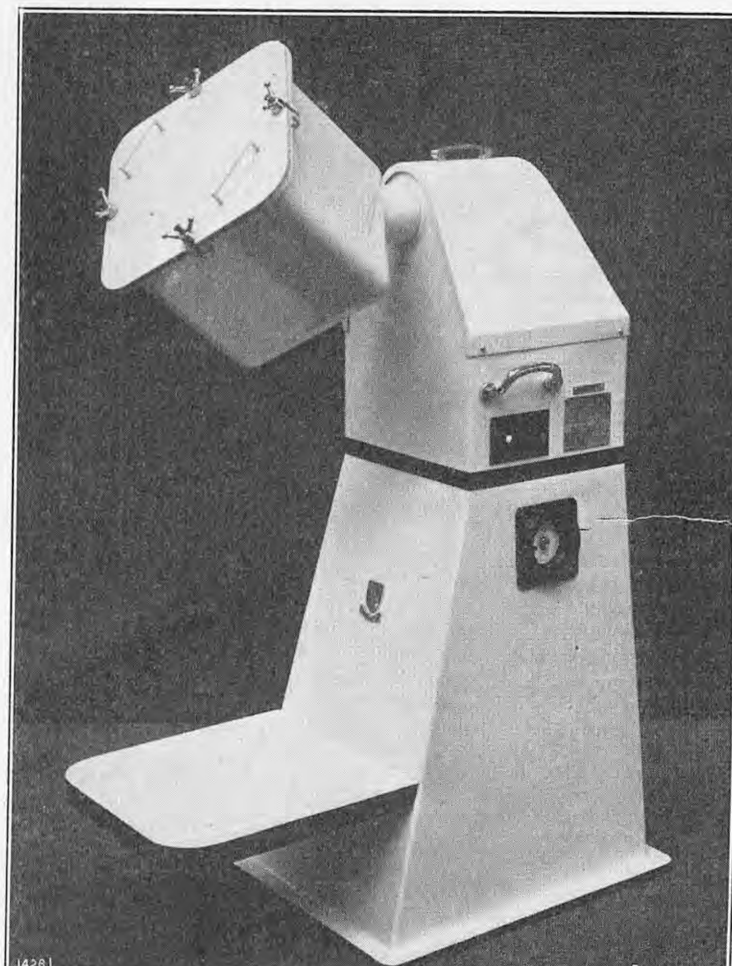


Fig. 8. "Rotocube" Mixing Machine; Foster, Yates & Thom, Ltd.

mum of 6 cub. in. of loose powder in each of six cavities, but two or more feeds may be linked together to fill a lesser number of larger cavities. The press contains many interesting features, from the unit frame, fabricated and stress-relieved, to the 2 tons per square inch hydraulic system, and a patented cam controller. This machine is being continuously demonstrated throughout the exhibition.

AUTOMATIC INJECTION-MOULDING MACHINE.

An extremely wide field of applications in all modern thermoplastic moulding materials, including nylon, is provided by the automatic "Fast-Cycling" injection-moulding machine, shown in Fig. 9, which is being exhibited by Messrs. Dowding and Doll, Limited, Greycoat-street, London, S.W.1. It has an exceptional performance and reduces moulding costs considerably; it produces at a high rate from moulds of single or a few impressions. It functions at over 1,200 complete moulding cycles per hour and has a smooth action, free from shock. The same firm will also show the new British-built Lester injection moulding machine—a 4-oz. machine with a 5-oz. capacity. It is of solid steel-box type frame construction with a fast double-toggle locking mechanism. It has an internally-heated injection cylinder with a vertical swing-out injection unit, and the high locking pressure of 250,000 lb. is concentrated over the total moulding area, which allows unobstructed use of the whole of the platen face for die mounting. The three other machines being shown by Messrs. Dowding and Doll, Limited, are a Hare $7\frac{1}{2}$-ton hydraulic press, a Lester die-casting machine, and a Westminster power-operated injection moulding machine of 15-gramme capacity.

200-TON TIE-ROD PRESS.

The Scottish Machine Tool Corporation, Limited, St. Vincent-street, Glasgow, are showing the 200-ton two-point tie-rod press illustrated in Fig. 10, on Plate XII. The crown, bed, and housing are made of steel, and steel gears are used in the drive. An air-operated friction clutch is fitted, and the slide balance is pneumatic. The stroke of the slide is 3 in., and the slide adjustment 8 in., and with the stroke and adjustment fully raised there is a vertical die space of 18 in. The width between the uprights is $60\frac{1}{2}$ in. The steel bolster is 60 in. by 48 in. and the slide face is of the same dimensions. The press has a speed of 40 strokes per minute and it is driven by a 20-h.p. 960 r.p.m. electric motor. A motor of 4 h.p., at 960 r.p.m., provides power for adjusting the slides, and the controls fitted on the press are the push-button type with an automatic stop at the top stroke position of the slide. Lubrication is by a built-in high-pressure motorised oil pump which delivers oil to the shaft bearings and guideways through individual pipe leads. All the parts are manufactured according to the standards adopted in the machine-tool industry, and a four-day test-run is made on every machine produced.

AUTOMATIC THERMAL STORAGE SYSTEM.

Messrs. G.W.B. Electric Furnaces Limited, Dibdale Works, Dudley, Worcestershire, are showing a range of electrode steam raisers and water boilers, among which, displayed for the first time, is a 15-kW water heater, the smallest of its type produced in the United Kingdom, suitable for intermittent supplies of heated water for space and process heating. The largest water heater on view consumes 800 kW. Fig. 11, Plate XII, shows an Autolec electrode water boiler applied to a thermal storage system. It consists of a boiler with ancillary switchgear, pumps and storage tanks. The latter are filled with hot water during the off-peak hours for use during the day for space and process heating, thus ensuring that no extra load is imposed on the normal electricity supply used during working hours. The installation is completely automatic, switching on and off for load adjustment during the night, and automatically changing to heating duties during the day.

FOUR-CYLINDER MARINE ENGINE.

One of the engines being shown on the stand of the Coventry Victor Motor Company, Limited, Coventry, is their new marine four-cylinder petrol engine, illustrated in Fig. 12, on Plate XII, which works on the four-stroke cycle. It is known as the Neptune W.C.4, and the power output is 20·2 b.h.p. at 1,500 r.p.m. and 33 b.h.p. at 3,000 r.p.m. It has a bore and stroke of 85 mm. (3·346 in.) by 80 mm. (3·149 in.) with a capacity of 1,816 c.c. This engine is of the water-cooled type and is a development of the Neptune four-cylinder air-cooled unit which has been used successfully in industrial and agricultural machines. It normally runs on petrol, and conversion sets are available which enable it to run on tractor vaporising oil. The overall length, less starting handle, is only 30 in., width 25 in., and its overall height is just over 19 in., which enables it to be installed in places where headroom is limited. The weight is approximately 366 lb. The lubricating oil is fed by pressure to all bearings by means of a gear-type oil pump and a relief valve is fitted in the pressure circuit to by-pass excess oil, and return it to the engine sump. The sump is provided with an oil strainer that is fitted with a detachable filter gauze. The crankshaft is a solid high-tensile steel forging with solid balance weights to the throws, and running on three large-diameter shell-type bearings. The camshaft is mounted over the crankshaft and driven from it by a sprocket and chain. The cylinders are monobloc castings, horizontally opposed, and they are fitted with detachable heads; the valve gear, which is easily accessible, is totally enclosed as in the case of the N-type engines. The connecting-rod big ends are fitted with shell-type bearings, and the pistons, which are of aluminium Y-alloy, have two compression rings and one oil-control ring. The ignition is by a Victor-Wico impulse starter magneto, the carburetter is a Victor-Zenith, and the cooling water is circulated by a gear-type pump. The engine is available without the reduction reverse gearboxes if required.

6-IN. BENCH GRINDER.

Black and Decker, Limited, Harmondsworth, Middlesex, are showing a new 6-in. standard bench grinder for the first time. This machine, illustrated in Fig. 14, Plate XII, has a centrally mounted $\frac{1}{4}$-h.p. motor, is of full ball-bearing construction and is fitted with a new type of centrifugal switch; a 6-in. grinding wheel and a 6-in. wire wheel brush are also normally provided. Another machine exhibited for the first time is the 8-in. "Rip-snorter" saw (Fig. 13), which is a "one hand" saw, combining balance with a powerful motor, and the machine will saw through timber, brick, asbestos sheets and the like, and cast iron. The drive is taken through helically cut, grease-lubricated gears and the machine may be inverted and used as a saw bench. The depth of cut can be adjusted up to $2\frac{13}{16}$ in. and angle cutting up to 45 deg. may be done. Also exhibited is the complete range of portable electric tools manufactured by the company for the engineering, building, and automotive trades; a new comer among this range of tools, however, is the No. 44 Orbital sander, shown also for the first time. This sander weighs only $5\frac{1}{2}$ lb. and the orbital motion of the pad is designed to eliminate all score or burn marks.

200-TON PRESS.

Two presses are exhibited by Cowlishaw, Walker and Company, Limited, Biddulph, Stoke-on-Trent, and one of these, rated at a capacity of 200 tons, is shown in Fig. 15, Plate XIII. This press is of the double-sided single-crank type and is one of a sturdily-constructed range of presses which have crankshaft strokes and speeds suitable for general purposes, but they are essentially deep-drawing models with rigid frames and long slideways. The other press exhibited is the type O.T.60 open-fronted multi-purpose press having a rated capacity of 75 tons; this model is a general-purpose machine, but was primarily intended for auxiliary press operations in motor-car body shops, and is extensively used for this purpose. This machine has an adjustable bed which can be swung out of the way and special knee beds then bolted on, and it can be used as a horning press, a device

THE BRITISH INDUSTRIES FAIR.

FIG. 9. AUTOMATIC INJECTION MOULDING MACHINE; DOWDING AND DOLL, LTD.

EXHIBITS AT THE BRITISH INDUSTRIES FAIR.

(*For Description, see Page* 545.)

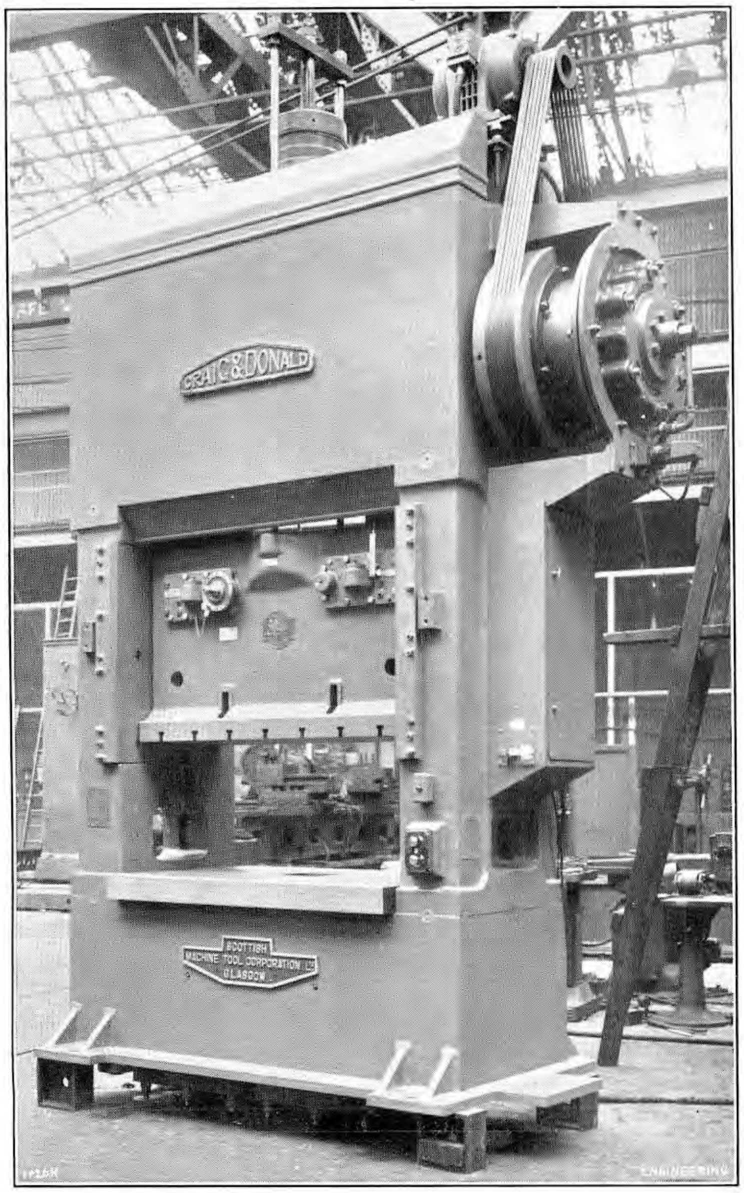


Fig. 10. 200-Ton Press; Scottish Machine Tool Corporation, Ltd.

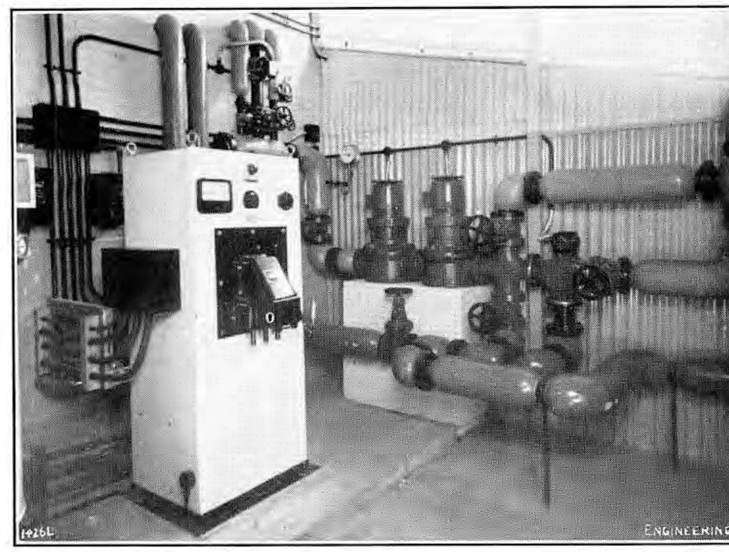


Fig. 11. "Autolec" Thermal-Storage Installation; G.W.B. Electric Furnaces, Ltd.

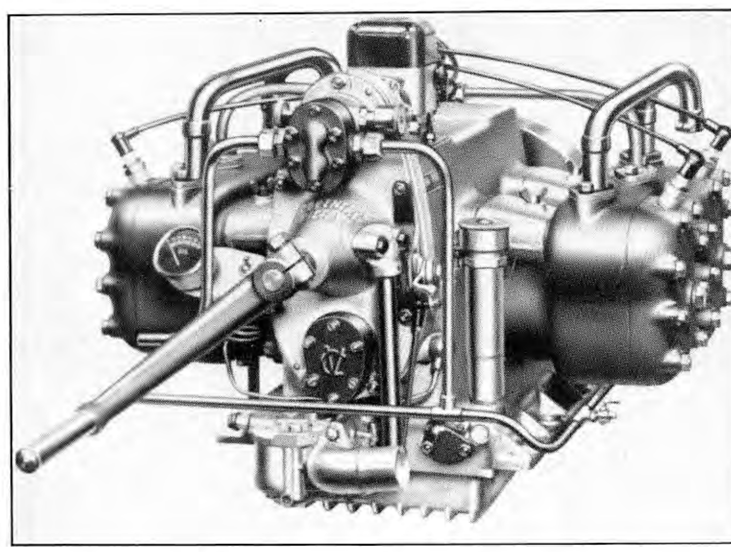


Fig. 12. Four-Cylinder Marine Engine; Coventry Victor Motor Co., Ltd.

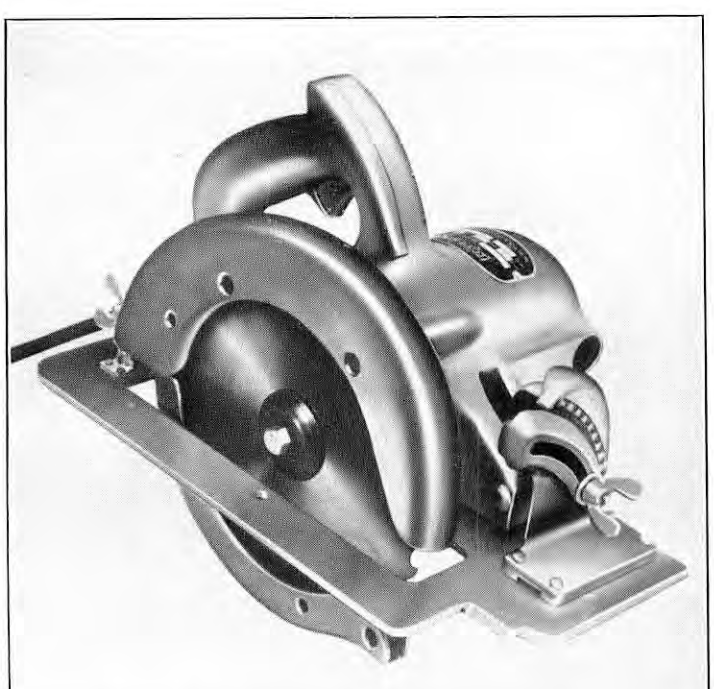


Fig. 13. 8-in. Saw; Black and Decker, Ltd.

Fig. 14. 6-in. Bench Grinder; Black and Decker, Ltd.

EXHIBITS AT THE BRITISH INDUSTRIES FAIR.

(*For Description, see Page* 545.)

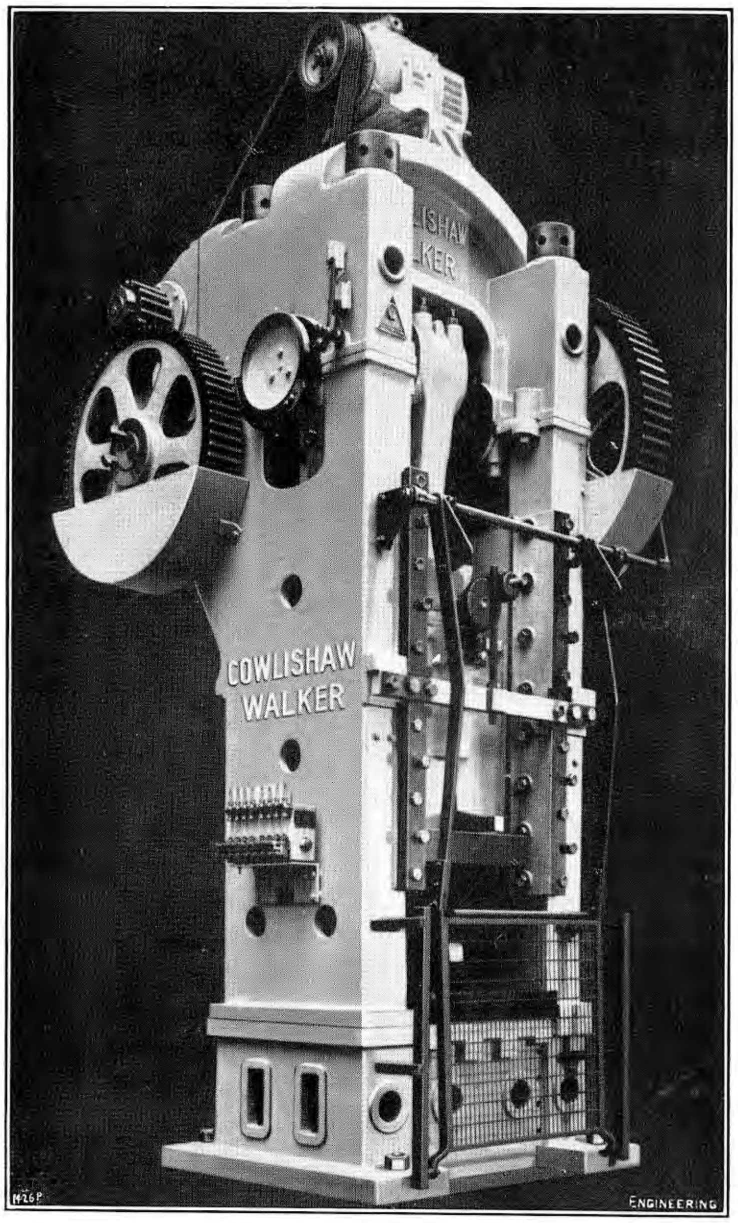


FIG. 15. 200-TON PRESS; COWLISHAW, WALKER & CO., LTD.

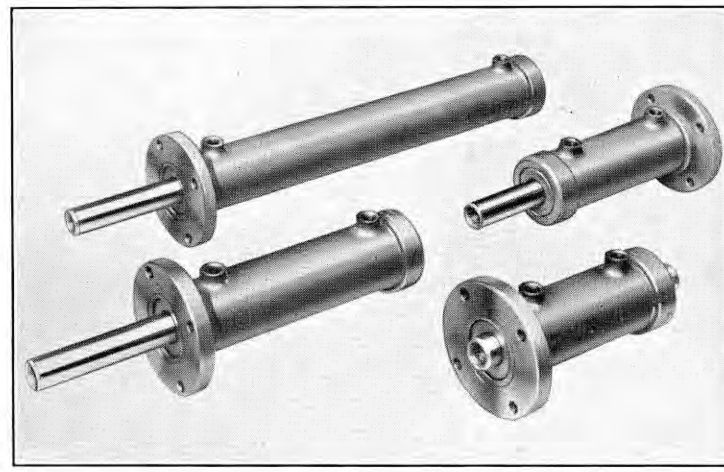


FIG. 16. HYDRAULIC CYLINDERS; KEELAVITE ROTARY PUMPS AND MOTORS, LTD.

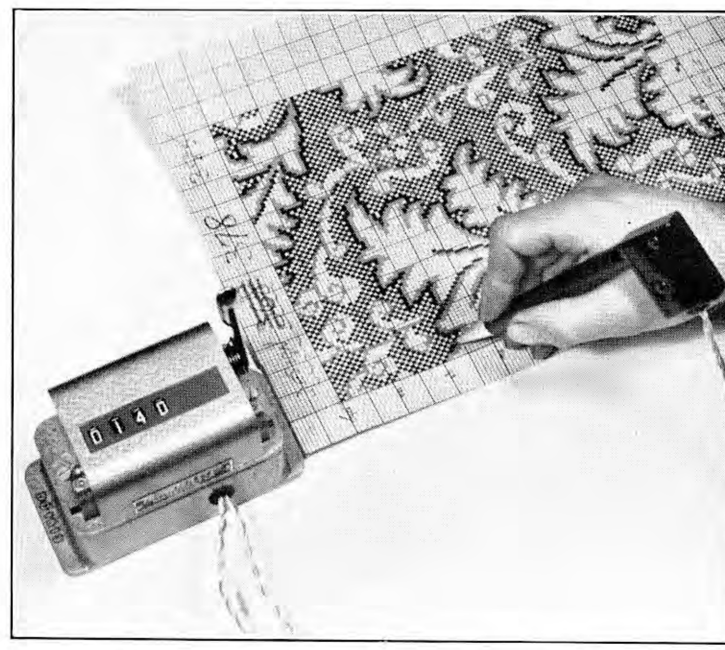


FIG. 17. "STYLUS" COUNTER; TRUMETER CO., LTD.

FIG. 18. PYROMETER KIT; ETHER, LTD.

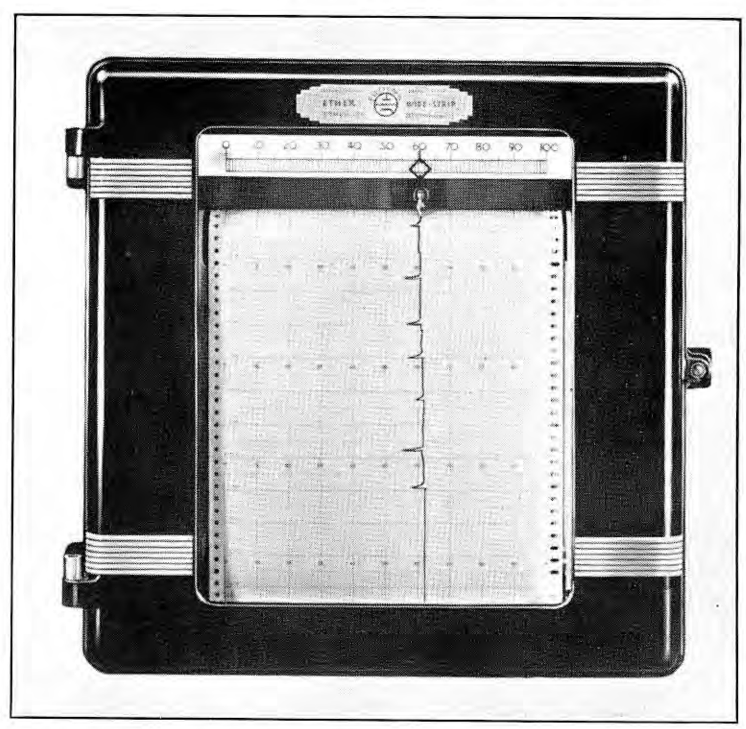


FIG. 19. ELECTRONIC POTENTIOMETER; ETHER, LTD.

EXHIBITS AT THE BRITISH INDUSTRIES FAIR.

(*For Description, see Page* 545.)

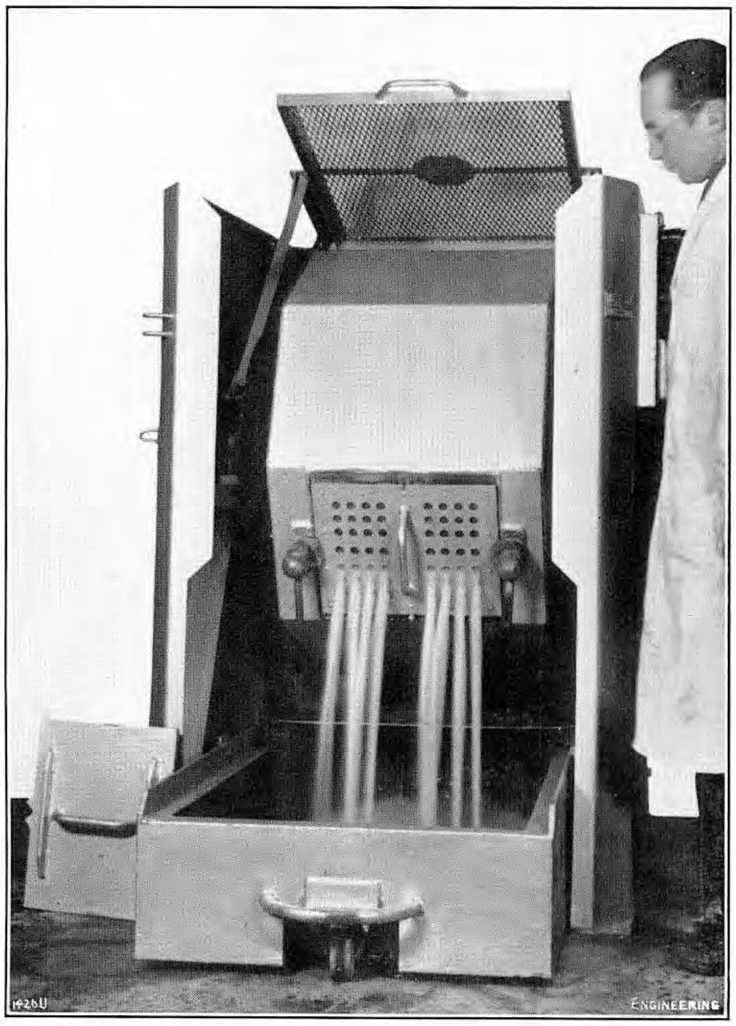


Fig. 20. "Roto-Finish" Machine; Roto-Finish, Ltd.

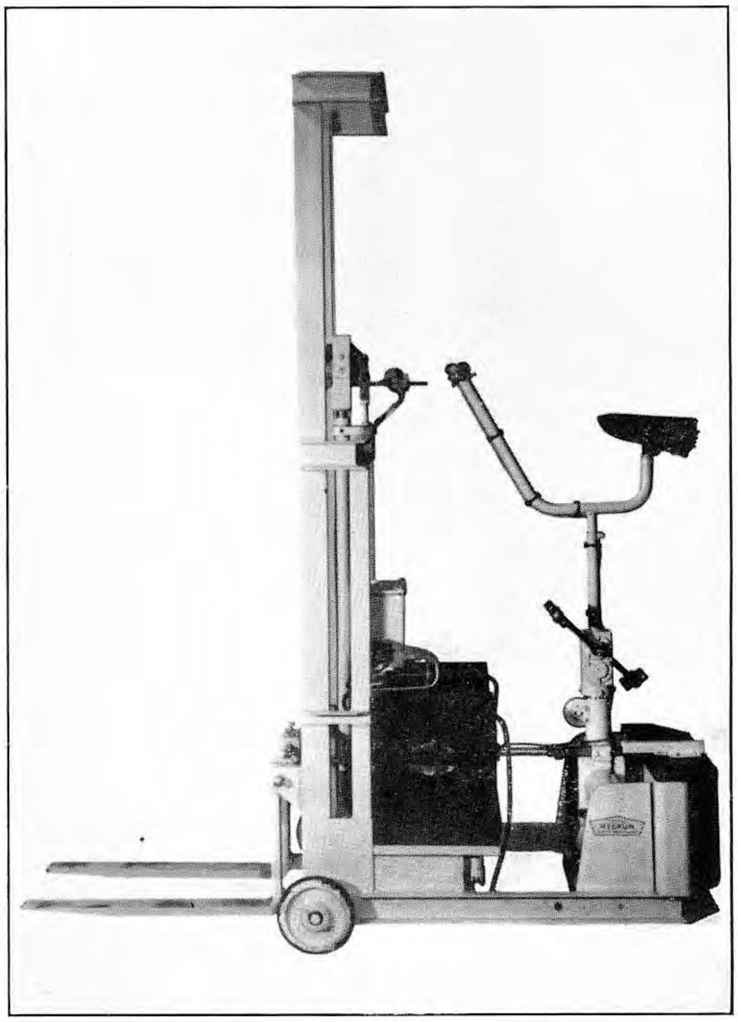


Fig. 21. Fork-Lift Truck; R. H. Corbett & Co., Ltd.

Fig. 22. Vehicle and Machine Recorder; Rotherham Recorders, Ltd.

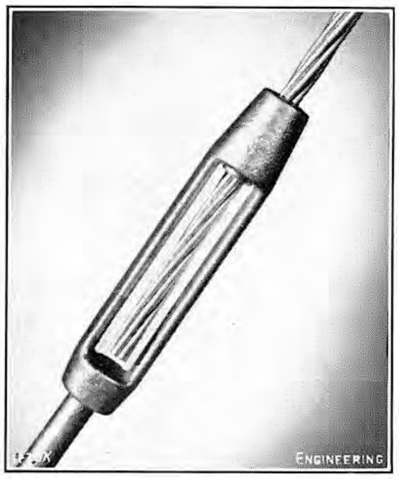


Fig. 23. Stay Rod; Cable Covers, Ltd.

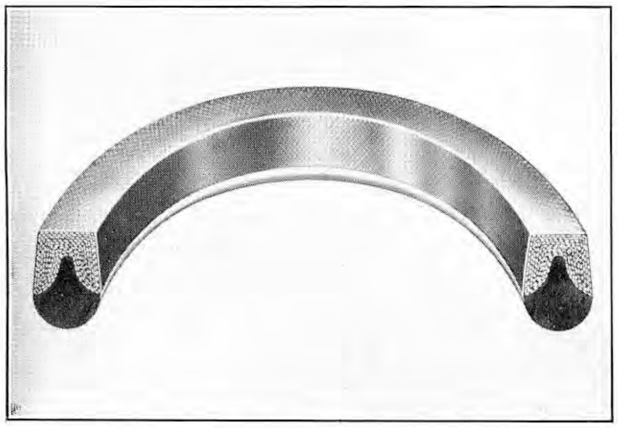


Fig. 24. Fluid Seal; Hall & Hall, Ltd.

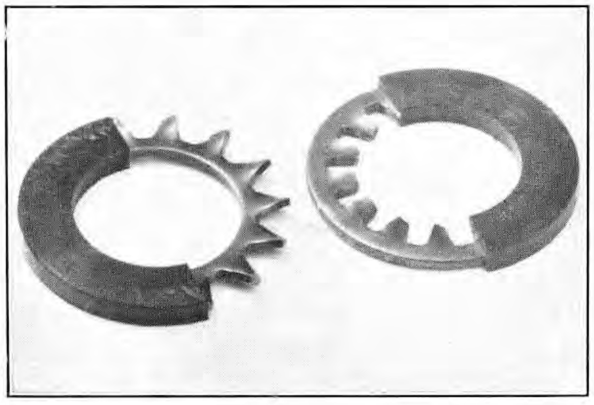


Fig. 25. Sealing Lock-Washer; Dowty Equipment, Ltd.

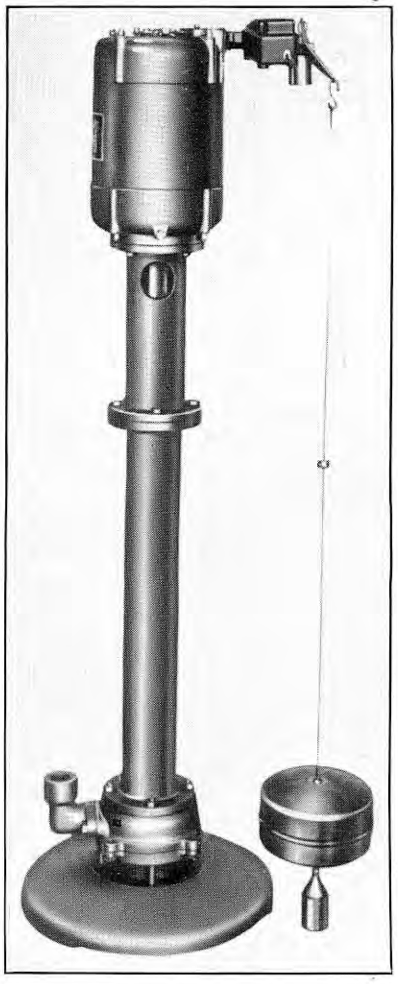


Fig. 26. Cellar-Drainage Pump; James Beresford & Son, Ltd.

EXHIBITS AT THE BRITISH INDUSTRIES FAIR.

(*For Description, see Page* 545.)

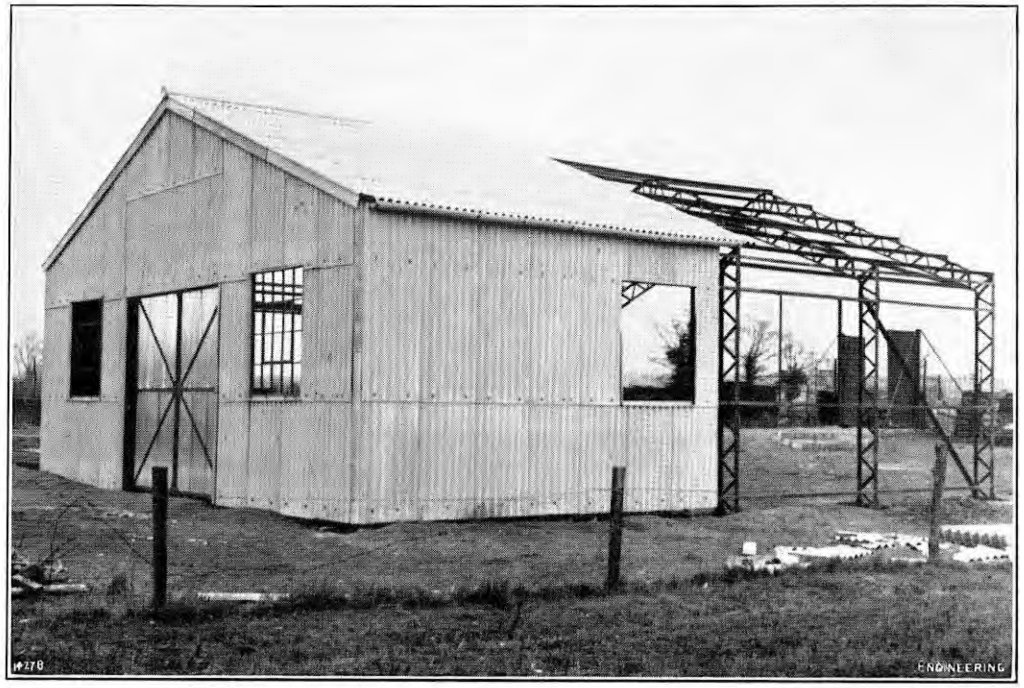


FIG. 27. "APEE" PORTAL FRAMED BUILDING; ALL PURPOSE BUILDING CO., LTD.

FIG. 28. INTERMEDIATE "ATOMILL" FINE GRINDER; BRITISH JEFFREY-DIAMOND, LTD.

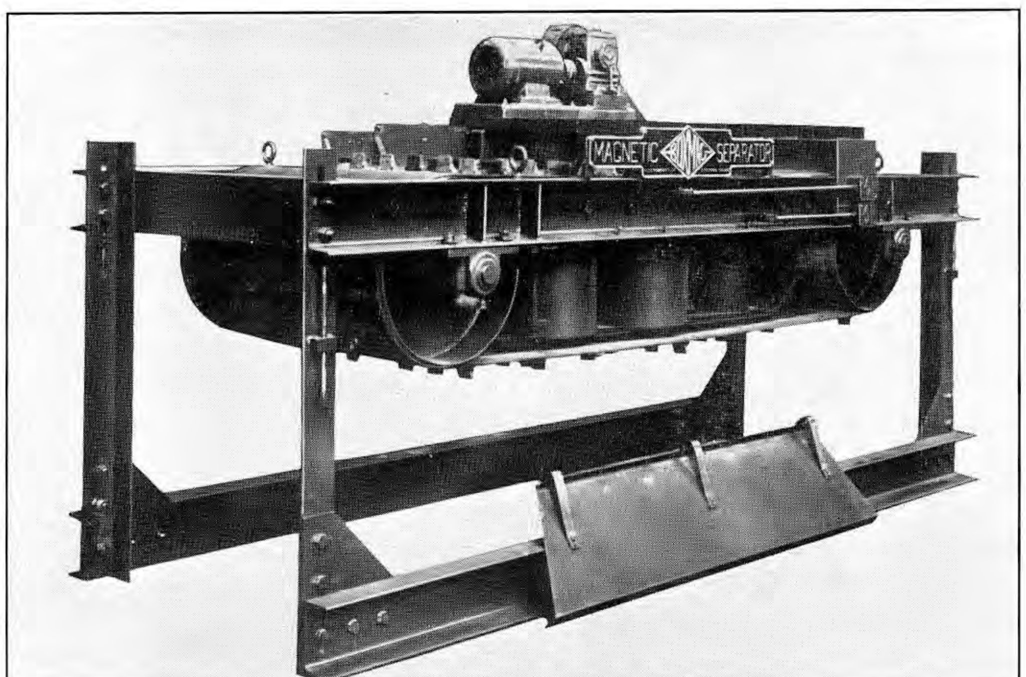


FIG. 29. MAGNETIC SEPARATOR; ELECTROMAGNETS, LTD.

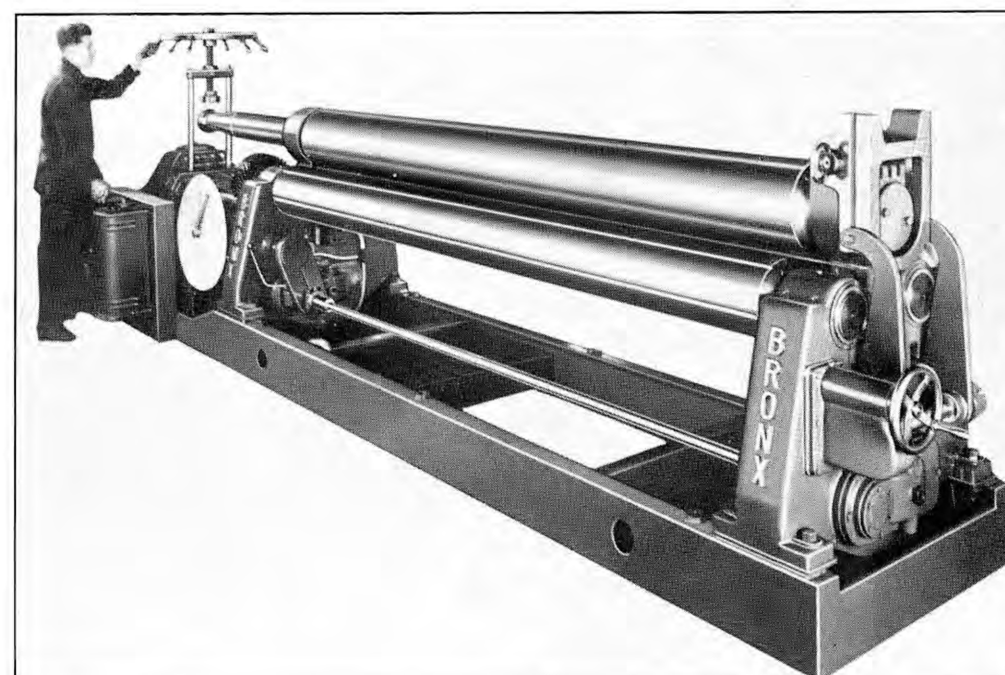


FIG. 30. THREE-ROLL PLATE-BENDING MACHINE; BRONX ENGINEERING CO., LTD.

(*To face page* 547.)

making the stroke adjustable from 1 in. to 5 in. being available. All models of press are provided with the manufacturers' patent electro-pneumatic clutch-brake unit, while the 200-ton model (type E.C.) has compressed-air slide balance and motorised slide adjustment and may be fitted with a device to adjust the stroke from 1 in. to 6 in. Their 100-ton press was described in ENGINEERING, vol. 173, page 641 (1952).

HYDRAULIC CYLINDERS.

Keelavite Rotary Pumps and Motors, Limited, Allesley, Coventry, are displaying a selection from their comprehensive range of equipment used in the hydraulic transmission of power, and illustrated in Fig. 16, Plate XIII, are some of the cylinders manufactured. These hydraulic cylinders are standardised in five bore sizes from 2 in. to 6 in., and the stroke can be arranged to suit the user, and up to 130 in. on the larger units. The bores are honed and the piston rods ground to a high degree of accuracy to ensure a high mechanical efficiency with a maximum working pressure of 1,500 lb. per square inch. Among the many other exhibits is, in particular, the patented rotary abutment unit which can function in either direction, with equal efficiency, as a hydraulic pump or motor. Fixed capacity units will displace from 2 to 4 cub. in. per revolution with a maximum working pressure of 1,500 lb. per square inch, and the variable capacity units will deliver up to 5·5 cub. in. per revolution at a maximum pressure of 1,000 lb. per square inch. Also displayed are gear pumps of various ratings delivering from 0·44 to 5·5 cub. in. per revolution at a peak pressure of 2,240 lb. per square inch, and also a wide range of flow and speed-control, non-return, relief, by-pass and reducing valves. An interesting working exhibit demonstrates the accurate synchronisation of movement which it is possible to obtain by using "Keelavite" dividing valves, when applied to hydraulic motors or cylinders. This exhibit explains how synchronisation is maintained within fine limits independently of a wide fluctuation in load.

"STYLUS" COUNTER.

The Trumeter Company, Limited, Milltown-street, Radcliffe, Lancashire, are showing counters for a variety of industrial and special applications. Fig. 17, Plate XIII, shows a new counter, known as the Stylus, for analysing the design of fabrics, in particular for the carpet industry, where it is necessary to know the exact amount of material used in each colour. Hitherto such counting was performed manually and might take several weeks; the Stylus simplifies and expedites the work appreciably. It consists of a pencil-like tube incorporating a built-in microswitch; a light pressure on the small movable steel tip causes contact to be made. For every impression of the Stylus, a count is recorded on the magnetic counter to which the Stylus is connected. The counter is fitted with a quick-resetting lever so that after every colour change the counter can be brought back to zero. It will operate on any mains voltage and can also be supplied for low-voltage operation.

PYROMETER KIT.

Ether, Limited, Erdington, Birmingham, are exhibiting a number of temperature recorders, and electronic controllers and indicators of advanced design. In Fig. 19, Plate XIII, is illustrated the "wide-strip" electronic potentiometer, type WSP/E, which gives six records in the form of continuous lines made up of closely-spaced dots, on the 10-in. chart. This instrument is capable of a chart speed of 360 in. an hour, and may be used as an automatic recording controller to maintain an exact furnace temperature by the high-low multi-stage and proportional systems. Shown for the first time is a new molten metal pyrometer made up as a complete and handy testing unit, as illustrated in Fig. 18, Plate XIII, and designed to cover a wide range of routine testing. In addition to the two instruments illustrated, there are exhibited the Ether potentiometer indicator, type P.C./10/E, which can be arranged through a multi-point switch to indicate temperatures automatically at up to 36 points. A full range of Ether-Wheelco electronic indicating controllers is also shown; these instruments are made under licence from the Wheelco Instrument Company, Chicago, United States.

"ROTO-FINISH" MACHINE.

Roto-Finish, Limited, 39, Park-street, London, W.1, are exhibiting a range of components from "Roto-Finish" installations in the works of several leading manufacturers, illustrating the standards of deburring or polishing obtained from these machines under production conditions. On display for the first time is the new machine (shown in Fig. 20, on Plate XIV) for precision barrel finishing; this machine is of medium size and is illustrated during its flushing-out operation. This new machine is designed to perform the full range of "Roto-Finish" processes from precision deburring, uniform radiusing, descaling to a bright polish, up to the final stage of high-quality polishing and honing. The process is very gentle and is fully controlled in action and it can be successfully applied to batch deburring and the polishing of engineering components to very fine limits; moreover, components of all metals and alloys may be treated, larger pieces being held in fixtures. Also on display are the various interchangeable screens and the "hoist pan" which form part of the "Roto-Finish" handling technique. These machines are a great asset where a high degree of polish has to be imparted with speed, efficiency and accuracy, to parts subsequently to be fitted to very close limits.

FORK-LIFT TRUCK.

R. H. Corbett and Company, Limited, Hydrum Works, Burgess Hill, Sussex, are exhibiting their "Hydruped" fork-lift truck, shown in Fig. 21, Plate XIV, and the Hydrum High Stacker.

The fork-lift truck is capable of handling a maximum weight of 1,000 lb., and the standard model has a lift of 6 ft. It can be made with a 10-ft. lift at special request. An unusual feature of this machine is its means of traction, which is pedal operated after the manner of a push-bike; this enables a reduction of the total weight to be effected, giving an increase in manœuvrability. The lifting and steering of the machine are electrically operated by current from a 12-volt battery. The frame is constructed of steel and the counterweight is cast iron. The mast assembly is made from steel channel electrically welded together, and the carriage, which is fabricated, runs on cast-iron rollers. The lift is operated by a piston-type hydraulic pump driven by an electric motor, and the controlling switches are placed on the handle bars, provided for steering. The operator's seat is a motor-cycle type saddle. The width of this machine is 2 ft. 4 in., overall length with 30-in. forks 6 ft. 6 in., height 7 ft. 8 in., and the turning radius, which is particularly small, is 3 ft. 7 in. The other machine, the Hydrum High Stacker, has been designed for use in narrow alleyways, and for loads which do not exceed 3 cwt. The operator has a platform at the rear of the machine which lifts him, with the load, to a height of 12 ft. to stack the goods.

VEHICLE AND MACHINE RECORDER.

The vibrations set up in a machine or vehicle when working are utilised in the Rotherham recorder, shown in Fig. 22, Plate XIV, to obtain an easily read graphical representation of relative periods of idle and working time. The recorder is being exhibited by the makers, Rotherham Recorders, Limited, Swan House, Hotwell-road, Bristol, 8. For use on a vehicle, the recorder, which has overall measurements of $8\frac{1}{2}$ in. by 6 in. by $4\frac{1}{2}$ in., is fixed by three screws to the dashboard or the cab wall. Inside the case is a stylus device that is operated by an eight-day clock movement and which makes a trace across a coated printed-paper chart. This chart is divided into the seven rows for each day of the week and is further sub-divided into the twenty-four hours of the day. With the vehicle standing idle, only a very thin trace is drawn across the chart; with the engine turning over, but the vehicle stationary, the trace is somewhat thicker, and when actually moving, a firm broad line appears. From the resultant chart, starting times, rest hours and finishing times can be extracted at sight to the nearest quarter of an hour; interpolation to shorter time intervals is quite practicable. Taken in conjunction with the driver's log book and the mileometer, the chart enables a detailed analysis to be made of the operating times of the lorry. As can be seen from the illustration, the correct time can be noted through the window on the face of the recorder, and this can prove of value in making up the log book so that both sets of information can be correlated. After fixing, the recorder requires only a rewinding of the clock once each week, removal of the preceding week's chart and resetting to the new chart, all of which can be done in two minutes. The instrument is locked when it is set and the makers claim that it is tamp-proof. Apart from transport users, the recorder can similarly be fitted to any machine where it is required to obtain a record of relative working and idling times.

STAY ROD.

The principal subject of the display on the stand of Cable Covers, Limited, St. Stephen's House, Westminster, S.W.1, is the "Talurit" wire-rope clamping system. This system, which obviates splicing when joins have to be made or eyelets inserted in wire rope, has already been described in ENGINEERING, page 723, vol. 173 (1952); the method, which is essentially one of swaging a ferrule on the rope, can be used on ropes of any size up to 7 in. in circumference. In addition to "Talurit," many items of overhead-line electrical equipment, manufactured by the company's Power Engineer's Equipment Division, are on view. The main items among this equipment are examples of the new stay rod, an example of which is illustrated in Fig. 23, on Plate XIV. The salient features of this new rod are, like the Talurit system, the complete elimination of splicing, a saving of between 9 in. and 12 in. of rope with each rod erected, together with a high speed of erection that reduces erection costs. The rods, which have a diameter of $\frac{7}{8}$ in., can be obtained in lengths up to 8 ft., although longer rods can be supplied to order and have eyelets of sufficient diameter to receive guys of $\frac{7}{8}$-in. diameter.

FLUID SEAL.

A new type of fluid seal, illustrated in Fig. 24, can be seen on the stand of Messrs. Hall and Hall, Limited, Oldfield Works, Hampton, Middlesex. The Hallprene fluid seal has been developed to overcome certain disadvantages of the U-type of packing ring, such as wear at the heel due to distortion of the packing under pressure, and the inwards collapse of the sealing lips. It has proved to be particularly suitable for use with shafts slightly out of alignment or with worn hydraulic cylinders. The seal comprises a U-ring made of synthetic rubber-impregnated fabric filled with a soft, resilient synthetic rubber, the whole being bonded together. It is impervious to hydraulic fluids at temperatures up to 250 deg. F., and is effective against air. In use, fluid pressure deforms the soft synthetic rubber and cause the sealing surface of the impregnated side walls to expand. The seal is moulded with slightly divergent walls, and, since the filling is resilient, the walls of the packing ring will not tend to collapse. Once put under pressure, it will retain a seal even though the fluid pressure falls to zero. The sealing lips of the U-ring are protected against damage by being bonded to the resilient filling; the rounded exposed surface of the latter helps to ensure that when used in a stuffing box, fluid pressure can readily reach all parts of the exposed surface.

SEALING LOCK-WASHER.

A sealing washer that is also a lock washer is shown in Fig. 25, Plate XIV, and is made by Dowty Seals, Limited, Ashchurch. It is called the "Seloc" and consists of a star-type shakeproof washer encased within a synthetic-rubber sheath. Upon tightening, the serrations of the washer pierce the rubber and provide the normal locking medium. The rubber sheath ensures an efficient seal and, at the same time, it protects the surface from scores, caused by rotation of the locking serrations, and from oxidation.

CENTRIFUGAL PUMPS.

A wide range of centrifugal pumps is displayed on the stand of Messrs. James Beresford and Son, Limited, Stork Works, Marston Green, Birmingham, 33, among which is the Stork self-priming single-stage centrifugal pump which can be supplied as a self-contained petrol- or electrically-driven unit, or with pulleys for a belt drive. It can, if desired, be supplied on a barrow-type trolley, or as a fixed unit, and is available for outputs ranging from 150 gallons to 1,200 gallons per hour, and heads up to 180 ft. The Stork pump is self-priming up to 27 ft. In Fig. 26, Plate XIV, is illustrated a sump, or cellar, drainage pump, which is automatically operated and is capable of removing either a steady trickle or large quantities of water. Also on view are examples of their multiple-stage pumps with outputs ranging from 115 gallons to 50,000 gallons per hour, and heads from 10 ft. to 1,000 ft.; suds pumps for machine tools with capacities ranging from 1·75 gallons to 45 gallons per minute and heads from 5 ft. to 20 ft., with alternating- or direct-current drive; a range of hot-water accelerator pumps for central heating systems; a car-washing outfit; a tractor-attachment pump; the automatic pressure water system, described last year on page 640 of our 173rd volume (1952), and submersible electric pumps for boreholes of 4 in. diameter upwards.

"Apee" Portal Framed Building.

The All Purpose Building Company, Limited, Sudbury, Suffolk, are exhibiting one of their new range of Apee portal framed building. These buildings are at present being made in three sizes of 40 ft., 50 ft. and 60 ft. span and in units each 12 ft. 6 in. long; although the standard building is taken to be 100 ft. long, that is eight bays, each of 12 ft. 6 in., buildings of either greater or lesser lengths can easily be supplied, made up in multiples of the unit 12 ft. 6 in. The exhibit is of the 40-ft.-span range and buildings of this span may be erected side by side to form multi-span units, thus making expansion sideways as simple as expansion lengthwise. The basis of all Apee buildings is light-weight lattice portal frames the form of which can be seen from the illustration in Fig. 27, on Plate XV.

The basic framework can be clad with alternatives of asbestos or corrugated aluminium sheeting and may be lined—as is part of the exhibit—with an approved wallboard. Windows can be located in any or all of the side-wall bays and door assemblies in either of the end walls or in the side walls to meet specific requirements. The light-weight form of construction eliminates the need for substantial foundations and at the same time ensures speedy erection by, if necessary, unskilled labour. To supplement this range of buildings, the company have introduced a complete erection kit which contains all the plant and equipment required for the erection of any size of this range of buildings, and includes a small prefabricated erection mast, chain blocks, guide ropes, spanners and other hand tools. This kit has already proved its worth where the units have been erected in undeveloped areas where tools and equipment are often not readily available.

"Intermediate" Atomill Fine Grinder.

British Jeffrey-Diamond, Limited, Stennard Works, Wakefield, Yorkshire, have six crushing or pulverising machines on their stand at Castle Bromwich. The largest machine on view is the Flextooth crusher, one of a range of seven machines capable of reducing friable or semi-friable materials to end products of between 1¼ in. and ¼ in. in a single operation at rates up to 250 tons per hour. A machine giving a somewhat larger end product, from 8 in. down to 1½ in., is the single-roll breaker, of which the Mark II model is being demonstrated. A range of machines capable of reducing friable and semi-friable materials to products that will pass between ¾-in. square mesh and 100 B.S. mesh at rates of between 1 and 200 tons per hour, is represented by the smallest of the range, the company's 15-in. by 8-in. Swing-Hammer Pulveriser; this range of machines is also suitable for shredding fibrous materials. For obtaining really fine end-products, the company are showing three versions of the "Atomill": the Atomill itself, the Microid Atomill and a new machine, the Intermediate, which is illustrated in Fig. 28, Plate XV. Designed to be fed with materials of up to ½ in. cube, the three machines will give an end-product that will pass a 300 B.S. mesh after a single operation; depending on the material, the Atomill has an output of 20 cwt. per hour, the new Intermediate about half this capacity, while the Microid is intended primarily for laboratory work. The form of construction of the three machines is similar, being of fabricated steel throughout, with the lower frame built integrally with the bed-plate to avoid joints and ledges.

The rotor, driven at 6,000 revolutions per minute through V-ropes by a 10-h.p. electric motor, is both statically and dynamically balanced for smooth, vibrationless running. The ten U-shaped hammers, freely suspended on pins threaded through the rotor discs and held in place by a quick-release locking device, are fitted with wear-resisting tips. An enamelled-steel cover encloses the machine and acts as a guard for the mill, motors and rope drives; the cover is fastened to the bed-plate by set-screws and is provided with an easily detachable section at the back that gives access to the interior for inspection, cleaning and maintenance. Electrical equipment can be supplied for any voltages on either alternating or direct-current supplies.

Magnetic Separator.

Electromagnets, Limited, Boxmag Works, Bond-street, Birmingham, 19, are showing a magnetic separator, illustrated in Fig. 29, on Plate XV. Many of these separators are in use for salvaging tins and general ferrous scrap from household refuse and for the removal of tramp iron from products in process, such as coal, limestone, foundry sand, and glass cullet. It gives a continuous discharge of all collected iron and is very easily applied to existing conveyor systems with little alteration to the layout. Also to be seen on the firm's stand are a lifting magnet, swarf separator, high-intensity chute-type separator, various types of permanent-magnet separators, and the Boxmag high-intensity conveyor-head unit built into a short-band conveyor. It gives three times the separating power of a magnetic pulley or drum of comparable size and it is patented both in this country and abroad.

Three-Roll Plate-Bending Machine.

Among the machine tools exhibited is a "Bronx" three-roll pyramid plate-bending machine, made by the Bronx Engineering Company, Limited, Dudley-road, Lye, near Stourbridge, and shown in Fig. 30, Plate XV. It will bend a mild-steel plate of 10 ft. width by ½ in. thickness. The rolls are forged from 0·45/0·50 per cent. carbon steel. The top roll is 12 in. diameter and the bottom rolls 10 in. diameter. Machined along the surface of the bottom rolls are grooves which assist in gripping the plate. The housings are box-section iron castings, and contained in the lower part of these housings is the worm gear for adjusting the top roll. The top and bottom rolls run in bearings of phosphor bronze; the lower bearings are fitted with loose caps and the top bearings are arranged so that they can be released and swung clear for the removal of cylinders. The main gear drive is totally enclosed in a cast-iron gearbox, sealed to prevent loss of oil, and the drive is provided by a 16-h.p. motor having a speed of 960 r.p.m. The reverse drive is obtained by a hand-operated control gear. An 8-h.p. motor provides the drive to the worm gear for adjusting the top roll. To permit tilting of the top roll a separate clutch is installed in the driving shaft for disengaging the worm gearing. An indicator is fitted by the operator's position to show the exact position of the ends of the top roll at any time. Electric limit switches are fitted to cut out the driving motor should the top roll be accidentally over-run either up or down, and an extension is provided on the top roll to counterbalance the weight when swinging down the end bearing. A support is arranged to engage the ball end of the roll and it is operated by spiral gears and a handwheel. The rolls are mounted on a bedplate fabricated from steel and the gearbox motors and control on a bed-plate of cast iron—all of which are securely tied to the main frame of the machine.

(To be continued.)

LITERATURE.

Weight-Strength Analysis of Aircraft Structures.

By F. R. Shanley. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 36, U.S.A. [Price 8.50 dols.]; and McGraw-Hill Publishing Company, Limited, 95, Farringdon-street, London, E.C.4. [Price 72s. 6d.]

This book belongs to the "Rand Series" of publications, which present the results of researches undertaken by the Rand Corporation, a non-profit making organisation, chartered "to further and promote scientific, educational, and charitable purposes, all for the public welfare and security of the United States of America." It is the sixth to appear in the series.

The theme is the design of aircraft structures of least weight which perform a specified duty. It is strongly emphasised that the problem of making a structure of minimum weight to perform a given numerically-specified function differs from that of making the strongest structure of specified weight, and this is undeniable. However, it is a fact of experience in war-time that aircraft structures of the highest efficiency were obtained by the gradual modification of an existing structure, sometimes at the cost of a little extra weight, so as to meet a substantially increased duty. This war-time procedure is a piece of useful opportunism which cannot be proper to the commercially competitive conditions of peace. Hence the author's approach to the design problem is unquestionably correct. He is, of course, not the first person to take up the question of designing structures of minimum weight. It is true, however, that the problem is here analysed in a very systematic and thorough manner. The treatment is based on the ideas of previous investigators, notably of H. Wagner in Germany and of H. L. Cox in this country.

The problem of designing a structure of specified duty and minimum weight is approached by considering structural elements of important simple types, and the aim is to obtain a comprehensive and general solution to the problem for each such type of element. Thus, the solution is not just that of one numerically-specified design problem but of a whole class of allied problems. In particular, the aim is to obtain the particulars of the structural element of least weight for all values of the load and of the principal linear dimensions. The questions then arise, "How can the treatment be made general and how can structures to meet differing requirements be fairly compared?" The answers to these questions are provided by the use of what is called "the structural index." In spite of the name, this is not a uniquely specified quantity; the expression for the structural index appropriate to each type of structural element requires special investigation. However, all the structural indices used in this book have the physical dimensions of stress (or elastic modulus) and consist of the specified load (force or moment) divided by an appropriate power or product of the specified linear dimensions. For example, when the structural element is a tie-bar or strut, the structural index is $\frac{P}{l^2}$, where P is the load and l is the length of the member. In this instance, a brief and simple investigation suffices to show that members for differing duties can only be compared directly provided that the structural index has the same value for all. The thesis is that a definite optimum design can be found for a structural element of given type, its proportions being functions of the structural index. It is to be noted that, although the structural index is independent of the size of a family of geometrically-similar bodies, it is not a non-dimensional quantity. This is deliberately contrived since the elastic properties of the material of the structural member are rightly regarded as quantities to be chosen so as to secure the best result. The author

POWER JETS' GAS-TURBINE PATENTS.

Fig. 1.

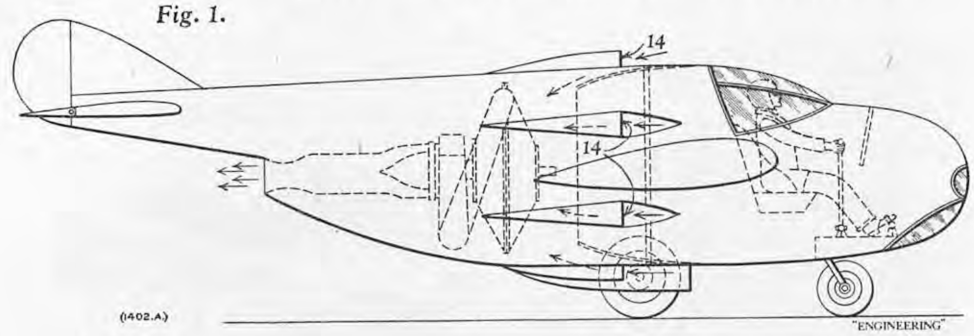


Fig. 2.

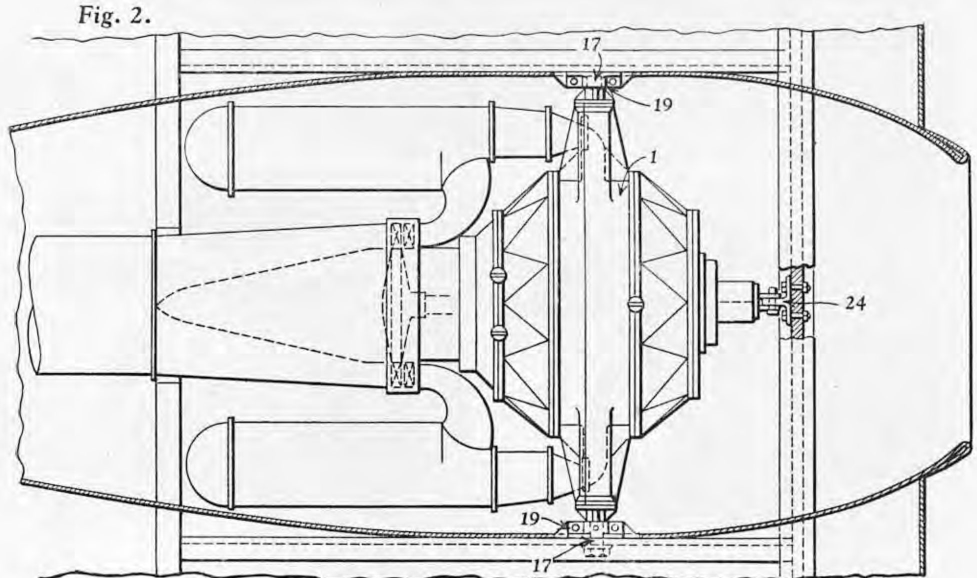


Fig. 3.

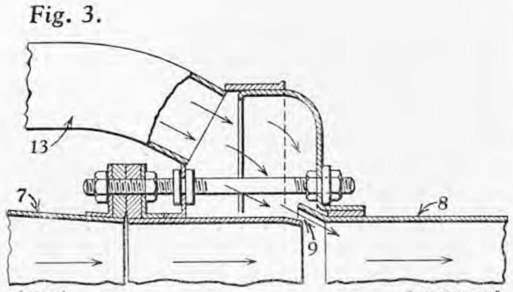


Fig. 5.

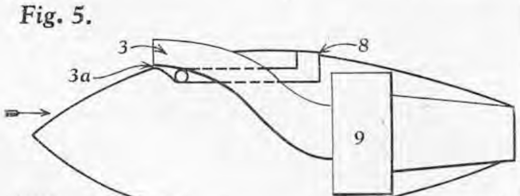


Fig. 6.

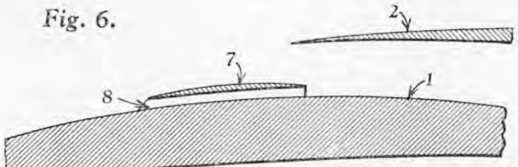
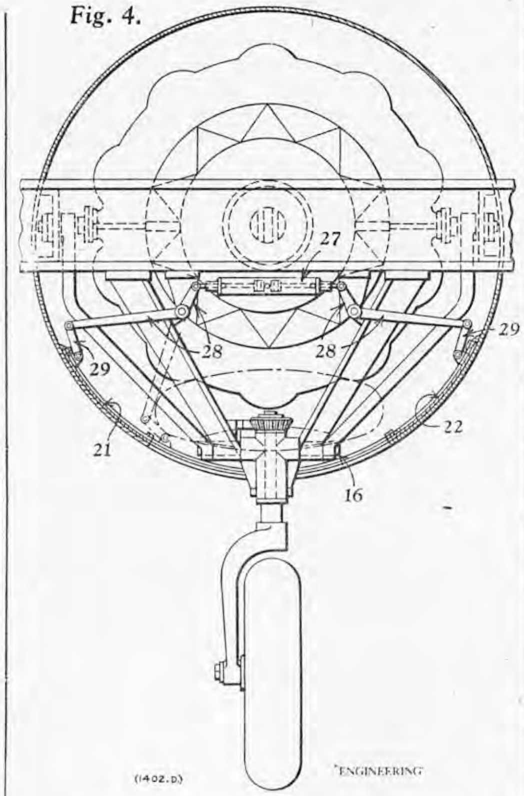


Fig. 4.



is well aware that the designer is nearly always forced to make a compromise, that other considerations usually prevent the adoption of the design which is the absolute optimum as judged on the basis of least weight. However, the graphs included in the book will enable the designer to make a quick assessment of the price which he must pay in departing from the optimum.

The structural index is thus an important and valuable conception. There are, however, some assumptions implicit in the conception which may not be valid in particular cases, especially in dimensionally extreme cases. Thus, it is assumed that the size of the member *per se* has no influence on the criterion for the optimum member, but this is liable to be untrue if the member is either very small or very large. An important observation is that for some members the requirement which is critical in design is a stiffness, not a strength, and this is often true in aircraft design. Such cases can be met by developing suitable new structural indices containing the specified stiffnesses.

This is a book which deserves study by all designers of aircraft, and it should also receive the careful consideration of those who are concerned with the design of structures of all kinds.

POWER JETS' GAS-TURBINE PATENTS.—III.*

INSTALLATION OF GAS TURBINES IN AIRCRAFT.

THE earlier sections in this series have dealt with patents relating wholly or mainly to aero gas-turbine engines; it is proposed here to review a block of patents concerned not with gas turbines as such, but with their installation in aircraft. Once again, chronology decides that a Whittle patent shall be the first to be considered; this patent, No. 512,064, is approaching the end of its allotted span of life, having been applied for in 1938—as the drawing here reproduced as Fig. 1 might well suggest. The invention consists primarily in the provision of intakes which are located so that some or all of the air to be consumed by an engine producing a propulsive jet comprises the boundary layer at a surface of the aircraft; in the arrangement illustrated, the intakes are forwardly-facing scoops 14 arranged in a ring around the fuselage at about its point of greatest girth. The patent specification makes interesting reading in that it shows that Whittle, at a relatively early stage in his development of the jet-propulsion unit, was already giving considerable thought to the effect which jet propulsion would have on aircraft design. Apart from the aerodynamic advantage of consuming air from the boundary layer, stress is laid upon other benefits to be obtained, such as the possibility of a short undercarriage, a good view for the pilot and the grouping of guns in the nose of the fuselage of a single-engined aircraft. The dotted-line indication of a power unit in the drawing is suggestive of the Whittle unit (with a single diffuser duct leading to the single combustion chamber) which first ran under its own power on April 12, 1937; this unit, designated WU, was rebuilt in two later versions, each having ten discharge pipes connecting the compressor to the combustion system. The third version suffered turbine-disc failure on February 22, 1941—a condition in which it was seen by visitors to the South Bank Exhibition of the 1951 Festival of Britain.

Patent No. 587,563 relates to the mounting of a gas-turbine unit in the airframe and covers an arrangement which has found almost universal adoption in the installation of certain types of unit. The invention may be illustrated by Fig. 2, from which it may be correctly inferred that the original conception was concerned with the classic Whittle configuration already mentioned in Section I of this series. In engines having this layout, much space is occupied by relatively light structures subject to great and rapid changes of temperature (such as the combustion system and exhaust ducting) and it is necessary that the whole unit shall be adequately mounted by attachment at parts capable of withstanding high mechanical loads; moreover, the mounting must be capable of resisting forces operating in three linear and three angular degrees. In the arrangement depicted in Fig. 2, the mounting comprises a pair of substantially coaxial trunnion bosses 17 carried by the compressor casing 1 at diametrically opposite points lying on a line which intersects the main fore-and-aft axis of the unit substantially at the unit's centre of gravity. The two bosses are received in sockets 19 carried by the airframe, one of them being free to slide in its socket to accommodate thermal expansion or minor inaccuracies of construction. The trunnion mounting, it will be seen, serves to restrain relative movement between the unit and the airframe in five degrees of freedom; relative movement in the sixth degree (i.e. rotation about the trunnion axis) is prevented by a third attachment 24 situated in the plane of the fore-and-aft axis of the unit.

According to patent No. 587,513, the entraining effect of the high-speed exhaust stream of a jet-

* Part II appeared on page 516, *ante*.

POWER JETS' GAS-TURBINE PATENTS.

Fig. 7.

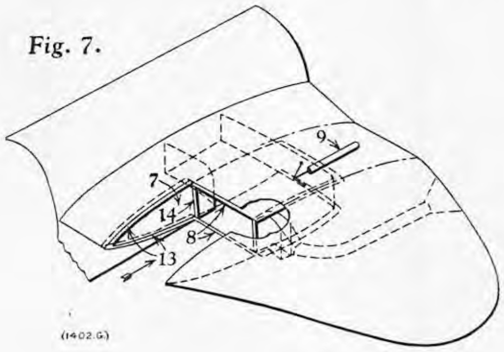
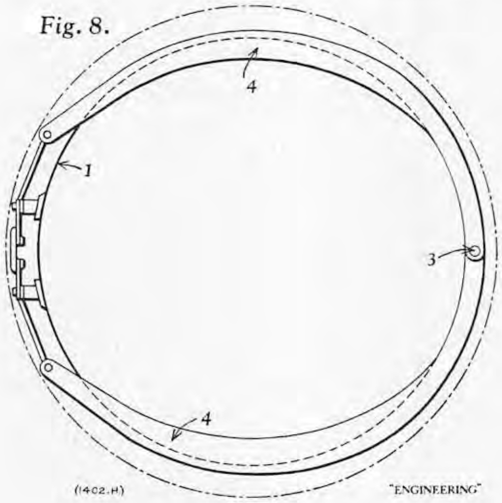


Fig. 8.



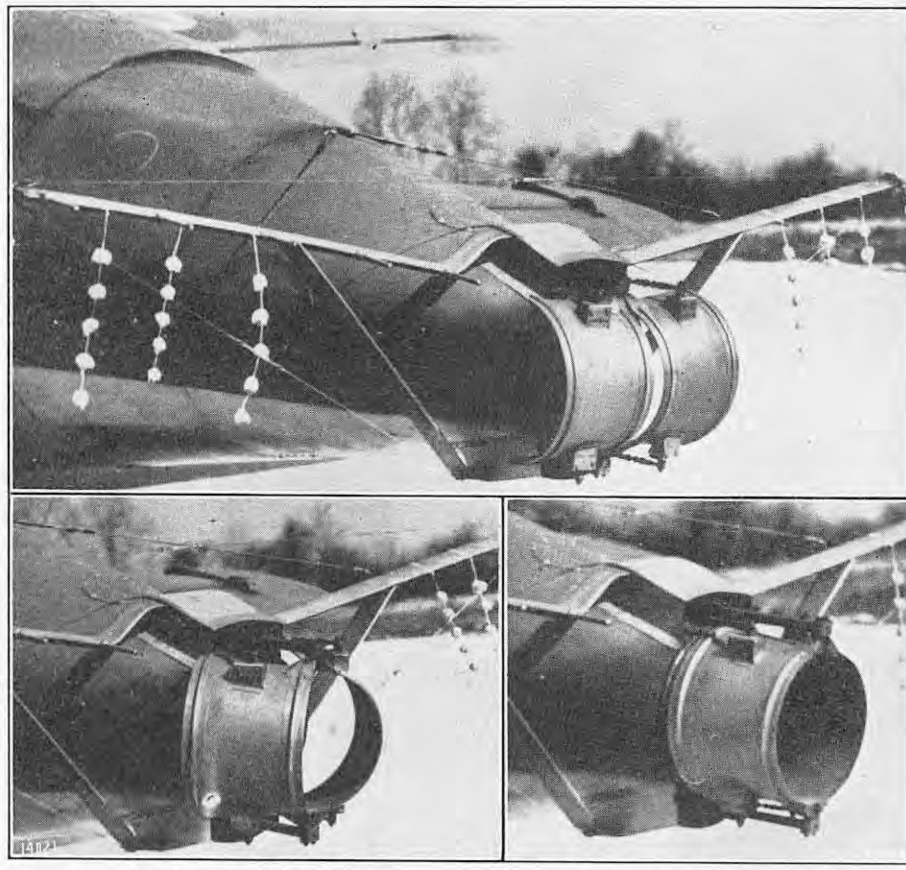


FIG. 9. THREE POSITIONS OF THRUST-SPOILING DEVICE.

propulsion engine is used to induce the flow of cooling air over or between parts of the engine. In the arrangement shown by the fragmentary section of Fig. 3, page 549, the jet pipe 7 discharges into an extension pipe 8 which leads to the propulsion nozzle and is separated from the jet pipe by an annular gap 9; the "injector" action of the gases flowing past the gap entrains air from pipes 13, or an equivalent annular duct surrounding the jet pipe, appropriately connected to induce a flow of cooling air as may be required in relation to the hot parts of the engine. The cooling air may simply follow a path over the external surfaces of hot components of the engine, such as the jet pipe or combustion chambers, or it may follow a more intricate path, say through a bearing housing or over the face of a turbine disc. In one installation in which the principle has been adopted, cooling of components of the engine itself is but one of the functions of the air-flow induced by the action of the jet stream; also of great importance are ventilation of the engine nacelle and thermal insulation of the wall of the latter from the jet pipe and other hot components. Although primarily conceived in connection with jet-propelled aircraft, the invention is also applicable to the cooling and thermal insulation of stationary and other gas-turbine plant in which the exhaust conditions are suitable.

Patent No. 579,657 is also concerned with auxiliary air-flow, but in this case the air concerned is part of the actual working medium of a gas turbine. Many aero gas-turbine installations are of the kind in which the compressor inspires its air from a plenum chamber formed within the fuselage or nacelle and provided with a main air intake which faces forwardly in the direction of flight so as to take advantage of the ram pressure obtainable during normal flight. Under some conditions of operation, for instance when the aircraft is standing on the ground or during take-off, the absence of adequate ram pressure may result in the formation of a depression in the plenum chamber and thus in reduced performance of the power plant. Some of the expedients described in the specification, whereby the persistence of a depression is avoided, comprise spring-closed flush-fitting doors which are mounted in the fuselage or nacelle walls and automatically open inwards when there is a tendency for the pressure in the plenum chamber to become sub-atmospheric; the auxiliary air intakes provided by the open doors are of sufficient area to ensure an adequate supply of air to the engine's compressor. Close-up photographs of modern high-speed aircraft often reveal apertures formed, in an otherwise smooth fuselage skin, by the automatic opening of doors of the kind described, thus indicating that the manœuvre of "formating" on the photographer's aircraft has necessitated flight at a speed so low that the ram pressure is insufficient for the engine's requirement for air to be satisfied by air inspired by way of the normal forwardly-facing intakes.

The construction illustrated by Fig. 4, page 549, intended for cases in which it may be assumed that additional air-intake area will be required only at such times as the retractable undercarriage is extended, that is to say, during running-up on the ground, during take-off and when full use of engine power is required during landing; thus, in the place of spring-pressed, suction-operated valves, the additional area is controlled by means of doors which are positively actuated by the undercarriage mechanism and may, in fact, replace doors normally employed to close the undercarriage embrasure. As shown in the drawing, the undercarriage leg is arranged, upon retraction, to pivot forwardly about the axis 16 and also to swivel about its own axis so that the retracted wheel comes to lie in the position indicated by chain-dotted lines. A double-acting hydraulic ram 27 is provided to actuate sliding doors 21 and 22 by way of bell-cranks 28 and links 29, and is so coupled to the hydraulic system provided for the undercarriage leg that the act of extending the undercarriage does not commence until the doors have been fully opened, while closure of the doors begins only after completion of the retraction operation; in this way, it is ensured that the auxiliary-air intake is sealed in normal flight, but is fully open at all times when it is calculated that the ram pressure will be insufficient to make full power possible.

The next patent, No. 579,758, is likewise concerned with air-intake problems; but here it is not the low-speed case which is catered for, but that of the intake which is required to operate under supersonic conditions. Since the taking-in of air by an aircraft travelling at supersonic speed must result in substantially instantaneous change from supersonic to subsonic velocity, allowance must be made for the effects of the resultant shock wave; so far as Mach numbers up to 1·5 or 1·8 are concerned, it had been established, at the date of the invention, that intake efficiency required the shock wave to be located as nearly as possible in the plane of the intake and at right angles to the relative fluid flow. The existence of a boundary surface extending upstream from the entry further complicates the problem, due to interference between the shock wave and the boundary layer; apart from the separation troubles associated with the boundary layer, there is difficulty in maintaining the desired location of the shock wave.

A popular form of gas-turbine installation for very high-speed aircraft is one in which the power unit is housed within the fuselage behind the pilot, the nose of the aircraft being used to house guns or radar equipment and the power unit being fed with air by a forwardly-facing intake or intakes situated at an intermediate point in the length of the fuselage. Examples are the "Nostril" type of inlet, in which part-annular scoops are provided on either side of the fuselage, and the single part-annular dorsal inlet provided at the rear of the pilot's cockpit; in such installations, the designer of a supersonic aircraft is almost inevitably faced with the problems to be associated with a boundary surface extending upstream of each inlet. The solution offered by the invention lies in the provision of a forwardly-facing boundary-layer bleed aperture in the region of the entry and arranged to abstract a part of the boundary layer. In the arrangement illustrated diagrammatically by Fig. 5, page 549, a gas-turbine power plant 9 receives air from a forwardly-facing inlet scoop 3 on the upper side of a nacelle; a boundary-layer bleed aperture is provided at 3*a*, the boundary-layer fluid extracted being conveyed to and discharged at a zone 8 of low pressure on the skin of the nacelle; in a "Nostril" arrangement, the bled air could be discharged by way of apertures on the upper and lower surfaces of a wing situated to the rear of the intake. In the aircraft application above described, the supersonic condition results from the passage of the intake relatively to the ambient air stream; the boundary-layer bleed could be equally useful in cases where the duct is stationary and the approaching air flow is supersonic, as in a wind-tunnel.

It is convenient, here, to break the self-imposed rule of chronology, since a somewhat later patent, No. 636,605, offers another solution to the problem of the supersonic intake of which a boundary surface extends in the upstream direction. In this case, a boundary-layer bleed aperture is provided slightly upstream of the main intake and the air bled off by way of the aperture is returned to the main flow at a point downstream of the intake. The drawing reproduced in Fig. 6, page 549, shows an inner fuselage or nacelle wall 1 which extends upstream of the intake aperture defined by a thin outer wall 2; a boundary-layer bleed is formed by a thin partition 7 which is supported at the correct spacing from the inner wall 1 by webs 8. The partition should be spaced from the inner wall so as to afford a passage of just sufficient depth to accept the whole of the boundary layer; the axial length of the partition should be about three times the width of the main intake aperture and the partition should extend into the intake to a sufficient depth to provide for the expected range of positions of the shock wave formed at the intake. The flow within the bleed slot is preferably supersonic since, in this way, choking of the slot may be more conveniently avoided than by aiming to get subsonic flow; the existence of a shock wave within the slot will have but a minor effect on efficiency, the shock system being confined by the partition, while the main shock wave will be able to interact only with the small boundary layer on the outer surface of the partition.

Whereas the two patents just reviewed are concerned with fixed members for achieving efficiency in inlets receiving air at supersonic velocity, patent No. 607,686 relates to an installation which is capable of adjustment to adapt it to varying intake conditions; objects of the invention are to control the location of the inevitable shock wave produced when the approach velocity of the intaken air is supersonic and to prevent the formation of a shock wave in certain conditions of subsonic approach such that supersonic velocity is reached by air passing over an external surface, such as that of a wing in which the intake is situated.

In the supersonic case there is, for any given approach velocity, a critical intake area above which the volume flow through the intake is less than the volume of air presented to it, which results in increase of the drag associated with the inlet. In the subsonic case, decrease of flow through the intake (due to throttling downstream) may result in a flow of supersonic velocity over the external surface. The invention provides variable-area intakes together with detector means for controlling the area automatically in accordance with conditions in the neighbourhood of the intake. In the example shown in Fig. 7, opposite, an intake in the leading edge of a wing is defined by lateral walls 7 and upper and lower walls 8 which slide in guide slots 13; the condition shown is that in which the upper and lower walls are fully retracted, giving maximum intake area, whereas zero intake area is obtained by sliding the walls fully forward so that they meet and virtually form portions of the wing surface. Since, with the upper and lower walls retracted, the side walls 7 represent boundary surfaces extending forward of the intake proper, boundary-layer bleeds in accordance with patent No. 579,758 (reviewed above) are provided as indicated at 14. The sliding walls 8 are actuated by a jack 9, which may be controlled by a pressure-detecting device situated in the shock zone. A convenient form of such a device may comprise static-pressure heads located upstream and downstream respectively of the point at which the intake shock wave should be ideally located under supersonic conditions. When the shock wave is properly located, the forward head will be in a zone of supersonic velocity and low pressure while the rear head is in a zone of subsonic velocity and high pressure; pressure-sensitive intermediate mechanism, associated with the detector, may thus be employed to control the jack 9 so that the shock wave is returned to the correct location by reduction of the intake area should the wave move upstream of the datum zone defined by the two static heads and by increase of area in the case of downstream movement. It is suggested in the specification that the adjustable intake may be an auxiliary in parallel with a main intake and intended for use in supersonic flight only; if the intake is used for subsonic conditions, it will be maintained at maximum area.

The four patents reviewed immediately above all relate to air-intake problems and thus fall into a natural group; chronology has, therefore been ignored once more. Now it becomes the turn of some patents concerned with the other end of the installation; that is to say, the propelling nozzle. The first of these, No. 606,176, relates to an early (1944) proposal for a variable-area nozzle applicable, for example, to a turbo-jet installation in which there is provision for afterburning. For reasons which will be obvious from Fig. 8, opposite, the construction is known as the "calliper nozzle" and comprises a pair of flat, plate-like constrictor elements 4, 4, pivoted at 3 and operable, by mechanism which need not be described in detail, to move in their own plane across the discharge orifice 1 of the associated jet-pipe to vary the cross-sectional area of the jet. The constrictor elements produce a *vena contracta* effect in the jet stream and the variation in cross-sectional area may be effectively greater than the extent of the protrusion of the elements into the stream. The following passage from the specification is worth quoting: "The constrictor elements according to the present invention when out of use are practically speaking not exposed at all to the working fluid or the high temperature associated with propulsion jets. The surprising thing about the present device is that despite its apparent crudity it does not materially detract from efficiency, at least in cases actually tested."

A rapidly-developing art at the present time is that of thrust-spoiling (or deflecting), that is to say, the diversion of a jet-stream from the purely rearward direction for the purpose, *inter alia*, of reducing the thrust exerted upon the aircraft in the forward direction; the ability to affect rapid and perhaps temporary reduction of thrust (without the necessity of reducing engine revolutions) may be highly desirable; for example, in the landing of carrier-borne aircraft. Many relevant patent applications are at present pending, but it is not yet possible to give details of the inventions concerned. Instead, two patents for which applications were made in 1945 may be mentioned briefly as being concerned with some early ideas on the subject; these are Nos. 600,075 and 613,989. The inventions forming the subjects of the two patents are adequately illustrated, for the present purpose, by the three interesting photographs reproduced as Fig. 9, opposite. These show a thrust-deflector provided on the jet pipe of a Power Jets W2/700 engine mounted in the tail of a research aircraft, complete with equipment for indicating gas and air flows, temperatures and pressures. As may be seen from the illustrations, the spoiler comprises two arcuate deflector plates which do not normally interfere with the rearward jet stream (see Fig. 9, bottom right), but which can be pivoted to positions (bottom left and top) in which they enter the jet stream and deflect it laterally.

THE INSTITUTION OF NAVAL ARCHITECTS.

(*Continued from page* 521.)

THE Spring Meeting of the Institution of Naval Architects, which began in London on March 25, was continued in the morning of March 26, when two papers were presented. The first of these was by Mr. E. L. Champness, M.B.E., M.Sc. and, dealt with "Large Dry Docks." The paper will be reprinted later but a summary of it is given below. The chair was taken by Sir Charles S. Lillicrap, K.C.B.

LARGE DRY DOCKS.

Mr. Champness, in his paper, dealt only with permanent graving docks; floating docks did not enter into his survey. His starting point was the report of the Dry Docks Committee, appointed by the Institution of Civil Engineers in 1948 to review the design and equipment of dry docks; Mr. Champness was a member of that committee. The results of their deliberations were published by the Institution in 1952 under the title *Dry Docks—Memorandum on Construction and Equipment*, but this publication merely summarised the conclusions; the paper by Mr. Champness gave in greater detail the views put forward by him to the committee as representing the views of naval architects. He found, on examining the dimensions of a number of large dry-docks, that the proportions ranged from beam $= \frac{L}{10} + 5$ ft. to beam $= \frac{L}{10} + 21$ ft., L being the length of the dock in feet. Certain special classes of vessel, e.g., whale factories, oil tankers, and ore carriers, were generally of the character of $\frac{L}{10} + 20$ ft. The natural direction for further expansion might have appeared to be in depth, said Mr. Champness; but, in fact, the draught of large ships was still limited by the depth of major dredged channels, so that, while the lengths of liners had increased from 700 ft. to 1,000 ft. in the period from 1910 to 1948, their load draught had only risen from 35 ft. to about 40 ft. Thus designers were still driven to accept length and beam as the only possible directions for expansion, a tendency which applied to naval as well as mercantile vessels. The largest naval vessels—namely, battleships and aircraft-carriers—tended to increase greatly in beam, requiring dry docks of extreme breadth which, normally, would be uneconomic from the mercantile point of view; for example, Germany had to construct three large docks, 1,020 ft. to 1,140 ft. long and 197 ft. in breadth, to accommodate the projected battleships of the H class, only one of which was laid down (but not completed). The three docks (at Hamburg, Bremen and Wilhelmshaven) were destroyed by the Allies. The need to protect future vessels against blast, heat and underwater explosions, the author continued, seemed to indicate that size would develop in the future much as it had done in the past, and that dockside cranes, high lighting standards, etc., should be kept 25 ft. or so clear of the maximum beam. A good depth was also necessary for war-time damage repair work, as vessels drawing as much as 42 ft. of water might have to be accommodated. Thickness of dock bottom was an important factor in such cases.

Commercially, the dominant factor of the present day was the constant development of the oil tanker, with its heavy upkeep repairs. Government-owned docks were not normally available for such work, and docks at liner ports often had regular commitments and could not undertake long repairs; but the position regarding private dry docks had been virtually stagnant for many years. In relation to its shipowning interests, the declining position of the United Kingdom, in failing to keep pace with the increasing size of ships, was significant, said Mr. Champness. There was a probable deficiency in the number of dry docks for merchant ships of all sizes, but certainly for ships over 65 ft. beam, yet the number of vessels of that size had probably increased tenfold in the past 30 years. As the construction of such a dock would take several years, the matter was not one that could be suddenly righted. The cost of a dock 700 ft. to 900 ft. long at the present time would be from one to two million pounds; yet, if in constant use for six days in the week throughout the year, it would earn a total return in dues, at present rates, of only about 90,000*l*. gross. The net return would probably be no more than 35,000*l*. There might be some opportunity for civil engineers to reduce the constructional costs by using the most up-to-date means of earth-handling; and the normal layout might be improved by building a dock in such a location as to be entered from either end, and providing one or more cofferdams at intermediate points so that the dock could be divided, to take two ships at the same time.

Discussion.

Sir Stanley Goodall, K.C.B., O.B.E., who opened the discussion, said that, when a new dry dock was contemplated, the civil and mechanical engineering problems, and especially the financial considerations, pressed the naval architect to accept the minimum width regarded as reasonable at the time, rather than the width that might be required 20 or 40 years later. A dry dock could usually be lengthened, but it was practically impossible to increase the width. He took exception to the author's statement that the proportions of the docks which he had indicated in his Fig. 1 were unlikely to be overtaken by developments in ship proportions such as had occurred over the past 40 years. Often similar forecasts had proved to be false. The extension of the Devonport yard proved inadequate, as far as docking facilities were concerned, in much less than 40 years. A short time afterwards, an Admiralty Committee considered the dimensions of the floating docks which were built later. They quickly became out-of-date because they were not of sufficient size; yet in the Committee's report it was stated, "It may be assumed that the recent rapid growth in the dimensions of capital ships will not continue." The large dry docks at Rosyth and Portsmouth, completed at the outbreak of the first World War, were now inadequate in width.

Some might think that he was dreaming of battleships, but he was not; he was thinking of a remark made by the First Sea Lord, to the effect that "at present naval shipbuilding is confined to those small units in which the Royal Navy is so deficient, but the time will surely come when we must consider replacing the larger types." If and when that time came, he hoped that the Director of Naval Construction would not be handicapped as he (the speaker) had been by having to accept dimensions which were not the most desirable, because there were artificial limitations, one of which was the limitation of breadth imposed by the docking facilities available. Mr. Champness took refuge in the atomic age, saying that it might well be that the fleet of the future would consist of smaller units; but one had only to consider the history of any new ship type to realise that, however small they might be at first, the rate at which their size grew was astounding. He asked Mr. Champness to add to his paper the length and width of the Panama Canal locks; because the late Sir Eustace D'Eyncourt had said, shortly after the first World War, that it should be possible to dock in this country any vessel, naval or mercantile, which could just squeeze through that Canal. He took exception to Mr. Champness's criterion of length overall divided by 10, plus 20 ft., for the beam of merchant ships. The memorandum published by the Institution of Civil Engineers stated that "The beam in feet of certain tankers has reached $\frac{L}{10} + 30$." If that line $\frac{L}{10} + 30$ were drawn in the upper part of Fig. 1, the picture would be more realistic, and would show that there was practically no difference between the dock widths desirable for merchant ships and for naval vessels. Mr. Champness had said nothing of the strategical side of the subject, but the situation in regard to docking facilities in this country was most disturbing. If a line were drawn from north of Liverpool to the mouth of the Thames, it would be seen that all the large dry docks were south of that line. It seemed dreadful that, while the large shipbuilding centres, such as the Clyde, the Tyne and Belfast, could put ships of a certain size into the water, they could neither complete them nor repair them, because they had not the docks.

Mr. M. G. J. McHaffie, formerly chairman of the Committee responsible for drawing up the Memorandum on the Design and Equipment of Dry Docks, welcomed the paper as a valuable and up-to-date contribution to the subject. The author drew attention to the fact that all but six of the United Kingdom mercantile dry docks lay below the curve of what he described as the line of ideal entrance width for present-day lengths. That curve, however, was a purely arbitrary one; if the upper end of the curve were raised to lie about midway between the Southampton and the Capetown docks, the Southampton dock would show up rather poorly. On the other hand, if the upper end of the curve were lowered a little, the Southampton dock would lie above it, and therefore, presumably, would be outside the range of the author's criticisms. He did not challenge the author's view that there was a tendency in this country to adopt a less entrance width than a reasonable anticipation of the beam of future ships would suggest to be prudent; but it should not be overlooked that any dock-owning authority would seek the advice of those best able to give it before deciding on the width of any large dry dock that they contemplated constructing. If shipowners and their naval architects sprang a surprise on them, the blame could hardly be laid on the shoulders of the dock authority. One instance was that of No. 6 dry dock at Southampton, which, when it was built, between 1903 and 1905, was the largest dry dock in the world. Only five years later, it had to be widened to accommodate the Olympic. It was originally 90 ft. wide at the entrance and was closed by gates. The entrance was widened to 100 ft. in 1910, but reduced to 99 ft. effective width by a 12-in. by 6-in. horizontal rubbing fender on each side of the entrance walls, and the new entrance was closed by a sliding caisson. Fortunately, the widening did not involve the demolition and rebuilding of one of the side walls, for the necessary width was obtained by cutting away some of the lower altars, and a continuous concrete counterfort was provided along the back of both walls to compensate for the loss of weight in the dock structure. Then they were caught napping again. After the first World War, the Cunard Company took over the German ship which was renamed the Berengaria. She had a beam of 98 ft. 10 in., and, to give more room at the entrance, the 12 in. by 6 in. horizontal rubbing fenders were replaced by 12 in. by 3 in. fenders, with a 1 in. belting iron along the faces. That gave an effective width of 99 ft. 4 in. between the fenders, and thus the difference between the beam of the ship and the effective width between the fenders was 6 in. The head wall of the dock had to be recessed to accommodate her length. The docking of that ship presented another problem. Information was at hand of a "shoehorn" docking at another port, where it was reported that the ship, while being docked, was brought up all standing when about halfway into the dock by water mounting up against her bow. To guard against this, when docking the Berengaria at Southampton, a maximum speed of entry was laid down, so that the water would flow out of the dock along the sides and under the ship to prevent any such happening.

Then came the Majestic, with a beam of 100 ft.; she could not get into the dock at all. In 1924, the Southern Railway installed the 60,000-ton floating dock at Southampton, which was then the largest floating dock in the world. It was capable of lifting the largest liners then afloat—the Berengaria, Majestic and Leviathan—and was designed so that an additional section could be added to accommodate larger ships in the future. It was decided, however, not to increase the lifting capacity in that way to take the Queen Mary; even the additional section would not serve to lift her weight. So the floating dock was sold and the King George V dry dock was built instead.

The author said that he looked to civil engineers for a technique and plant, by drag-line or otherwise, which would reduce the present heavy cost of construction, particularly the high cost and time of excavation and disposal. The excavation of the "dumpling"—the spoil between the side walls which has to be removed for the construction of the dock floor—was always carried out by dragline. It would not be economical, except in very special circumstances, for the side-wall excavation to be taken out by dragline. The usual practice, unless there were good reasons to the contrary, was for the side-wall excavation to be taken out in trench, the earth on each side of the trench being used to retain the concrete. If the side-wall excavation were also performed by dragline, the sides would have to be allowed to stand at the natural slope of repose of the soil, and shuttering would have to be provided to retain the concrete, which would be very expensive indeed. Civil-engineering contractors could be relied upon to adopt the cheapest and speediest methods in carrying out their work.

Mr. B. P. Ingamells said that there could be few people in the country who knew more about the subject than Mr. Champness, who had guided the interests of the largest private dry dock on the East Coast for many years with great success. Its size, 714 ft. by 90 ft., which for so long had been large, had suddenly become small in relation to shipbuilding trends. He disagreed with the author's statement that inevitably, in times of emergency, the Admiralty became a major user of private facilities. At no time during the recent war was the Admiralty a major user of private facilities. The demand for the repair of naval ships during a war was so urgent that a proportion of the private docks must be available, but the need for merchant-ship repairs was quite as urgent, and a just balance was worked out satisfactorily during the last war. Mr. Champness had listed the attendant facilities which, at any dry dock, played a part in its efficiency, and, though the list was long, there was very little of it which was not necessary. The speaker commended particularly the fitting of lifts to the dock bottom; these were being incorporated in the only large dock at present under construction in the United Kingdom, that at North Shields. Another item which had received scant attention in the past was a sufficient water supply for the testing of tanks; ample water could save many hours in tank filling, which was imperative under modern conditions. He agreed fully with the author concerning the large increase in the number of broad-beamed ships, but thought that the author had not gone low enough in his beam categories. The construction of the Liberty ships, with a beam of 57 ft., had become a major factor in judging dry-dock facilities, especially in the United Kingdom. The number of ships on the British Register of 57 ft. beam and over since 1938 had doubled, whereas the number of dry docks in the United Kingdom which could take such ships had risen by only one or two. The shortage was particularly marked in the higher ranges of beam.

The author had stated that a capital expenditure as low as a million pounds would scarcely justify the enterprise by itself, and it would be necessary to rely on attracting additional repair contracts, which would not be obtained but for the possession of such a dock. That statement was only too true, and he was reminded of the inter-war years, when it was not unknown for a dry-dock owner to waive the dues in order to entice a ship into his dock. Once she was there, he had confidence in his own ability to make something out of the docking, and he was seldom disappointed. The proposal for a double-entry dock was most ingenious, and had much in its favour. The major disadvantage would seem to be the need for an extensive river frontage. He agreed with the figure quoted in the paper, of from one to two million pounds, as the cost of a large modern dry dock, and would be interested to learn if the author had obtained any estimates for the proposed double-entry dock and ship-repairing yard he had illustrated. He suggested that the cost of such a plant must be somewhere around 10*l.* to 15*l.* millions. He commended the realism of the author's plea to civil engineers for improvement in methods of construction. Already, at North Shields, there were indications of such possibilities.

Mr. D. Rae said he was glad the author had referred to an important commercial aspect of the question of providing adequate large dry-dock facilities. The existing depreciation allowances applied to dry docks were totally inadequate and completely failed to recognise the incidence of obsolescence. Dry docks were treated for depreciation purposes on the same basis as buildings, i.e., the cost had to be written off over a period of 50 years. The ship-repairing industry contended that that was an entirely wrong conception and that dry docks should be treated as what they really were—items of heavy industrial plant. The Dry Dock Owners' and Repairers' Central Council had been pursuing that question consistently since 1949, enlisting the interest of the Admiralty, representing their case to the Board of Inland Revenue, submitting evidence to the Tucker Committee on the Taxation of Trading Profits, and, recently, to the Royal Commission on Taxation. Two fruitless endeavours had been made to represent the position by deputation to the present Chancellor and to his predecessor; it was a matter for great regret that they seemed so reluctant to take speedy action on that important matter. Every year saw a growth in the number of large tankers and other large vessels, and more big dry docks are vitally necessary to provide the services required by modern merchant fleets. The industry's case was that, as regards expenditure on new dry-dock construction, or extensions and modernisations of existing dry docks, the annual allowances should be on a scale to write off the whole of the expenditure within the period of the anticipated useful life of the asset, which had been put at an average of 25 years. They asked that the existing law should be amended to permit the annual allowances in relation to capital expenditure on dry docks to be negotiated by the Commissioners of Inland Revenue and bodies representative of dry-dock owners. An anomaly in existing legislation was that, while depreciation was allowed on the dry dock itself, i.e., the walls and floor, the allowance did not apply to the cost of excavation, which was just as much a part of the total expenditure as any other money spent on construction and equipment. Much more encouragement by way of taxation reliefs was given in other countries, and it was essential that ship-repairing firms in the United Kingdom should not be handicapped in relation to their overseas competitors by being deprived of the means of providing all the modern facilities required. There was also the anomaly that floating docks were treated as plant for depreciation purposes, whereas dry docks were not—a position which was patently absurd. If that matter did not receive recognition in the only quarters where something could be done about it, sooner or later the technical, aspects of the whole question would become merely academic.

Mr. H. S. Pengelly said that, ever since the first World War, British large warships had been restricted in beam by the docking facilities available. The German large ships were restricted in draught by the depth of water in the Kiel Canal, thus leading to large beams.

An Admiralty Dry Dock Committee, under the chairmanship of Sir Lawrence Edwards, had kept under review the private and public dry docks available in the country in relation to the trend of increase in size, and particularly in beam, of merchant ships. In 1951, the occupancy of docks capable of docking Liberty ships and larger vessels had reached a practical limit of about 80 per cent. average (private and public docks). The number of ships of 57 ft. beam and over on the United Kingdom register had increased from just over 800 in 1938 to just over 1,300 in 1951, and to nearly 1,400 at the present time; the indications were that this increase would continue. There was already a need for some increase in the number of large dry docks. A capital asset costing millions should not remain idle. With a five-day week and restricted hours of work, the effective occupancy of dry docks might be as low as 20 per cent. Double-shift working and higher dock dues might provide a solution, welcome to both dock owners and shipowners.

Mr. J. Guthrie Brown, speaking as a civil engineer and a member of the Committee which prepared the Memorandum on Dry Docks, said that he was concerned with the design of the large Captain Cook graving dock at Sydney, and was at present interested in the design of a new dry dock for the naval requirements of the Republic of India. There was no doubt that the dry docks constructed in Britain and elsewhere were too narrow in relation to their length; as Mr. Champness had said, the draught was governed by the limitations of dredged channels, etc., and the naval architect had perforce to increase the size of vessels mainly in length and beam. Normally, it was relatively simple to lengthen an existing dry dock, but widening and deepening were much more expensive and difficult. It was essential, therefore, to provide ample width in designing any new dock. The dry dock under consideration for the Republic of India was being designed with a proportion of width equal to $\frac{L}{10} + 30$, which appeared adequate for requirements up to the cruiser class; he was glad to see that was the ideal width given by Mr. Champness. It also allowed destroyers to be docked abreast. Provision was being made, of course, for extension by 150 ft. or so, if required in the future. The author's reference to two or three years as the time required for constructing a large dry dock was certainly optimistic; his own estimate, based on the construction of major civil-engineering works in the United Kingdom and overseas, was nearer four years as a minimum. Means of reducing the cost of dry docks were not easy to visualise; the excavation was certainly not the critical factor. Costs were largely tied up with the site and foundation conditions and the cofferdam, and, of course, the concrete in the walls and floor were two major items. One of the factors affecting the increased cost of dry docks at present was indicated by the author's impressive list of the services which were necessary in the modern dry dock. It would seem, therefore, that the increasing cost of dry docks was not necessarily the fault of the civil engineer; the naval architect had some responsibility in respect of the demands which were made for a multiplicity of services at and around the dock.

Mr. J. Hunter said that there was no doubt that the dry-docking facilities in the United Kingdom, so far as the larger ships were concerned, were not only obsolete, but totally inadequate. In 1939, the biggest tankers afloat were in the region of 25,000 tons deadweight. There were only 13 tankers in the world exceeding 22,000 tons; the general run of tankers at that time were from 15,000 to 18,000 tons, and the total number of tankers in the world of 15,000 tons and over was 168. At the end of 1952, there were 279 tankers of 18,000 tons deadweight and over, of which 138 were over 22,000 tons, and by 1958 there would be 774 of those bigger tankers afloat, of which 395 would be over 22,000 tons, neglecting any lost or scrapped. Looking at the matter from the dry-dock point of view, whereas in 1939 there were 18 private dry docks in the United Kingdom capable of taking the general run of tankers, i.e., from 15,000 to 18,000 tons deadweight, which numbered 129, there were to-day only three docks capable of taking the general run of large tankers, i.e., from 22,000 to 32,000 tons deadweight, and their number would be 395 by 1958. It was well to bear in mind, when contemplating the dimensions for a new large dock, that the right dimensions to suit any particular size or circumstances could not be obtained from a curve of means. The correct criterion was the maximum size existing and foreseeable; the author's curve of maximum proportions of merchant ships gave the beam of a ship of 736 ft. 6 in. length overall as 98 ft., whereas, in fact, the beam of the 45,000 tons deadweight tankers of that length which were building in the United States was 102 ft. Also, whereas with the modern raked stems it was often possible to dock a ship of a length overall exceeding that of the dock by a number of feet, the breadth of the dock at entrance should, for preference, exceed that of the ship by at least 3 ft. for lengths up to 800 ft., and probably more beyond that size. He considered that, for ships up to 700 ft. to 800 ft. overall, the breadth of a modern dry dock should be in the region of $\frac{L}{10} + 30$; certainly not less, allowing for future developments. He would like to emphasise the point that the cost of excavation in the construction of a dry dock should be allowable for depreciation. The money spent on excavation was lost for ever to the dry-dock owner, and it was no small proportion of a very large capital outlay.

Mr. A. Logan said he thought that, while three or four private dry-dock owners, within the last year or two, had carried out or embarked upon new or enlarged dry docks, the dry-dock construction in the United Kingdom had definitely not kept pace with the increase in the size of ships. It was noteworthy that no public authority had undertaken any new construction or enlargement programme in recent years. Investigation showed that, of some 370 tankers of 21,000 to 40,000 tons deadweight, either in service, building or on order throughout the world, about 180 were owned by European countries, the balance of 190 belonging to American owners or companies whose interests were mainly in the United States. The majority of those vessels would be employed in the transport of crude oil from the Middle East to the United Kingdom, the Continent, and to the United States and Canada. The new vessels building, which numbered about 240, were mainly scheduled for delivery by 1958. It might be assumed, therefore, that 200 vessels per annum was a fair assessment for docking in Europe, of which possibly up to 20 could be docked at a given time. While a number of the dry docks in the United Kingdom and Europe could undoubtedly accommodate them, limited measurements, as given by Lloyd's Register, would appear in some cases to leave very little working space, which was very important when dealing with shell-plating repairs, renewals, etc. Making appropriate allowance for working space, along the lines stated by the author, it would appear that there were about 30 dry docks in Europe suitable for 21,000 to 25,000 tons deadweight tankers, decreasing to 18 for 26,000 to 32,000 tons, and to 11 for ships of approximately 40,000 tons. Allowing for an operating margin of 10 per cent. for contingencies, there might then be about 27 dry docks to take care of, say, 20 large tankers at one time, apart from liners. During discussions he had had with dry-dock owners in the United Kingdom, the high cost of present-day dry-dock construction was given as the deterrent to new schemes. He suggested, however, that increased dry-dock dues would not be the solution, for, as was stated in the paper, there were already a number of dry docks of suitable size in operation on the Continent, which would react competitively.

Captain J. P. Thomson, speaking as a shipmaster, said that with regard to the approaches to docks, he had found that the most dangerous part of a voyage was the leaving and entering of dry docks. Often the approaches were direct from the river, and there were difficult wind and tide conditions, plus a narrow entrance. He had been associated with large tankers, which had to be dry-docked when carrying the minimum of ballast. With regard to the attendant facilities, it must not be forgotten that present-day ships were built to a very high standard, and facilities for removing waste, etc., from them were not normally provided at dry docks. He hoped that dry-dock owners would have that in mind when dealing with further construction. With regard to the provision of a perpendicular wall at the side of the dock, he recalled an occasion when, in docking a ship which fairly well filled the dock, they were unable to get the ship directly on the middle line of the dock over the blocks. The dock was a tidal one, and, as the water ran out, the ship appeared to list to starboard. The wall at the end of the dock, instead of being perpendicular, had a step. The keel caught on the step and the ship listed to 15 deg., smashing the bilge keel.

Mr. Champness said he would reply in writing.

(To be continued.)

THE PHYSICAL SOCIETY'S EXHIBITION.

(*Concluded from page* 524.)

AMONG the exhibits of the Research Laboratories of the General Electric Company, Limited, Wembley, Middlesex, at the recent Physical Society's Exhibition, mention may be made of a new vector slide rule, the object of which is to carry out calculations referring to two-dimensional relations, such as those between vectors and complex numbers. As such calculations involve combinations of addition, subtraction, multiplication and division they cannot be carried out directly with an ordinary logarithmic slide rule and a good deal of intermediate writing is therefore necessary. The most important feature of the new rule, a photograph of which is reproduced in Fig. 19, is that it enables resistance and reactance to be rapidly converted into impedance and phase angle, while by its use it will be possible to reduce the time taken in analysing real and complex electrical networks by a convenient combination of direct and reciprocal scales.

The principle of the new rule may be explained by considering the logarithm of a complex operator, such as an alternating-current impedance. It can be shown mathematically that there is a simple interrelation between the two pairs of numbers R and X and Z and ϕ, where R is the real component (resistance) and X the imaginary component (reactance) in the Gaussian plane, Z being the absolute magnitude of the complex operator and ϕ its phase displacement relative to the real axis. This interrelation is shown in Fig. 20 for arbitrary values of R and X. If the two curves $\phi_1 \left(\log \frac{1}{\cos \phi_1}\right)$ and $\phi_2 \left(\log \frac{1}{\sin \phi_2}\right)$ are plotted, but are shifted relative to the origin by log R for ϕ_1 and log X for ϕ_2, then they will intersect at a point for which $\phi_1 = \phi_2 = \phi$ (log Z).

In the new slide rule, there are two pairs of curves, formed by the contours of two templates, which can be shifted by the movement of the two normal slides to which they are fixed. The left-hand contours represent the functions ϕ_1 and ϕ_2, while a linear scale ϕ is marked on the blade attached to a cursor. The main scales are made up of three logarithmic decades with their reciprocals and are repeated three times, once for each template slide and once for the normal slide rule at the bottom of the instrument. With these scales, it is possible to read Z and ϕ directly, if the templates are shifted with their base marking lines to R and X, by adjusting the cursor so that the vertical angle scale line coincides with the intersection between the left-hand contours. The hair line on the bottom part of the cursor then indicates the value of Z, while the vertical angle scale shows the phase angle ϕ.

The right-hand contours give the functions ϕ_1 and ϕ_2, with reference to the lower logarithmic scale. This scale involves only $1\frac{1}{2}$ decades, that is the square root of the upper (main) scales. The origin of these right-hand contours is, for practical reasons, shifted by one decade relative to that of the left-hand contours. The angle scale is extended over 90 deg. only, but a quadrant fixed to the frame gives an easy survey over the range of angles and scales to be used if one or both of the real and imaginary components of a complex operator are negative. The bottom part contains a slide on which both the upper (three-decade) scale and its reciprocal and the lower ($1\frac{1}{2}$-decade) scales are repeated as on an ordinary slide rule, but extended over a greater decade range.

Among the numerous instruments shown at the exhibition by W. G. Pye and Company, Limited, Granta Works, Cambridge, mention may be made of the portable potentiometer illustrated in Fig. 21 opposite. This has been designed with particular attention to compactness and easy operation; and has three ranges, 0 to 1·8 volts, 0 to 180 millivolts and 0 to 18 millivolts, which can be selected by a switch. The determination is made by reading straight across two dials which are visible behind windows. One division of the second dial represents

THE PHYSICAL SOCIETY'S EXHIBITION.

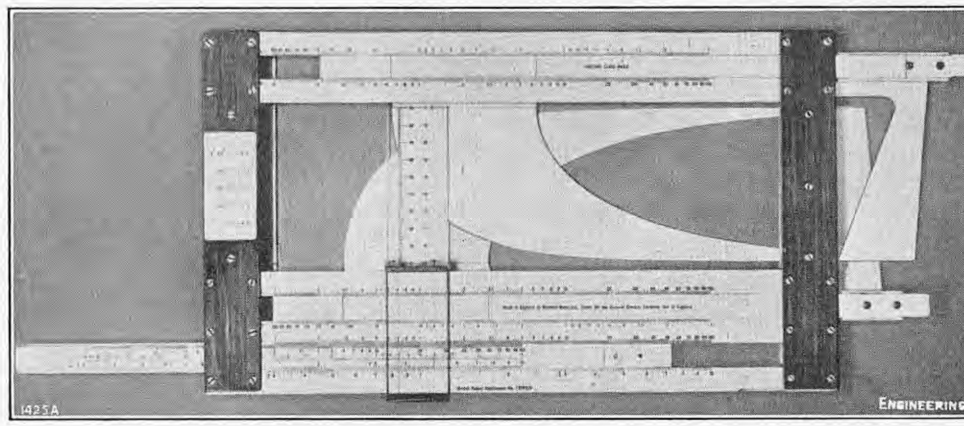
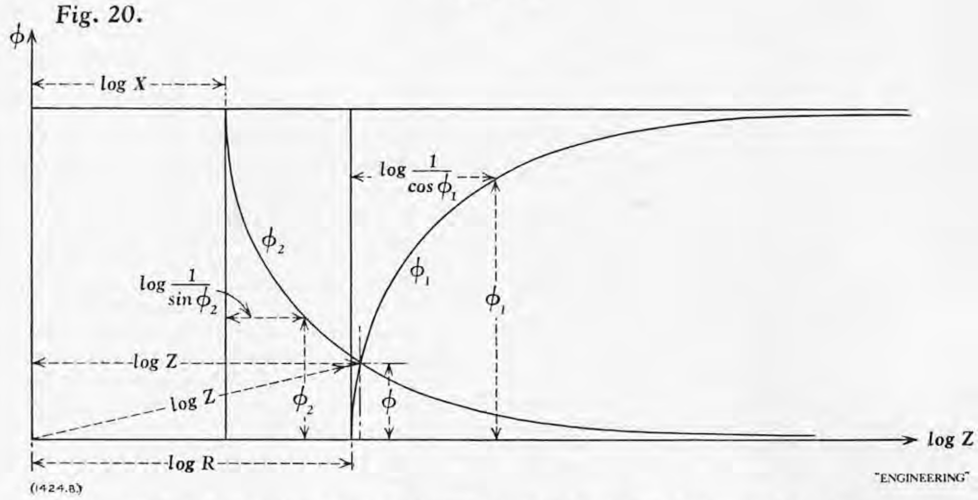


FIG. 19.

Fig. 20.



FIGS. 19 AND 20. VECTOR SLIDE RULE; GENERAL ELECTRIC CO., LTD.

1 millivolt, 100 microvolts and 10 microvolts on the three ranges, the accuracy being to within 0·1 per cent., or one division. A pointer galvanometer is incorporated and is sufficiently sensitive for most purposes, but an external galvanometer can be used through a jack socket if required. A small dry-cell accumulator and miniature standard cell are also incorporated, so that the instrument is self-contained. A switch disconnects the accumulator and short-circuits the galvanometer when the lid is closed.

Fig. 22 shows a sin/cos potentiometer which was exhibited by the same firm and is a precision instrument with a number of applications in electronic computing equipment. It produces two sine and two cosine outputs which are derived from four potentiometers, the sliders of which are driven by two Scotch crossheads. This drive, which is normally geared down to 8 to 1, has special bearings and is sprung to eliminate backlash. The potentiometer windings have a resistance of 48,000 ohms and a working voltage up to 250 may be employed. The overall accuracy is to within 1 per cent. and the mechanism operates normally over a temperature range of -40 deg. to $+70$ deg. C.

Mention may also be made of an improved version of the firm's *p*H meter. This has a built-in manual temperature compensator which allows any electrode system to be used, and an electrode kit which enables at least three basic assemblies to be set up. The glass and reference electrodes are contained in a polythene sheath into the bottom of which is sealed a platinum winding to provide automatic temperature compensation. The same pair of electrodes can be fitted into a clip-type holder to form an open assembly and a rod-type resistance thermometer fitting into a third clip can also be provided. For measuring very small volumes the reference electrode can be rotated in this holder so that its tip is nearly in contact with the glass bulb.

Dawe Instruments Limited, 130, Uxbridge-road, Hanwell, London, W.7, were showing the stroboscope illustrated in Fig. 23, opposite. This is designed for direct operation from the mains and consists of a neon flash tube mounted on a handle in which the necessary controls are housed. The tube is triggered at the mains frequency, an arrangement which increases its simplicity, robustness and cheapness, although it limits its use to some extent. It is, however, recommended for the examination of apparatus the operation of which is dependent on the mains frequency or multiples thereof, including time switches and certain domestic appliances. It can also be used for the examination of induction motors with a small slip relative to the synchronous speed. When both the motor and the stroboscope are connected to the same mains, the rotor will appear to be turning backwards at the speed of the slip. Under these conditions the slip can be counted directly and, if the rotor is loaded, the point at which the torque reaches stalling point can be seen. On synchronous motors the point of pull-out can be tested.

A sound-level indicator was also exhibited by the same firm. This instrument may be regarded as a complement to the firm's sound-level meter by means of which the sound level can be taken to an accuracy of about 1 decibel. Such an instrument may, however, be too elaborate for many routine surveys and the indicator is therefore useful for locating sources of noise by unskilled operators as a preliminary to a more detailed examination. The indicator, which is very compact, consists of a microphone amplifier and meter together with a self-contained battery and can be read by the operator as he walks about. It has a range of 40 to 130 decibels, so that it will cover most sounds within normal audible range.

Fig. 24, opposite, shows a high-gain selective amplifier exhibited by the Plessey Company Limited, Ilford, Essex. This has been designed for use in conjunction with a crystal detector to detect, compare and measure low level modulated radio-frequency voltages. It is provided with two independent input sockets and gain controls, which are selected by a switch. When this switch is in

THE PHYSICAL SOCIETY'S EXHIBITION.

FIG. 21. PORTABLE POTENTIOMETER; W. G. PYE AND CO., LTD.

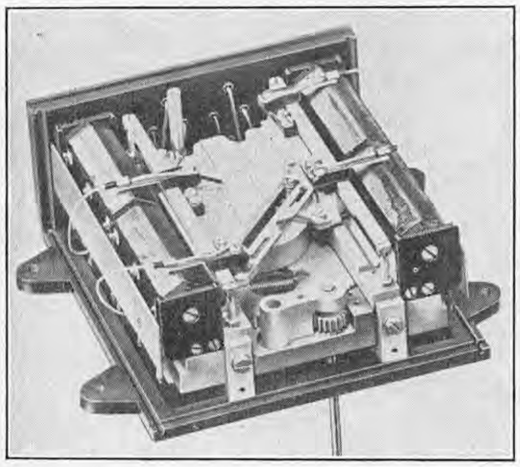


FIG. 22. SIN/COS POTENTIOMETER; W. G. PYE AND CO., LTD.

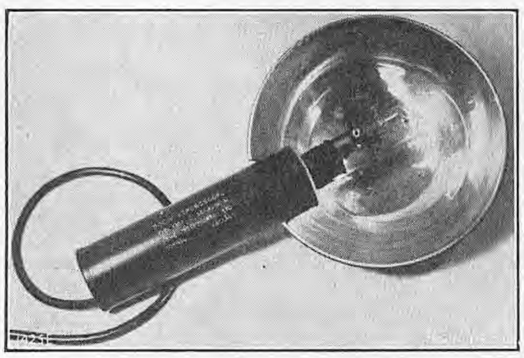


FIG. 23. MAINS-FREQUENCY STROBOSCOPE; DAWE INSTRUMENTS, LTD.

FIG. 24. HIGH-GAIN SELECTIVE AMPLIFIER; PLESSEY CO., LTD.

its central position a 200 kilo-ohm resistor is connected between the input grid and earth, thus giving an indication of the noise generated with this input impedance. A calibrated attenuator and a fine gain control, which are common to both inputs, are also provided. The instrument may be used as a selective or wide-band amplifier. In the former case it can be tuned over the 300 cycle to 6 kilocycle band by frequency control. The maximum sensitivities are not less than 1·6 microvolts in the selective and not less than 4 microvolts in the wide-band condition with the full-scale deflection on the meter. Output sockets are provided for a cathode-ray oscilloscope and an external meter.

The same firm were exhibiting a frequency source calibrator, in which any frequency from 1 kilocycle to 100 megacycles per second can be produced. It is operated by synthesising frequencies with static filters and thus selecting the desired product. The required output has a maximum sideband output of 0·05 per cent.; 10 milliwatts is available for all frequencies up to 10 megacycles and 1 milliwatt for higher frequencies. A system of motor-driven switches is fitted for the selection of required static filters from a manual digit control. Certainty of frequency division is ensured by the use of harmonic selector circuits and, as the output is sinusoidal it is possible to establish the fundamental frequency of a complex input. A built-in dekatron counter permits accurate checking of the narrow range oscillator which is employed for continuous coverage.

The attendance at the exhibition was as numerous as usual, a fact which is not surprising when the wide range of instruments displayed is taken into account. As the foregoing description briefly indicates, not only electronic computers and their associated equipment were on view, but microwave components, semi-conductors and servomechanisms, as well as strain gauge equipment and Geiger Muller counters. The whole formed a striking demonstration of the high quality of British instruments.

LONG FLYING TIME OF JET ENGINES BETWEEN OVERHAULS.

AVON jet engines made by Messrs. Rolls-Royce Limited, Derby, have recently given a convincing demonstration of reliability. To determine the ultimate overhaul life of Avon engines to the latest modification standard, and to assess servicing requirements, the Royal Air Force carried out intensive flying trials on three Canberra aircraft, manned by crews from three different stations. Two engines, examined after 400 hours flying, and one after 450 hours, were found to be in satisfactory condition, and it was therefore decided to continue flying the remaining three engines until 600 hours had been flown. One of these engines has now completed 600 hours at an average utilisation of 12 hours per day, covering about 300,000 miles. The peak utilisation was reached when 73 hours were flown in a period of 84 hours. As the trials progressed, the average turn-round time was reduced from 1 hour 35 minutes to 36 minutes.

To achieve the high utilisation rate, it was often necessary to salt and sand the runways in order to take off. No signs of salt corrosion were evident when the first engine was stripped after 450 hours. Maintenance work during the period of the trial was negligible, and the performance of the engine still conformed to the Rolls-Royce schedule at the end of the 600-hour period, the thrust being within 3 per cent. of the standard figure, and the increase in specific fuel consumption amounting to only 0·11 per cent. The parts rejected after the engine had been stripped and examined comprise four compressor-rotor blades, two auxiliary-drive roller bearings, two auxiliary-drive oil seals, two flexible fuel pipes, and two compressor-shaft taper bolts. The flame tubes, which commonly determine the life of gas-turbines have been accepted for a further 400 hours. The turbine was completely satisfactory.

"DELTIC" HIGH-SPEED MARINE DIESEL ENGINE.

THE "Deltic" marine Diesel engine shown in Figs. 1 and 2, on page 556, has been designed and developed for the Royal Navy by D. Napier and Son, Limited, London, W.3. It is an engine of the opposed-piston type, operating on a two-stroke cycle with cylinders arranged in the form of an equilateral triangle, as shown in Fig. 3, to give an extremely compact layout. The bore is $5\frac{1}{8}$ in. and the stroke $7\frac{1}{4}$ in., giving a total swept volume of 5,384 cub. in. and an effective swept volume of 5,300 cub. in. The piston speed at 2,000 r.p.m. is 2,416 ft. per minute; the brake mean effective pressure at maximum power is 91·9 lb. per square inch; and the maximum shaft horse-power, 2,500, is reached at 2,000 r.p.m., as shown by the performance curves in Fig. 7. The continuous rating is 1,875 s.h.p. at 1,700 r.p.m. The engine has 18 cylinders and 36 pistons, which, like all its other components, are small enough to permit the use of modern aero-engine materials and production methods, and all the individual components and major assemblies have been made interchangeable for ease of replacement and maintenance. It is a self-contained power plant, complete with pumps and filters, and control of both the engine and the reverse gear is effected by a single lever. Two of these engines have been installed in the Navy's Fast Patrol Boat 5212, which is an E-boat taken from the Germans at the end of the second World War. They have nearly completed their initial 1,000 hours of running at sea. The 5212, based at H.M.S. Hornet, Gosport, recently gave a demonstration run for Press representatives.

The triangular disposition of the cylinders is an unusual departure. With this arrangement, one crankshaft must rotate in the opposite direction from the other two; in this case, it is the bottom one. Two advantages arise from this layout. Firstly, there is automatically a phase-angle difference of 20 deg. between the exhaust and inlet crankshafts, which, with the exhaust crankshaft leading, permits the use of an efficient porting layout for scavenging and cylinder charging. Secondly, each crankpin carries one inlet and one exhaust piston so that the load on each crankpin, and therefore the load transmitted by each crankshaft, is identical. By extending the triangular arrangement through the length of a six-throw crankshaft, with each shaft arranged for a cylinder firing order of 1, 5, 3, 4, 2, 6, the resultant 18-cylinder engine has equal firing intervals of 20 deg., giving extremely smooth running.

The triangular body of the engine is built from three identical cast-aluminium six-cylinder blocks which form the sides, and three aluminium crankcases, which form the corners. The upper crankcases are identical, but the lower one is deepened in section to carry engine bearers and to provide for oil drainage. The whole of this unit is held together by high-tensile steel bolts which extend from each crankcase through the cylinder block to the other crankcase. These bolts carry the combustion loads, and the cylinder blocks remain in compression.

The cylinder liners (Fig. 5) are of the wet type, machined from hollow steel forgings. They are located in the cylinder blocks at one end, and rubber water seals are used. Their bores are chromium-plated and finished by lapping. Exhaust ports are provided around approximately half the circumference at one end and the bars between the ports have holes through them for water cooling. The inlet ports at the other end are arranged around the whole circumference, with a tangential entry angle to impart swirl to the inlet and thereby assist scavenging and mixing. Two injectors, of the outward-opening valve type, are provided for each cylinder and both injectors are fed from a single injection pump. The pumps are the C.A.V. type, modified to suit the special requirements of the engine; one is shown in Fig. 6. The six pumps for each cylinder bank are carried on a camshaft casing extending the length of the cylinder block, and all three camshaft casings are interchangeable. The rack control is by a rotating shaft, the pumps being connected together by small couplings which

"DELTIC" HIGH-SPEED MARINE DIESEL ENGINE.

D. NAPIER AND SON, LTD., LONDON.

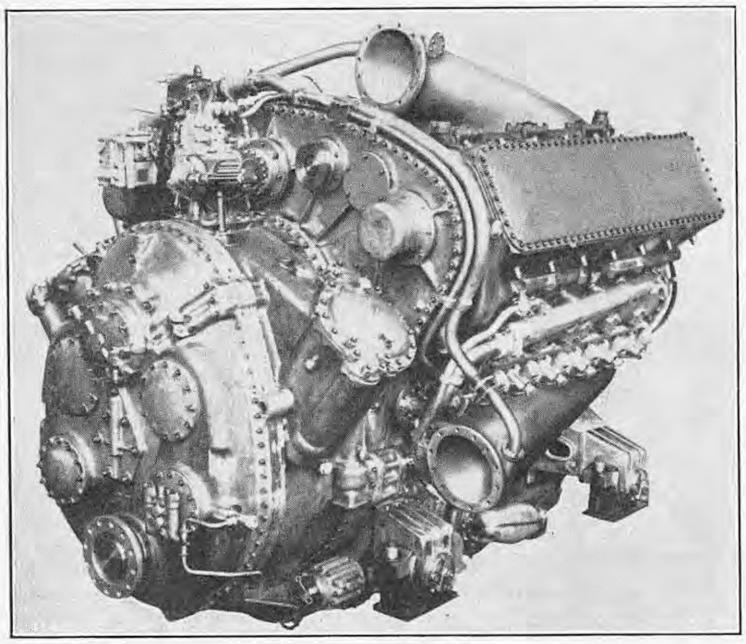


FIG. 1. DRIVING END WITH REVERSE GEARBOX.

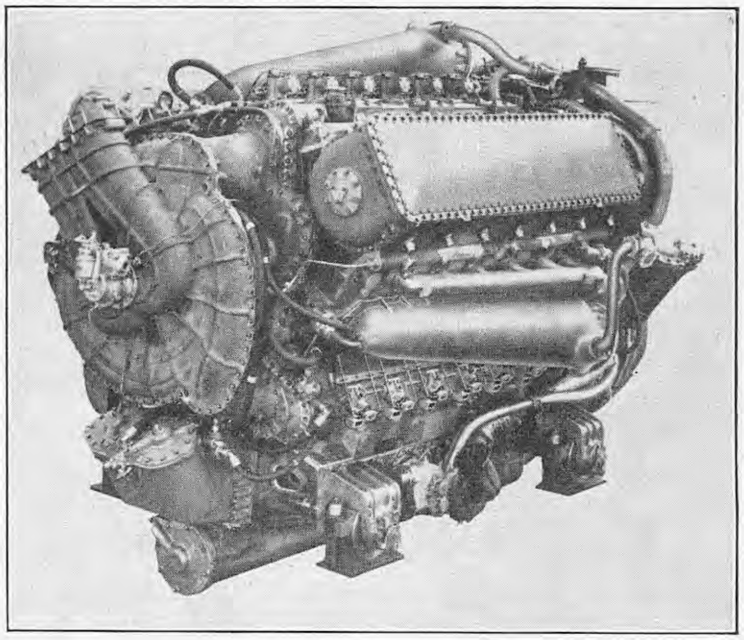


FIG. 2. FREE END WITH SCAVENGE BLOWER.

are torsionally stiff but axially flexible, thereby eliminating differential expansion effects. The design is so arranged that one pump can be removed and replaced by another and the correct timing and matching be automatically retained.

The special patented pistons, shown in Fig. 4, are constructed of two parts held together by a spring circlip. The inner member is machined from a Y-alloy forging and carries a hardened-steel gudgeon pin which fits tightly in it. The outer member is cast aluminium. It has an unbroken skirt and is provided with a cast-in austenitic-iron insert, in which the two top gas rings are seated. Between the outer and inner members is an annular chamber for cooling purposes; it extends from the bottom of the skirt to behind the gas rings. Grooves in the side connect with others that run across the top of the inner member and pass directly beneath the piston crown. Oil is fed to this chamber from the connecting rod, and escape holes are provided. It is claimed that the movement of the piston and continuous flow of the oil cause swilling around these surfaces and aid cooling. The connecting rods are made from high-tensile steel stampings, machined and polished all over, and the two rods connecting to one crankpin are in the form of a fork and blade, one big-end fitting between the yoke of the other. The big-end of the forked rod is fitted with a steel shell, nitrided on its outer surface and carrying in its bore a steel-strip bearing, lead-bronze lined and lead-plated, which runs direct on the crankpin. The outside surface of the shell provides the bearing surface for the blade rod, the big-end of which is also fitted with a steel-strip lead-bronze and lead-coated bearing. The small ends of both rods are drilled for the purpose of feeding oil from the crankpin for small-end lubrication and for piston cooling. The seven-bearing crankshafts are nitrided all over, and the bearing surfaces finished by lapping. The main journals run in steel-strip lead-bronze and lead-plated bearings carried direct in the cast-aluminium crankcases. Oil is supplied to each journal through oil galleries extending the length of the crankcase and thence through passages in the crankshafts to the crankpins.

The three crankshafts are coupled together through gears at one end, and drive a common output shaft, at the centre of the triangle, which runs slightly faster than the crankshafts. By alternative assemblies of idler gears in this phasing system the output shaft rotation can be reversed, the crankshaft rotation remaining unchanged, thus providing a method of meeting the requirement for engines having "handed rotation." The reverse and reduction gearing takes the form of two constant-mesh systems, one for ahead running and one for astern, the appropriate gear train being connected when required by hydraulically-loaded plate clutches. The clutches connect to the output shaft from the phase gear train, and the clutch controls are interconnected with the engine power control. The gear trains in the reverse gearbox also provide appropriate speed reductions; the crankshaft to propeller-shaft gear ratio is 2·106 ahead and 2·397 astern. All main drives for camshafts, pumps, scavenge blower, and other auxiliaries are taken from the driving end of the engine.

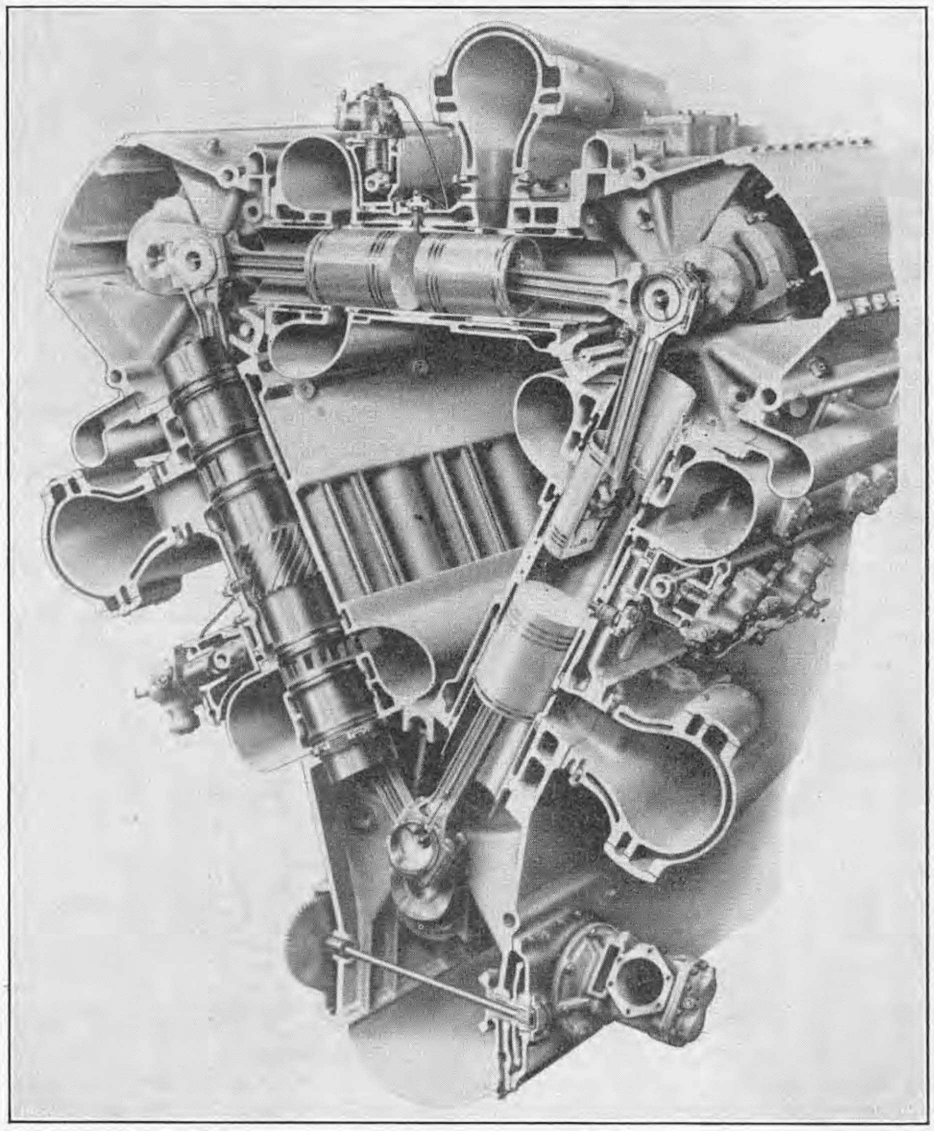


FIG. 3. SECTION THROUGH NO. 5 CYLINDER, VIEWED FROM DRIVING END.

"DELTIC" HIGH-SPEED MARINE DIESEL ENGINE.

D. NAPIER AND SON, LTD., LONDON.

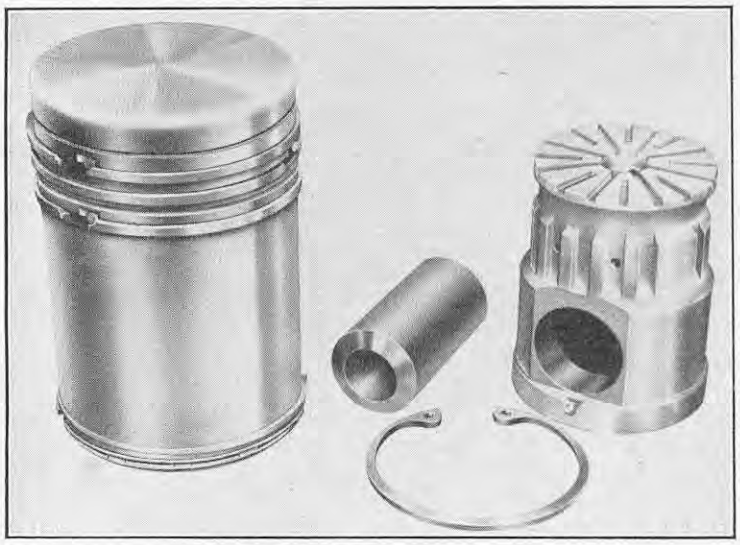


FIG. 4. PISTON COMPONENTS.

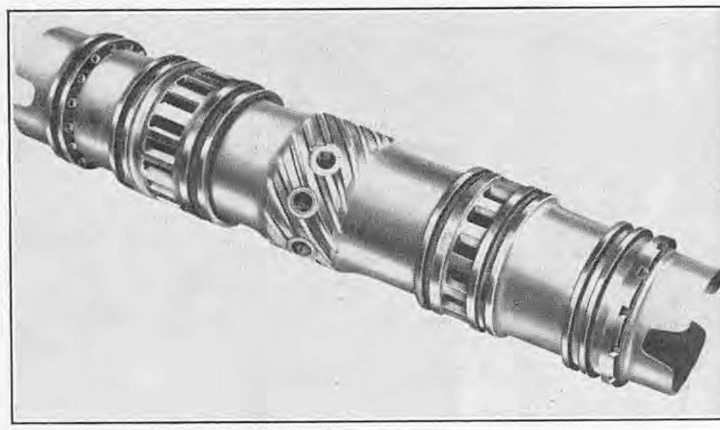


FIG. 5. CYLINDER LINER.

Fig. 7.

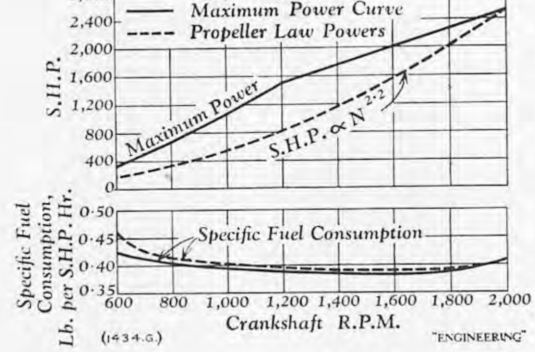
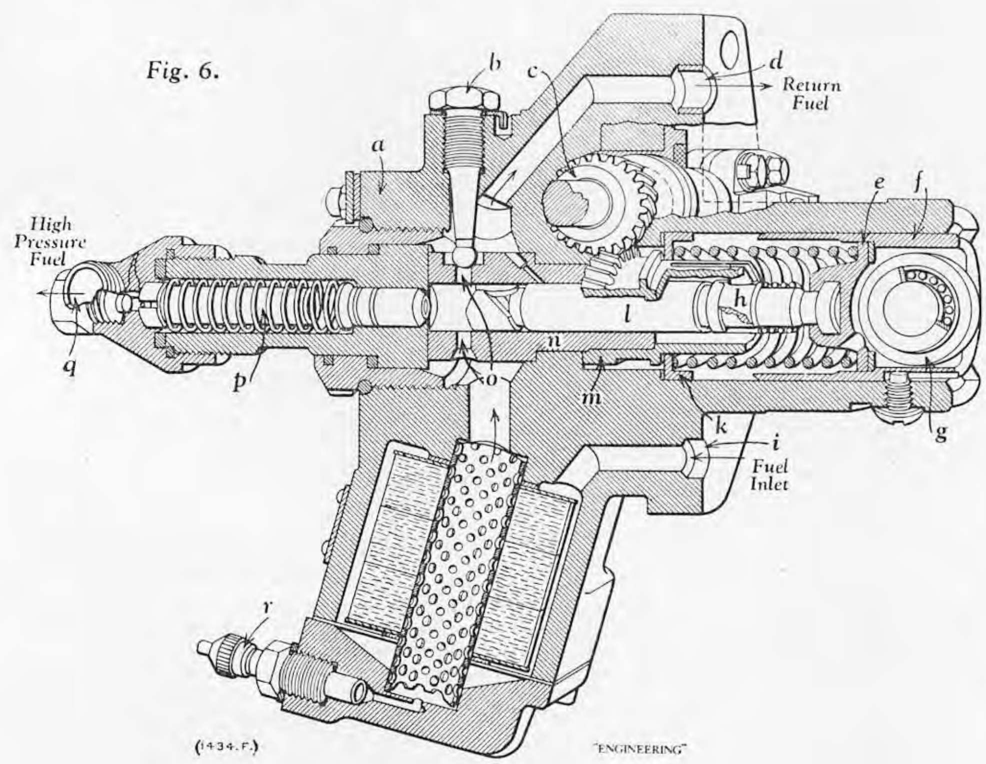


Fig. 6.



a Injection-Pump Housing.
b Barrel-Locating Bolt.
c Control-Rod Gear.
d Return Line Duct.
e Lower Spring Plate.
f Tappet Shell.
g Tappet Roller.
h Plunger Dog Clutch.
i Supply-Line Duct.
k Upper Spring Plate.
l Plunger.
m Control Sleeve.
n Pump Barrel.
o Fill and Spill Ports.
p Delivery Valve.
q Fuel Outlet T-Piece.
r Schrader Air-Release Valve.

Scavenge air for the engine is supplied by a single-stage double-side centrifugal blower. The impeller is cut from a Y-alloy forging and it delivers air through a diffuser into a casing having three exits, one to each bank of cylinders. The blower is driven by two flexible shafts connecting with gears at the driving end of the two top crankshafts. The lubrication system is the dry-sump type, and all bearings and gear meshes are supplied with oil under pressure; the oil is returned to the tank by a scavenge pump. A heat exchanger cooled by sea-water is used for cooling the oil, and thermostats control the oil temperature. The engine is water-cooled and the cylinder jackets form part of a closed system in which distilled water is circulated through a heat exchanger by a centrifugal pump. A thermostatic control is fitted in the circuit and the heat exchanger is cooled by sea-water circulated by a gear-type pump. The starting of the engine is performed by a combustion-type starter, cartridge-operated, the claw of which engages a gear meshing directly with one of the upper crankshafts. The overall length of the engine, including reverse gear, is 10 ft. 11 in., the width is 6 ft. 2½ in., and the height is 7 ft. 1 in. The dry weight, including the reverse gear, is 10,500 lb.

SYNTHETIC RESIN FOR SURFACE PROTECTION OF METALS.

A SURFACE-COATING resin for light alloys and other metals, with exceptional properties of hardness and flexibility, adhesion and chemical resistance, and good dielectric properties, has been developed by Messrs. Cita, Limited, Basle, Switzerland, and is manufactured in the United Kingdom by their associated company, Aero Research, Limited, Duxford, Cambridge. Particulars of the resin are given in Bulletin No. 123 of *Aero Research Technical Notes*, issued by the latter company. Araldite 985 E consists of two components, designated C1 and C3, which are mixed in the proportion of 1 part to 3 parts by weight. After standing for at least 24 hours, the mixture is diluted with solvents such as acetates, ketones, glycol ethers, alcohols and aromatic carbons, the solvent chosen depending on whether the coating is to be applied by spraying, dipping or by rollers. No plasticicers are required, since the coating is highly flexible. Pigments and dyes can be added, and it can be mixed with other resins, but strongly basic pigments may gradually increase the viscosity and decrease the useful life of the mixture.

Before applying the mixture, the metal surface to be coated is degreased. The curing time and temperature, after the metal component has been coated, depends on the desired colour of the coating, which ranges from colourless to brownish yellow. Light yellow or gold coatings provide the highest chemical resistance. Some discoloration occurs at temperatures exceeding 180 deg. C.

The Araldite class of synthetic resins was developed in the first place as adhesives for light alloys; the coating resin Araldite 985 E is a modified form of the adhesive resin, and thus gives an unequalled adhesion to metal surfaces. Under test, two Araldite-coated aluminium-alloy strips, bonded together to form a ½-in. lap joint, have withstood a stress of 3,200 lb. per square inch, when loaded in shear in a tensile testing machine, before the surface coating parted from the metal. The hardness values of Araldite 985 E coatings, in Sward units, range from 77 to 88 (on the Sward scale the maximum hardness value, 100, signifies the hardness of plate glass), and are affected only slightly by stoving conditions. Araldite 985 E coatings were unaffected by six weeks' exposure to tropical conditions—i.e., temperatures ranging from 20 deg. to 35 deg. C., and relative humidity 95 per cent., and were unimpaired by repeated spraying with a salt-water solution, and by a year's immersion in water at room temperature. For resisting boiling water, several coats of the resin are recommended.

The resin is particularly suitable for use in the food-manufacturing and chemical industries, being non-toxic and highly resistant to acids occurring in foods, and many other corrosive agents. Metal panels with a single coating of Araldite 985 E have withstood, without any effect, 30 days in contact with various acids, etc.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

REORGANISATION SCHEME FOR RAILWAYS.—The scheme for the reorganisation of the railways, which will provide, *inter alia*, for the establishment of a Scottish Board, will be ready for submission to the Minister of Transport in the near future, said Lord Hurcomb, chairman of the British Transport Commission, in Glasgow on April 23, after discussions during the week between members of the Commission and Scottish trade and industrial bodies. He said it would be up to the Scottish board to formulate proposals for the electrification of the railways in the Glasgow area.

SUGGESTED "SMOKELESS ZONES" IN SCOTLAND.—The Scottish Fuel Efficiency Committee have suggested to the Government that experiments with smokeless zones, similar to those in Manchester, should be carried out in Glasgow, Edinburgh, Dundee, Aberdeen, Greenock, Paisley, Kilmarnock, and the new towns of East Kilbride and Glenrothes. The Smoke Abatement Society have been asked to associate themselves with the approach.

COUNTY ROAD MAINTENANCE GRANTS.—Estimated grants to county highway authorities in Scotland for road maintenance and minor improvement, in the current financial year, are less by a total of 135,040*l*. than the amounts granted in 1952-53, according to a written answer by the Minister of Transport. The one county showing an increase is Bute, for which the grants are up by 2,442*l*. to 26,500*l*. The largest single estimate is for Fife, at 887,000*l*.

ENGINEERING CENTRE PREMISES.—The premises in Sauchiehall-street, Glasgow, which are to be vacated by the Engineering Centre in September, will be purchased by the South-West Scotland Electricity Board. After alterations, they will become the board's area headquarters.

CLEVELAND AND THE NORTHERN COUNTIES.

MANUFACTURING COSTS AND EXPORTS.—Speaking at his re-election as President of the Tees-side and South-West Durham Chamber of Commerce, Mr. J. C. H. Booth gave a warning that another round of wage increases, like that of 1952 would make the possibility of the export trade drying up a real one. Industry's main task, this year and next, would be to keep down costs to a competitive level. Miners generally led the way in claims for higher wages and he thought that the National Coal Board and the National Union of Mineworkers should try to reach a long-term agreement on wages and prices. This should guarantee stable prices for fuel for several years with progressive reductions as production methods improved. Mr. Booth, referring to local water supplies, expressed regret that Tees-side had lost two new industries because water supplies were not adequate.

RURAL ELECTRIFICATION IN THE NORTH EAST.—At the quarterly meeting of the Consultative Council of the North-Eastern Electricity Board, at Newcastle-on-Tyne, it was reported that the Board had approved development schemes costing 810,838*l*. for supplying electricity to 95 housing schemes and 77 rural areas. It was also announced that during the past quarter, the Board had brought into operation 88 substations, and 101 farms and 10 villages had been supplied with electricity.

TRANSFORMER STATION AT PENRITH.—The North-Western Electricity Board are building a new transformer station at Penrith, Cumberland, to meet the greatly increased demand for electricity locally. Since 1932, the demand for electricity in the district has increased from 320 kW to 15,000 kW, and the number of consumers from 450 to 11,000. The transformer station will tap the Carlisle to Preston transmission line.

FUTURE OF IRON AND STEEL.—In his half-yearly report to the Cleveland-district delegate meeting of the National Union of Blastfurnacemen, Mr. J. Owen, the union's general secretary, expressed fears that with a slowing down in rearmament there might be, in a few years, over-production in the steel industry. The British Iron and Steel Federation was forecasting an output of 17,500,000 tons of steel ingots for this year and the ultimate output was 20,000,000 tons of steel ingots and 15,000,000 tons of pig iron. Mr. Owen said that the output for 1952 had surpassed all expectations. The country's pig-iron capacity had been increased by one million tons by bringing into operation new, or rebuilt, furnaces.

PROPOSED REWARDS FOR WORKS SAFETY SUGGESTIONS.—A suggestion that rewards should be made to workmen in industrial concerns who make worth-while proposals for increasing works safety, was made by Mr. W. D. Pugh, managing director of the Darlington Forge, Ltd., at the annual dinner of the Tees-side Industrial Accident Prevention Council. Mr. Pugh said that workmen sometimes received awards for suggestions to bring about increased production, but he had never heard of an employee being rewarded for a safety recommendation. He said that it might be a good idea to organise a works safety week or a production-with-safety week. Mr. P. G. Horsley, H.M. Inspector of Factories, said that there had been a steady decline in the number of works accidents in the Middlesbrough and Darlington areas in the past few years. In 1948, there were 7,176 accidents. Last year, the figure had dropped to 6,198.

ADMIRALTY TANKER "OLCADES" TO BE SCRAPPED.—The 4,000-ton Admiralty tanker Olcades has arrived at Hughes Bolckow Shipbreaking Co. Ltd., Blyth, for breaking up. Earlier this year, while being towed to Blyth, the Olcades went aground off Norway during a gale. It was decided to scrap the ship after she caught fire at Singapore last year.

LANCASHIRE AND SOUTH YORKSHIRE.

INCREASED COAL PRODUCTION.—Coal consumers are hopeful that the notable increase in coal production in the week ended April 18 is a foretaste of what may be expected in subsequent weeks. Sheffield industrialists complain that they are not able to secure all the coal they require to build up reserves to what they consider safety level. This is partly due to a bigger demand for best steams for export. Yorkshire collieries, in the week ended April 18, had their best production for a normal week this year and, in some instances, records which had stood for twenty years were broken. The aggregate production was 1,066,500 tons.

PLANT EXTENSIONS AT THORNCLIFFE.—An additional mechanised foundry for light castings is nearing completion at the works of Newton, Chambers & Co., Ltd., Thorncliffe, Sheffield. It is to meet the greatly-increased sales of modern fuel-saving stoves and similar products. Progress also is being made with extensions to the mobile engineering department and it is expected that by the end of the year a ½-yd. excavator will be in production to meet the demand for a smaller machine than the new 1½-yd. excavator.

PURCHASE TAX CONCESSION.—A statement by the Sheffield Chamber of Commerce says that the purchase tax concession in the Budget is regarded as an acceptance of a principle rather than a help to the cutlery and silverware industries. Cutting 100 per cent. to 75 per cent. in silverware, it is contended, will not make enough difference to sales to provide the necessary stimulus to demand. It is urged, moreover, that cutlery is as essential as table pottery and should be similarly exempt even from the new 25 per cent. tax.

THE MIDLANDS.

OIL-GAS PLANT.—The West Midlands Gas Board are to erect, at Stafford, an experimental oil-gas plant for the extraction of gas from crude oil. The development of Stafford in recent years has brought increased demands on the existing gasworks (which also supply the nearby town and district of Stone). As a result, there is an urgent need for additional means of producing gas at Stafford. There is, however, a shortage of gas coal in the area. The new plant, which is similar in some respects to a carburetted water-gas plant, will produce 1,000,000 cub. ft. of gas a day. The gas will be mixed with the output of the existing gasworks and distributed through the mains in the normal way.

EXPORT PACKAGING.—Two years ago, George Salter & Co., Ltd., spring manufacturers, West Bromwich, Staffordshire, opened a small department to pack their products to meet Ministry of Supply specifications, for goods to be sent overseas. Only two persons were employed at first, but the company made their services available to other manufacturers, and the staff had to be increased to meet the growing demand. Fifty persons are now employed. The department undertakes packing to Ministry "P.I.P." specifications (preservation, identification and packing), and is at present dealing with only about 5 per cent. of the company's products. The remaining 95 per cent. consists of a wide variety of goods, including electrical, radio and engineering products. Facilities are available for de-rusting, degreasing, and coating or wrapping with approved preservatives.

PARENTS' DAY AT RUGBY WORKS.—On Saturday, April 18, parents of apprentices in their first year at the British Thomson-Houston Co., Ltd., Rugby, had the opportunity of visiting not only the works, including the various apprentice training establishments, but also the Rugby College of Technology and Arts (by the kind permission of the Principal, Mr. W. Cooper), as well as the firm's apprentice residences—Coton House, where just under 300 apprentices are in residence, and The Laurels (Dunchurch Road), together with The Laurels Apprentice Association Club.

PRODUCTIVITY COMMITTEES.—The Midland Regional Board for Industry have decided to set up some 14 local productivity committees, under the scheme proposed by the British Productivity Council. At least one committee will be formed in Birmingham. Other committees will be established to operate in the districts centred on Dudley, Wednesbury and Darlaston, Wolverhampton, Stoke-on-Trent and Stafford, Coventry and Rugby, Leamington, Warwick and Stratford, Worcester, Kidderminster, Shrewsbury and Coalbrookdale.

HOT STRIP ROLLING MILL.—Ductile Steels, Ltd., Willenhall, Staffordshire, have opened a new "planetary" rolling mill for hot-rolling steel strip. The mill has been made to the designs of Sendzimir, Ltd., London, by W. H. A. Robertson & Co., Ltd., Bedford. The opening, which was performed by Mr. C. R. Wheeler, joint managing director of Guest Keen Baldwins Iron and Steel Co., Ltd., Cardiff, coincided with the 21st anniversary of the founding of Ductile Steels, Ltd.

FERGUSON TRACTOR PRODUCTION.—The output of Ferguson tractors by the Standard Motor Co., Ltd., Coventry, is to be raised for the second time this year. The daily production figure will now be 265, instead of 206. The increase has been made possible largely as a result of improved overseas business.

NOTTINGHAM ELECTRICAL CLUB.—It has been decided to form an electrical club in Nottingham to foster co-operation between the various sections of the industry, to participate in social activities, to hold lectures and discussion groups, and to arrange works visits. Particulars of membership may be obtained from the honorary secretary, Mr. J. D. Furse, Traffic-street, Nottingham.

SOUTH-WEST ENGLAND AND SOUTH WALES.

IMPORTS OF ANTHRACITE FROM IRELAND.—Anthracite from Eire—a country which, in the past, has taken considerable quantities of Welsh anthracite—is now being received in the south-western counties of England. The coal comes from a newly-developed mine in County Tipperary and is claimed to be equal to the best Welsh in quality. The theory has been advanced that the seam may be the same as the Welsh. The quantities are so far small and the first was discharged at Fremington for delivery to Ilfracombe.

NEATH BY-PASS ROAD.—The first part of the Neath by-pass road, which is to cost 1,500,000*l*., will be opened either late in 1954 or early in 1955, as a result of steel supplies having been made available for the Neath River Bridge. Steel for the bridge is being fabricated in Darlington and should be delivered on the site this autumn.

CARDIFF CHAMBER OF COMMERCE.—Mr. A. M. C. Jenour, T.D., J.P., chairman of the Aberthaw and Bristol Channel Portland Cement Co., Ltd., has been elected President of the Cardiff Chamber of Commerce. Alderman D. T. Williams, principal of D. T. Williams (Cardiff), Ltd., and Mr. David Skae, managing director of Mountstuart Dry Docks, Ltd., have been elected vice-presidents. Mr. Jenour is a director of Fernhill Collieries, Ltd., chairman of T. Beynon & Co., Ltd., and the Beynon Shipping Co., Ltd., and the Ruthin Quarries (Bridgend), Ltd.

FRENCH STEELWORKERS VISIT WALES.—Two technical missions, which are shortly to visit the United States, came from France on April 20 to spend a few days in this country, during which they saw some major works in Wales. It was suggested to the steel industry by the French authorities that it would be of great value to members of these two missions if they could be given this opportunity.

NOTICES OF MEETINGS.

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

INSTITUTION OF ELECTRICAL ENGINEERS.—*South Midland Centre:* Monday, May 4, 6 p.m., James Watt Memorial Institute, Great Charles-street, Birmingham. "Telemetering for System Operation," by Mr. R. H. Dunn and Mr. C. H. Chambers. *North-Western Centre:* Tuesday, May 5, 6.15 p.m., Engineers' Club, Albert-square, Manchester. Annual General Meeting. "Design Features of Certain British Power Stations," by Mr. S. D. Whetman and Mr. A. E. Powell. *North Midland Centre:* Tuesday, May 5, 6.30 p.m., Offices of the Yorkshire Electricity Board, 1, Whitehall-road, Leeds. Annual General Meeting. *Utilization Section:* Thursday, May 7, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. Lecture on "Research in the Electrical Manufacturing Industry," by Mr. L. J. Davies. *Radio Section:* Wednesday, May 13, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. Section Annual Lecture on "Recent Work in France on New Types of Valve for the Highest Radio Frequencies," by Dr. R. Warnecke and Mr. P. Guenard. *Institution:* Thursday, May 14, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. Annual General Meeting (for corporate members only). *London Students' Section:* Monday, May 18, 7 p.m., Savoy-place, Victoria-embankment, W.C.2. Annual General Meeting and Film Display.

INSTITUTION OF CIVIL ENGINEERS.—*Railway Engineering Division:* Tuesday, May 5, 5.30 p.m., Great George-street, Westminster, S.W.1. "The Design and Equipment of Modern Mechanised Marshalling Yards," by Mr. R. E. Sadler. *Structural and Building Engineering Division:* Thursday, May 7, 5.30 p.m., Great George-street, Westminster, S.W.1. Discussion on "Would the Strength Grading of Ordinary Portland Cement be a Contribution to Structural Economy," opened by Mr. E. Burke, Dr. L. J. Murdock, Dr. F. M. Lea, and Mr. F. S. Snow. *Midlands Association:* Thursday, May 14, 6 p.m., James Watt Memorial Institute, Great Charles-street, Birmingham. Annual General Meeting.

INCORPORATED PLANT ENGINEERS.—*London Branch:* Tuesday, May 5, 7 p.m., Royal Society of Arts, John Adam-street, Adelphi, W.C.2. "Running a Hotel," by Mr. E. C. S. Price. *South Wales Branch:* Wednesday, May 6, 7.15 p.m., South Wales Institute of Engineers, Park-place, Cardiff. Discussion on "Modern Electrical Control Systems." *Southampton Branch:* Wednesday, May 6, 7.30 p.m., Polygon Hotel, Southampton. "Pumps and Pumping," by Mr. J. B. Scivier. *Dundee Branch:* Monday, May 11, 7.30 p.m., Mather's Hotel, Dundee. "Textile Machinery," by Mr. Robert Baird. *East Lancashire Branch:* Tuesday, May 12, 7.15 p.m., Engineers' Club, Albert-square, Manchester. Film Display. *East Midlands Branch:* Wednesday, May 13, 7 p.m., Welbeck Hotel, Nottingham. "Industrial Applications of the Thickness Gauge," by Mr. R. Y. Parry.

BRITISH INSTITUTION OF RADIO ENGINEERS.—*London Section:* Wednesday, May 6, 6.30 p.m., London School of Hygiene and Tropical Medicine, Keppel-street, Gower-street, W.C.1. "Recent Advances in the application of Electronics to Chemical Instrumentation," by Mr. G. I. Hitchcox. *Merseyside Section:* Thursday, May 7, 6.45 p.m., Electricity Service Centre, Whitechapel, Liverpool. Annual General Meeting. "The Development of the Radio and Electronics Industry in India," by Mr. G. D. Clifford.

JUNIOR INSTITUTION OF ENGINEERS.—*Midland Section:* Wednesday, May 6, 7 p.m., James Watt Memorial Institute, Birmingham. "Some Notes on the Technique of Casting Aluminium Billets by the Semi-Continuous Process," by Mr. E. Mitcheson.

ROYAL SOCIETY.—Thursday, May 7, 4.30 p.m., Burlington House, Piccadilly, W.1. Bakerian Lecture on "Dislocations, Plastic Flow and Creep in Metals," by Professor N. F. Mott, F.R.S.

LEEDS METALLURGICAL SOCIETY.—Thursday, May 7, 7.15 p.m., Chemistry Department, The University Leeds. Annual General Meeting. Various short papers by junior members.

CHEMICAL SOCIETY.—Thursday, May 7, 7.30 p.m., Chemical Society's Apartments, Burlington House, Piccadilly, W.1. Various short papers for discussion.

ROYAL INSTITUTION.—Friday, May 8, 9 p.m., 21, Albemarle-street, W.1. "The Civil Engineer in the Laboratory," by Professor A. J. Sutton Pippard. Friday, May 15, 9 p.m., 21, Albemarle-street, W.1. "The Observational Evidence for an Expanding Universe," by Dr. Edwin Hubble.

ILLUMINATING ENGINEERING SOCIETY.—Tuesday, May 12, 6 p.m., Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Annual General Meeting.

INSTITUTION OF PRODUCTION ENGINEERS.—*Birmingham Graduate Section:* Tuesday, May 12, 7 p.m., James Watt Memorial Institute, Great Charles-street, Birmingham. "Mechanised Inspection," by Mr. J. Loxham. *Wolverhampton Graduate Section:* Tuesday, May 12, 7.30 p.m., Star and Garter Royal Hotel, Victoria-street, Wolverhampton. Brains Trust Meeting on "Production Engineering Problems." *Stoke-on-Trent Section:* Friday, May 15, 7.30 p.m., Building Department, North Staffordshire Technical College, Cauldon-place, Shelton, Stoke-on-Trent. "Education for Industrial Management," by Professor T. U. Matthew. *Sheffield Graduate Section:* Tuesday, May 19, 6.30 p.m., Royal Victoria Station Hotel, Sheffield. "The Application of Tungsten-Carbide Tooling," by Mr. A. Brooke.

ROYAL SOCIETY OF ARTS.—Wednesday, May 13, 2.30 p.m., John Adam-street, Adelphi, W.C.2. Trueman Wood Lecture on "Training for Science and Technology," by Sir Richard Southwell, F.R.S.

ROYAL STATISTICAL SOCIETY.—*Research Section:* Wednesday, May 13, 5.15 p.m., London School of Hygiene and Tropical Medicine, Keppel-street, Gower-street, W.C.1. "New Light on the Correlation Coefficient and Its Transforms," by Professor Harold Hotelling. *Study Section:* Tuesday, May 19, 6 p.m., Lighting Service Bureau, 2, Savoy-hill, W.C.2. "Sample Surveys and Their Use for Administrative Purposes," by Mr. L. Moss.

SOCIETY OF CHEMICAL INDUSTRY.—*Corrosion Group:* Wednesday, May 13, 6.30 p.m., Chemical Society's Apartments, Burlington House, Piccadilly, W.1. Annual General Meeting. Chairman's Address on "Corrosion: A Field for Action," by Dr. W. H. J. Vernon.

INSTITUTION OF STRUCTURAL ENGINEERS.—*Wales and Monmouthshire Branch:* Wednesday, May 13, 6.30 p.m., Mackworth Hotel, Swansea. Annual General Meeting. *Institution:* Thursday, May 14, 6 p.m., 11, Upper Belgrave-street, S.W.1. "The Structural Aspect of Power-Station Design in South Africa," by Mr. G. M. Frost. Thursday, May 21, 5.30 p.m., Royal Technical College, George-street, Glasgow. Annual General Meeting of the Institution. "Engineering Aspects of the New Atomic Research Extension, University of Glasgow," by Mr. D. M. Hamilton and Mr. J. Hardie Glover.

INSTITUTION OF SANITARY ENGINEERS and INSTITUTION OF HIGHWAY ENGINEERS.—Thursday, May 14, 6 p.m., Caxton Hall, Victoria-street, Westminster, S.W.1. Joint Meeting. Discussion on "Re-Instatement of Pipe Trenches: Public Utilities Street Works Act, 1950," to be opened by Lieut.-Col. S. M. Lovell and Mr. N. J. Tatman.

ROYAL METEOROLOGICAL SOCIETY.—Wednesday, May 20, 5 p.m., 49, Cromwell-road, South Kensington, S.W.7. (i) "Annual Recurrences in Edinburgh Temperature," by Mr. D. H. McIntosh; (ii) "Climatic Fluctuations in the Greenland and Norwegian Seas," by Mr. P. R. Brown; and (iii) "The Mean Temperature of Central England, 1698 to 1952," by Mr. G. Manley.

PHYSICAL SOCIETY.—*Acoustics Group:* Thursday, May 21, 10 a.m. and 2.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, Westminster, S.W.1. Joint All-Day Meeting with the ROYAL AERONAUTICAL SOCIETY on "Aeronautical Acoustics, with Special Reference to Jet Noise."

LAUNCHES AND TRIAL TRIPS.

M.S. "SAMOA."—Single-screw cargo vessel, built and engined by Burmeister and Wain, Ltd., Copenhagen, for the East Asiatic Co., Ltd., Copenhagen, Denmark. Main dimensions: 456 ft. between perpendiculars by 62 ft. 6 in. by 29 ft. 6 in. to second deck; deadweight capacity, 9,944 tons on a draught of 26 ft. 4 in. B. and W. seven-cylinder single-acting two-stroke Diesel engine, arranged for burning boiler or Diesel oil and developing 9,800 i.h.p. at 115 r.p.m. in service. Speed, about 16·8 knots. Launch, March 12.

M.S. "LONGFELLOW."—Single-screw vessel, designed for the carriage of bulk cargoes, built by Henry Robb, Ltd., Leith, for the Rodney Steamship Co., Ltd., London, E.C.4. Main dimensions: 335 ft. between perpendiculars by 50 ft. by 26 ft. 6 in. to upper deck; deadweight capacity, about 5,500 tons on a mean draught of 21 ft. 10 in. Five-cylinder Diesel engine, developing 2,000 b.h.p. at 155 r.p.m., constructed by Sulzer Brothers, Ltd., Winterthur, Switzerland. Service speed, 11 knots. Launch, April 14.

M.S. "SYLVAFIELD."—Single-screw oil tanker, built and engined by William Doxford & Sons, Ltd., Sunderland, for Hunting & Son, Ltd., Newcastle-upon-Tyne. Second of two vessels for these owners. Main dimensions: 515 ft. by 70 ft. by 39 ft.; deadweight capacity, 16,500 tons on a draught of 30 ft. Doxford six-cylinder opposed-piston oil engine, developing approximately 6,450 b.h.p. at 117 r.p.m., and a speed of about 14 knots. Launch, April 14.

M.S. "IREX."—Single-screw oil tanker, built and engined by Harland and Wolff, Ltd., Belfast, for Sameiet Irex (Managers: Hans Kiaer & Co.), Fredrikstad, Norway. Main dimensions: 460 ft. between perpendiculars by 59 ft. by 34 ft. 10 in.; gross tonnage, 8,200; deadweight capacity, 12,000 tons on a draught of 27 ft. 6 in. Harland-B. and W. six-cylinder single-acting four-stroke Diesel engine. Launch, April 15.

PERSONAL.

SIR HARRY RAILING, M.I.E.E., has been re-elected President of the British Electrical and Allied Manufacturers' Association, 36 and 38, Kingsway, London, W.C.2, for a further year of office. MR. D. D. WALKER, M.A., M.I.E.E., has been elected chairman in succession to MR. T. F. LISTER, and MR. E. H. BALL has been elected vice-chairman.

MR. P. D. CANNING has been elected chairman of the Radio and Electronic Components Manufacturers' Federation in succession to MR. H. V. SLADE.

MR. C. B. CHARTRES, C.B.E., has been elected an honorary member of the Institution of British Agricultural Engineers, 24, Portland-place, London, W.1.

MR. J. A. V. WATSON, O.B.E., director and general manager of the Castrol oils department, has been elected to the boards of the associate companies of C. C. Wakefield & Co. Ltd., 46, Grosvenor-street, London, W.1, namely, W. B. Dick & Co. Ltd., and J. B. Pillin Ltd. MR. H. H. R. DROSSI has relinquished his directorship of W. B. Dick & Co. Ltd., owing to ill-health.

DR. S. W. SAUNDERS has been appointed joint managing director of I.C.I. (Billingham Division) in succession to DR. R. HOLROYD, who has been appointed to the main board.

MR. A. L. HANCOCK, B.Sc., has been elected a director of Walker, Crosweller & Co. Ltd., Cheltenham, and of their subsidiary company, the Arkon Manufacturing Co. Ltd.

MR. MERVYN F. BOYD, technical manager, has been appointed a director of William Hamilton & Co. Ltd., shipbuilders, Port Glasgow.

MR. H. O. HINTON, O.B.E., T.D., and MR. E. COOPER, have been appointed to the board of directors of A. C. Morrison (Engineers), Ltd., Loughborough.

MR. J. HENDERSON, of C. A. Parsons & Co. Ltd., Newcastle-upon-Tyne, has been elected chairman of the North-Eastern section of the Institute of Welding in succession to MR. C. STEVENSON.

MR. JOHN S. BIRD has been appointed sales liaison executive of Kent Alloys Ltd., Temple Manor Works, Rochester, Kent.

MR. T. L. KENDALL, director and marine manager of Ruston and Hornsby, Ltd., Lincoln, has relinquished his marine-engine post to become sales director of the company. The new marine sales manager is MR. P. H. HYLTON, M.I.Mar.E., A.I.N.A.

MR. W. R. CLARK LEWIS, M.Inst.T., has retired from the position of traffic manager to Babcock & Wilcox Ltd., after 45 years of service.

MR. W. B. G. COLLIS, M.B.E., T.D., B.Sc., A.M.I.E.E., has been appointed assistant sales manager, traction department, Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17. He is in charge of traction sales in London.

ROSE, DOWNS & THOMPSON LTD., Old Foundry, Hull, have concluded an agreement with MR. VICTOR MERZ and MERZ PATENTS LTD., for the manufacture and sale throughout the world, under sole licence, of the whole range of Merz solvent extraction plants. Mr. Victor Merz has joined the organisation at Hull.

MACKAY INDUSTRIAL EQUIPMENT LIMITED, Faggs-road, Feltham, Middlesex, sole concessionaires in the United Kingdom for the industrial tractors made by the ALLIS-CHALMERS MANUFACTURING CO., announce that the latter company have acquired the former LA PLANT CHOATE organisation and will produce their motor scrapers and motor wagons. An agreement has been reached whereby JOHN BLACKWOOD HODGE & CO., LTD., will continue to furnish spares and provide services for La Plant Choate scrapers and equipment already operating in this country.

MR. L. J.-B. FORBES, Fourth Floor, 165, Bloor-street East, Toronto, 5, has been appointed general representative, in Canada, of Vickers Ltd., and of their subsidiary and associated companies.

THE BRUSH ELECTRICAL ENGINEERING CO., LTD., Loughborough, have opened a new branch office at 14-16, Baldwin-street, Bristol, 1 (Telephone: Bristol 27000), to serve the West of England. The manager is MR. J. H. BEAUMONT ROBINS, B.Sc., A.M.I.E.E., A.M.I.Mech.E. The temporary office in Bath has now been closed.

WILLIAM CURRIE & CO. (RUBBER MANUFACTURERS) LTD., Caledonian Rubber Works, Edinburgh, 11, have opened a new London office at 44, Tower Hill, E.C.3. (Telephone: ROYal 1461). MARSHALL-HOWLETT LTD. have been appointed Messrs. Currie's London agents.

The sales and technical departments of the refractories group of the MORGAN CRUCIBLE CO. LTD., Battersea Church-road, London, S.W.11, are now operating from the firm's works at Neston, Wirral, Cheshire.

The goodwill and assets of the AJAX MACHINE TOOL CO. LTD., makers of radial drilling machines, and AJAX DOMESTIC APPLIANCE CO. LTD., have now been transferred to ADA (HALIFAX) LTD.

ENERGY CONSUMPTION OF STEEL AND LIGHT-ALLOY ELECTRIC TRAINS.

(*For Description, see Page* 566.)

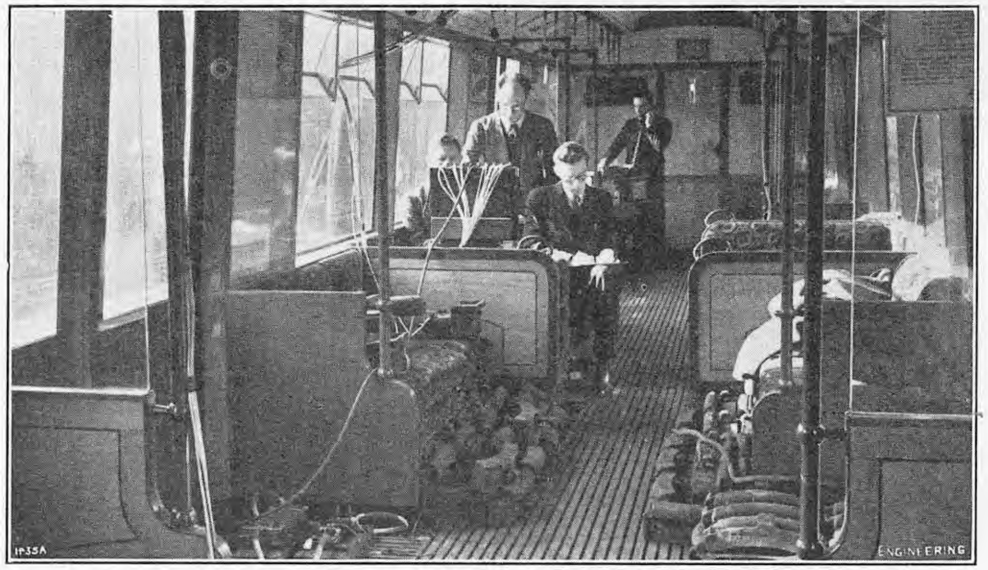


Fig. 1. Light-Alloy Car with Blocks to Simulate Passenger Load.

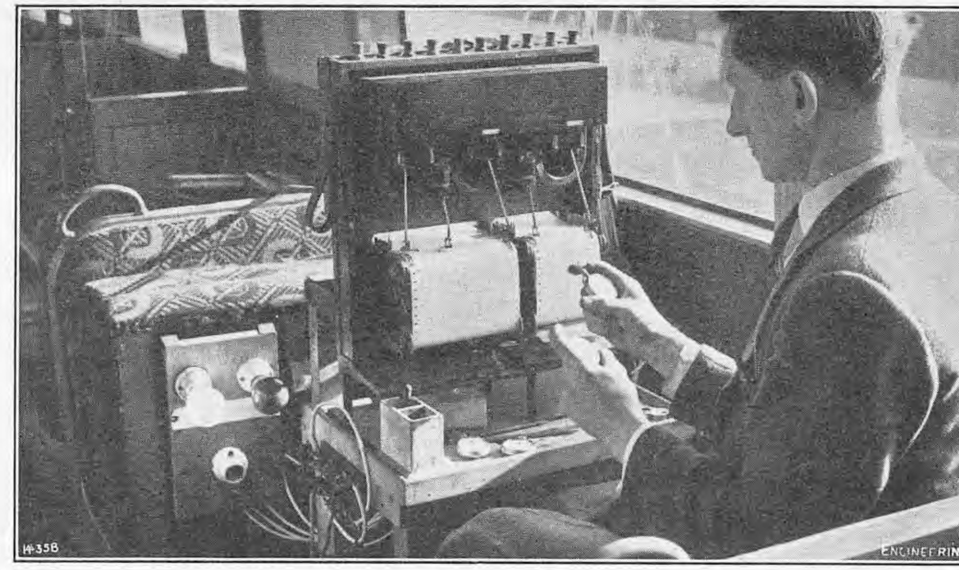


Fig. 2. Observer in Light-Alloy Train.

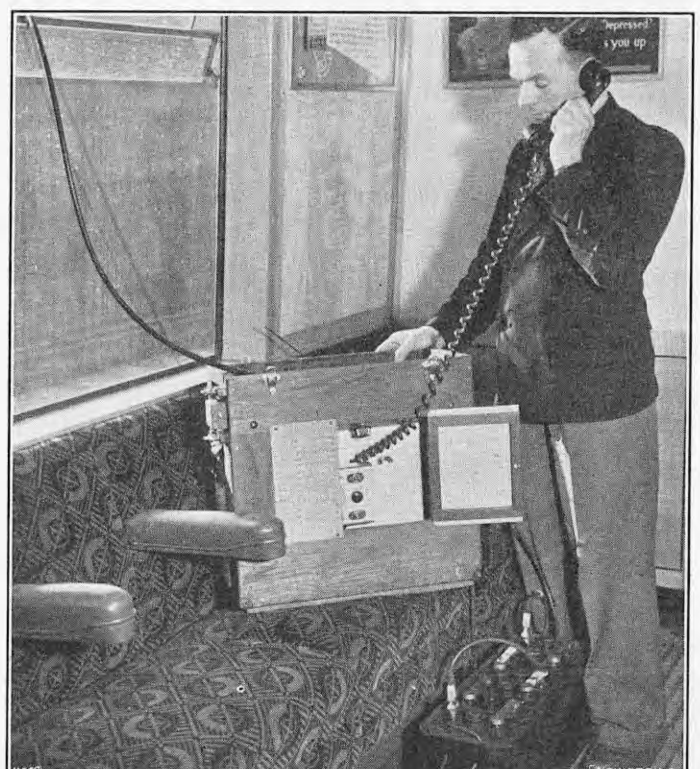


Fig. 3. Radio-Telephone for Communicating with Substation.

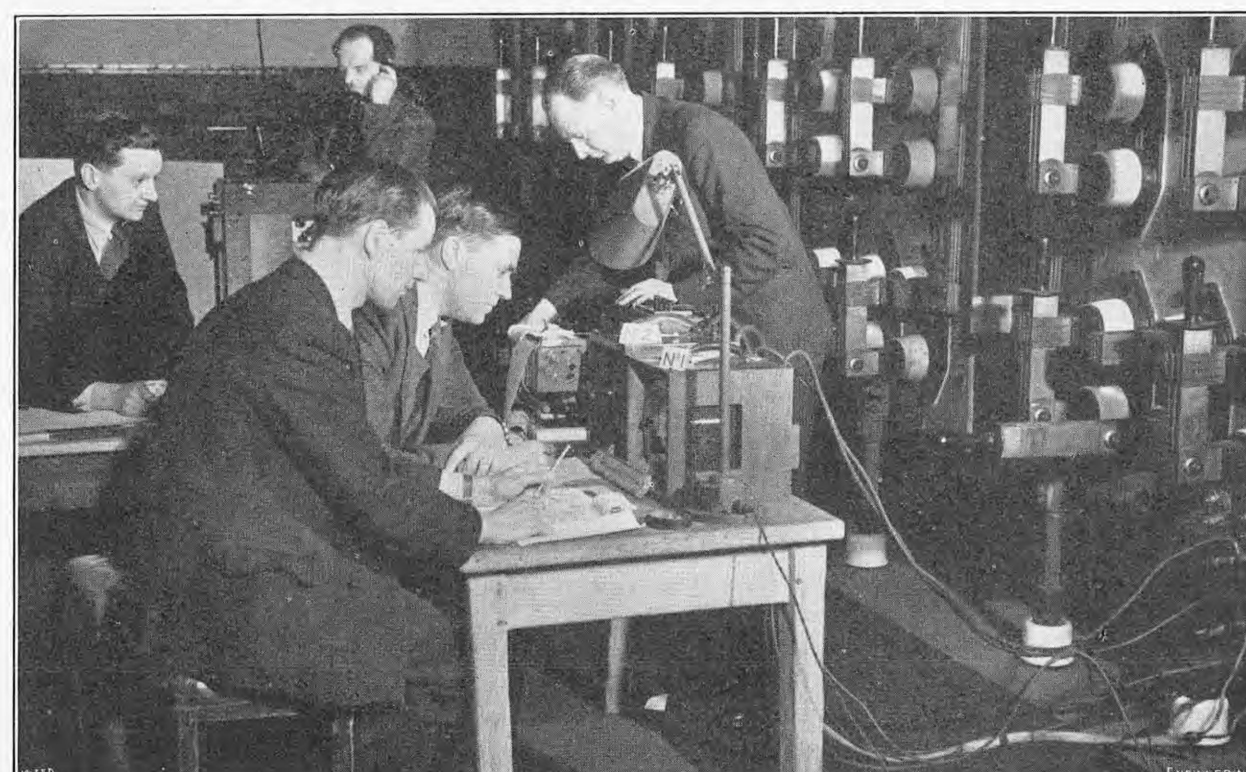


Fig. 4. Test Equipment in Northfields Substation.

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Telegraphic Address :

ENGINEERING, LESQUARE, LONDON.

Telephone Numbers :

TEMPLE BAR 3663 and 3664.

All editorial correspondence should be addressed to the Editor and all other correspondence to the Manager.

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

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

For the United Kingdom and all places abroad, with the exception of Canada	£5 10 0
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Subscriptions for periods less than twelve months are based on the price of a single copy, namely, 2*s.* 3*d.* post free.

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ENGINEERING

FRIDAY, MAY 1, 1953.

VOL. 175. No. 4553.

BOILER AVAILABILITY.

It was in the early years of the second World War that, on the suggestion of the Central Electricity Board, the Boiler Availability Committee was formed. At that time, the maintenance and increase of electricity supply was of primary importance and, as the conditions ruling greatly limited the possibility of installing new boilers, those in operation were operated at their maximum capacity. Boilers and turbo-generators constitute the two main items in a power station, and while it may broadly be said that the latter will run continuously under full load throughout a winter of heavy demand, the former may have to be taken out of operation, or may have to be derated, after comparatively short periods owing to deposits.

The research work carried out under the auspices of the Boiler Availability Committee was sponsored by the Water-Tube Boilermakers' Association and was supported by a number of the larger electricity-supply undertakings, which actively collaborated in investigation and tests. When the electricity-supply industry was nationalised in 1948, these undertakings went out of existence, but the new British Electricity Authority continued the support given to the Committee, which is thus, at the present time, financed by the Water-Tube Boilermakers' Association and the Authority. The Committee now also includes representatives of the British Coal Utilisation Research Association and the Fuel Research Station.

Although the power-supply position is now better than it was in the early years of the war, boiler outages and derating are still of crucial importance. As an example of the conditions which may arise, the Second Interim Report,* published recently, quotes the case of two high-pressure boilers, fired by retort stokers, in Battersea Power Station, which in the initial stages of operation had to be derated owing to serious deposit trouble and even then had to be shut down at the end of periods varying from 300 to 600 hours, depending on combustion conditions, boiler load and fuel quality.

The cause of deposits in water-tube boilers is a highly complicated problem involving physical, chemical and engineering factors. Power-station operators will not find that this Interim Report puts forward any general solution for their troubles. The type of grate, the method of firing and the constituents of the coal used all have important influence and their interaction and relations in boilers present what may fairly be called an enigma which is likely to require years of work in power station and laboratory before it is solved. The report gives information about work which has been carried out, and is in progress, on various aspects of the matter and furnishes guidance which may help towards improvement even though it may not carry determinate solutions.

There is, however, one procedure, easy to specify, although perhaps not always easy to carry out in practice, which in the opinion of the Committee is "a vital necessity . . . if maximum availability is to be obtained." This is to clean boiler plant, "thoroughly down to the bare metal." The Committee did not merely make this recommendation without guidance about how to carry it out, but, in September, 1945, issued an instructive report with the title "Methods of Cleaning Modern Stoker Fired Boiler Plant." Some account of this report appeared in our issue of November 9, 1945. Water lancing, one of the basic operations in cleaning, was introduced during the war. Briefly, it consists in subjecting the slag to repeated quenchings with cold water while the boiler is under load. The operation has the effect of loosening the scale so that it falls away. The intervening years have in no way lessened confidence in this procedure, and the present reports state that the methods remain "the most effective practical method of improving availability."

The report lists three types of high-temperature deposit and two types of low-temperature deposit. The former are the alkali-matrix type, consisting of fly-ash particles bonded by a matrix of sulphates or pyrosulphates of sodium and potassium, mainly occurring on superheater surfaces; phosphatic type resulting from the chemical attack on fly-ash particles by acidic phosphorus compounds; and fusion or slag-type deposits consisting of fly-ash particles bonded together as a result of sintering or fusion, usually with an inner layer of alkali sulphate where the deposit is attached to the tubes. The two types of low-temperature deposit are economiser deposits usually consisting of masses of the sulphates and phosphates of iron, calcium and aluminium (they are most difficult to remove when consisting of more than 10 per cent. of phosphate); and, secondly, air-heater deposits, consisting of accumulations of loose dust usually consisting of a mixture of flue dust, sulphuric acid and the products of acidic corrosion of the underlying metal surfaces.

It is obvious that the constituents of the coal which is being burned are of major importance in both corrosion and the formation of deposits. Investigations have shown that sodium, potassium, sulphur and phosphorus are mainly responsible for bonded deposits and corrosion, and that calcium and iron may have much influence in the formation of slag deposits. There is much evidence showing that the formation of deposits is to a considerable

* *Second Interim Report on External Deposits and Corrosion in Boiler Plant* (1946-1951). The Boiler Availability Committee, 8, Waterloo-place, Pall Mall, London, S.W.1.

extent dependent on the nature of the fuel bed and the furnace conditions, and also that pulverised-fuel fired boilers are less subject to deposit troubles than stoker-fired boilers, although, in connection with this latter point, the report issues a warning that, in view of the trend towards higher steam temperatures, it cannot be assumed that pulverised-fuel firing will always retain this advantage. As, however, it is broadly established that firing conditions as well as coal constituents are important agents in the formation of deposits, something may be done towards eliminating trouble by allocating various classes of coal to the types of boiler best fitted to deal with them, and the report contains a table relating the various classes of coal to the type of boiler in which they should preferably be burned. It is clear that such allocation on any considerable scale would be difficult, owing to transport and other considerations, but it has been found possible to effect coal redistribution in some individual cases with good results.

Laboratory investigations and practical work have established that the presence of sulphur trioxide in the flue gases is one of the major factors in the formation of deposits, and much attention has been given to the problem of ascertaining under what conditions it may be produced. One opinion holds that it is produced by dissociation of sulphates in the fuel bed; another is that it is formed in combustion chambers and in boiler passes, where secondary combustion occurs, by the combination of sulphur dioxide and atomic oxygen. As combustion temperatures in modern boilers may be of the order of 2,500 deg. F., and as sulphur trioxide is highly unstable at such temperatures, a third opinion is that its production must occur after the combustion process has taken place and that the subsequent catalytic oxidation of sulphur dioxide on the heating surfaces is the responsible factor. The initial cause of sulphur trioxide is naturally the sulphur in the coal, and it is stated that the percentage in the coals available is tending to increase. The average is 1·5 per cent., the higher figure in some cases being as much as 5 per cent.

An investigation was carried out at Ribble Power Station to determine if this hypothesis about the formation of sulphur trioxide was valid. The station, which burned fifty varieties of coal with an average sulphur content of 2·8 per cent., presented severe availability problems. Superheater blockage made it impossible to keep the boiler plant in commission for more than from two to four weeks, and it became necessary to by-pass the air heaters. It was thought that sulphur trioxide was probably formed at the superheater tube surfaces, which reached a temperature of 1,100 deg. F. with a steam temperature at the superheater outlet of 850 deg. F. To reduce the temperature of the superheater, and its supporting steelwork, the gas speed through the unit was reduced by baffle modifications, further reduction in temperature being obtained by regulating the primary and secondary air controls. After these modifications, it was found that the temperature of the superheater metal had fallen by more than 200 deg. F. and that there was also a reduction in the gas temperature at the boiler outlet. The requisite superheated steam temperature could, however, still be maintained and it was possible to bring the air heaters into continuous operation. Superheater fouling, air-heater blockage and corrosion have been so reduced that the boilers can be operated from one annual inspection to the next.

The Committee has also published a report on the relationship between the chlorine content of coal and boiler availability, a summary of papers, and a bibliography of papers relating to the subject with which it is concerned. The four documents will, no doubt, be consulted and studied by all concerned with the design and operation of high-pressure boilers.

AS OTHERS SEE US.

A TEAM consisting of representatives of the American electricity-supply industry visited this country early last year at the request of the British Electricity Authority and has prepared a report which has been published this week.* The main object of the British productivity teams was to discover what could be learnt from the Americans, while that of the American team was to indicate what they could teach us. The traffic was, therefore, essentially " one-way," a fact which should not be allowed to engender inferiority complexes in the psyche of those in this country who are responsible for the operations of an important British industry.

This comment is necessary, since a close study of the American report fails to indicate that very much is wrong with British electricity supply. Moreover, the weaknesses that are disclosed are as often as not due to the operation of external influences, of which the industry is likely to be more aware than any visiting team. Some of the criticisms on technical points are, moreover, due to a natural lack of acquaintance with British conditions and a disregard of the proposition that there may be several ways of doing a thing, all of which are right, as Kipling remarked in commenting upon the writing of tribal lays. The report contains a good deal of history and a fair proportion of statistics, most of which will be familiar to those engaged in the industry and some of which will be read with rather a wry smile. As the contents are directed at a British target, these parts could well have been abbreviated, or even omitted. If they are intended to interest American readers it is significant that there is no hint that anything is other than for the best in the United States or that anything in British practice would be worth adopting.

After a short chapter on the organisation of the British Electricity Authority and the Area Boards, considerable space is devoted to the problems of generation, many of the points in which, it is admitted, have already been dealt with in the reports of the British productivity teams. One criticism is that, while only 0·4 to 0·6 men per megawatt are required in modern American power stations, at Castle Donington the figure will be as high as 1·0, and that the proportion of those engaged on maintenance in British stations generally is unduly high. As regards design, attention is called to the difference in the size of British and American boilers and generating units, to the handicap imposed by the uncertainties surrounding fuel supplies in this country, to the less use of instrumentation, to the larger, even excessive, space allowed for the accommodation of the plant, and the smaller output of the boilers installed; the implication in every case being that these things are better ordered in the States. The use of remote control and centralised control rooms for combined boiler-turbine-electrical operation from one board by one operator is recommended; so, too, are the erection of more plant out of doors and the employment of earth-moving tractors for handling coal. The most important suggestions made, however, are that inland river sites for power stations should be abandoned in favour of those on estuaries and the coast and that, as a corollary, the decision to transmit large blocks of power from stations near the coal mines to the principal load centres should be rescinded. This opinion is based upon what is described as " a distinct impression," but there is no clue as to the identity of the protagonist. It runs counter to the expressed policy of the British Electricity Authority—a policy which has not been adopted without close consideration of all the factors involved.

A chapter on " The Electrical System " deals both with transmission and distribution conditions, and is mainly factual. In commenting on the labour position, it is, however, pointed out that many substation attendants have no authority to operate major equipment except during extreme emergency, and that as these men are " college-trained " there is thus a waste of technical man-power. Failure to adopt the American practice of working on live high-voltage lines is deplored, as is the lack of labour-saving machinery in the construction of both overhead and underground systems. Dealing with more technical points, the opinion is expressed that the capacity of the present 132-kV grid lines could be increased from 90 to 120 MVA by installing capacitors and synchronous condensers at the load centres, and thus relieving the transmission system of the reactive kilovolt-ampere load. If this were done it might be possible to delay the completion of the 275-kV grid, with corresponding economic advantages. The installation of capacitors or synchronous condensers would also enable on-load tap-changing equipment to be eliminated from the present grid substations, thus reducing the cost of voltage regulation, while the same practice would enable the kilowatt load of the generators to be increased. In fact, it is believed that as system loads and generating capacities increase it will be necessary to install automatic equipment to permit better plant loading and the control of frequency within narrow limits. These suggestions are worth attention.

Another aspect of the same subject is embodied in the recommendation that the short-circuit capacity of the circuit-breakers in the larger 33-kV substations should be increased from the present standard value of 750 MVA to 1,500 MVA. It is also suggested that the load on the transformers might more regularly be allowed to exceed the name-plate rating; and that an examination should be made to determine whether the factors which originally dictated the conservative ratings of cables are really justified. In fact, it is argued, substantial savings in investment would be possible if measurements showed that higher loadings were permissible. It is believed, and many will agree, that a major obstacle to the progress of the British electricity supply industry is the number of restrictions placed upon its development, many of which, it is remarked, seem entirely without justification. In particular, requirements regarding road, railway and communication line crossing should be relaxed, conditions regarding strengths should be modified, and the acquirement of way-leaves should be facilitated. Other suggestions are that the joint use of poles by high-voltage lines and communication circuits should be allowed, and mutually-acceptable rules regarding earthing should be formulated.

If we were asked to find a leitmotiv for this report, we should be inclined to say that the team's view was that the electricity supply industry was unduly cautious. The phrase crops up again and again. For instance, the report points out that it would be economically beneficial to install larger turbo-alternators and to supply each from a single boiler. It would be desirable for the same reason to go in for outdoor installations in a big way, to employ steam re-heating and hydrogen cooling more widely, and to take steps both technical and organisational to relax the requirements regarding inspection and overhauls. That there is some truth in all these hints may be admitted, although their full implications must be questioned. One reason is that, in this country, great, perhaps some would say almost morbid, important is laid on the necessity of maintaining the supply—a requirement demanding a margin of safety which, regarded from other aspects, may seem unnecessarily wide. If the industry cannot insist on a verdict of " not guilty," it may at least escape with a judgment of " not proven."

* *The British Electricity System.* British Productivity Council, 21, Tothill-street, London, S.W.1. [Price 3s.]

NOTES.

THE JUNIOR INSTITUTION OF ENGINEERS.

AERONAUTICS was the chief topic of the speakers at the annual dinner, held last week, of the Junior Institution of Engineers—an institution which has been lively for 69 years in spite of, or perhaps because of, its lack of formal examinations. The dinner was held at the Connaught Rooms, London, on April 24 with the President, Air Commodore F. R. Banks, C.B., M.I.Mech.E., in the chair. Mr. S. Scott-Hall, C.B., Director-General of Technical Development (Air), Ministry of Supply, proposing the toast of "The Air and the Future," pointed out that, according to one view, the design of a military aeroplane should start with the weapons; but that, he said, was not true—it started with the engine. The gas turbine had been, at first, almost an embarrassment to the aircraft designer because of the greatly increased drag which the aircraft had to withstand. Gas turbines were, moreover, prodigal in their use of fuels, but improvements were in the offing. For military purposes, there was no limit to high speeds, but for civil applications supersonic speeds were, for the time being, ruled out, because the power required was roughly three times that required at subsonic speeds. Civil aircraft should be designed so that the traveller could readily forget that he was travelling, in the same way that a traveller on the Queen Mary could forget. He had had that impression when travelling in the Brabazon, and he remarked that flying-boats (appropriately, for a nation of seafarers) of very large size could be built. In this country, he thought, we were going to take the lead in the use of helicopters for reducing the time between airport and city. A halt must be called to the current excessively high landing speeds and long runways. Gas turbines might solve the problem in the future, because their thrust-to-weight ratio was approaching unity; vertical take-offs would then be possible, leaving the wings to their proper function, namely, cruising. Speaking of Air Commodore Banks, who responded to the toast, Mr. Scott-Hall said that it was he who had taken the extremely bold step, during the war, of switching aircraft factories from piston engines to jet engines; in Germany, Goring had rejected a similar suggestion. Air Commodore Banks, replying, said that the Institution could help young engineers to gain the experience which was so essential, over and above academic qualifications, to their professional ability and usefulness. He expressed the thanks of the "Juniors" for the facilities granted to members by the Society of British Aircraft Constructors to visit the Farnborough Display on a private day.

INSTITUTION OF ELECTRICAL ENGINEERS.

The proceedings at the meeting of the Institution of Electrical Engineers, on Thursday, April 23, began with the presentation of the Certificate of Honorary Membership to Sir Harry Railing, and of the Faraday Medal for 1953 to Sir Stanley Angwin. Both presentations were made by the President (Colonel B. H. Leeson), who briefly reviewed the careers of the recipients and their connection with the Institution. In returning thanks for the honour the Institution had done him, Sir Harry said that he had chosen electrical engineering as a career because it appealed to him as a philosophy. The work of an electrical engineer provided an opportunity to add something to the knowledge of matter, to extend the use of natural resources and, perhaps, to contribute to the progress of mankind. In acknowledging the presentation of the Faraday Medal, Sir Stanley said he had been fortunate in that his period of service in the British Post Office had coincided with a tremendous advance in radio communication and in long-distance transmission, both by radio and line. In the Post Office, he had received every encouragement to develop the art of telecommunication, and would like to pay a tribute to those who had served with him. The 44th Kelvin lecture, of which we give a summary on page 567, was then delivered by Professor P. I. Dee.

OPERATING COSTS OF AIRCRAFT.

With the revision of the "Standard Method for the Estimation of Direct Operating Costs of Aircraft," the Society of British Aircraft Constructors have made available to airline operators for the first time a standard for comparing the direct operating costs—i.e., the costs depending directly on the aircraft's characteristics—of jet-, propeller-turbine-driven, and piston-engine transport aircraft. The first issue of the standard method, which was designed as a basis for assessing the relative economic merits of different aircraft, was published in 1949 and was reviewed in some detail on page 696 of our 168th volume (1943). At that time, no operating experience of turbine-propelled civil aircraft was available. To-day, British jet- and turbine-propelled transport aircraft have accumulated sufficient flying hours to enable provisional values to be laid down for their capital costs, costs of maintenance and overhaul, and fuel consumption. The turbine-driven aircraft is still in the earliest stages of commercial operation, and the values based on existing experience are expected to give a conservative picture in comparison with piston-engine aircraft. In the revised issue, the values for airframe and piston-engine maintenance and overhaul have also been brought up to date in the light of statistics supplied by air-line operators from various parts of the world; insurance rates have been decreased, as a result of fewer accidents, but the costs of fuel, oil and crews' salaries have risen. In the original issue, a standard annual utilisation of 3,000 flying hours per annum was laid down; for short haul operations, for example, most of the Continental routes, this figure could not readily be attained in practice, and accordingly, in the revised issue, an alternative standard utilisation of 1,500 hours per annum may be adopted in considering cases where the higher intensity of operation is not feasible.

THE INSTITUTE OF FUEL.

When proposing the toast of the Institute of Fuel at the annual luncheon of the Institute, held on April 23 at the Connaught Rooms, London, Mr. Geoffrey Lloyd, P.C., M.P., Minister of Fuel and Power, emphasised that the United States and Russia had a much greater fuel potential than Great Britain and if we in this country wished to maintain our place as a fuel-exporting nation, we must pay the strictest attention to efficient fuel utilisation at home. It was in this matter that fuel technologists and their Institute had a key part to play. In reply, the President, Dr. G. E. Foxwell, stated that the Ministry of Fuel and Power and the Institute of Fuel were conducting work on gas turbines, waste-heat recovery, the heat pump, domestic fuel appliances, and in other directions, which, if carried to their logical end would bring important results. It had sometimes been contended that too many technicians were employed, in proportion to the manual employees, in several of the nationalised industries. If, however, progress towards greater efficiency were to be made, it would be necessary to employ, not fewer, but a far greater number of fuel technologists in these industries. In the course of his speech when proposing the toast of the guests, Sir John Charrington put in a plea that highly-placed executive officers in the nationalised industries should be allowed to get on with their tasks with the minimum of official interference. When responding to this toast, Mr. H. F. H. Jones, deputy chairman of the Gas Council, stated that, in the twelve months from March 31, 1951, to March 31, 1952, the yield of gas from each ton of coal had increased by more than one therm per ton, namely, from 71·62 to 72·77. The use of methane drained from coal mines, with the object of speeding up the extraction of coal and increasing the safety of underground workings, would no doubt add to the resources of the gas industry. It might be that the last had not yet been heard of the search for natural gas in this country, and should an appreciable supply become available it could transform the present rate of growth of the gas industry. During the luncheon the Melchett Medal for 1953 was presented to Dr. Harold Hartley, C.B.E., chairman of Radiation Ltd., who has been awarded the Medal for his scientific attainments in the development of domestic-heating appliances and his work in other spheres of fuel technology.

STANDARD RUBBER- AND POLYVINYL-CHLORIDE INSULATED CABLES.

A revised edition of British Standard specification No. 7, which deals with rubber-insulated cables and flexible cords for power and lighting purposes, will shortly be issued by the British Standards Institution, as will a new specification covering polyvinyl-chloride insulated cables for similar purposes. These specifications differ from British Standard specification No. 7-1946 in a number of respects, of which the most important are reductions in the thicknesses of the insulation for 250-volt cables and the adoption of more rational thicknesses for the sheaths. The result will be that cables with tough-rubber, polvinyl-chloride and lead sheaths within the prescribed range will have common overall dimensions. The opportunity has been taken to include further physical tests on both insulating and sheathing materials. Other changes of interest are the inclusion of house-service overhead system cables, tough-rubber sheathed cables with semi-embedded braid and figure-eight flexible cords in the specification. As the revision of British Standard specification No. 7-1946, involves a modification of the insulation thickness of cables dealt with in other specifications, especially British Standard specification No. 883, for ship-wiring cables and vulcanised-rubber insulated wire armoured cables for collieries, it is proposed that new or revised specifications for these cables should also be published. We are informed that the changes we have outlined have the support of the Cable Makers' Association and of many user organisations and are the result of extensive experimental work, particularly into the qualities of the rubber mixes used for insulating and sheathing and into improved manufacturing techniques. The new thicknesses are, in fact, put forward with the knowledge that they give a satisfactory margin of safety both electrically and mechanically. Supplies of the new cables will not be available until after the revised specifications have been published.

THE INSTITUTION OF CHEMICAL ENGINEERS' ANNUAL DINNER.

The annual dinner of the Institution of Chemical Engineers was held at the Mayfair Hotel, in the evening of April 23. After proposing the loyal toasts, the President, Mr. Stanley Robson, said the membership of the Institution was increasing rapidly, and had now reached the figure of 2,900. He paid a tribute to the younger members, congratulating them on their varied interests and activities, and also said that the increasing importance of chemical engineering had resulted in full degree courses in this science now being available to the young men of the present day. Among others he mentioned London, Birmingham, Leeds, Manchester and Durham Universities, where such courses were now being held. When proposing the toast of the Institution, the Rt. Hon. the Lord Percy of Newcastle, likened the sciences of chemistry and engineering to a sandwich, with the chemical engineer in the middle, where the best part of a sandwich was to be found; he said it was necessary to look at the technical colleges as well as to the universities for the chemical engineers of the future. In his response, the President said that Mr. J. A. Oriel, C.B.E., M.C., had been selected as this year's recipient of the Osborne Reynolds Medal, awarded by the Institution to those materially advancing its prestige and activities. After receiving the Medal, Mr. Oriel thanked the President for the honour, and said he felt that the future of this country was linked with the profession of the chemical engineer and industrial productivity, and we should, therefore impress the rising generation, not only with the attractiveness of industry, but that it was a national service of the highest order. Mr. Oriel then proposed the toast of the Guests, to which Mr. C. G. Hayman, Chairman of the Association of Chemical Manufacturers, replied. The toast of "Our President," was then proposed and the President briefly replied.

THE WORLD'S SHIPBUILDING.

That the activities of the shipbuilding industry of Great Britain and Northern Ireland, as a whole, show little sign of abating is indicated by the fact that, on March 31, the steamers and motorships under construction in shipyards in the United Kingdom totalled 323 vessels, of 100 gross tons and upwards, making together 2,132,903 gross tons, a decline of only 13,499 tons as compared with the total on December 31, 1952, and equivalent to 35·52 per cent. of the tonnage building in the world. Of the 323 vessels under construction, 135, making together 1,035,958 tons, are steamers and 188, comprising 1,096,945 tons, are motorships. Moreover, 85 of the ships, totalling 498,535 tons, are being fitted out afloat, while 238, aggregating 1,634,368 tons, were still to be launched. The progress made during the quarter is shown by the fact that 51 vessels, making together 305,343 tons, were commenced during the period, 47 ships, aggregating 227,691 tons, were launched and 64 vessels, comprising 310,821 tons, were completed. Just over 27 per cent. of the tonnage being built in this country, amounting to 82 ships totalling 577,816 tons (94,027 tons less than was the case on December 31, 1952) are for registration abroad or for sale. The oil tankers under construction on March 31 numbered 111 and their aggregate tonnage was 1,225,777, representing 57·5 per cent. of the tonnage being built in this country. The steamers and motorships under construction abroad on March 31 amounted to 879, making together 3,871,854 tons, a decrease of 100,329 tons as compared with the total for December 31. As has been the case for some time, no figures are available for China, Poland and Russia. The tonnage building in the United States on March 31 was 586,511, in Germany 559,562, in the Netherlands 452,983, in Japan 450,562, in Italy 354,980, in Sweden 346,855 and in France 346,479. The only two countries to have increases, as compared with the previous quarter, were Germany and the Netherlands; the totals of all the other countries showed more or less heavy declines. The ships commenced in foreign shipyards numbered 227, aggregating 820,174 tons; 203 ships comprising 835,713 tons were launched, and 196 vessels, making together 909,737 tons, were completed. As in this country, oil tankers form a high proportion of the vessels building abroad and, on March 31, there were 185 of these ships, aggregating 2,041,482 tons, being built and representing 52·7 per cent. of the total tonnage under construction abroad, against 52·1 per cent. on December 31, 1952.

OBITUARY.

MR. J. H. RIDER.

ELECTRICAL engineers of the older generation will learn with regret of the death of Mr. J. H. Rider, which occurred at Woldingham, Surrey, on Thursday, April 23, in his 90th year. Mr. Rider was one of the pioneers of electricity supply in this country and had been responsible from the very early days up to recent years for carrying out a number of projects which increased in size and importance as the use of this form of power developed.

John Hall Rider was born at Bristol on January 30, 1864, and was educated in that city. He began to study electricity and magnetism at the Bristol Trade and Mining Schools in 1880 and three years later was apprenticed to Messrs. Paterson and Cooper, being engaged with them on the installation of electric lighting plant both in this country and in Norway. In 1887 he became electrical engineer to Messrs. Blakey, Emmott and Company, of Halifax, by whom he was employed on the design and installation of electrical machinery for various purposes. He began his long connection with the supply side of the electrical industry in 1893 when he was appointed borough electrical engineer at Bolton and became responsible for designing and erecting the municipal generating plant in that town. Later he was similarly responsible for the inauguration of the tramway system. In 1896, he was appointed borough electrical engineer at Plymouth, where he was engaged on similar duties; and five years later became electrical tramways engineer to the London County Council. At this time the Council were engaged on the conversion of their tramway system from horse to electric traction on the underground conduit system, work which necessitated the erection of a generating station for the supply of the necessary power. This station, which had an installed capacity of 34 MW, was constructed and equipped to Rider's designs. He was also responsible for the erection of a number of the substations which formed part of the system. During this period he also played a leading part in the preparation of schemes promoted by the Council for the bulk supply of electricity in London; and it was on his recommendation that the recently closed subway between the Embankment and Theobalds Road was built.

In 1910 Rider left the Council's service to become chief electrical and mechanical engineer to the Central Mining and Investment Corporation in Johannesburg, for whom he carried out a number of important works connected with electricity supply in South Africa. In 1915, he returned to this country and joined the consulting engineering firm of Preece, Cardew, Snell and Rider, with whom he was engaged until his retirement some 32 years later. During this period the firm were responsible for the design of many generating stations among which three of the more recent were those at Fulham (310 MW), at Tir John North, Swansea (134 MW) and at Kingston (123 MW). He also did important work as an expert witness in arbitration proceedings connected with electricity undertakings.

Rider was elected an associate member of the Institution of Civil Engineers in 1896 and was transferred to the class of members in 1902. He joined the Institution of Mechanical Engineers as member in 1899, while his connection with the Institution of Electrical Engineers began as long ago as 1885, when he became an associate. He was transferred to the class of members in this institution in 1891 and had served on the Council and as vice-president. He was a past-president of the South African Institution of Electrical Engineers and of the Incorporated Municipal Electrical Association, of which latter body he was the founder. He was also a Member of the American Institute of Electrical Engineers. Rider was the author of a book on "Electric Traction" and of a number of papers.

MR. C. W. EVE.

WE also regret to record the death of Mr. C. W. Eve, which occurred at Bournemouth on Sunday, April 19, at the age of 66.

Charles Walter Eve joined the staff of Standard Telephones and Cables, Limited, in 1906, and after working in several other departments of the company entered the sales department five years later. In 1915, he was entrusted with the task of establishing a department to handle the domestic supply business and spent some time in the United States investigating commercial methods and practices in that country. After his return to Great Britain he was appointed assistant sales manager in 1923 and in 1928 was given a special assignment to cover international information work. In 1930, he became general sales manager, a position which was later known as commercial manager, while in 1940 he joined the Board with the title of commercial director, a post he held until his retirement in 1947.

Eve was also a director of Kolster-Brandes, Limited, and vice-chairman of the British Radio Valve Manufacturers Association's Board of Management. During the immediate post-war period he played a leading part in the formation of the Radio Communication and Electronic Engineering Association and the Radio Industry Council, which became the co-ordinating body for the British Radio Equipment Manufacturers' Association, the Radio Component Manufacturing Association, the Radio Communication and Electronic Engineering Association and the British Radio Valve Manufacturers Association, when questions of overall interest were concerned. He was also closely connected with the formation of the Telecommunication Engineering and Manufacturing Association.

CORROSION OF FUEL-INJECTION NOZZLES.*

By W. P. MANSFIELD, B.Sc. (Eng.).

THE Laboratory at Slough of the British Internal Combustion Engine Research Association recently received a request for assistance from a member company which was confronted with a serious problem in connection with engines of a modified design. A considerable number of these engines had been sold mainly to overseas customers. After they had been in service a short time, reports were received of rapid nozzle failure due to loss of metal from the wall of the nozzle body resulting, in many cases, in discharge of fuel through the nozzle wall. The problem had not been encountered in prototypes used since 1947 for the development of the engine. Most of the affected engines were operating on A Class fuels. It was later learned that the same trouble had been experienced in varying degrees of severity in many engines of other makes. In the light of some preliminary fundamental work which had recently been carried out for another purpose, the Laboratory was able to suggest the probable cause of the trouble. Experiments proved the theory to be correct, and showed that the trouble could be remedied easily.

The type of nozzle used in the engine in question was the widely used S-size long-stem nozzle. A standard solid-copper washer was fitted at the cap-nut seating face. The design of the injector housing in the cylinder head was such as to provide ample cooling of the injector. Examples of corroded nozzles are illustrated in Fig. 1, opposite. That on the left, returned from Portugal, had failed three months after installation of the engine. When the nozzle was tested it was found that the fuel discharged through the side wall instead of the normal orifice. The nozzle in the centre, which was returned from Syria, had also discharged through the side. It had been welded in an attempt to effect a repair, as this was sometimes found to be sufficiently successful to enable the engine to be kept running. Later, brazing was found to give better results, but even then success was only achieved in very few cases. The nozzle on the right, also returned from Syria, was the only example seen by the engine makers in which the attack had extended beyond the shoulder of the nozzle to the large-diameter portion housed inside the cap-nut. The number of hours service completed by the above nozzles was not known, but, in general, failure had been found to occur in about 300 hours, and sometimes much less.

LOW-TEMPERATURE THEORY.

With a view to making a more fundamental approach to the question of the formation of corrosive substances in internal-combustion engines, which was considered to be important in connection with work on lower-grade fuels, the Laboratory had recently studied research carried out elsewhere on corrosion by combustion products. The work carried out by the British Coal Utilisation Research Association on the problem of corrosion of the external heating surface of water-tube boiler plant was found of particular interest. A major fact emerging from this work was that the presence of traces of sulphur tri-oxide in the flue gas could be responsible both for the formation of bonded deposits and also for the corrosion and blocking of the air heater and other cooler sections of the plant. Other investigators had found that the presence of a few parts per million of sulphur tri-oxide in boiler flue gas elevated the dewpoint considerably above what might be expected in relation to the water vapour content, and that the condensate at these higher temperatures was strong sulphuric acid capable of ready attack on iron and steel surfaces. The British Coal Utilisation Research Association had shown further that carbon particles absorbing sulphur tri-oxide can corrode steel surfaces at temperatures as much as 104 deg. F. (40 deg. C.) above the acid dewpoint. With the assistance of the B.C.U.R.A., some preliminary tests had been made in the Laboratory to assess the sulphur

* Communication from the British Internal Combustion Engine Research Association, Slough. Abridged.

CORROSION OF FUEL-INJECTION NOZZLES.

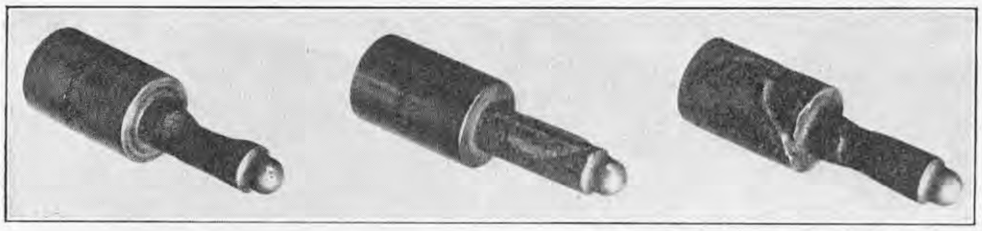


FIG. 1. EXAMPLES OF NOZZLES CORRODED IN SERVICE.

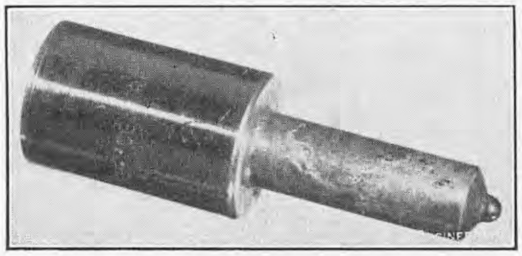


FIG. 3. NOZZLE WITH ARTIFICIALLY-INDUCED CORROSION.

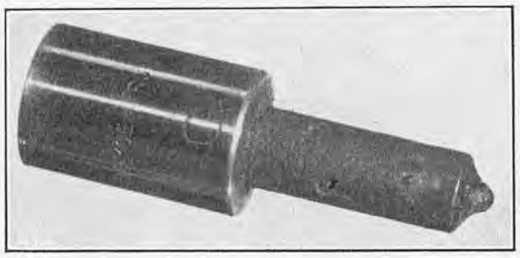


FIG. 4. NOZZLE BEFORE CLEANING.

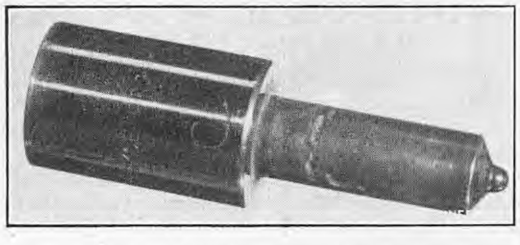


FIG. 5. NOZZLE AFTER CLEANING.

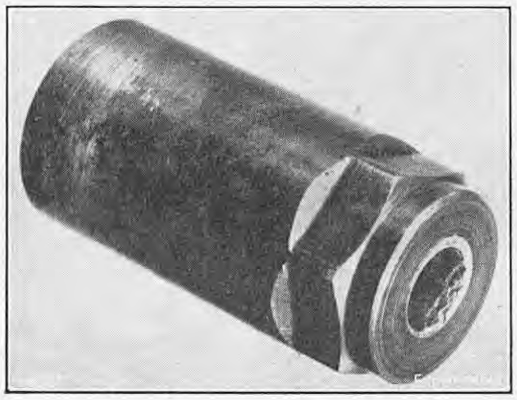


FIG. 6. CORROSION OF CAP-NUT USED WITH NOZZLES SHOWN IN FIGS. 3, 4 AND 5.

tri-oxide content of engine exhaust gases using the B.C.U.R.A. dewpoint meter. This instrument consists of a glass tube the closed end of which is exposed to the gases under examination and progressively cooled by an internal air stream until condensation occurs at the exposed surface, this point being indicated by the passage of current between two electrodes embedded in the glass surface.

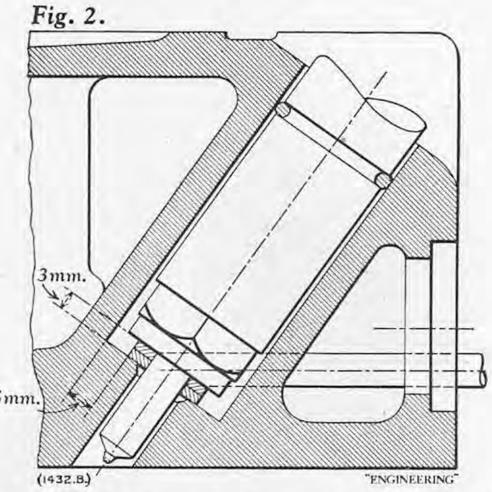
All this work emphasised the fact that the temperature of the surface exposed to combustion products is a factor of first importance in this type of corrosion problem. Consequently, when two examples of the affected fuel-injection nozzles were received at the Laboratory, attention was given to the possibility of the surface being overcooled. The surfaces of the nozzles had many interesting features, but the most significant was judged to be the complete absence of attack at the discharge end of the nozzles. This end, being subjected directly to the heat produced in the combustion chamber, is at a high temperature, while the end adjacent to the cap-nut is shielded from the heat and cooled through a short heat-flow path. It was considered very probable that the attack was due to the temperature of the nozzle surface remote from the combustion chamber being too low and it was therefore suspected that the nozzles were being cooled more effectively than usual.

CONSIDERATION OF VARIOUS THEORIES.

At this juncture the Laboratory was asked to send a representative to a meeting with the fuel-injection equipment makers, and various possible explanations of the loss of metal from the nozzles were considered. Since the trouble had not occurred in the experimental engines on which the development work had been conducted, the engine makers thought that the fault lay with the material or heat treatment of the nozzles. It had been found that some of the nozzle bodies when received from the makers could be marked with a file; others could not. The nozzle makers stated later that the nozzle bodies were of high nickel-chrome steel which could be more easily filed than carbon steel of the same hardness number. Three nozzles had been returned earlier for examination, two of which had been attacked heavily in 300 and 500 hours, while the third was quite unaffected after 6,000 hours service. All three were found to have a satisfactory case structure, with hardness between 655 and 678 V.P.N. at 10 kg., which was within accepted limits, and there was no significant metallurgical difference between them. The hardness of some other affected nozzles ranged between 634 and 707 V.P.N. The depth of the case-hardening was correct, but the casing of some of the nozzles was slightly deficient in carbon. The fact that the attack was heaviest on the surface adjacent to the copper washer naturally suggested electrolytic attack, the copper forming the anode and the steel of the nozzle the cathode. If this were in fact occurring, the substitution of a steel or an aluminium washer would affect a cure. It was learned, however, that tests had been made with both materials but neither had made any improvement.

Gas Erosion.—It was believed in some quarters that the loss of metal was due to erosion by the cylinder gases moving at high velocity over the surface. It was suggested that the swirl imparted to the air during the induction stroke was greatly intensified in that part of the gases which was compressed into the clearance space round the nozzle, and that these gases scoured the surface of the nozzle. An allied theory was that the surface was abraded by particles of hard carbon carried by gases moving into and out of the space at high velocity. Against these theories it was pointed out that the gas velocity would be highest at the discharge end of the nozzle where no attack occurred and lowest at the cap-nut end where the attack was greatest. Moreover, it had been reported that the clearance space near the washer where the attack occurred was invariably found filled with soft damp carbon.

Fig. 2.



A representative of the injection-equipment manufacturer recalled his first acquaintance with the effect under study. The nozzle of a swirl-chamber engine was heavily attacked near the washer. When the injector was removed, a layer of carbon which had formed across the face of the nozzle, remained in position at the end of the bore in the cylinder head, there being only a small hole in the middle through which the spray had passed. With this carbon layer in position there could be no question of high-velocity gas movement in the clearance space round the nozzle.

Two complete injectors, included in the exhibits, had a thick coating of tacky lacquer over the greater part of their external surface. This showed that combustion gases had been leaking past the nozzle washer and it had been suggested that the nozzle trouble might be associated with this condition. To disprove this, the engine maker had made a test in which every precaution had been taken to ensure gas-tight joints at the washer faces, and no trace of leakage occurred; but the nozzle was attacked as before. A second test had then been made using an old iron washer which leaked so much that strong puffs of gas could be felt at the end of the injector bore; but no attack occurred. It was pointed out that this evidence supported the low-temperature theory since the effect of the blowing of cylinder gases past the clearance round the nozzle would be to raise the temperature of the nozzle.

Attention was then turned to the theory that the trouble occurred when the temperature of the nozzle surface was low enough to permit chemical attack by sulphur compounds produced by combustion. It was seen that all the affected nozzles exhibited were practically free from attack at the discharge end, and that the loss of metal was greatest at the cool end. Thermocouple measurements made at the Laboratory in the copper nozzle-washer in a vertical engine, otherwise similar to the horizontal engine in question, were quoted. The results are given in Table I. The fuel-injection equipment

TABLE I.—*Temperature Measurements.*

Running Condition.	Water Outlet Temperature.		Washer Temperature.	
	Deg. F.	Deg. C.	Deg. F.	Deg. C.
Full load for several hours)	140	60	216	102
Idling	113	45	135	57
Full load (for 15 min. after idling)	140	60	198	92

makers considered these figures very low. The engine maker said the nozzle temperature in the horizontal engines in service would be even lower, and he described the cooling system of these engines. Water, from a large tank, which took some hours to warm up, entered the lower side of the cylinder block and passed almost directly to the lower side of the cylinder head where the injector was situated. The injector was quite cold to the touch. To test the low-temperature theory further, the various

ENERGY CONSUMPTION OF ELECTRIC TRAINS.

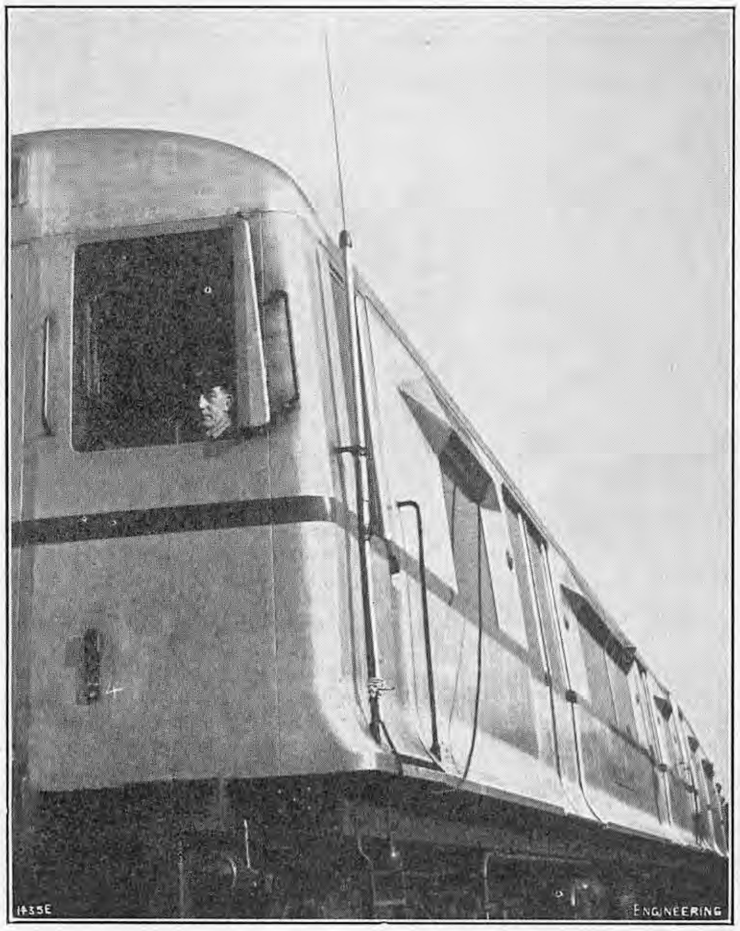
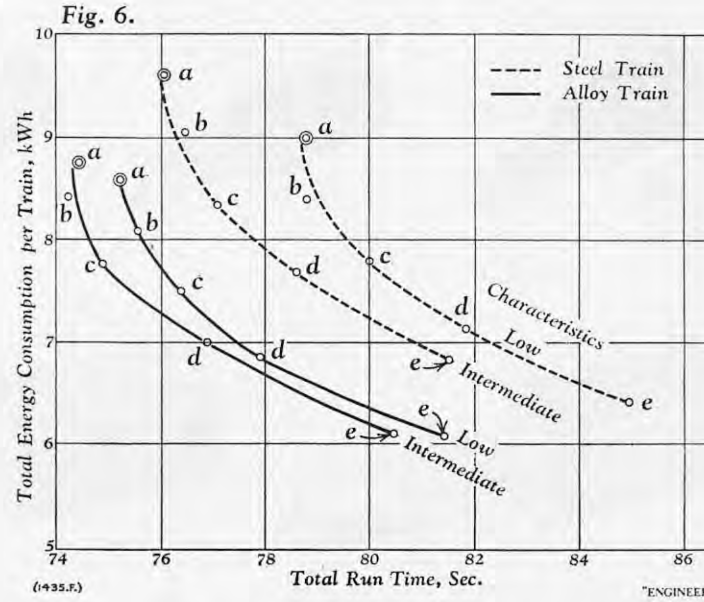


Fig. 5. Light-Alloy Cars.

Fig. 6.



cases which had come to the fuel-injection equipment makers' attention were then reviewed and the cooling system was considered in each case. The great majority of these cases had occurred in coastal districts, mostly with marine engines. Hence it had been thought that a salt-laden atmosphere might be the cause. The many marine engines concerned were sea-water cooled directly, and hence had low nozzle temperatures. The other engines employed in coastal districts which had given trouble were vehicle engines. In these engines the cooling water was passed to the cylinder-head first, where a full flow was maintained, while only a part of the water passed, under the control of a thermostat, through the cylinder jackets. In certain other vehicle engines in which the trouble was almost unknown, though the nozzles used were taken from the same batches as those supplied to the member company, the water flow through the cylinder head was under the control of a thermostat which kept the temperature high.

In the case of the swirl-chamber engine mentioned earlier in connection with the gas-erosion theory, the short-stem nozzles used were situated in a passage well back from the combustion chamber, and were cooled by a jet of cool water arranged to impinge on the injector housing in the cylinder head. Another instance in which the trouble had occurred was in engines used in barges on the Venetian canals. Here again, the cold water was probably passed directly through the cooling passages of the engines. The low-temperature theory was supported by every case that could be recalled.

Experimental Investigation.

Although the evidence in favour of the low-temperature theory was very strong, it was considered desirable to obtain definite proof that temperature was the controlling factor. To this end, an engine was chosen in which long-stem nozzles were used but which was entirely free from the trouble, and steps were taken to produce the nozzle attack by simply lowering the nozzle temperature. In place of the normal washer, two copper washers of smaller outside diameter were fitted in front of the cap-nut leaving an annular space, of section measuring 3 mm. axially by 5 mm. radially below the cap-nut, as shown in Fig. 2, page 565. The cylinder head was drilled to take two copper pipes through which cold water was passed at high velocity round the annular space, thus cooling the nozzle cap-nut and washer and hence the nozzle. In addition, cold water from the mains supply was passed through the cylinder head. The engine was run for 9 hours 20 minutes on Pool gas oil at two-thirds full load and the nozzle was then removed for examination. Fig. 3, page 565, shows its appearance. The same type of etching observed in all the affected nozzles was present and the characteristic irregular grooves had started to form even in this short time. As with the service specimens, the end of the nozzle adjacent to the combustion chamber was free from attack.

A further test was then made with another nozzle which had previously been used for over 500 hours in the same engine without any effect on its surface. Examination after 9 hours 20 minutes showed that the attack was occurring but at a somewhat slower rate than in the previous case. Running was, therefore, continued to a total of 20 hours 30 minutes. Figs. 4 and 5, page 565, show the nozzle on removal before and after cleaning, respectively. The characteristic features were again present. The grooving had reached a depth of 0·36 mm., i.e., 18 per cent. of the nozzle-wall thickness, so that complete penetration of the wall could be expected in a total of 114 hours of running. The nozzle cap-nut which had been used in both tests was also found to have been heavily attacked, as shown in Fig. 6, page 565. The nozzles used in these tests were made by a different manufacturer from those which had suffered in service. This, together with the corrosion of the cap-nut, is further evidence that the trouble is not connected with nozzle material or heat treatment.

Conclusion.—This brief investigation sufficed to show that this type of nozzle corrosion can be eliminated simply by a suitable increase in nozzle temperature. Raising the cooling-water temperature is normally an effective method of achieving this. Where the use of cold water cannot be avoided, the cylinder head should be designed to ensure that a moderate nozzle temperature is attained shortly after starting the engine. On the other hand, it is well known that excessively high temperatures lead to other nozzle troubles.

ENERGY CONSUMPTION OF STEEL AND LIGHT-ALLOY ELECTRIC TRAINS.

Nearly two years ago, we gave a description of a light-alloy car,* 90 of which were being built for London Transport by the Metropolitan-Cammell Carriage and Wagon Company, Saltley, Birmingham, under the direction of the late Mr. W. S. Graff-Baker, Chief Mechanical Engineer (Railways). The material used in the construction of these cars was an aluminium-magnesium-silicon alloy, supplied by Imperial Chemical Industries, Limited, and known as Kynal M 39/2; and the reason for its use was to effect a saving in current consumption. To check the actual savings a series of comparative tests with steel and light-alloy trains was arranged, the results of which have now been made public.

One of the trains used in these tests consisted of four cars of District Line "R" stock, the bodies of which are of steel construction, while the other also consisted of four cars with bodies of light alloy. Both trains are of the same external appearance, and a view of a light-alloy car appears in Fig. 5, on this page. Each train was loaded in turn with cast-iron brake blocks to produce a total weight equal to half that of the equivalent eight-car average loaded train (50 passengers per car). The wheel diameters of all the driving axles on both trains were matched to within a total range of ½ in. Half the axles on the cars carried motors, so that 55 per cent. of the true weight was available for adhesion and the acceleration was 2 m.p.h. per second. To obtain this acceleration with a lower maximum current demand the notching relays on the light-alloy cars were set lower than those on the steel cars. In addition, the shunt-field resistances were arranged so that the light-alloy cars ran with a higher percentage of full field than the equivalent value for the steel cars. The two types should therefore have the same speed-distance characteristics although the current for the lighter train would be lower.

All the tests were made start-to-stop in both directions over a length of ½ mile (the average distance between stations on the inner sections of the District Line). One of the four roads between Acton Town and South Ealing was used, at a time when there would be no interference with the normal traffic. This road is normally supplied from a sub-station at each end, but to avoid difficulties it was supplied from Northfields substation only during the tests. For this reason, four-car, instead of eight-car, trains were used so that the voltage drop in the collector rail and hence the voltage at the trains should approximate to that with an eight-car train on a line fed from both ends. The

* See Engineering, vol. 171, page 705 (1951)

test road was measured and marked in both directions to indicate the shut-off points for runs with varying motoring and coasting distances. The positions of the braking points were also marked. A series of tests were made by motoring distances of 1,900, 1,600, 1,300 and 1,000 ft., then shutting off and coasting, as well as by applying the brake as soon as the power was cut off. In the case of the steel train, field strengths of 100 per cent., 80 per cent. and 53·5 per cent. of full field were used, while the corresponding figures for the light-alloy trains were 100 per cent., 84 per cent. and 56 per cent.

A constant rate of braking was employed on all tests for both trains, to obtain which braking points were estimated for all the runs and the driver each time made a "full service" application of the electro-pneumatic brake with retardation control at the braking point. The brake handle was not moved again during the stop. This procedure called for careful judgment, but with practice it became possible to bring the train to rest within $\pm$ 10 ft. of the half-mile mark. Readings of the line voltage were recorded on the train itself and the total motor current on one car, the train speed, current-on and braking times were also measured; the apparatus installed for this purpose is illustrated in Fig. 2, on page 560. Spot checks of the traction voltage and current were made during the tests and the speed readings were also checked every day by timing runs at constant speed over ¼-mile sections. The total run time was measured on the train by a stop watch, as was the current-on time, to check the speed of the clockwork-driven charts. Two special kilowatt-hour meters were installed in the Northfields substation, where the only load measured was that used for traction plus that of the two motor-generators which supplied 50-volt direct-current for control purposes, since the train compressors and heaters were switched off before each run. A view inside the substation, showing the observers operating the recording kilowatt-hour meters and the recording voltmeter and ammeter, appears in Fig. 4, on page 560.

A novel feature of the tests was the use of two 15-watt mobile very high frequency radio telephones, such as are used by London Transport to deal with breakdowns and to control crowds. One of these sets was installed inside the substation with a temporary aerial on the roof and the other on the train with an outside aerial at one end of the train, as shown in Fig. 5, opposite. A view of the apparatus itself, which was fed from a 12-volt battery, is given in Fig. 3, on page 560. By this means, continuous contact could be maintained between the two groups of observers; and it was thus possible to carry out the tests with a minimum of delay during the limited period of special track possession from 11 a.m. to 3.30 p.m. each day. On one day, in fact, 30 ½-mile runs were made in under three hours testing time.

The curves reproduced in Fig. 6 show the energy consumption of the two average loaded trains when operating on their low- and intermediate-speed characteristics, respectively. The points marked *a* on the curves are the readings for a "no-coasting" run and those marked *b*, *c*, *d* and *e* for motoring runs of 1,900 ft., 1,600 ft., 1,300 ft., and 1,000 ft., respectively, followed by shutting off the power and coasting. These results may be considered in several ways. First, the two curves which have the closest no-coasting run times—the intermediate characteristic for the steel train and the low-speed characteristic for the light-alloy train—can be compared for the same total run time of 80·1 seconds, which is based on the run time of the steel train with the usual allowance for make-up time. In this case the energy consumption for the 148·2-ton steel train is 7·20 kWh and for the 127-ton light-alloy train 6·31 kWh, a saving of 0·89 kWh, or 12·4 per cent. for a run of just over ⅝-mile.

A second comparison can be made when both trains are running on their low-speed characteristic, i.e., with 100 per cent. field. The motors on both trains will then have the same tractive effort/speed characteristic after notching has been completed; and the light-alloy train, being of lower weight, will have both higher average and maximum speeds. Thus, the no-coasting run times are 78·7 seconds for the steel train and 75·3 seconds for the light-alloy train. When the same allowance is made for make-up time on both trains, the run-time for the steel train is 82·7 seconds and for the light-alloy train 79·3 seconds, the energy consumption being 6·89 kWh and 6·48 kWh in the two cases. Part of the saving is therefore in reduced run time and part in energy consumption. When, on the other hand, the same run time (82·7 seconds) is used for both trains, the energy consumed is again 6·89 kWh for the steel train, but is reduced to 5·88 kWh for the light-alloy train; and all the saving is in reduced energy consumption. In this case, power is shut off earlier in the run on the faster train to obtain equal run times.

The general shape of the curves shows that a large increase in energy consumption is required to produce a small saving in run time, or conversely, and more important, how much energy can be saved by shutting off the power early and coasting, with only a small increase in run time. For instance, with the steel train working on its intermediate characteristic the energy consumption is reduced by 1·27 kWh, or 13·2 per cent., and the run time increased by only one second, if the power is cut off after 1,600 ft. compared with a no-coasting run.

The economies of light alloy, compared with steel, construction can be used either to give the same run time for a given distance with a lower energy consumption; a shorter run time with the same energy consumption; or a smaller saving of both time and energy. The actual distribution will depend on the way in which the trains are driven and on the characteristics of the particular train. Where all the saving is required in energy, it is desirable to adjust the train characteristics so that the saving with the light-alloy train will be obtained whatever the method of operation. Some idea of the different effects of driving and train characteristics may be given by saying that with 1,600 ft. motoring, the run time at low speed is 80 seconds for the steel train and 76·4 seconds for the light-alloy train, a saving in favour of the latter of 4·5 per cent., while the energy consumption is 7·79 kWh and 7·5 kWh in the two cases, a saving of 3·7 per cent. On intermediate speed the corresponding figures for run time are 77·1 seconds and 74·9 seconds, a saving of 2·9 per cent. in favour of the light-alloy train; and for energy consumption, 8·34 kWh and 7·76 kWh, a saving of 7 per cent. Comparing the intermediate characteristic for the steel car with the low-speed characteristic for the light-alloy car, the run time for the first is 77·1 seconds against 76·4 seconds for the second, a saving of 0·9 per cent., while the energy consumption is 8·34 kWh for the first and 7·5 kWh for the second, a saving of 10·1 per cent. It is felt that the results of these tests confirm the calculations regarding savings in energy consumption which were originally used to justify the extra cost of the light-alloy cars. In this connection it may be pointed out that the annual cost of the electricity consumed by London Transport is about 3½*l.* million and that, therefore, relatively small economies may be of considerable value.

INSTITUTE OF BRITISH PHOTOGRAPHERS: EXHIBITION.—The annual exhibition of the Institute of British Photographers, which opened at the R.B.A. Gallery, Suffolk-street, London, S.W.1, on Thursday, April 23, will be open to the public until Saturday, May 16, from 10 a.m. to 5 p.m. on Mondays to Thursdays, and from 10 a.m. to 7 p.m. on Fridays and Saturdays. Among the exhibits are some interesting industrial, aeronautical and motor-racing photographs.

THE FIRTH CLEVELAND GROUP OF COMPANIES.—This Group has recently opened a London showroom at 7-9, St. James-street, S.W.1, where the large range of tools and accessories manufactured by the various constituent companies are displayed. The Group manufactures fibre and nylon loaded stop nuts and other fixing devices designed to speed up assembly; all types of wire and wire ropes; "Fram" oil filters, to the range of which is now added an ingenious petrol filter which by-passes fuel should the filter element become clogged; and a range of electric vulcanisers for vulcanising joints and branches in rubber insulated cables. There is also a range of garage tools, including the "Wandess" cylinder-boring bar, which is designed for boring to limits of 0·0002 in.

THE DILEMMA OF LORD KELVIN.

THE 44th Kelvin Lecture, with the title "The Dilemma of Lord Kelvin," was delivered at the Institution of Electrical Engineers on Thursday, April 23, by Professor P. I. Dee, C.B.E., F.R.S. The lecturer began by drawing attention to the fact that, while the first nine Kelvin lectures had been concerned with various aspects of his life and work, nearly 30 years had elapsed since the last direct tribute had been paid to this great man. During his lifetime, Kelvin had published no fewer than 661 scientific papers and, although therefore it was impossible to present anything approaching a comprehensive account of his work in one hour's lecture, by concentrating upon a very small number of these communications certain points of view emerged which were of great interest in connection with the problems that confronted scientists to-day.

In 1847, Kelvin published a paper in the *Cambridge and Dublin Mathematical Journal* in which he suggested that to every problem connected with the distribution of electricity upon conductors or with the forces of electrical attraction, there was a corresponding problem in the theory of elastic solids. Although in a letter to Faraday about the same time he disclaimed any intention of presenting a physical theory of the propagation of electric and magnetic forces, there could be little doubt that he had set himself the task of evolving a theory which would afford a dynamical explanation of mechanical, optical, electrical and magnetic qualities. This letter, it was interesting to note, was written 17 years before Maxwell published his famous paper on the relationship between light and electromagnetism, and showed that Kelvin was within striking distance of Maxwell's solution.

A long period was, however, to elapse before this question again became Kelvin's chief preoccupation. From 1847 to 1852 his main interests lay in thermodynamics, culminating in his famous enunciation of the second law, while in 1853 the publication of a paper "On Transient Electric Currents" marked the beginning of a new phase in his career. In this paper, he considered the discharge of a condenser when earthed by a conducting wire and, after showing that this discharge was oscillatory, went on to give an approximate specification of the oscillations with which Hertz, 34 years later, was to generate electromagnetic waves in the laboratory. It was tempting, therefore, to conclude that had Kelvin not been deflected by other interests, he might have combined his own work with that of Maxwell and Hertz, and have ranked in fame with Newton. At the end of this paper, Kelvin also, considered the rise of current in a conductor to which an electromotive force had suddenly been applied. He was thus excellently prepared to deal with the problem of the retardation of signals in submarine telegraphy and from the date of his association with the Atlantic cable project he became increasingly interested in practical applications. In fact, the success of that endeavour added so greatly to his reputation that for the rest of his life his advice was sought upon innumerable developments in electrical technology.

In 1889, however, in a presidential address to the Institution of Electrical Engineers, he again returned to the search for mechanical analogies of electrical and magnetic effects; and demonstrated how possible structural concepts of the ether might serve to provide that medium with the properties requisite for his purpose. On the other hand, a paper published in the following year showed that he was still far from his original objective and that the triple alliance of ether, electricity and ponderable matter was "rather a result of our want of knowledge than a reality of nature." In fact, as he himself admitted, he had failed to attain his objective, partly, no doubt, owing to the unlimited character of the problem he had hoped to solve, for progress in science is normally achieved by drastic limitation of the field of study. It was, however, also partly due to his absorption in the applications of science and even more to the material success which attended his work in that field.

BRITISH RESEARCH ON NON-FERROUS METALS.

During the past two or three years, a good deal of fundamental and long-range research work on the properties of titanium and its alloys has been carried out, and, in spite of the present high cost of the metal and several other disadvantages, the use of titanium in a number of applications is likely to increase. Reference was made to this metal in a statement delivered by Lt.-Colonel the Hon. R. M. Preston, D.S.O., chairman of the Council of the British Non-Ferrous Metals Research Association, at the 33rd annual general meeting of the Association, held at the Savoy Hotel, London, on April 22. Colonel Preston said that work done on titanium for the Ministry of Supply had shown that, while this metal was not going to be a common industrial material in a few years' time, replacing steel or aluminium, its use for special purposes would increase rapidly and considerably more would be heard regarding it in the future. Colonel Preston further stated that 32 main researches had been included in the Association's research department's programme during 1952. Of these, six had now been terminated or suspended and 11 new investigations had been put in hand in 1953. Of the completed researches, that dealing with the causes and prevention of stretcher-strain markings in certain aluminium alloys when used for sheet pressings was of particular interest. Practical recommendations for the avoidance of these unsightly markings had been made and the effectiveness of the remedial measures had been confirmed by works trials.

Some particularly interesting researches in the field of electroplating have also been carried out, and brief particulars of these and of other investigations are given in the 33rd annual report of the Association, which was presented at the annual general meeting. Thus, work carried out to examine the properties of alternatives to nickel as an undercoating in chromium plating has shown the relative efficiency of a variety of such alternatives and has also given some interesting information concerning standard nickel-plated finishes; this work is being followed up. Research on hot-dip galvanising has been aimed at minimising the amount of dross formed and thus conserving zinc. In the melting of copper and copper alloys, steady progress is being made in trials of various refractory linings in low-frequency electric furnaces, while work on the extrusion of satisfactory lead pipes over bridge cores has made good progress. It has been confirmed, moreover, that clean billets are essential if satisfactory pressure welds are to be made in such pipes. A study of the creep and fatigue properties of lead and certain lead alloys at 20 deg. C. has been completed, and a programme to study these properties at temperatures up to 80 deg. C. is now in hand. This further research will include the effect of slow cyclic stressing.

At the luncheon which followed the annual general meeting, the toast of the Association was proposed by Brigadier A. R. W. Low, C.B.E., D.S.O., M.P., Parliamentary Secretary to the Ministry of Supply. In the course of his speech, Brigadier Low stated that in the future, even more than in the past, British industry, in competing for markets overseas, would be dependent upon quality. It had often been repeated that we, in Great Britain, possessed the best scientific knowledge in the world. The question was whether we could apply that knowledge and whether we knew how to apply it to detailed industrial problems. It was in that field that the work of the Association was particularly valuable. In the sphere of research and of the technical information and liaison with industry that went with it, a little more effort at the present time might lead to a greatly increased reward in the future. In his reply to the toast of "The Guests," Professor Sir Ian Heilbron, D.S.O., F.R.S., chairman, Advisory Council, Department of Scientific and Industrial Research, appealed for increased industrial subscriptions to the Association, which, he contended, the industry could well afford to pay and thus enable a higher Government grant to be earned.

LABOUR NOTES.

Productivity and efficiency in industry, and the necessity for the adequate industrial training of young people, were referred to by Sir Walter Monckton, the Minister of Labour and National Service, in a speech at the Cutlers' Feast at Sheffield on April 21. The responsibility for ensuring extra productivity and increased efficiency, he affirmed, rested clearly upon every individual. All those engaged in industry, employers and workpeople alike, needed to adopt the right attitude to production problems and to be properly and sufficiently trained. The establishment of good human relationships was also an essential requirement to the national well-being. Industry in Britain had great potentialities and its resources had not yet been fully deployed.

At the present time, the training of youth was more important than ever, because young persons were much fewer in number than they used to be. Compared with 1939, there was a decline, by nearly 10 per cent., in the number of boys and girls reaching the school-leaving age. In those circumstances, the nation could not afford to waste any of its available material. It was the responsibility of industry to see that the education of these young people did not cease when they entered the workshop or office. In this connection, he referred to the training of young people given at the Thorncliffe Works, Sheffield, of Messrs. Newton Chambers and Company, Limited, of which firm the Master Cutler, Sir Harold West, was the managing director, as a striking example to industry.

Only about one out of every four or five young persons entering industry was trained, Sir Walter stated, for a skilled craft or trade under apprenticeship or learnership conditions. The remainder were employed on a wide variety of jobs. Many of these jobs were merely of a repetitive character and very few of them called for long periods of vocational training. The question was, therefore, what more could be done to ensure that the best possible use was made of the more limited number of boys and girls now available, or likely to be available in the near future. So far, some 70 sections of industry had produced systematic schemes for recruitment and training, and had set up machinery for their application, but much scope for progress in this direction still remained.

Referring to employment, Sir Walter said that this depended upon success in trade and industry, and that, in turn, depended upon productivity and efficiency. In spite of difficulties in the motor-car industry, unemployment had declined by some 36,000 during the past twelve months, mainly owing to substantial improvements in the textile and clothing trades. There had, moreover, been some short-time working, but this also had been reduced, by nearly 50 per cent., during the past year. The position at the present time was that, although there was a high general level of employment, there did exist a measure of unemployment in some trades and in some localities. This lack of work in certain quarters was, however, comparatively small when compared with the unemployment position between the two world wars, at which time the number of persons without work averaged 1,750,000. He concluded by saying that the greatest need of all was to sell more British goods overseas.

A claim for increased pay for male clerks employed in the Civil Service came before the Civil Service Arbitration Tribunal in London on April 21. The demand, which applies only to civil servants whose basic earnings do not exceed 500*l.* a year, was presented by the men's union, the Civil Service Clerical Association. Mr. L. C. White, the Association's general secretary, pressed for an advance of 7 per cent., on the ground that the Ministry of Labour index of wages, for employees in industry and commerce outside the Civil Service, had shown an upward movement of eight points since December, 1951, just before the last settlement for male clerks in Government employment was made. He also proposed that the increase of 7 per cent., if granted, as well as the previous increase of 10 per cent., should be added to the existing basic rate and thereby form a new consolidated scale for these grades.

Referring to the Civil Service's lack of attraction, Mr. White contended that, if there was any reduction in the pay of clerks in Government employment, in relation to the rates obtaining in other jobs which sought to attract persons of similar age and education, it might seriously affect the recruitment of suitable persons. He pointed out that the number of boys and girls entering open competitions for the Civil Service had declined from 2,403 in January, 1950, to 1,713 in January, 1952, and to 1,675 in September, 1952. The last wage settlement for these clerical grades was directly related to the movement in the Ministry's index of wage rates during 1951, but the Treasury had refused to negotiate the present claim on that basis.

On behalf of the Treasury, Mr. A. D. Peck stated that, when the claim was submitted, discussed, and eventually rejected in January last, the Treasury offered a new consolidated scale for these men "rounded up" by amounts of about ten pounds a year. The Treasury asked the Tribunal to find in favour of that offer. He suggested that it was one thing to assert that movements in industrial wages should not be entirely disregarded in considering claims for clerks in the Service, but it was quite another to assert that they should be exclusively relevant, and that any increase should be based on a mathematical formula which produced an exact equation between the movement of industrial wages and the pay of Civil Service clerks.

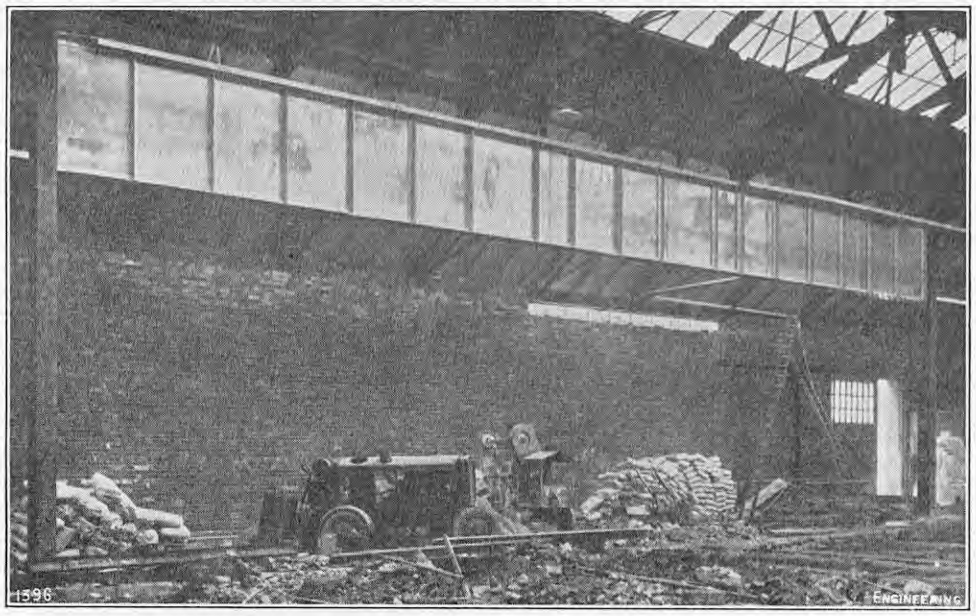
Mr. Peck contended that the decline in recruitment was not due to pay in the lower grades of the Service, but to the decline in the birthrate and because so many boys and girls now remained at school for further education. About 150,000 men are affected by the claim, the cost of which, if granted in full, would amount to approximately 2,500,000*l.* in a full year. It is generally anticipated that new scales for women clerical employees in Government departments will be negotiated on the basis of the Tribunal's award on the present claim.

The salaries of men and women aged 21 and over employed in certain capacities on the technical and scientific staffs of engineering establishments have been increased by from 7*s.* 6*d.* to 10*s.* a week by a recent award of the Industrial Disputes Tribunal, the terms of which were announced on Saturday. Some 15,000 persons in these grades are expected to benefit from the award.

The 1951 Census of Industrial Production in Northern Ireland is now almost complete. The selling value of goods made and the value of productive work accomplished, by all branches of industry in the Province, together amounted to 333 million pounds in 1951, compared with 284 million pounds in 1950, with 253 million pounds in 1949, and with 60 million pounds in 1935. These figures do not take into consideration the activities of small firms employing ten or fewer persons. There is some duplication in these totals, which must be discounted, in that the value of semi-finished goods made by one section of industry and supplied to another as material for the manufacture of more finished products is accounted for more than once. Moreover, in the 1951 figures, firms engaged in mining and quarrying, with a gross output of 1,250,000*l.* and employing some 2,800 persons, are excluded.

Persons employed in the various industries in the Province numbered 211,400 in 1951, against 210,663 in 1950, 204,603 in 1949, and only 140,176 in 1935. In making these comparisons, allowance should be made for the exclusion of the mining and quarrying industry from the 1951 census. If workpeople employed in this industry are taken into account, the increase in employment between 1950 and 1951 amounted to about 3,500 persons, and the increase between 1935 and 1951 to 74,000, or 53 per cent.

ALUMINIUM GIRDER OF 67-FT. SPAN.



ALUMINIUM PLATE GIRDERS.

An example of the use of aluminium plate girders to reduce deadweight to a minimum and to ease the difficulties of erection under the limited head-room available, is to be found in the remodelling of one of the depots of the Birmingham City Transport Department. The depot is being converted from tram to 'bus use, and as 'buses need a different parking arrangement from that of trams, in particular, greater space to manœuvre, alternate stanchions are being removed. Supporting the roof has required the erection of large-span roof girders between the remaining stanchions. Three girders, 67 ft. long, with a depth of nearly 6 ft., and each weighing $2\frac{1}{2}$ tons, together with two girders of 50-ft. span and a number of 23-ft. span, are being installed in this depot. Aluminium members of a size of the largest of these girders are as yet unusual and the present example is a good instance of the increasing use of light alloys in structural engineering. Although there have been some notable examples of aluminium construction in recent years, it is likely that, as experience with the material increases, there will be a greater proportion of structures designed in light alloys, particularly where self-weight is an important factor, as in long-span roof girder and bridge members.

The use of aluminium for the girders at Birmingham has ensured that the dead load on the remaining stanchions is increased as little as possible, while the problems of transporting and handling such large members have been considerably reduced. These girders, which have been fabricated by Samuel Butler and Sons, Limited, Stanningley, Leeds, are built up of plate of Noral 65-SWP alloy and of extruded angle sections of Noral 51-SWP alloy. These two materials, supplied by the Northern Aluminium Company, Limited, Banbury, Oxford, are both heat-treated aluminium-magnesium-silicon alloys of the type that is now being used for general structural work of all kinds, for they combine a resistance to atmospheric corrosion with a yield strength comparable with that of structural steel. The highest design stress accepted was 4·94 tons per square inch in the compression flange; for Noral 65-SWP plate, a typical 0·1 per cent. proof stress in compression is $17\frac{1}{2}$ tons per square inch, so that a factor of safety of over $3\frac{1}{2}$ with respect to the yield point has been obtained in this case.

The web of the largest girders, one of which is shown in the accompanying illustration, after being erected at site, is of $\frac{5}{16}$-in. plate, 5 ft. 9 in. deep, with angle stiffeners on both sides, generally at 3 ft. 9 in. centres; the angles used for the stiffeners have either 5 in. by 3 in. or 4 in. by 3 in. legs. There are six splices in the web, the connections being made with double cover plates. The tension flange is built up from two 6-in. by 4-in. angles, the longer legs outstanding, and a $\frac{5}{16}$-in. flange plate, 14 in. wide. The compression flange is similar except that the flange plate is 20 in. wide by $\frac{3}{8}$ in. thick, and is stiffened along the edges by angles with equal 3-in. legs. The three splices in each flange were made by a cover plate outside the main flange plate, by angles inside the flange angles, and by cover plates on the outside of the up-standing leg of the stiffening angles along the edge of the compression flange. Hot-driven rivets of mild steel, $\frac{13}{16}$-in. in diameter, were used throughout, the usual precaution of staggered riveting being observed during assembly to avoid local overheating of the aluminium alloy.

DANISH HALL WITH MECHANICALLY-ADJUSTABLE FLOOR.

An exhibition of photographs, models, and drawings of modern Danish housing, together with samples of contemporary Danish furniture, is now open to the public, until May 9, 1953, at the Building Centre, Store-street, Tottenham Court-road, London, W.C.1. The most interesting exhibit is the collection of photographs and plans of the new Civic or Festival Hall at Aalborg, which, of its kind, must be one of the finest examples of engineering allied with architecture now in existence. This steel-frame and reinforced-concrete building covers 86,000 sq. ft., the main hall being 236 ft. by 105 ft., and an ingenious feature is that the floor of the main hall is mechanically adjusted to assume different degrees of slope so that the hall can serve simply as a meeting place seating 3,400, as a concert hall seating 1,796, or as a theatre (equipped with a revolving stage) seating 1,381 persons; the hall can, therefore, be put to a number of entertainment uses. The building additionally houses a *théâtre intime*, seating 270 persons.

Effluent Disposal.—The graduates' and students' section of the Institution of Chemical Engineers held a symposium on "Effluent Disposal," at University College, Gower-street, London, W.C.2, on Friday, April 17. Held in two sessions, the symposium discussed the national problem during the morning and the industrial problem during the afternoon. The principal speaker during the morning was Dr. B. A. Southgate, F.R.I.C., Director of Water Pollution Research, Department of Scientific and Industrial Research, who opened the meeting with a paper entitled "Statutory Obligations and the Nature of the Problem." The afternoon session was opened by Mr. C. Lea, Imperial Chemical Industries, Limited, Millbank, London, who discussed "The Chemical Industry." The symposium was concluded by a summary of the day's work by Professor D. M. Newitt, F.R.S.

M.V. "WOKINGHAM" FOR TRAMP SERVICE.

The second of a new class of tramp motorship, the Wokingham, built by the Caledon Shipbuilding and Engineering Company, Limited, Dundee, for the Britain Steamship Company, Limited, for whom Watts, Watts and Company, Limited, are the managers, completed her trials in the North Sea on Wednesday, April 8, and is now in the Millwall dry dock for painting before making her maiden voyage. She has a single screw and is similar to the M.V. Windsor launched on May 23, 1952, and described in Engineering, page 681, vol. 173 (1952). The Windsor recently returned from her maiden voyage and figures of her performance have been published. A breakwater has been fitted aft of the forecastle of the Wokingham partly for this purpose and also to try and eliminate the 5-deg. weather helm which the Windsor normally carries. During the trials, it is believed that this change was proving effective, but until full seagoing conditions have been experienced no comments are available.

The dimensions of the ship are: length, 465 ft. overall; breadth, moulded, 58 ft. 6 in.; and depth, to shelter deck, 38 ft. The main engine is a Vickers-Doxford Diesel of the opposed-piston type built by Vickers-Armstrongs Limited, Barrow-in-Furness. It has four cylinders of 670 mm. bore and 2,320 mm. combined stroke. A Bibby detuner flywheel is fitted and it is claimed that the torsional vibrations in the crankshaft have been eliminated for all speeds encountered in normal service. The engines burn heavy fuel oil and special provision has been made for the purifying and heating of the oil. The forced lubrication, fresh water for piston and jacket cooling, and sea-water circulating pumps are lever-driven by the main engine, as also are the two scavenge pumps. Standby pumps and other auxiliaries are steam driven, the steam for this purpose being provided at sea by means of a cylindrical boiler having an exhaust-gas furnace with an additional oil-fired furnace. Steam for the winches is provided by another cylindrical oil-fired boiler which is fitted with superheater elements. Both boilers work under cold-air forced draught. Electric power is provided by four 75-kW generators, one of which is steam-engine driven while the others are Diesel-engine driven. Special attention has been given to the ventilation of the engine room. Large natural down-draught vents are led in below the floor-plates and sparred openings are fitted. In addition, there are motor-driven exhaust fans which ensure continuous circulation of the air.

A notable feature of the ships managed by Watts, Watts and Company is the comfort of the crews' quarters. Each member of the crew has a well-fitted room for his own use, besides public rooms provided for general use. These quarters are all amidships and they are finished in plastics and wood veneers. It is claimed that interior decoration of this kind actually results in a saving, because redecorating is rarely necessary. The hull of the ship is fitted with deep knuckles for and aft, constructed to the owners' patented design. These knuckles ensure dry decks and combine with the effect of the deck ballast tanks to make the ship very steady in a seaway. There are five holds, two abaft and three, together with associated 'tween-deck space, forward of the machinery space. The ship is designed for the carriage of grain and cargoes. In the case of grain, an addition to the conventional feeders to holds and 'tween decks has been provided by a new arrangement which enables the full square of the hatch to be boxed 'tween decks and used as a feeder for loading the grain.

Temporary Low-Power Television Stations.—Test transmissions started from the temporary low-power television station at Glencairn, near Belfast, on Wednesday, April 22, and from the similar station at Pontop Pike, near Newcastle, on Friday, April 24. It is hoped to begin regular transmission from both stations to-day, Friday. In each case, the frequencies of the vision and sound carriers will be slightly offset from those of the high-power transmitters at Alexandra Palace and Wenvoe to reduce interference in the fringe areas.

FATIGUE IN AIRCRAFT.

To discuss in broad terms the problems of fatigue in aircraft that have been exercising the industry greatly in the last few years, the Royal Aeronautical Society held an all-day meeting in London on Friday, March 27. The meeting was organised in four sessions, two in the morning and two in the afternoon, and concluded with a general discussion. Major P. L. Teed was in the chair during both the morning sessions, the first of which, under the heading "Fatigue in Structures," was opened by Mr. H. L. Cox.

Stress Concentration and Fatigue.

Mr. Cox's paper was not, in fact, concerned with the fatigue of structures, but was largely a review of some of the factors affecting fatigue fractures, and was accompanied by many slides. A puzzling observation in laboratory testing was, he said, that some cracks refused to spread, although the elastic stress concentration at their roots must be tremendous. It had been shown that the material ahead of the crack deformed plastically, but it was difficult to believe that this could continue through hundreds of millions of reversals, preventing the high stress concentration and yet not damaging the material. As to the mode of stressing under which fatigue cracks spread, he concluded that the crack was likely to start in a region of maximum stress range and that it might develop in tension or in shear, with a slight preference for tension.

In a series of combined bending and torsion tests on test-pieces with small diametral holes in a number of materials, it had been determined that, in all the specimens, the practical stress-concentration factor at failure was about 87 per cent. of the theoretical. He considered that the reduction of the notch sensitivity below unity was related to the stress gradient at the points of stress concentration. This hypothesis, due to Neuber, implied that fatigue occurred in a region typified by a characteristic length in the material itself. Further investigations were needed; the size of the region was not determined by grain size. The stress-gradient effect resulted in a variation of behaviour with size. A few experimental results on steels and aluminium alloys did suggest that a very small hole reduced the fatigue strength only very slightly; the behaviour of cast iron under combined repeated bending and torsion was also qualitatively consistent with the concept that the fatigue strength was considerably increased when the high stress was developed only in a very small region.

To ensure that fatigue-test results were comparable, a number of repeat tests were necessary. To illustrate this point, Mr. Cox showed a slide with the results of 40 tests on helical springs, made from one batch of hard-drawn steel wire, and loaded in the same machine. The results showed a wide scatter of endurance, particularly when the average endurance amounted to several millions.

Referring again to stress-concentration effects, Mr. Cox pointed out that slight stress concentrations were more severe than might be expected. In contrast to the highly localised stress concentration resulting from sharp corners, the stress increase due to shallow grooves was liable to spread over a considerable region, and the effective notch sensitivity might well approach unity. For example, steel and aluminium-alloy test-pieces with very small diametral holes quite often failed at the ends of the fillets, where the nominal stress-concentration factor was about 1·2 to 1·3, instead of at the hole where the nominal stress-concentration factor might amount to 3.

Among the points raised in the discussion which followed Mr. Cox's paper was the possibility that, now that plastics were under consideration for structural use, fatigue under static loads, as a function of time, might be encountered. In answer to a question on the possibility of restoring the life of a component that had been repeatedly stressed, Mr. Cox said that many inconclusive attempts had been made; resting appeared to have no beneficial effect. There was conflicting evidence on the effect of annealing.

In answer to queries on the effect of rate of loading on the fatigue range, Mr. Cox said that it appeared that varying the rate between 500 cycles and 5,000 cycles per minute had no effect. Above 10,000 cycles per minute, there was usually an improvement. Below 500 cycles per minute, creep effects might be found at high temperatures; and at room temperatures, the fatigue range might be lower by some 10 to 15 per cent. At really high rates of loading, above 1,000 cycles per second, there was great difficulty in computing the stresses accurately, and published results of such experiments as had been done at high loading rates were of doubtful validity.

Metallurgical Factors Affecting Fatigue.

The second morning session, on "Fatigue from the Metallurgist's Point of View," was opened by Mr. E. R. Gadd. Work on non-metallic inclusions, he said, had been carried out mainly on steels; certain types of inclusion appeared to have no effect on fatigue strength, whereas others had an adverse effect, particularly when situated in regions of stress concentration. In steels, when stressed transversely relative to the grain flow, the endurance limit was reduced by a percentage which increased with increasing ultimate strength; there were few data available for non-ferrous alloys.

Surface hardening by nitriding could produce considerable increases in the fatigue strength of notched test-pieces, due to the compressive stresses imparted to the case. The balancing tensile stress in the core could, however, be detrimental in components of small cross section. Compared with carburised components, nitrided components could operate in conditions of higher temperature, above 200 deg. C., and the distortion resulting from the treatment was less. If, however, case depth was required, carburising, which also produced compressive stresses in the outer layers, was preferable. Decarburising by oxidation during heat treatment, or by removing the carburised layer during machining, could seriously reduce the fatigue strength of steels. Flame or induction hardening could also produce an 80 per cent. or more increase in the bending endurance limit of a medium carbon steel, probably due to surface compressive stresses. If, however, thermal cracking occurred the fatigue strength would be reduced. Parts surface-hardened by heat treatment could not be used at temperatures above 200 deg. C.

Compressive surface stresses imparted by cold work were accompanied by an increase in notch sensitivity. The methods available were rolling, drawing and shot-peening. Cold-drawn mild-steel specimens had shown an increase of 46 per cent. in their endurance limit, compared with untreated specimens. Cold-rolling was used for hardening the surfaces of steel shafts, fillets and keyways; there was little information available for non-ferrous alloys, but some tests on magnesium-alloy specimens had shown a 20 per cent. increase in fatigue strength. Shot peening was useful for restoring the fatigue properties of components with unsatisfactory surface conditions. It was not, however, beneficial to austenitic steels, and too prolonged peening could result in a reduction from the optimum properties. Cold-straightening could produce detrimental residual stresses, and could lead to surface cracks in nitrided or carburised components.

The electro-deposition of nickel or chromium on steel components, to improve their corrosion resistance, had been found to reduce their endurance limit by amounts ranging from 40 to 70 per cent., depending on the thickness and condition of the plating. The treatment was, however, valuable under corrosion-fatigue conditions. A subsequent heat treatment could improve the fatigue strength, but it would still be well below that of the unplated part. Nitriding before plating had, however, proved to be very beneficial, and improved the corrosion resistance of steel under repeated stresses. Hot galvanising was usually detrimental, but had been found valuable for spring-wire working under corrosive conditions. Metal-sprayed coatings generally were bad.

In general, the fatigue strength of metals decreased with rising temperature. The fatigue properties of notched specimens of some materials, such as magnesium alloys, decreased at low temperatures. At high temperatures scaling and oxidation could substantially reduce fatigue strength. Fortunately, steels for high-temperature applications usually contained chromium, which formed a thin surface scale which sealed the surface and gave good fatigue properties.

In the discussion which followed Mr. Gadd's paper, it was suggested that the effect of shot-peening on austenitic steels should be investigated further, varying the size of shot and other variables such as pressure, distance of the nozzle from the test-piece, etc. Other contributors emphasised the detrimental effects of residual tensile stresses on the fatigue life of forgings, especially in aluminium alloys heat-treated to give high-tensile strengths. Internal stress could be eliminated by modifying the quenching procedure (for example, boiling-water quenching) or by using materials in the partially-annealed condition.

Fatigue in Engine Design.

The first afternoon session was devoted to "Fatigue in Engine Design." Dr. E. S. Moult was in the chair, and a short introductory talk was presented by Mr. F. M. Owner. In engine design, Mr. Owner said, since the main engine components were subjected to many millions of stress variations during their working lives, they were stressed on fatigue considerations; this usually provided an ample margin to cover high loading for short periods, such as gyroscopic and catapult-loading cases.

The stresses resulting from the higher modes of vibration of gas-turbine blades (which might have frequencies of 12,000 cycles per second) could not be calculated by routine methods, but it was comparatively easy to determine the vibration characteristics experimentally on a sample blade. It was also necessary to know the magnitude of the excitation arising from non-uniformities in flow produced by other rows of blading, struts, etc. Although the application of strain gauging to a red-hot turbine blade was difficult, this technique offered the only source of information at present available for assessing the vibration loading. If the blade material had a high damping capacity, the low response to vibratory forces might be offset by a reduction in fatigue strength; in general, heat treatments which improved fatigue strength tended to reduce damping capacity. There was, however, no inherent relationship between either fatigue strength or notch sensitivity and damping capacity.

Although a considerable literature was available on the effect of type of stress (direct or shear) and the range of stress variation, full-scale testing of actual components under simulated operating conditions, or overload tests on the engine itself, was essential because the interaction of many factors affecting fatigue—e.g. stress concentrations, surface treatment, corrosion and fretting, temperature, size effect, and rate of loading—could not be predicted. Fortunately for the designer, the high stress-concentration factors predicted by theory and photo-elastic experiments were only approached in the harder materials. In most engineering applications the practical stress-concentration factors varied widely with the stress range and depended on the material and on the shape of the component. In most steels and light alloys they increased steadily through the fluctuating to the alternating range. The reason for this was that, under fluctuating loads, the material was able to distribute the stress by plastic flow at the more highly loaded points, whereas stress reversals tended to initiate work-hardening and local embrittlement. In well-designed parts, the practical stress-concentration factor seldom exceeded 3 even under reversed stress.

A superficially smooth surface after final polishing did not necessarily guarantee that all the damage produced by previous machining had been removed. When repeated loading took place under corrosive conditions, there was a steady decline of fatigue strength with time—an important consideration in turbine and compressor blading. The fatigue strength tended to be lower, and stress concentration factors tended to be higher, in large specimens in comparison with small specimens of the same material. In large components, adverse residual stresses resulting from heat treatment or machining could reduce their fatigue strength; stress-relieving treatments were necessary in such cases.

The fatigue history of a component began with the first application of stress. A case-hardened engine part that cracked after some 250 applications of a high fluctuating load had shown no signs of damage when examined about a dozen cycles before failure. Under-stressing or over-stressing in the early history of a part could be either beneficial or detrimental. It was difficult to estimate the working life of a part subject to fatigue, particularly if the stress-endurance curve for the material had no horizontal portion; the scatter in life could then be very large. Actual engine tests were therefore required and, since the engine could not be run indefinitely, overload tests had to be adopted.

The discovery of a non-destructive method of determining whether a component had been operating within a stress limit which would result in a satisfactory life would be a great asset. At present, there was no method of determining whether a part was going to break. Work by Gough and Wood on crystal structures in mild steel had shown promise, but, unfortunately, it was not applicable to the highly alloyed steels used for most parts.

Among the points brought out in the discussion which followed Mr. Owner's paper was the fact that, in evaluating the strength of gas-turbine blades, fatigue and creep effects could not be separated, and that it was essential to carry out fatigue tests at creep temperatures under representative loading conditions. At supersonic speeds, the loads on the engine could only be guessed, and tests on engines under supersonic conditions were vitally necessary. In connection with forecasting fatigue life, one contributor pointed out that some work had been done on the prediction of damping and fatigue life in idealised test-pieces, but the results were not applicable to full-scale components, and it was difficult to see how they ever could be.

FATIGUE IN AIRCRAFT DESIGN.

The final session, on "Fatigue in Aircraft Design," was introduced by Mr. B. Stephenson, with Mr. B. S. Shenstone in the chair. The problem of fatigue in aircraft design, Mr. Stephenson said, had recently become prominent on account of (i) the greatly increased utilisation rate of transport aircraft; (ii) higher cruising speeds and hence higher loadings, and (iii) the development of light alloys of high ultimate strength in which the fatigue resistance had not proportionately increased.

To establish a standard by which the fatigue lives of different designs could be assessed, the Royal Aircraft Establishment (R.A.E.) had framed a fatigue criterion, which specified the loading conditions as 2×10^6 reversals of a loading of $1\,g \pm 7\frac{1}{2}$ per cent. of the ultimate design load under a 50-ft. per second gust at the design cruising speed. This criterion, which was very difficult to meet, was believed to cover the worst conditions ever likely to be encountered, i.e., when flying low in the tropics.

Mr. Stephenson then discussed the wing joints of the Vickers-Armstrongs Viking and Viscount air liners in relation to fatigue. For the inner-wing spar joint of the Viking aircraft, the tubular spar boom, of aluminium alloy, was attached by taper pins to a high-tensile steel sleeve and plug. Lightening holes were introduced into the outer steel sleeve to render its effective Young's modulus more comparable with that of the light alloy. A number of these joints tested in a 60-ton Avery-Schenck machine at the Royal Aircraft Establishment gave disappointing results, and led to withdrawing two Viking aircraft, with about 7,000 flying hours, from service with British European Airways for testing pieces of their spars under the same conditions. These tests gave encouraging results. Further new joint specimens tested showed a considerable improvement over the first batch, because they were assembled and pinned in a jig, instead of on the bench, and a better interference fit of the taper pins was obtained—a most important factor in the fatigue strength of a joint. Further fatigue tests carried out on used Viking spars showed a wide scatter of results. One spar boom taken from an aircraft that had completed nearly 7,000 hours flying in turbulent tropical conditions was completely severed.

The first full-scale tests on the Viscount outer-wing spar joint were disappointing as a result of the taper bolts becoming slack under repeated loads. This fault was corrected by changing the design of the washers in the second batch of specimens; they were pre-loaded to $2g$ before testing, and all the specimens satisfied the R.A.E. criterion. All the Viscount spar joints employed taper bolts in shear; the degree of interference fit could be controlled accurately by adjusting the nut through a specified amount.

Recent work had indicated that the number of gust loads experienced was proportional to the distance flown and was independent of speed. Speed, however, determined the severity of the load due to a given gust. There was some evidence (admittedly scanty) that a gust of 10 ft. per second or more was encountered once in about 30 miles at a height of 10,000 ft., but only once in about 2,400 miles at altitudes of 30,000 ft. or higher. The operator could do much to lengthen the fatigue life under gust loads, by minimising low-altitude flying and by reducing speed under turbulent conditions.

There were other sources of fatigue than gust loading. The "plumbing" of pressure-cabin systems was a constant source of trouble, due to high-frequency pulses from the blowers. Although the jet engine had almost eliminated mechanical vibration, high-frequency pressure waves from the jet cone could subject a structure in the vicinity to loadings at frequencies quite outside the range of present experience, and beyond the frequency range of existing fatigue-testing machines. With more powerful engines, this might be serious.

In the discussion on Mr. Stephenson's paper, it was suggested that, if structures redundant to fatigue were adopted (e.g., multiple-spar wings) in which fatigue failure was insidious instead of catastrophic, it would not be necessary to ground a whole fleet of aircraft on detecting the first fatigue cracks. The general feeling, however, was that this policy was unsound.

GENERAL DISCUSSION.

After an interval for tea, the meeting was thrown open for general discussion. In answer to a question as to whether small-scale tests could be developed, to reduce the cost of full-scale component testing, it was explained that it was impossible to simulate the interaction of the various factors affecting fatigue and to forecast when dangerous exciting forces would be in existence. Small-scale models, moreover, usually developed a higher fatigue strength owing to scale effects, and might be misleading. Several contributors cited poor results for welded structures under repeated loads, but it was noted that welded chains were completely satisfactory under fatigue loading.

Discussing the rate of crack spreading, it was stated that whereas, in parts subjected to a low level of stress, it was possible for a crack to form but not to spread, in aircraft engines working at high stress levels, the crack almost invariably propagated rapidly to failure. High-frequency stress also led to a high rate of crack propagation. In gas-turbine blades, each row of blades had its own vibration spectrum, and excitation could not be eliminated by imposing limitations on operating speeds, as in the piston engine.

In conclusion, perhaps the most important contribution to the discussion was a statement by the Royal Aeronautical Society that, in order to disseminate all available information on fatigue relevant to aircraft and engines, the Society was reviewing the existing state of information and was collecting the results of all *ad hoc* work being carried out, which was to be issued in the form of reports.

FUSED TAPPED CABLE TRUNKING.—The General Electric Co., Ltd., Kingsway, London, W.C.2, have introduced a fused tapped cable trunking system, which enables multiple runs of conduit and distribution boards to be dispensed with. Instead, each outlet is equipped with a unit consisting of a steel case with a hinged door and receiving lug, which is fixed to the trunking. The case contains 20-ampere porcelain unit fuses with high rupturing-capacity cartridge or reversible fuse holders, and, where necessary, a three-way neutral connector. The terminal bases are of moulded insulated material and the line-contact terminals are of tinned brass, which are secured with countersunk screws.

DEVELOPMENT OF THE SULZER MARINE DIESEL ENGINE.

IN a paper presented to the Institute of Marine Engineers recently,* present-day tendencies in the use of marine Diesel engines and details of the new Sulzer design were discussed. The problem of using heavy fuel oil was considered, together with results obtained from test work. A prototype engine was described, and special reference made to the use of heavy fuel, the application of welding, and the overhauling and maintenance aspect. The results of shop trials were given, and brief mention was made of future plans, with particular reference to supercharging. The author spoke of two new engines, the RS76/155 and the RS58/76, recently developed by his company to supplement their existing range. The latter engine was described in ENGINEERING, vol. 174, page 108 (1952).

In designing these engines, first consideration was given to the desire to use cheap boiler fuels, and to the demand for higher outputs brought about by the need for larger and faster ships. To achieve this, it was decided that the desired results could best be obtained by using an engine with a longer stroke for a direct-drive propeller, or by a number of smaller and faster engines connected by couplings and gearing to a common shaft. The RS76 was designed to meet the former requirement, where a single propeller turning at a little over 100 r.p.m. with a high concentration of power on the propeller shaft gives the maximum propulsion efficiency. The bore is 760 mm. and the stroke 1,550 mm., which gives a reasonable piston velocity; 900 b.h.p. to 1,000 b.h.p. is delivered per cylinder at shaft speeds of 110 r.p.m. to 115 r.p.m. The engine can be built in units of four to twelve cylinders, giving corresponding maximum outputs of between 4,000 b.h.p. and 12,000 b.h.p. Even higher outputs of up to 15,000 b.h.p. can be obtained by moderate supercharging. The increased length of stroke gives the engine an increase in height which is not considered detrimental in cargo vessels, but in passenger vessels it would be troublesome. The RS58 was therefore designed for use in the latter case, and is intended chiefly for geared installations. Its bore is 580 mm. and stroke is 760 mm. The rated cylinder output is 520 b.h.p. at 240 r.p.m. This engine may also be built in units of four to twelve cylinders, and from one to four engines may be geared to one shaft. Such variations allow a choice of from four to 48 cylinders, and corresponding outputs of 2,000 b.h.p. to 25,000 b.h.p. per shaft. A single RS58 engine with a direct drive would be suitable for small fast vessels or for generator drives in power stations. In the Dutch passenger vessel Willem Ruys two additional decks are carried above the engine room as a result of the height saved by the installation of a geared drive.

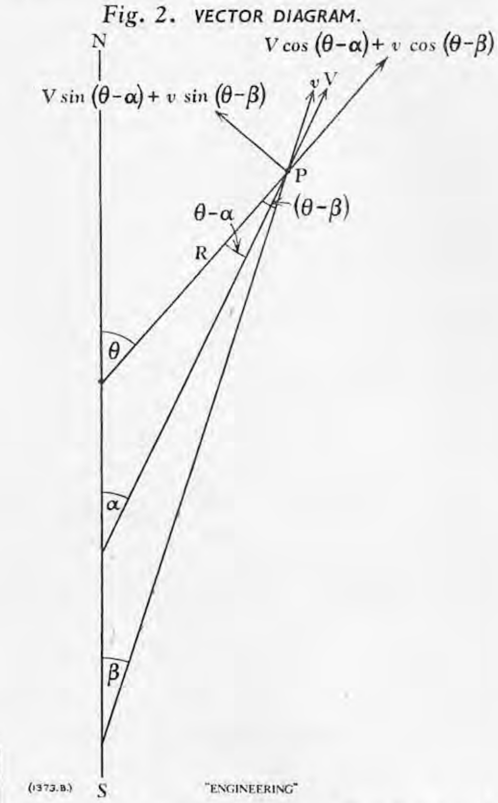
To meet the request of users for ease of overhaul and for operation on heavy boiler oil, which should be rendered as satisfactory as when using fuels of a lighter quality, a considerable number of tests have been made and previous work has led to the conviction that the combustion of heavy fuel is not so much a problem of the Diesel engine itself, as far as trouble-free running is concerned, as of the fuel and its preheating and cleaning. To find the most advantageous methods of preparing various fuels with viscosities of 1,500 seconds to 6,000 seconds Redwood 1 at 100 deg. F., a 720-mm. bore single-cylinder engine was used to carry out tests of 2,000 hours' duration over a period of one year. During these tests, investigations were made to find the best centrifugal method, the number of centrifuges necessary for cleaning, the correct operating temperature, and the temperature required for trouble-free injection. Some knowledge was said to have been gained of the wear to be expected and of the scavenge system, and a new exhaust-valve and injection system were given a thorough try-out. It is known that the centrifuge has to be reduced below the nominal rating for

* "New Designs of Large Two-Stroke Marine Diesel Engines," by W. Kilchenmann. Delivered at a meeting of the Institute of Marine Engineers on April 14, 1953.

TRAINER FOR AIR-TRAFFIC CONTROL BY RADAR.

FIG. 1. CALCULATING EQUIPMENT AND REMOTE-CONTROL BOX.

Fig. 2. VECTOR DIAGRAM.



more viscous grades of fuel, which suggests that the economic advantage of using the heavier fuels must be considered carefully. Usually, the price reduction of fuels over 1,500 seconds is not great, and the addition of 10 per cent. of gas oil to fuel of 6,000 seconds reduces the viscosity to 1,500 seconds. The detailed results of these centrifuge tests will be published by the company later. Conclusions given were: centrifuging is most efficiently carried out at the highest possible temperature; this temperature is limited by vaporisation of water and the lighter fuel constituents, which creates foaming and fire risk; an advantage might be obtained from using a sealed centrifuge which would allow cleaning under pressure and at still higher temperatures.

The effect of using heavy oil was practically to double the wear on the cylinder liner, and a large part of the wear was due to corrosion of the liner metal beneath a brownish layer of varnish occurring on the liner surface. Piston-ring wear was measured by 630 individual readings, and again the rate was approximately twice the normal figure obtained with an average Diesel fuel, and an attempt to reduce wear by the use of a detergent lubricating oil gave no conclusive results. The rate of wear appeared, apparently, to depend on the quality of fuel burnt. In the injection system, clearances for the fuel-pump plunger and fuel needle had to be increased to approximately 0·0004 in. to provide adequate lubrication of the parts when using the more viscous fuel, and to prevent binding due to differential expansions with changing fuel temperatures. For fuels above 1,500 seconds the nozzle holes were made smaller because of a loss in atomisation, the fuel jets impinging on the piston crown. Boiler oil also enlarged the holes by erosion and made frequent checking necessary; nozzles of high-alloy steels or nitrided steels may be used to some advantage in this case. Cooling of standard nozzles was insufficient for fuels over 3,000 seconds, and carbon formation occurred after 48 hours' running. To overcome this trouble, a new nozzle with increased cooling was designed which performed satisfactorily with a fuel of 6,200 seconds. No trouble arose during the tests from liner deposits; the surface was usually covered by a brownish-black varnish, and the exhaust ports and scavenge ports remained practically clean.

Test bed trials on the RSG 58, built as a ten-cylinder unit, were said to have been carried out in detail and proved satisfactory. The run lasted 235 hours and over three million revolutions were made. For 100 hours the engine ran on heavy oil. Noise was greater than expected and was considered to be due to the increased speed of running. Diesel oil gave a consumption of 0·370 to 0·375 lb. per brake horse-power hour and for heavy oil an increase in proportion to the change in calorific value took place. The heat consumption remained the same. The maximum load obtained during these test bed trials was 6,000 brake horse-power, corresponding to a mean effective pressure of 80 lb. per square inch. The volume of scavenge air was 1·3 times the piston displacement at a scavenge-air pressure of 3·4 lb. per square inch. The exhaust temperature at full load equalled 320 deg. C. (610 deg. F.) at 225 r.p.m., with a mean effective pressure of 64·6 lb. per square inch. After the test the engine was dismantled and all parts scrutinised for excess deposits, abnormal degree of wear, and signs of cracks or fractures that might have occurred. No such signs were found and test results are said to have confirmed the calculated performance figures.

It is usually considered that while there is a definite need for investigation into the use of heavy fuel, the economic aspect of doing so in all cases requires special consideration. Some cases have been encountered where it would have been cheaper to standby on Diesel fuel during long waiting periods than to keep the whole system heated with the aid of the donkey boiler or the auxiliary burner of the exhaust boiler. No free steam from the exhaust energy of the main engines is available in such a case, and the additional steam required has to be paid for by expenditure of boiler oil. One possibility is the installation of a small exhaust boiler on the auxiliary engines, another is to preheat the system by electricity, but the cheapest solution to cope with such special cases would be to switch over to light fuel on the main engines.

Future development in the testing of the RS type is to be done on a single-cylinder version of this engine. Extensive supercharging tests are to be made, and more investigations in the use of heavy oil are planned. Some thought will probably be given to raising the mean effective pressure. Satisfactory results from these tests on the single-cylinder RS 58 may lead to an introduction of an RS engine of 580 mm. and 760 mm. bore, with moderate supercharging and a reasonably increased mean effective pressure for ship propulsion and stationary installations.

COAL TRANSPORT BY BRITISH RAILWAYS.—During the seven days ended April 20, British Railways transported 3,390,930 tons of deep-mined and opencast coal. This was the largest clearance of coal from British collieries during a single week for more than three years.

TRAINING APPARATUS FOR AIR-TRAFFIC CONTROL BY RADAR.

To facilitate the training of air-traffic control officers in the use of radar, the Ministry of Civil Aviation, Air Traffic Control Experimental Unit, have recently developed a form of training apparatus which utilises artificially produced aircraft tracks on radar display screens. Until the new trainer was introduced this year at the Ministry's Air Traffic Control School at Hurn Airport, Hampshire, the time that each trainee could spend in becoming familiar with radar control was limited by the high cost of maintaining aircraft in the air solely for training purposes. The new training apparatus will enable the number of aircraft hours per trainee to be reduced by 25 per cent., and moreover trainees can be given experience in controlling up to four imaginary aircraft at the same time, whereas the cost of providing simultaneously four actual aircraft for training would have been prohibitive. The Ministry of Civil Aviation have made their design available to the radio industry, and Marconi's Wireless Telegraph Company, Limited, Chelmsford, Essex, have recently commenced commercial production of a ground radar trainer, intended principally for civil radar training overseas, and based on the same principle but built from easily-replaceable standard types and units of equipment. We are indebted both to the Ministry of Civil Aviation and to the Marconi Company for the information and illustrations from which this article has been prepared.

THE M.C.A. TRAINER.

In the Ministry of Civil Aviation radar trainer, illustrated in Fig. 1, the calculating equipment is housed in four racks and produces signals representing four aircraft. The heading, rate of turn, airspeed, and initial position of each "aircraft," but not the altitude, can be regulated from a remote-control box, on which are also mounted three distant-reading compass dials, indicating the instantaneous range, bearing and heading of the aircraft, and a control for adjusting the amplitude of the radar echo. The speed of the aircraft may be varied over the range 150 to 450 knots, and its heading can be varied through 360 deg. Standard turns at rate ½, rate 1 or rate 2, i.e., at changes of aircraft heading of 90 deg., 180 deg. or 360 deg. per minute, can be carried out. In addition, controls

TRAINER FOR AIR-TRAFFIC CONTROL BY RADAR.

Fig. 3. SCHEMATIC DIAGRAM OF RADAR TRAINER.

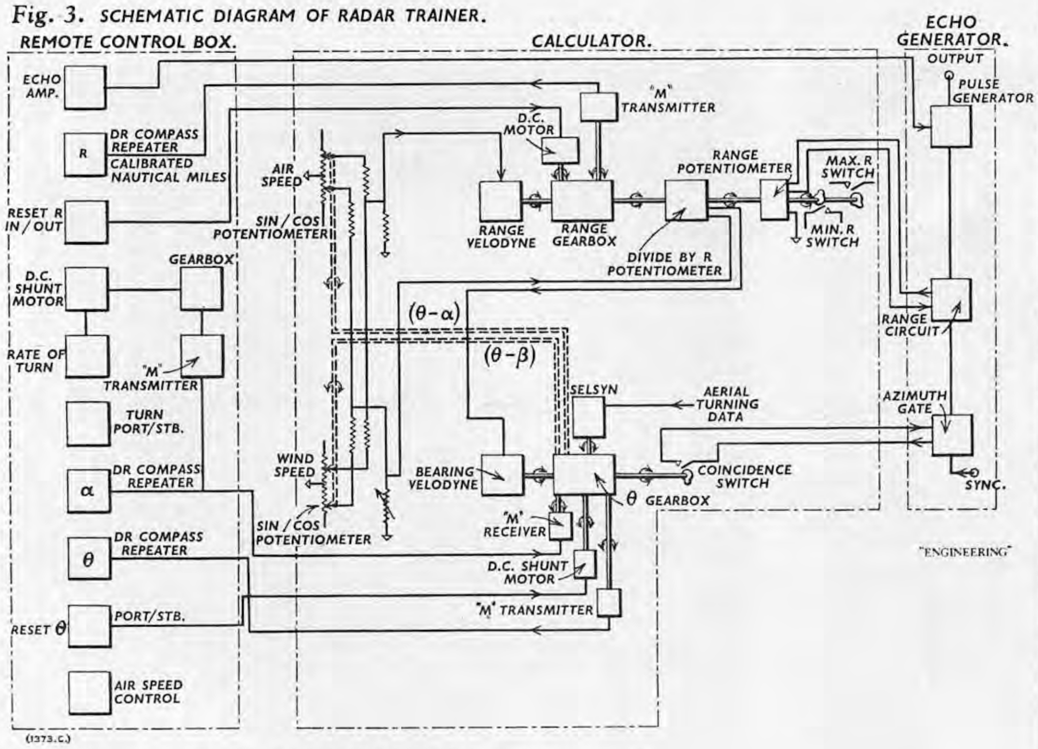
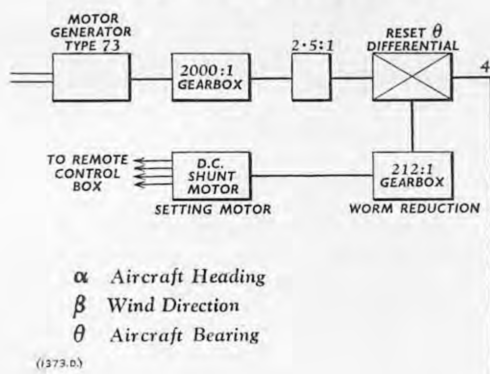
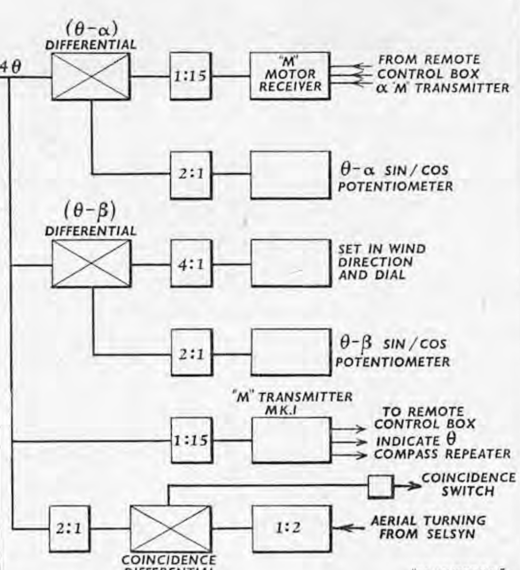


Fig. 4. BEARING CALCULATOR GEARBOX.





are provided on the calculator for feeding in the effect of a wind at any bearing and at speeds from 0 to 50 knots; controls are also provided for varying the pulse width from 1 to 5 microseconds and the "aerial" beam width from 1 deg. to 5 deg. The speed of "aerial" rotation can be adjusted from zero to 30 r.p.m. The limits of range between which the "aircraft" can fly lie between 2 and 90 nautical miles; warning lights on the remote-control box indicate when these limits are reached, and the equipment is then automatically switched off.

Operating Principles.

The way in which the trainer carries out its task is to calculate continuously, by electro-mechanical means, the position in range and in bearing of the imaginary aircraft from the radar site. The angular positions of two shafts representing range and bearing are then used to produce a short pulse, which appears on the radar plan-position indicator. From Fig. 2 it will be seen that, if θ denotes the bearing of an aircraft from a radar aerial relative to a datum line N S, V the airspeed of the aircraft at a point P, α the aircraft heading relative to N S and β is the wind direction relative to N S, the wind speed being v, R the range of the aircraft and t denotes time, then

$$\mathrm{V}\cos(\theta-\alpha)+v\cos(\theta-\beta)=\frac{d\mathrm{R}}{dt}, \quad (1)$$

and

$$\mathrm{V}\sin(\theta-\alpha)+v\sin(\theta-\beta)=\mathrm{R}\frac{d\theta}{dt}. \quad (2)$$

The training equipment solves these equations continuously.

Referring to the block diagram reproduced in Fig. 3, a voltage E, proportional to the airspeed, is applied across a sine-cosine potentiometer; the outputs from the sliders are proportional to E cos $(\theta-\alpha)$ and E sin $(\theta-\alpha)$, where $\theta-\alpha$ is the angle through which the sliders have turned from the datum position. A second sine-cosine potentiometer resolves a voltage proportional to windspeed into radial and tangential components. The voltages representing radial-velocity components are added in a resistive network and are applied to a range velodyne, comprising a motor-generator which produces a shaft rotation proportional to the range of the aircraft from the radar aerial.

The velodyne shaft drives, through a reduction gearbox with an overall reduction ratio of 40,000 to 1, two potentiometers. One of these, the range potentiometer, produces a voltage proportional to range, which is fed to the echo-generator range circuit. The other potentiometer, the "divide by R" potentiometer, forms part of the bearing-calculator circuit. In order to prevent the range and "divide by R" potentiometers from over-running, a cam connected to the potentiometer shaft operates a switch, which, when maximum range is reached, stops the range velodyne and lights a lamp on the remote-control box. Since the maximum permissible speed of the velodyne cannot be exceeded, the lower limit of range increases as the aircraft speed increases. Two minimum-range cams are therefore provided: the "lowest minimum range" cam which stops the calculator when the minimum range possible at low airspeeds is attained; and the "higher minimum range" cam, which will only stop the calculator when the range exceeds the appropriate minimum value and the air speed exceeds 250 knots. The voltage proportional to the tangential velocity component, $\mathrm{R}\frac{d\theta}{dt}$, is applied to the divide-by-R potentiometer and the output from the slider, proportional to $\frac{d\theta}{dt}$, is integrated by the bearing-calculator velodyne to give a shaft rotation θ which drives the bearing-calculator gearbox.

Changes in range, heading, wind direction, and bearing are fed in through differential gearboxes incorporated in the range and bearing calculator gear trains. Fig. 4 shows in greater detail the scheme of the bearing calculator. The heading of the aircraft is altered, from the remote-control box, by a direct-current shunt motor driving an M-type transmitter which, in turn, drives two M-type receivers, which move in 30-deg. steps. By the use of a 60 to 1 reduction gear train, however, the aircraft heading can be altered in $\frac{1}{2}$-deg. steps. One of the M-type receivers drives one of the two input shafts in the $\theta-\alpha$ calculator differentia gearbox; the other input shaft is driven by the θ shaft, and the output shaft, moving through an angle proportional to $\theta-\alpha$, drives the airspeed sine-cosine potentiometer. It will be observed from Fig. 4 that the bearing differential gear input shafts actually rotate at four times the respective angular speeds; this arrangement has been chosen so that any errors in the output due to backlash will be correspondingly reduced. The second M-type receiver drives a distant-reading compass repeater dial on the remote-control box indicating the aircraft heading. The wind direction iis fed into the wind-speed potentiometer through a similar differential gearbox, but by hand.

A third differential, the "coincidence differential," in the bearing calculator has one input driven from the θ shaft and the other from a Selsyn which simulates the rotation of a radar aerial. If such an aerial were rotating clockwise at a steady speed, it would scan a stationary target at fixed intervals, depending on the speed of rotation. If, however, the target also had a clockwise component of velocity, the time between successive scans would be increased. The output of the coincidence differential is the difference between the angle through which the radar aerial has turned and the instantaneous bearing of the aircraft. A cam mounted on the output shaft closes a switch at the instant when the aerial scans the target. This triggers a multivibrator which opens the azimuth gate circuit for a time depending on the aerial beam width which is to be simulated, and allows the triggering of a circuit which produces a pulse equal in length to the simulated radar pulse, appearing on the plan-position indicator as an aircraft response correctly located in bearing and range, and moving in the manner indicated by the remote-control box.

If it is desired to alter the position of the aircraft quickly, this is carried out by the "Reset R" and "Reset θ" controls, which switch on direct-current shunt motors driving through differential gearboxes in the range and bearing gear trains respectively. As already noted, the instantaneous range and bearing of the aircraft are fed back to distant-reading-compass repeaters on the remote-control box, by M-type transmitters from the range and bearing gearboxes, respectively.

Marconi Ground Radar Trainer.

The foregoing summary of the principle of operation of the radar trainer applies also to the Marconi production version. The Marconi trainer, however, designed to be suitable for training on a small station in any part of the world, provides for two echoes per rack, and covers a wider range of performance, namely, with airspeeds from 150 to 600 knots and corresponding ranges from two nautical miles minimum at 150 knots, and five nautical miles minimum at speeds above 210 knots, to 200 nautical

ELECTRONICALLY-CONTROLLED GLASS-GRINDING MACHINE.

GENERAL ELECTRIC CO., LTD., LONDON.

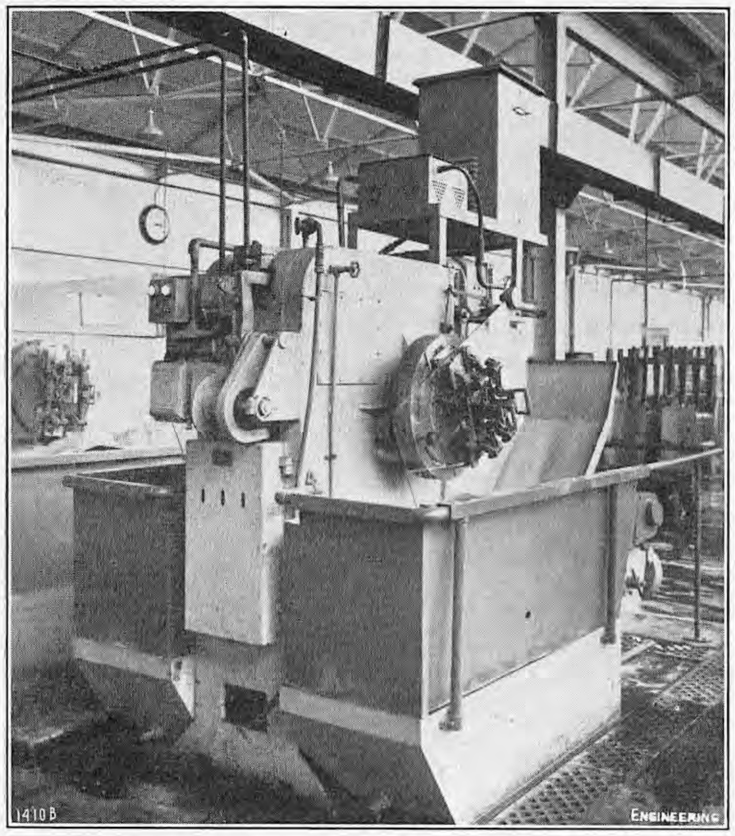


FIG. 1. GENERAL VIEW OF MACHINE.

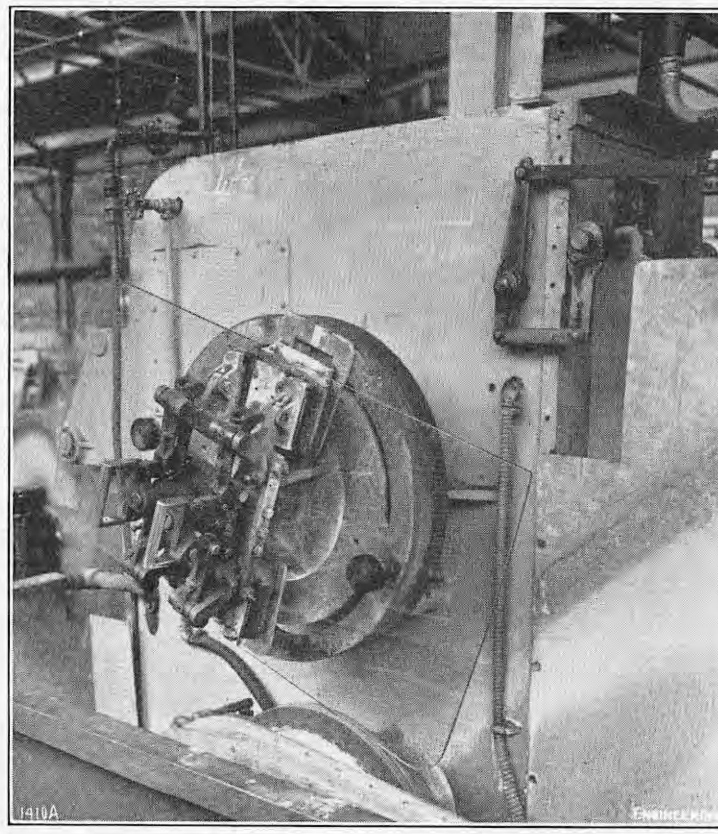


FIG. 2. DETAIL VIEW OF CHUCK.

miles maximum. In other respects, the performance specification is identical with that of the Ministry of Civil Aviation trainer. The Marconi trainer consists of three separate units—the trainer itself, housed in a Marconi standard 7-ft. receiver cabinet; the control unit from which the echoes are controlled, and track recorders tracing a continuous record on tracing paper of the tracks of both echoes. Several cabinets and control units may be built up together to provide up to 24 independent echoes. Later, it is expected that a height unit will be added to enable the height of each aircraft to be displayed on an elevation scan display.

DIRECT-READING EMISSION SPECTROSCOPY.—The Industrial Spectroscopy Group of the Institute of Physics have formed a panel of members interested in direct-reading equipment for spectrochemical analysis. These devices combine spectrographs with electronic equipment in such a way that the intensities of characteristic spectral lines give a direct reading of the percentage of the elements present in the specimen. The object of the panel is to organise meetings which would serve the interests of users and potential users of this equipment. Persons who would like notices of the meetings on this subject are invited to join the Group, particulars of which may be obtained from the secretary, Institute of Physics, 47, Belgrave-square, London, S.W.1.

DIESEL SHUNTING LOCOMOTIVES FOR PARKESTON QUAY.—The Eastern Region of the British Railways recently took delivery of three Diesel locomotives, Nos. 11108, 11109 and 11110. They were made by Vulcan Foundry, Ltd., Newton-le-Willows, Lancashire, and are fitted with five-speed gearboxes to facilitate rapid acceleration. The brakes are operated by compressed air, and a vacuum exhauster is installed for use when working vacuum-braked rolling stock. Thus they can be used for stabling Continental trains and the B.A.O.R. leave trains. They are proving to be more economical than the 0-6-0 steam engines, which they have replaced, and only need attention once a week when refuelling, whereas their predecessors required attention each day. The transit sheds at Parkeston quay were recently repainted, and it is hoped that a further saving will result, as painting should now be required less frequently, due to the reduced pollution of the atmosphere. Each locomotive weighs approximately 30 tons, has a fuel capacity of 225 gallons, and is rated at 204 h.p.

ELECTRONIC CONTROL OF GLASS-GRINDING MACHINES.

ELECTRONICALLY-controlled direct-current motors are now being increasingly adopted in many industrial processes where variable-speed drives are required, owing to the high accuracy and rapid response which is obtainable by their use. The static nature of such controls also removes many possible causes of unreliability, while a further advantage is that they can easily be combined with automatic regulating apparatus. An example is to be found at the St. Helens works of Triplex (Northern), Limited, where the General Electric Company, Limited, Kingsway, London, W.C.2, has recently installed electronic equipment to control the speed of the machines used for grinding the edges of glass windows.

In these machines, a view of one of which is given in Fig. 1, the windows are mounted in pairs on a rotating chuck, which is driven by a 1-h.p. direct-current motor, and are held in position by toggle clamps, as shown in Fig. 2. The grindstone, which rotates at constant speed in bearings mounted on one end of a pivoted arm, is maintained in contact with the edge of the glass by counterweights. The speed at which the glass passes over the stone is critical and the chuck speed must therefore be accurately controlled in order that the windows shall be ground to the correct profile. The speed range required is considerable and at certain points, particularly where sharp corners are being ground, the speed of the chuck must be varied very rapidly.

The system of control adopted is shown diagrammatically in Fig. 3. As will be seen, the motor driving the chuck is excited from a bridge-connected metal rectifier *a*, which, in turn, is fed from the secondary of a transformer *b*. The motor armature is supplied from a pair of thyratrons *c* and *d*, the current through it (and therefore the speed of the motor) being controlled by comparing a fixed proportion of the output voltage of the thyratrons with a reference voltage, which is proportional to the required motor speed. The resulting "difference" voltage is fed into an electronic amplifier, the output of which controls the operation of a phase-shifting network in the grid circuit of the thyratrons in such a way that the motor speed is increased or reduced to the required value.

The reference voltage just mentioned is obtained from the potentiometer shown at *e* in Fig. 3, which is supplied from a stabilised direct-current source. The setting of this potentiometer can be varied by a cam, which is mounted at one end of the machine and rotates in synchronism with the chuck. The profile of this cam varies with the size and shape of the windows that are being ground and the motion of its follower is transmitted to the slider of the potentiometer through a link mechanism. The output of the potentiometer is compared with the voltage across the resistor *f*. This resistor forms one arm of the potentometer *f*, *g*, which is connected across the output terminals of the thyratrons.

The way in which the phase-shifting network is used to vary the output of the thyratron may be explained by considering a simple circuit consisting of a pure resistor R and a pure reactor X, which are connected in series and supplied at a voltage E_S from the secondary winding of a transformer, as shown in Fig. 4. If the voltages across R and X are represented by the vectors E_R and E_X, respectively, as shown in Fig. 5, then the supply voltage will be represented by the resultant vector E_S. The vectors E_R and E_X will be at right angles to each other whatever the relative values of R and X. For varying values of these components and constant supply voltage, the locus of the point at which the vector E_R meets the vector E_X will be a semi-circle, of which the vector E_S is the diameter. If new connections are taken from the centre point of the transformer secondary and the connection between R and X, as shown in Fig. 6, the voltage V, between these leads, can be represented by a vector drawn from the centre of the vector E_S to the point where vectors E_R and E_X join, as shown in Fig. 7. It will be seen that this vector is the radius of the semi-circle, of which the vector E_S is the diameter. Consequently, if the relative values of R and X are varied, the vector V, in Fig. 7, will rotate about the centre of vector E_S, although its length will be constant. In other words, if either R or X is variable, an output of constant voltage equal to

ELECTRONICALLY-CONTROLLED GLASS-GRINDING MACHINE.

GENERAL ELECTRIC CO., LTD., LONDON.

Fig. 3.

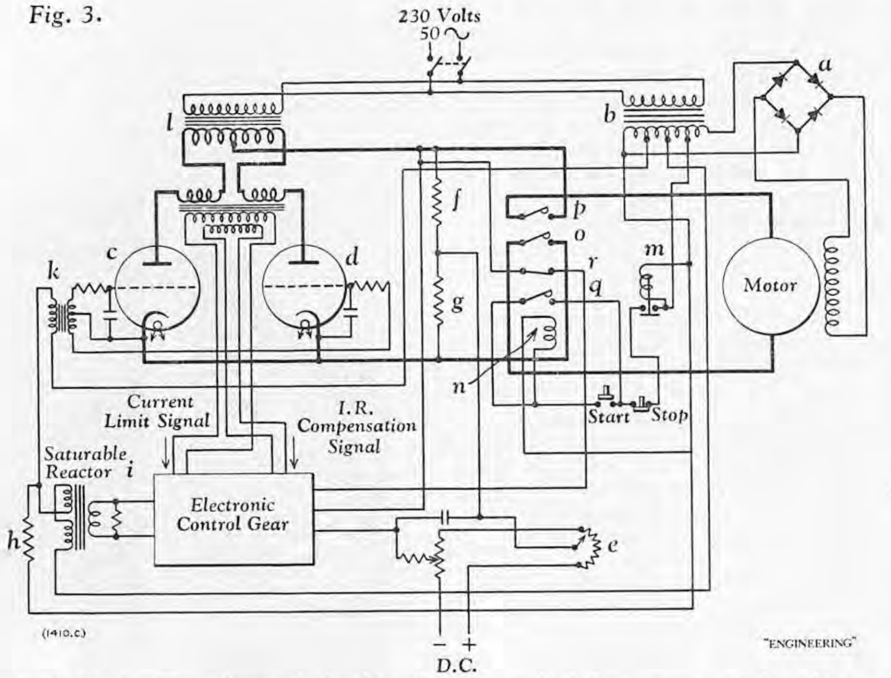


Fig. 4.

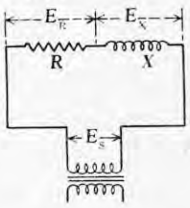


Fig. 5.

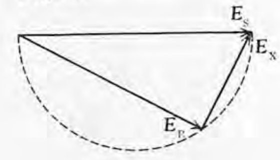


Fig. 6.

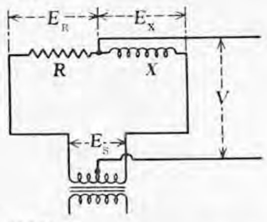
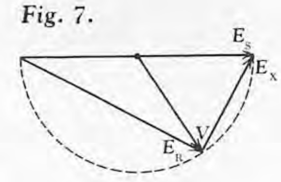


Fig. 7.



$\frac{1}{2}$ E_S can be obtained. The phase relationship of this voltage with the supply voltage is, however, variable.

In the actual control circuit, as shown diagrammatically in Fig. 3, the series components are a fixed resistor *h* and a saturable reactor *i*, while the supply is obtained from tappings on the secondary of the transformer *b*. The control winding of the saturable reactor is fed with the amplified "difference" voltage, obtained from the control circuit, so that any variation in this voltage produces a corresponding variation in the inductance of the reactor. The resulting output from the phase-shifting network (the voltage of which is constant but of variable phase) is supplied to the primary winding of the grid transformer *k*. One end of the secondary of this transformer *k* is connected to the grid of thyratron *c* and the other end to the grid of thyratron *d*. The centre point of this winding is connected to the common cathode lead. Thus the grid voltages of the two thyratrons are 180 deg. out of phase, as is necessary for full wave rectification. Since the supply to the anodes of the thyratrons is in phase with the supply to the phase-shifting network, any variation in the "difference" voltage from the control circuit will produce a proportional variation in the phase difference between the grid and anode voltages of the thyratron. The result will be that the firing period of the thyratrons will vary with the armature current. Further, any movement of the cam follower will cause a proportional variation of the motor speed; and the grinding speed at all stages of the operation will thus be automatically determined by the cam profile.

To start the machine the primary windings of the transformers *b* and *l* are connected to the 230-volt 50-cycle supply by closing the main switch. As a result, the motor field is energised from the secondary of the transformer *b*, and the thyratron heaters, power pack for the electronic control gear and reference potentiometer are supplied from the same source. Simultaneously, the operating coil of the time-delay relay *m* is energised and the relay closes after an adequate time for the thyratrons to warm up has elapsed. The motor can now be started by depressing the "start" button, pressure on which completes the circuit through coil *n* and causes the associated contactors to close. Contactors *o* and *p* connect the motor armature to the output from the thyratrons, while contactor *q* maintains the circuit through coil *n*. The remaining contactor *r*, which opens when the other contactors close, ensures that the load is applied gradually to the thyratrons.

There are two auxiliary control circuits, which are energised from a current transformer in the anode circuit of the thyratrons. One circuit is designed to limit the armature current to a predetermined value and thus to prevent the thyratrons being overloaded, while the other compensates for the drop in the speed of the motor as the mechanical load increases.

Each direct-current motor drives two chucks, one on each side of the machine, so that four windows may be ground simultaneously. The reference potentiometer is mounted alongside the motor, but the rest of the control gear, including the thyratrons, is housed in a sheet steel cubicle. This cubicle, which also contains the main transformer, is carried on a platform above the motor.

METALLURGICAL REQUIREMENTS OF THE CHEMICAL ENGINEER.*

By SIR CHRISTOPHER HINTON, M.A., M.I.C.E., M.I.Mech.E.

THE foundations of the modern heavy-chemical industry lie in the second half of the 18th century, when the manufacture of sulphuric acid, bleaching powder, and black ash began on an industrial scale. Throughout the Industrial Revolution there was a steady expansion. The manufacture of heavy alkalies was put on its present basis by the introduction of the ammonia soda process in 1873 and the invention of the electrolytic soda process in 1890; the contact process for the manufacture of sulphuric acid was made practicable in about 1870. Meanwhile, similar developments were taking place in the industries centred around coal tar. By 1802, Boulton and Watt were lighting their factory at Birmingham by coal gas, and from the growth of the coal-distillation industry arose the developments of synthetic dyestuffs which continued throughout the 19th century, though the initiative was largely lost to Germany before the war of 1914-18. That war called for an expansion of the chemical industry on a scale which was without precedent; later, it will be noted that the late war stimulated the beginnings of atomic energy in a similar way.

Until 1925, the chemical engineer had never demanded from the metallurgical industry the materials which he preferred or required for the manufacture of his plants; he had taken the materials which had been developed for other industries, and had devised processes which could be worked in vessels made of the available materials. Thus, his vessels were made of cast iron or mild steel, lined with blue brick if necessary; they were of timber lined with lead, or of copper. The engineering and metallurgy of chemical plants followed the growth of technique in the general engineering industry—it did not lead it.

The late 1920's marked a turning point, and from then onwards chemical engineers began to demand the materials which they require for the construction of their plants. In 1925, the 18 per cent. chromium, 2 per cent. nickel steel, now covered by British Standard S 80, was evolved. This martensitic steel was of only limited interest to the chemical engineer, but the later development of the austenitic, and to a lesser extent the ferritic stainless steels went far to meet his requirements.

Simultaneously with these advances in ferrous metallurgy, there had been a corresponding widening in the range of non-ferrous alloys available for chemical-plant construction. The manufacture of nickel had been put on an industrial basis at the beginning of the century, and at the end of the 1914-18 war it was important as an alloying material in ferrous metallurgy and as a plating material. In the period of which we are now talking its merits and the merits of non-ferrous nickel alloys as corrosion and heat-resisting materials were realised. To complete our outline picture of the second quarter of the century, we should call to mind the progress which took place in the non-metallic protection of plant by rubber and glass covering, and in the use of plastics.

Provided suitable fabrication techniques are worked out, the austenitic stainless steels meet most of the reasonable requirements of the chemical engineer in oxidising corrosion conditions. But there are limitations to their use; firstly, their resistance results from the formation of a protective surface film, and for this reason they are not fully satisfactory where there is erosion; and secondly, their resistance to corrosion is destroyed in the presence of halides. The position in the field of halide attack is far less satisfactory than in the field of oxidising attack. In the case of dry halides, mild steel can be satisfactorily used provided the temperature is not too high; even fluorine can be handled in the dry state in mild-steel plant, provided the temperature is below 200 deg. C. Above this temperature violent attack can take place. The temperature limitation can be raised by using nickel or Monel, but even these are not safe above 500 deg. C.

Where hydroxyl ions are present, the problem becomes very much more difficult. In the case of hydrochloric acid and its corrosive compounds chemical engineers usually take refuge in the use of glass-lined or rubber-lined vessels. Glass-lined vessels have limitations in size and complexity, while rubber lining cannot be employed at temperatures much above 90 deg. C. if it is to give a reason-

* 43rd Annual May Lecture delivered in London, on Monday, March 23, 1953, during the annual general meeting of the Institute of Metals. Abridged.

able life. The only metals which give good corrosion-resisting properties in this field are the nickel-molybdenum alloys in the Hastelloy group, but these are extremely difficult to fabricate.

The position in regard to bromine is still less satisfactory, since rubber can be less readily utilised, but one meets the greatest difficulty in dealing with the fluorine compounds. Here, not only rubber-lining but also glass-lining and ceramics are normally excluded. Mild steel, nickel and nickel alloys, copper, and aluminium can be used with suitable temperature limitations and in "dry" conditions, but these are very severe limitations to place on the plant designer. Thus, the second reasonable request that the chemical engineer may make to the metallurgist is for a better range of materials to resist halogen action, and within this field I stress the need for materials to withstand fluorine attack. I believe that this is of peculiar importance, as there is likely to be great growth in the status of fluorine chemistry in the next ten years. The only substance that can at present be recommended for use under severe conditions of fluorine attack is graphite, and even with modern developments there are limitations to the plants and vessels which can be built of this material.

The plant designer has found it perhaps too easy to provide the higher standard demanded of him by using expensive corrosion-resisting alloys merely to secure cleanliness. This is a question to which the metallurgical industry might wisely give attention. Unless they are able to provide a cheaper means of providing materials which give cleanliness, there may be a swing towards the use of inexpensive plastic materials in these conditions. There is already some indication that this is taking place in the food industries.

I should like now to speak of some of the metallurgical problems which arise in connection with atomic-energy development. These can be divided into two groups: those associated with the atomic piles and those associated with the ancillary chemical plants. The chain of processes involved in the manufacture of fissile material starts with the extraction of uranium from its ore, followed by its purification and reduction to the metallic form. In this form it is made into rods which are enclosed in aluminium cans. The canned uranium rods are placed in the atomic-energy pile, where part of the uranium is converted into plutonium. The irradiated rods containing this plutonium and the associated fission products are discharged from the pile; they are then extremely radioactive and can only be handled remotely. The irradiated rods go to the chemical-separation plant, where they are dissolved in nitric acid and processed to separate an impure plutonium, impure uranium, and the fission products. The plutonium goes through a purification process and is reduced to metallic form; the fission-products solution, which contains most of the radioactivity, is stored indefinitely.

It is not widely realised that in these early days of atomic energy, more than half the industrial effort and technical difficulty lies not in the piles but in the chemical plants, and these problems are engineering, chemical, and metallurgical in nature. This will probably not always be the case and, as the use of atomic energy for power production develops, the volume of effort will probably swing in the other direction, but we shall consider first of all the present and future metallurgical requirements of the chemical plants. The processes for the manufacture of uranium from ore are fairly conventional; they involve corrosion problems throughout, but these are well covered by the suggestions which I have already put forward in connection with the development of materials to withstand oxidising corrosion and halide attack.

The chemical plants in which the separation of the plutonium and fission products is carried out, after the uranium has been irradiated, are unconventional in that they are handling materials of such high radio-activity that the plants must be remotely controlled, and many of these plants cannot be approached for repair when they have once operated. Basically, therefore, the problem of materials of construction is the same as for other chemical plants which are subject to oxidising corrosion, but the problem is made more difficult and interesting by the consideration that repairs cannot be carried out, and failure must therefore be avoided. Very careful consideration of methods of fabrication has therefore been necessary.

The metallurgical problems in connection with the atomic piles are quite different and have nothing in common with those of the chemical plants. Piles (or as they are now more often called reactors) can be divided into two broad classes, thermal reactors and fast reactors. The thermal reactor uses as its fuel either natural uranium which contains 0·7 per cent. of the fissionable U_{235} isotope, or uranium which has been slightly enriched in this isotope by a physical process of isotope separation. We must increase the probability that neutrons will cause fissions of U_{235}; this is done by slowing them down in a moderator to energies which correspond with the temperature of that moderator; they are then called thermal neutrons. A neutron is a valuable article; we need all we have got in the pile, either to form plutonium or to cause further fissions of U_{235}; we cannot afford to waste them by having them uselessly absorbed by other materials. Our problem therefore in a thermal reactor is to select metals for use in the reacting core which will absorb the minimum number of neutrons and yet will meet our other requirements; those most readily available are aluminium and magnesium.

Until now aluminium has been used, particularly for the manufacture of the cans in which the uranium is enclosed. And here we have met the problem, so common in atomic-energy experience, that for the conditions which have to be met the material has defects. There is reason for interest in beryllium and zirconium, which also have low neutron-capture cross-sections and which have higher melting points.

The position in the fast reactor is different; here the fuel element contains a high proportion of fissile material; there is no need to maintain a balance between the neutrons which are captured to form plutonium and those which cause further fissions because the quantity of U_{238} in the fuel element is small enough to take care of this. It is therefore unnecessary to slow our neutrons down by using a moderator and we make use of the fast neutrons. They are less likely than thermal neutrons to be captured by metals used in the construction of the reacting core, and in the design of a fast reactor nuclear physics gives us a greater choice of materials. But we run into many other difficulties.

There is one other metal which I should mention as being of interest in atomic-energy work. Uranium is our only source in nature of fissionable atoms; we can use neutrons from these fissionable atoms to convert part of our uranium into plutonium which is also fissionable. But we can also use the neutrons which are produced from fission of U_{235} to bombard atoms of thorium and so produce another isotope of uranium with atomic mass 233 which is fissionable and which has many desirable properties. It is from this that our interest in the metallurgy of thorium arises.

TRADE PUBLICATIONS.

Chain Wheels.—The Renold and Coventry Chain Co., Ltd., 28, Deansgate, Manchester, 3, have sent us a leaflet listing their range of cast wheels for the Coventry Mark 5 roller chains.

Mobile Cranes.—The "Stanhay" mobile pneumatic crane, capable of handling loads up to 3 tons and designed for use in restricted spaces, is the subject of a leaflet published by Stanhay (Ashford), Ltd., Elwick Works, Ashford, Kent.

Shaping Machines.—A leaflet received from the Engineers Tool and Supply Co. (Wholesale), Ltd., 40, Monkton-street, Kennington, S.E.11, gives details of the 24-in. stroke hydraulic shaping machine for which they are the distributors.

Taper-Lock Bushes and Pulleys.—J. H. Fenner & Co., Ltd., Marfleet, Hull, have sent us a leaflet describing their taper-lock device for speedy attachment of pulleys and bushes to shafts. Their full range of "C" section V-belt pulleys is now available with taper-lock fixing.

Rolling Mills.—An illustrated brochure has been received which shows the range of two-high rolling mills with rolls from 32 in. to 6 in. diameter and a maximum width of 72 in., together with auxiliary equipment, manufactured by W. H. A. Robertson & Co., Ltd., Bedford.

MINER'S "SELF-RESCUER" RESPIRATOR.

A "SELF-RESCUER" respirator has been developed for the National Coal Board by Siebe, Gorman and Company, Limited, Tolworth, Surbiton, Surrey, to give protection for a short period (up to about half an hour), against concentrations of carbon monoxide which are likely to occur in mines. It enables men to pass through areas contaminated by carbon monoxide after an explosion or fire when making

FIG. 1.

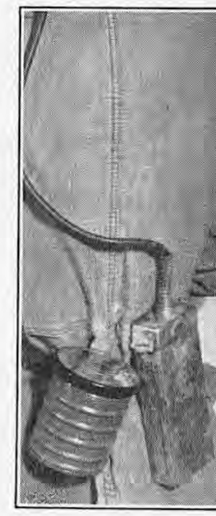


FIG. 2.

their escape to the pit shaft. The respirator, shown in Fig. 1, consists of an absorbent canister, 3¼ in. in diameter by 2¾ in. long, fitted with a mouthpiece, non-return inhalation and exhalation valves, nose-clip and a simple supporting harness tying behind the head. The canister is filled with Hopcalite, which converts carbon monoxide to comparatively harmless carbon dioxide, and an efficient drying agent which protects the Hopcalite. The canister weighs 16 ounces. The respirator is packed in a cylindrical metal container and sealed with a standard press cap. A loop is fixed to the container so that it can be carried on the man's belt, as shown in Fig. 2. The container is painted a distinctive green and is 3½ in. in diameter by 4½ in. high. The complete "Self-Rescuer" weighs 24 ounces. It will afford protection against "after-damp" only when there is sufficient oxygen in the atmosphere to sustain life.

BOOKS RECEIVED.

La Méthode de Hardy Cross et ses Simplifications. By SERGE ZAYTZEFF. Second revised and enlarged edition. Dunod, 92, Rue Bonaparte, Paris (6e). [Price 1,420 francs.]

United States National Bureau of Standards. Supplement to Circular No. 460. *Supplementary List of Publications of the National Bureau of Standards, July 1, 1947, to June 30, 1952.* The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 75 cents.]

Anniversary Volume on Applied Mechanics. Dedicated to C. B. Biezeno by some of his friends and former students on the occasion of his sixty-fifth birthday, March 2, 1953. N. V. De Technische Uitgeverij H. Stam, Zijlweg 1, Haarlem, Holland. [Price 20 florins.]

United States Coast and Geodetic Survey. Special Publication No. 251. *Conformal Projections in Geodesy and Cartography.* By PAUL D. THOMAS. The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 60 cents.]

Unites States National Bureau of Standards. Applied Mathematics Series No. 24. *Introduction to the Theory of Stochastic Processes Depending on a Continuous Parameter.* By HENRY B. MANN. The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 30 cents.]

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