

THE INTERNATIONAL MACHINE TOOL EXHIBITION AT OLYMPIA.

ONCE every four years the Machine Tool Trades Association stage an exhibition at Olympia, London. The interval is long enough to allow the machine-tool makers to develop entirely new designs and to improve existing machines, and such changes are reflected in the series of articles of which this is the first. From the user's point of view, too, it is expedient, every four years, say, to concentrate on an examination of machine tools and to make a critical comparison of machines at the user's works with those improved designs which the industry has produced. Such a comparison cannot fail to stimulate thought. There will be about 2,000 machines from this country and from Belgium, France, Italy, Germany, the Scandinavian countries, Switzerland and the United States. The exhibition opens next Wednesday, September 17, and closes on Saturday, October 4; the hours will be 9.30 a.m. to 6 p.m. every day except Sundays. The Minister of Supply, the Rt. Hon. Duncan Sandys, M.P., is to visit the exhibition on the morning of September 18, and will subsequently attend the exhibitors' luncheon.

VERTICAL MILLING MACHINE.

Machines for milling, screwing, and broaching will be exhibited by Messrs. Kendall and Gent, Limited, Gorton, Manchester, 18. The two illustrated and described in this article are a vertical milling machine of unusual design, which has some unique features and is particularly easy to

load and operate, and a large vertical milling machine which, though of more conventional design than the other, is stated to be "probably the largest of its type in continuous production anywhere in the world." The Kenco screwing machines, of which a number will be shown, are suitable for screwing tubes and bolts up to 6-in. bore and 3-in. diameter, respectively. The two largest machines are equipped with taper-threading attachments. The firm's No. 3 horizontal broaching machine has recently been improved, particularly in stability and appearance, and the electrical components are now better integrated in the design of the machine. Of the other machine tools to be exhibited, the open-side vertical and horizontal milling machine is a standard model except that two of the traverse gearboxes have been replaced by electronic drives which give infinitely-variable feeds; and the plano milling machine, weighing 50 tons, is the largest the makers have shown at an exhibition, though by no means the largest they have built, since they have supplied one weighing about 300 tons.

The vertical milling machine, illustrated in Fig. 1, on this page, is an improved version of the novel prototype which was introduced about three years ago. Certain modifications have been effected, as a result of the experience gained with the original, and the makers state that good reports have been received from production engineers who are using machines of the later design. The milling head of the latest model has been modified, principally to

achieve higher power and easier operation and control. A 30/30-h.p. two-speed motor has replaced the 15-h.p. motor used on the original model, and the slip gears in the feed and speed boxes have been eliminated. Both gearboxes are now of the direct-change type. Controls have been simplified and centralised so that all operating levers are within easy reach of the operator. A pendant box carrying all the push-buttons has been fitted. The milling head is entirely self-contained, housing all the spindle-driving and feed and traversing mechanisms. The spindle gearbox gives eight changes which, together with a two-speed motor, provide a range of 16 speeds from 15 to 310 r.p.m. Although it covers most requirements, this range can be altered to suit particular conditions. A single lever only is required to obtain any speed. The feed gearbox is carried at the rear of the milling head and is driven by a 5-h.p. motor. Eight changes of feed are obtained, independently of the spindle speed, and the range is 2 in. to 24 in. per minute. In addition, a rapid power traverse of 45 in. per minute is provided for setting purposes. Feed change is accomplished by rotating a hand-wheel carried on the front of the milling head. Behind the handwheel a large dial engraved with the individual feeds immediately indicates the particular feed engaged. This simple arrangement greatly assists the operator, especially where varying depths of cut on a job make frequent feed changes essential. Hand motions equipped with micro-

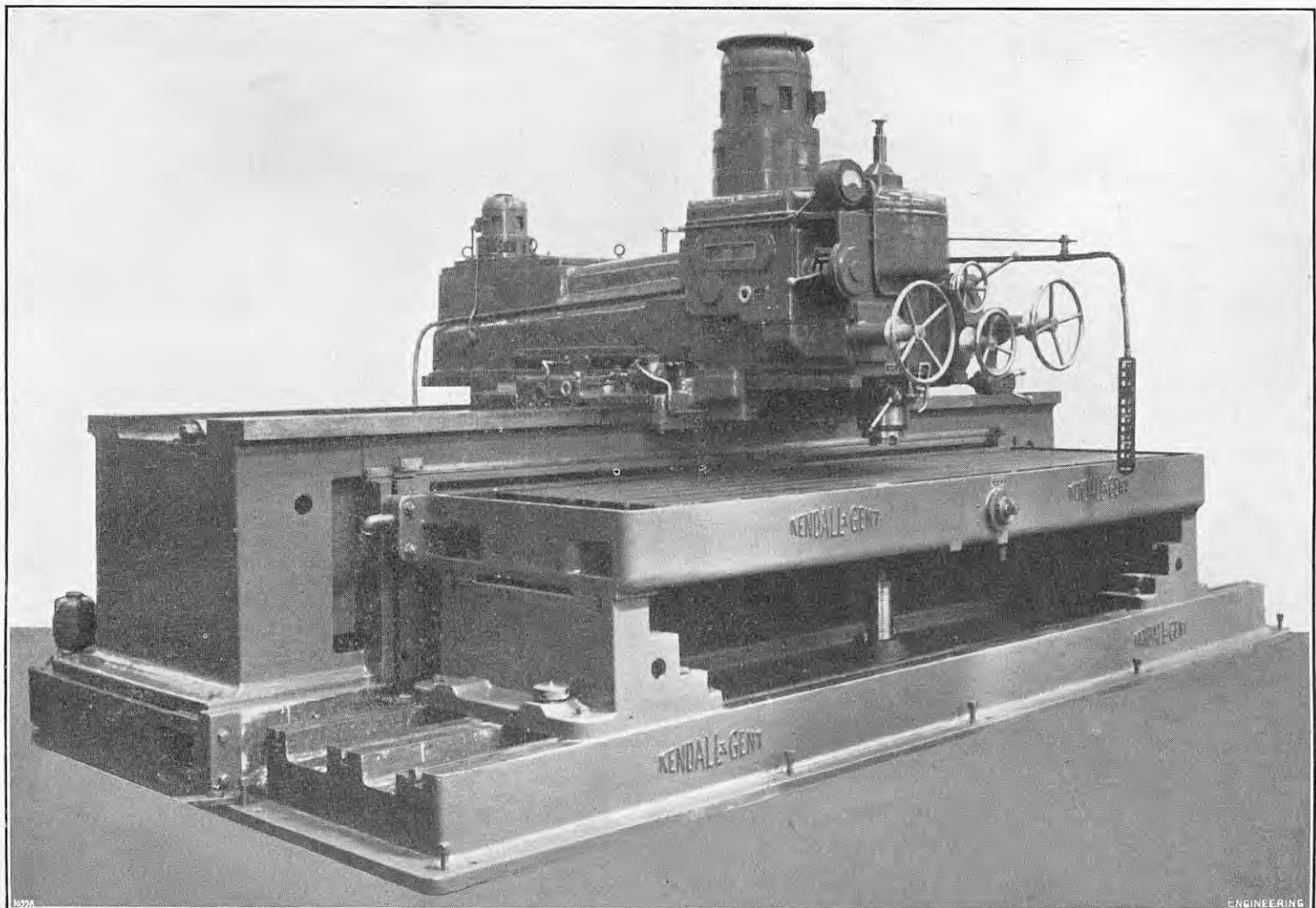


FIG. 1. VERTICAL MILLING MACHINE; KENDALL AND GENT, LTD.

meter dials are, of course, provided on all motions for fine setting, and efficient locks securely hold the spindle and other members when milling.

The main components of the machine are of massive construction, as can be seen from Fig. 1. The baseplate is heavily walled and cross-ribbed, and a suds tank is formed in the base. To the baseplate is tongued and bolted the bed casting on which the milling head slides. Wide return flanges, carried internally, allow a solid seating on the baseplate. The top between the slideways is enclosed and heavy ribs securely tie the vertical walls together. The main bed slideways are wide and deep, and as the casting is moulded upside down, permitting the slideways to be chilled, a hard wearing surface free from "pin-holes" is produced. A cavity for the electrical control panel is arranged in the rear of the bed.

The work-holding area lends itself to quite a number of combinations. The machine exhibited is fitted with a table resting on solid supports at each end. The table is a casting, well ribbed on the underside to support the heaviest load, and it is power elevated by means of a separate 5-h.p. motor beneath the table. The supports at each end have three steps and they are adjustable longitudinally by means of a rack and pinion to bring any required step into position. Resetting from one step to another is very quickly done. An examination of the machine, however, will prove that this arrangement can be amended quite simply. For instance, for work requiring considerable headroom, the bed plate can be T-slotted or special fixtures bolted to it. The design is extremely versatile and lends itself readily to adaptation to suit special conditions. The principal dimensions of the machine are: vertical adjustment of the spindle, 8 in.; table, 12 ft. by 3 ft.; vertical adjustment of table, 18 in. in three steps; maximum distance admitted between spindle nose and table, 3 ft. 2½ in.; longitudinal traverse of head, 13 ft.; and transverse traverse, 3 ft.

VERTICAL MILLING MACHINE.

The C.V.M. 60, shown in Fig. 2, is the newest in the range of Kendall and Gent vertical milling machines. Two types are available, the one to be exhibited being the carbide-cutter model, which has the power and stability fully to exploit the production potential of the modern tungsten-carbide milling technique. The wide range of speeds and feeds ensures that all materials can be dealt with at maximum efficiency, and the 40-h.p. drive to the spindle provides adequate power for any contingency.

The milling head is entirely self-contained, with the main motor driving through a short rigid transmission, with consequent increase of efficiency. The gears are of heat-treated nickel-chromium steel, with ground teeth. Eighteen spindle speeds are provided, in a range of 15 to 840 r.p.m. Change of speed is accomplished by a single lever and is simplified by a system of symbols which signify immediately the particular speed engaged. A substantial construction characterises the base. The slideways have a high degree of hardness, and those at the rear of the table are protected by sliding covers. The base rear extension on which the column is rigidly mounted forms the coolant tank. The column, of substantial proportions, carries the milling head and elevating motor. Its base is secured to the base extension both horizontally and vertically, ensuring rigidity and correct alignment. The spindle is made from heat-treated high-tensile steel and runs in precision roller bearings which take the radial load. A double thrust ball washer takes the reaction of the cut and also supports the weight of the spindle. A large sleeve carries the spindle with the main bearings, and is equipped with micrometer hand adjustment for setting the depth of cut. Backlash and end play are eliminated by a patented arrangement. A large dial indicator with adjustable depth stop eliminates the constant checking of the work on the table and enables the operator to set the cut to within 0.001 in.

Table feeds are reversible and are obtained from a constant-speed motor coupled through reduction gearing to the change-feed box. The box has a direct-reading feed-change indicator projecting to

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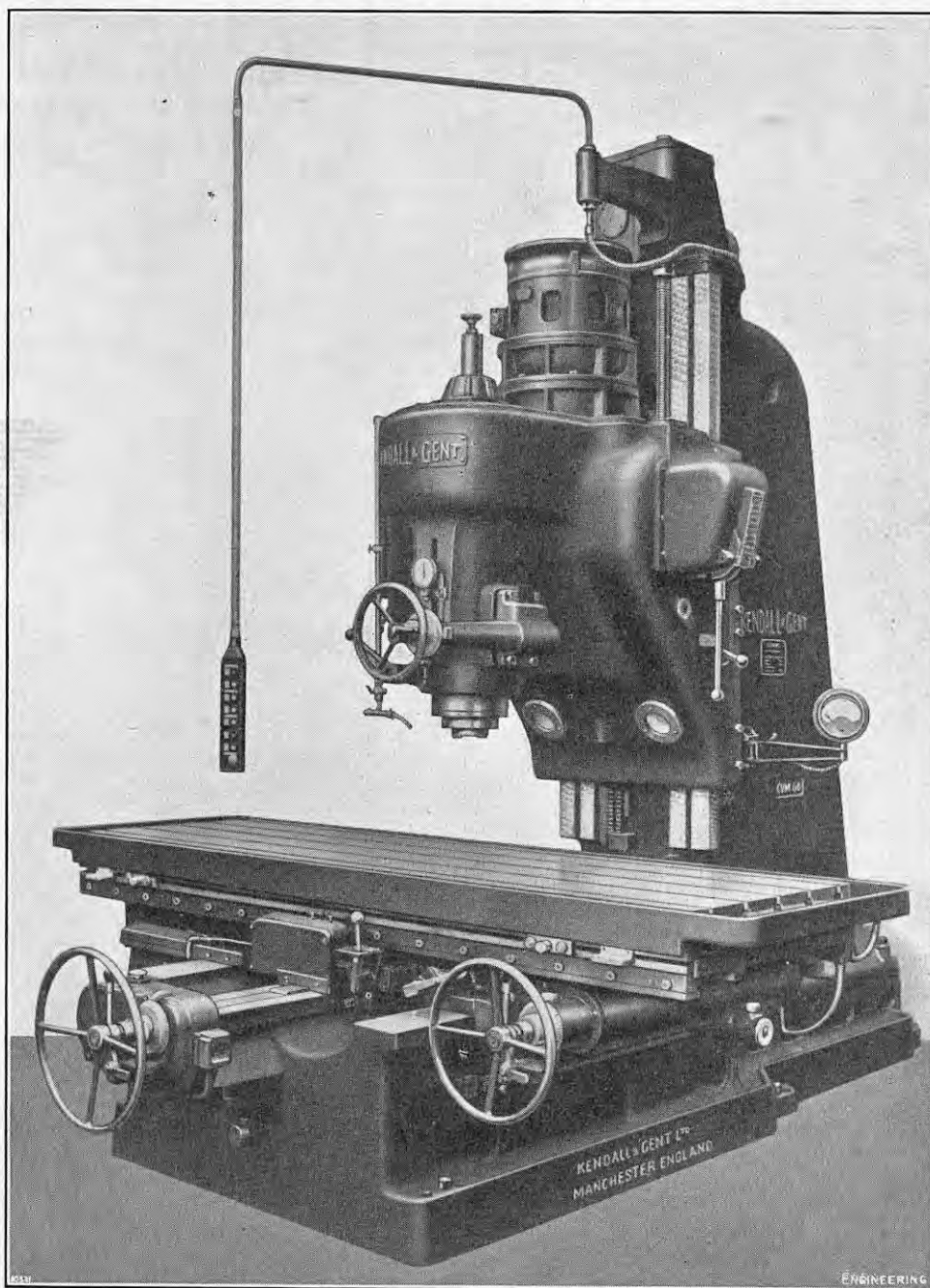


FIG. 2. VERTICAL MILLING MACHINE; KENDALL AND GENT, LTD.

the front. The enclosed sliding gears provide eight changes of table feed for each spindle speed, from 1½ in. to 18 in. per minute. The direction of the table traverse is controlled electrically by push-buttons in the pendant box, and the feeds can be tripped at any predetermined position in both the longitudinal and transverse directions by means of adjustable stops. Longitudinal traverse is through a worm and semi-circular rack, and transverse traverse is through a large-diameter screw protected against falling chips. All handwheels are clutch-operated and, when engaged, a lever mechanism cuts out the power circuit of the table-traverse motor. This simple device prevents accidents to the operator caused by handwheels revolving at high speed on rapid traverse, or by the engagement of power traverse when the hand motion is in use. The electrical control panel is built into the side of the column. An ammeter graduated in amperes and horse-power, with a red line at full-load current, is carried on the column. Besides indicating the load imposed by the cut, it also provides a ready guide for the regrinding of milling cutters. The principal dimensions of the machine are: distance from the spindle axis to the face of the column, 3 ft.; maximum height admitted between the spindle nose and the table, 3 ft. 5 in.; table working surface, 9 ft. by 2 ft. 9 in.;

longitudinal traverse, 7 ft. 2 in.; transverse traverse, 3 ft. 3 in.; and spindle sleeve adjustment, 6 in.

20/24-IN. SWING LATHE WITH HYDRAULIC COPYING ATTACHMENT.

Messrs. John Lang and Sons, Limited, Johnstone, Renfrewshire, will exhibit eight lathes of 13 in. to 26 in. swing. Apart from the two illustrated in Figs. 3 and 4, opposite, there will also be several sliding, surfacing and screwcutting lathes, two surfacing and boring lathes, and two prototypes of new designs, one a 17-in. swing lathe with a high-speed headstock (up to 2,140 r.p.m.), and the other a 17-in. swing lathe with hydraulically-operated gear change, a new speed being selected while the machine is running and automatically brought in when the spindle comes to rest.

The 20/24-in. lathe with hydraulic profiling attachment enables stepped and tapered shafts to be turned at one setting. A slide is arranged on the saddle at 45 deg. to the axis of the lathe and is operated by a hydraulic cylinder. The movement of this cylinder is controlled by a retraction valve which is coupled to a sensitive stylus. A specimen of the part to be turned is mounted between centres at the rear of the machine in easy view of the operator. The centres can be moved longitudinally,

EXHIBITS AT THE INTERNATIONAL MACHINE TOOL EXHIBITION.

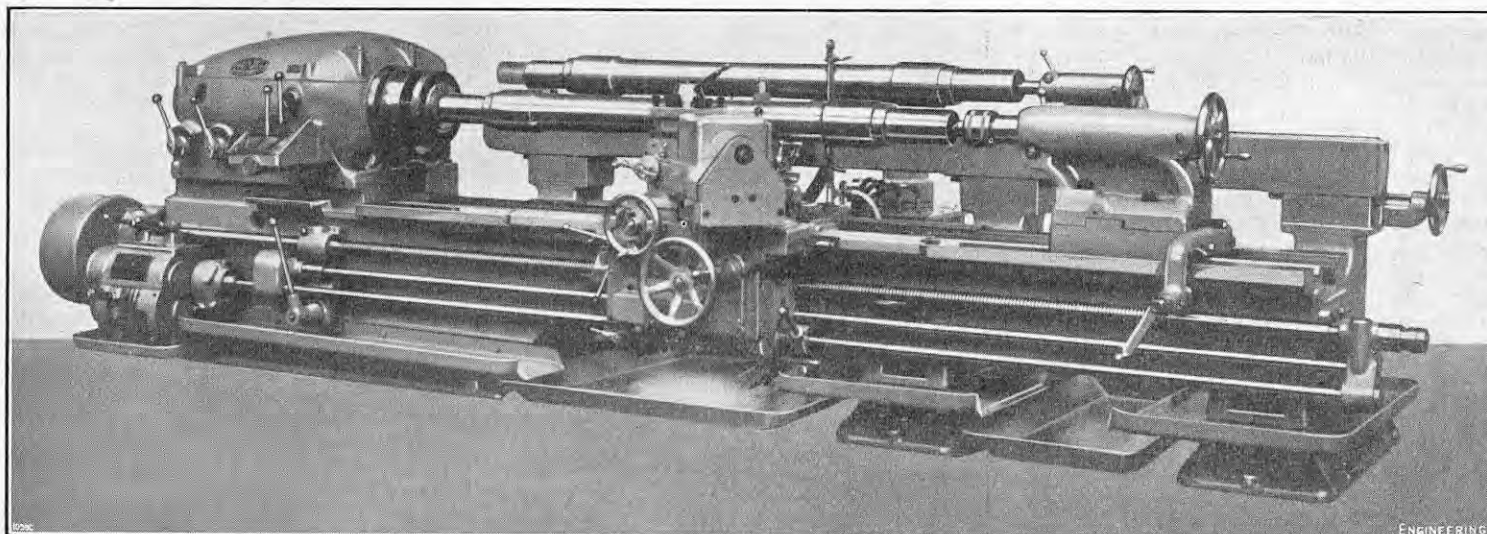


FIG. 3. 20/24-IN. SWING LATHE WITH HYDRAULIC COPYING ATTACHMENT; JOHN LANG & SONS, LTD.

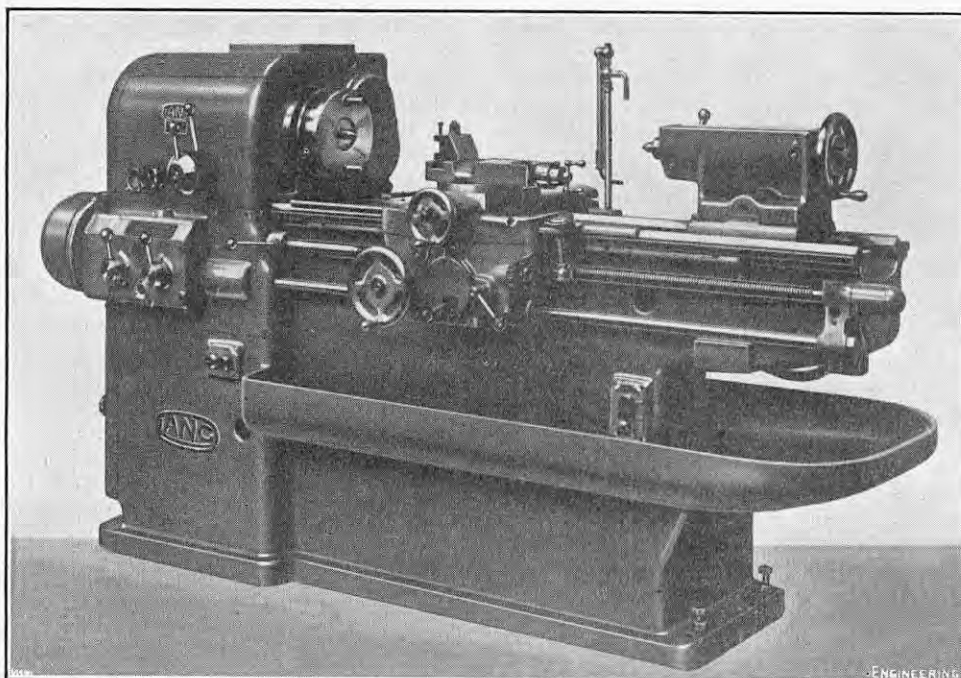


FIG. 4. "JUNIOR" CENTRE LATHE; JOHN LANG & SONS, LTD.

separately or together, and adjusted for parallelism to give accurate setting. The distance from the tool to the stylus is also adjustable to suit the final diameter of the work. Roughing cuts may be put on by the saddle screw until the stylus comes into operation for the final cut. The specification for this machine is substantially the same as for the firm's 24-in. swing lathe, except that only three speeds (instead of 12) are available in the reverse direction. The 24-in. lathe is made with or without a gap, and the bed can be made in various lengths from a minimum of 12 ft., giving a distance between centres of 5 ft. The headstock provides 12 spindle speeds in both the forward and reverse directions, and all gears are of heat-treated nickel-chrome steel with the teeth shaved and lapped or ground on the profile. Speed control is by gate change-levers and the main drive is through multi-plate friction clutches operated from both the headstock and operator's working position to give start, stop or reverse rotation to the spindle. The spindle, of large diameter, is mounted at the front end in a patent preloaded spherical-roller bearing to take the radial and end loads, and at the rear end in a double-row plain roller bearing. The spindle flange has a patent quick-release for easy changing of the driving plate, faceplate or chucks. The bed is of hard close-grain cast iron, of about 200 Brinell

hardness, deep in section and with diagonal webs to withstand torsional strains. Sliding surfaces are protected by means of covers attached to the saddle. The saddle is mounted on the square shears of the bed and carries compound slides which can be arranged with a four-bolt tool-slide or a square turret. Ground Acme operating screws, covered for protection, are fitted with micrometer dials reading to 0.001 in. An indicator dial is fitted to facilitate engagement of the lead-screw when screwcutting. The apron has all controls grouped for ease of manipulation, one lever engaging the multi-tooth clutches for sliding or surfacing feeds and another engaging the lead-screw. These levers are interlocked so that two motions cannot be engaged at the same time. A third lever at the lower left of the apron is arranged to reverse the feed motions. The gearbox is of the multi-change type, giving 28 changes for normal feeds and threads; by moving a lever on the headstock two further ranges can be obtained: a coarse range for quick-pitch screwcutting at the six lowest spindle speeds, and a fine range of feeds at the six fastest spindle speeds for fine finishing at high speeds. A swing plate is provided so that, with the necessary change wheels, metric or odd threads can be cut. A special attachment is fitted as an extra for cutting leads up to 160 in. The tailstock is guided by inverted-V and

flat ways on the bed, which are independent of the saddle guides, and it is provided with side adjustment for setting.

"JUNIOR" CENTRE LATHE.

The Lang "Junior" lathes of 13 in. and 17 in. swing, with built-in electrical equipment, have flush surfaces to give a pleasing appearance and for ease of cleaning. One of them is illustrated in Fig. 4, on this page. They have two ranges of six spindle speeds, the change from one range to the other being made by reversing the position of pick-off gears; thereafter the six speeds in each range are obtained by lever control. All gears are of nickel-chrome steel, with the teeth shaved and lapped or ground after heat-treatment. Lubrication to the gears and bearings is automatic, by a plunger pump which is readily removed for cleaning. Multi-plate friction clutches controlled from a lever at the front of the headstock enable the operator to start, stop or reverse the rotation of the spindle. The latter is mounted at the front end in a patent preloaded spherical-roller bearing to take radial and end loads, and at the rear in a double-row plain roller bearing. The spindle flange has a patent quick-release for changing the driving plate, faceplate or chucks. The bed is deep in section and made of hard close-grain cast iron, with diagonal webs to withstand torsional strains. A chute is arranged inside the bed to deflect cuttings and coolant to the rear of the lathe into a deep trough cast integral with the base. Ground sliding surfaces of the bed are protected by sliding covers attached to the saddle. The latter is mounted on inverted-V and flat ways on the bed and carries compound slides with either an open-sided tool-holder or a square turret, as desired.

The apron has control levers grouped for the convenience of the operator, one lever engaging a multi-tooth clutch for sliding and surfacing feeds, and a separate lever engaging the lead-screw. The change from sliding to surfacing is by a pull-and-push control, and all motions are interlocked so that two motions cannot be engaged at the same time. The gearbox gives six changes of feed and screwcutting by means of two levers. All gears run in an oil-bath and the bearings are lubricated by gravity from a reservoir. Change-gears are provided for cutting Whitworth and metric pitches. The tailstock is guided by inverted-V and flat ways on the bed, independent of the saddle guides, and has side adjustment for setting. The 17-in. lathe is fitted with a monobloc hydraulic profiling attachment, which is fixed at the rear of the saddle and does not interfere with the normal working of the lathe. The specimen is mounted at the rear of the bed, the profiling slide feeding in at 45 deg. and from the rear. The attachment gives greatly increased production on such work as stepped and

tapered shafts, but leaves the lathe immediately available for any urgent single job which does not require the use of the attachment.

10-FT. PLANING MACHINE.

Messrs. John Stirk and Sons, Limited, Halifax, will show the all-electric double-housing planing machine illustrated in Fig. 5, on Plate XV. It has a planing capacity of 10 ft. long by 42 in. wide by 36 in. high. The bed has a continuous top plate, with numerous cross ribs, and the table-ways, of the flat type, are lubricated by a motor-driven pump which is started simultaneously with the main driving motor. The box-type table has openings at each side to facilitate chip removal, and troughs at the ends. Chip guards are also fitted to reduce the risk of scoring. A safety device mounted on the bed comprises a hydraulic table stop and jack. If, owing to a mechanical or electrical fault, the table should leave the driving gear, it is brought safely to rest within a few inches. The same device enables the operator to push the table back to re-engage the gearing without other assistance. The device is provisionally patented. The drive to the table is of the single-helical type, the helical gear hardened and ground and meshing with a Meehanite rack. The gear runs in an oil-bath and is coupled direct to a slow-speed 32-h.p. reversing motor. End pressure is taken on ball thrust washers fitted to the motor cover. This Stirk "Wonworm" drive is claimed to be extremely steady, and to eliminate tooth marks on finished surfaces. The cutting speeds range from 40 to 240 ft. per minute, and the return speeds from 160 ft. to 240 ft. per minute. A tachometer is fitted to indicate the table speed. The cross slide has been designed so that deflection under heavy cutting is negligible. The tool boxes are of a universal swivelling type, and the maximum slide movement is 10½ in. The slideways are of improved design, with raised narrow V-guides to maintain alignment and to provide increased bearing surface. Relief is provided on the return stroke, at any position of the tool, by a patented arrangement. The cross-slide boxes have converging and diverging motions, as well as simultaneous movement in one direction.

The feed box is mounted at the right-hand end of the cross slide, and 11 reversible feeds, ranging from ¼ in. to ¾ in. can be obtained by the movement of two levers. Drive for the feed is provided by a 5-h.p. motor enclosed in the cross-rail, together with the elevating gears. The same motor is used for raising and lowering the cross-slide and for the rapid traverse of the tool-boxes. Safety trips are provided for all motions, and the gearing is lubricated by a one-shot system. The cross-slide has a fully automatic electric clamping arrangement, which is electrically interlocked with the elevating motion. A side tool-box of the same type, and with the same feeds as those on the cross-slide heads, is mounted on each column. These boxes are balanced, the weights being enclosed in the uprights, so that there is no undue load on the traversing screws. Buttress-type uprights, of substantial proportions, house all the electrical equipment with the exception of the generator and starting gear. All the controls are mounted on the upright at the operator's side, including the disc for setting the stroke. Graduations on the disc enable settings from a few inches upwards to be readily made. An accelerator switch is provided on the left-hand side of the machine for speeding up the table when there are gaps in the surfaces to be machined. Improvements have been made in the electrical control to give reduced peak loads on reversal and better performance on the high-speed range, with provision for increasing the cutting speeds after the cut has started when using cemented-carbide tipped tools. Balanced swivelling pendant switches are provided.

CONTINUOUS ROTARY MILLING MACHINE.

Messrs. William Asquith, Limited, Highroad Well Works, Halifax, will exhibit, in addition to some of their well-known radial drilling machines, several unusual machine tools. These include the continuous rotary milling machine illustrated in Fig. 6, on Plate XV, and described below; a vertical drilling machine with an electronically-controlled spacing table, details of which were not available

at the time this article was prepared; a milling machine for machining drum and face cams; and a radial drilling machine with infinitely-variable spindle speeds. Among new designs there is also a 10-ft. radial machine illustrated in Fig. 7, on Plate XV, and described below.

The continuous rotary milling machine consists of a bridge-piece mounted on vertical columns and spanning a rotary table 9 ft. in diameter. The bridge-piece carries six vertical milling spindles arranged in two groups of three spindles. The machine is designed for a continuous duty of removing a maximum of 72 cub. in. of cast iron per minute, i.e., each set of three spindles will rough and finish a face 12 in. wide, with a ¼-in. deep cut at a table feed of 12 in. per minute. The spindles are mounted on anti-friction bearings in large sleeves, and have 5⅞-in. British Standard spindle ends arranged for carrying cutters fastened with screws. Each spindle has its own driving motor, driving the spindle through V-ropes, speed slip-gears for speed changes, and a final worm and wheel. Each spindle sleeve is adjusted vertically by a rack and pinion operated by a handwheel through a worm and wheel. The sleeve is clamped in its working position. The driving motors are mounted on top of the bridge-piece, and each spindle has its own lubrication system so that it can be run individually. The spindle bearings are drip-fed through visible metering valves and sights to ensure that the correct amount of oil is supplied. The centre of the base is in the form of a well in which the table is mounted on a large central bearing. The worm for revolving the table takes its drive from the table feed box which is bolted on the base and is a separate unit. The table has a plain top surface for carrying fixtures, and is supported by annular ways in the base. The table feed worm is mounted in the base and is readily accessible for inspection, or for removing when the table has to be lifted for any purpose. The table feed box is carried on a facing on the base and is of unit construction, allowing the table worm-shaft to be removed without dismantling the feed box. A 5-h.p. motor mounted on the box drives through V-ropes, reduction gears, feed slip-gears and final worm and wheel, to the table-feed worm-shaft passing through the base. A clutch operated by a hand lever selects either "feed" or "quick rotation" to the table. A 12-feed Wakefield lubricator mounted at the end of the base provides pressure lubrication to the table centre bearing, plain bearings on the table worm-shaft and the table worm and wheel. Provision is made for priming this lubricator in order to lubricate the bearings prior to starting the machine, after which the pump motor will run whenever the table rotates.

All controls are electrical push-buttons, except the lever which selects the drive to the table for feed or quick rotation. This lever is mounted on the front of the feed box and incorporates a switch which renders the corresponding push-buttons operative. Mounted on the end column adjacent to the feed box is a control desk with most of the push-buttons. Various interlocks are provided to safeguard the machine and operator. The main spindle motors are 10-h.p. machines, and the range of spindle speeds is from 12 r.p.m. to 72 r.p.m. The vertical traverse of each spindle sleeve is 4 in.; the centre-to-centre distance of the roughing spindles is 10-13 in.; and the pitch-circle diameter of the fixtures is 80 in.

O.D. 4 RADIAL DRILLING MACHINE.

The Asquith radial drilling machine, illustrated in Fig. 7, on Plate XV, is of new and advanced design. The maximum distance from the spindle axis to the column axis is 10 ft., but a range of machines of this type is made in seven sizes, from 6 ft. to 12 ft. On the standard machine, 18 spindle speeds and nine spindle feeds are provided, the speed range being either 1,550 to 19 r.p.m., 1,100 to 14 r.p.m., or 775 to 9½ r.p.m. In addition to the nine feeds, which range from 0.002 in. to 0.048 in. per spindle revolution, change wheels can be provided for threads between 6 and 40 threads per inch. The spindle is driven by a 15-h.p. reversing motor, flange-mounted vertically on top of the slide. Stop, start and reverse of the spindle are controlled by a single lever which also controls the arm

elevating motion. Inching of the spindle rotation is effected by means of a push-button. The spindle slide is well balanced on the arm, on which it runs on ball-bearing rollers, and all controls are compactly grouped. The spindle feed is a patented self-applying type, coming into operation automatically when the spindle having been wound down to the work, the operator continues pressing for a moment. A reverse movement of the hand-wheel first disengages the feed and then withdraws the spindle. An automatic feed-trip motion can be set to disengage the feed at any point in the travel of the spindle, and a fine hand feed is provided.

The spindle, of heat-treated alloy steel, runs in a special system of ball and roller bearings in the barrel, and is reversed electrically, i.e. by reversing the motor. A patented form of wiper in the barrel bearing prevents the ingress of dirt. The slide and the arm are locked simultaneously by means of two controls, and a red light appears when the arm is locked. The following phases are provided for: slide and arm completely locked; slide completely locked, arm unlocked—from this condition the arm can be locked against radial adjustment only, leaving it free to be elevated and lowered; and the arm completely locked, with the slide unlocked. The arm has been designed to give the maximum strength in relation to its section, and will adequately resist the lifting and twisting stresses during drilling. It is carried on the pillar by a special form of ball and roller mounting. At the base of the pillar internal ribbing gives it strength, and the box at the top is mounted on ball bearings and houses the collector gear as well as the electrical connection to the spindle slide. The elevating screw does not rotate and only a portion of it is exposed when the arm is in the topmost position. Other features of the machine are an illuminated oil-flow indicator at the front of the slide, and a device for ejecting drills, sockets, etc. The range of vertical movement of the arm is 5 ft. 6 in., and the minimum radius from the spindle axis to the pillar axis is 2 ft. 10½ in.

UNIVERSAL PATTERN MILLER.

Wadkin, Limited, Green-lane Works, Leicester, will exhibit a number of their latest types of wood-working and pattern-makers' machines, of which we illustrate and describe two—the universal pattern miller shown in Fig. 8, on Plate XVI, and the universal cutter grinder shown in Fig. 9, on the same Plate. The other machines on their stand will be two high-speed routing machines, a new 12-in. surface planer, a heavy-duty spindle moulder with a top speed of 9,000 r.p.m., a high-speed planer and moulder, a straight-line edger, a hydraulic cross-cut saw, a straight-knife grinder, a wood-turning lathe, a combined surfacer and thicknesser, a canting-spindle dimension saw, a disc and bobbin sander, a cross-cutting and trenching machine, a 30-in. band saw, and a 20-in. general-purpose saw bench.

The Wadkin universal pattern miller (Fig. 8) is the latest design of a machine which originated in 1897, when it was known as the mechanical wood-worker. Further improvements have recently been made, notably in the design of the spindle and the transmission of the drive to it. Previously, the drive to the spindle was from a motor mounted at the opposite end of the arm to the cutter-head, and the drive was through a shaft and worm and worm-wheel. On the new machine, the drive to the spindle is by a short-centre flat stretchless belt, driving from a four-speed motor built into the head-stock. The motor provides speeds of 4,500, 3,000, 2,250 and 1,500 r.p.m. A frequency-changer built on to the end of the arm provides the top speed and the 2,250 r.p.m. The remaining two speeds, of 3,000 and 1,500 r.p.m., are obtained directly from the line. The cutter spindle is mounted in ball bearings housed in a large-diameter sleeve. A movement at right-angles to the arm is provided by means of a rack cut in the sleeve; the pinion engaging the sleeve is controlled by a hand lever on the front of the head for quick adjustment. A fine screw-feed operating on the rack is also provided. The spindle is counterbalanced at every position by means of a weight mounted in the head, having rack teeth which engage with the opposite side of the pinion operating in the sleeve rack. The driving

EXHIBITS AT THE INTERNATIONAL MACHINE TOOL EXHIBITION.

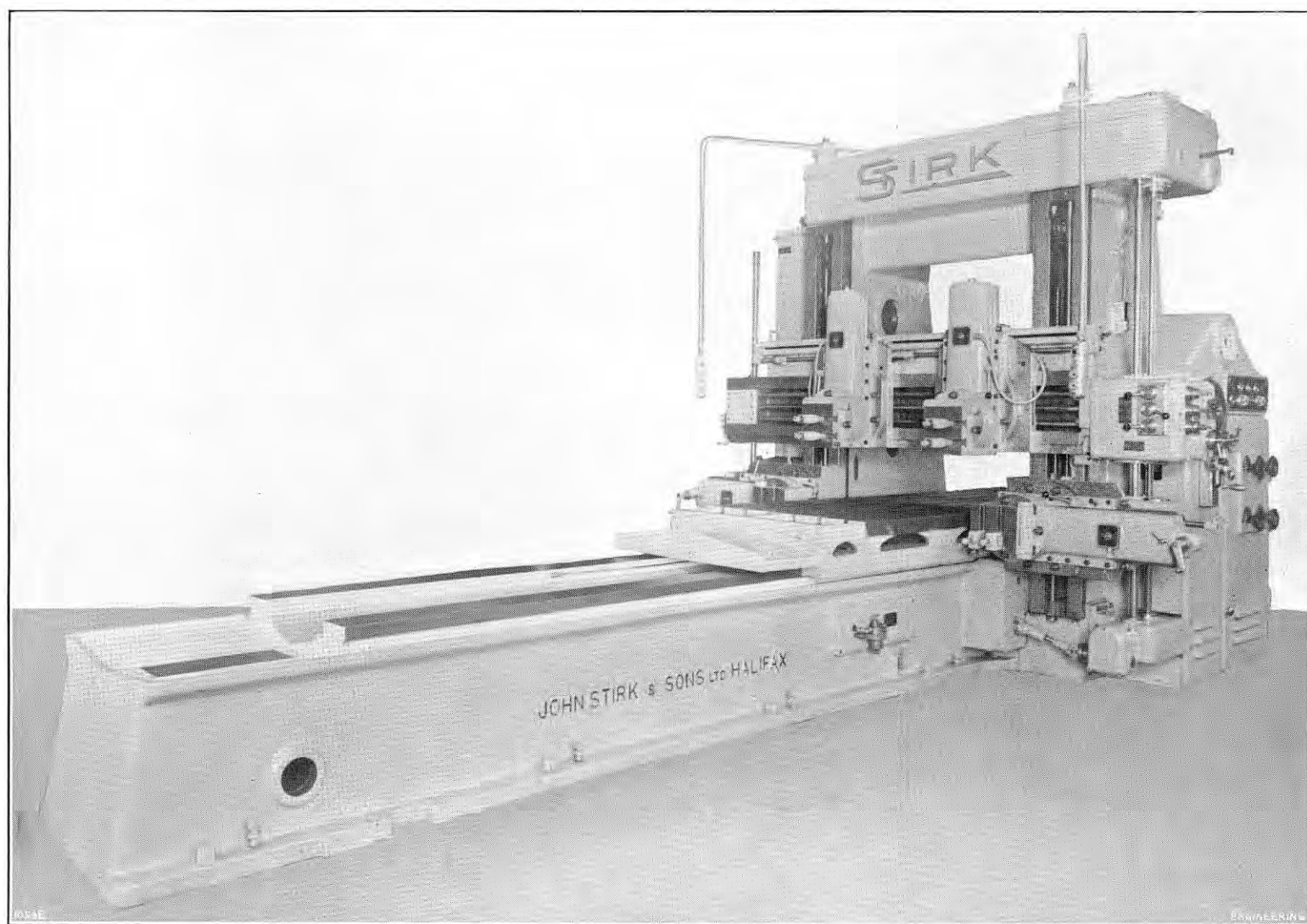
(For Description, see Page 324.)

FIG. 5. 10-FT. PLANING MACHINE; JOHN STIRK AND SONS, LTD.

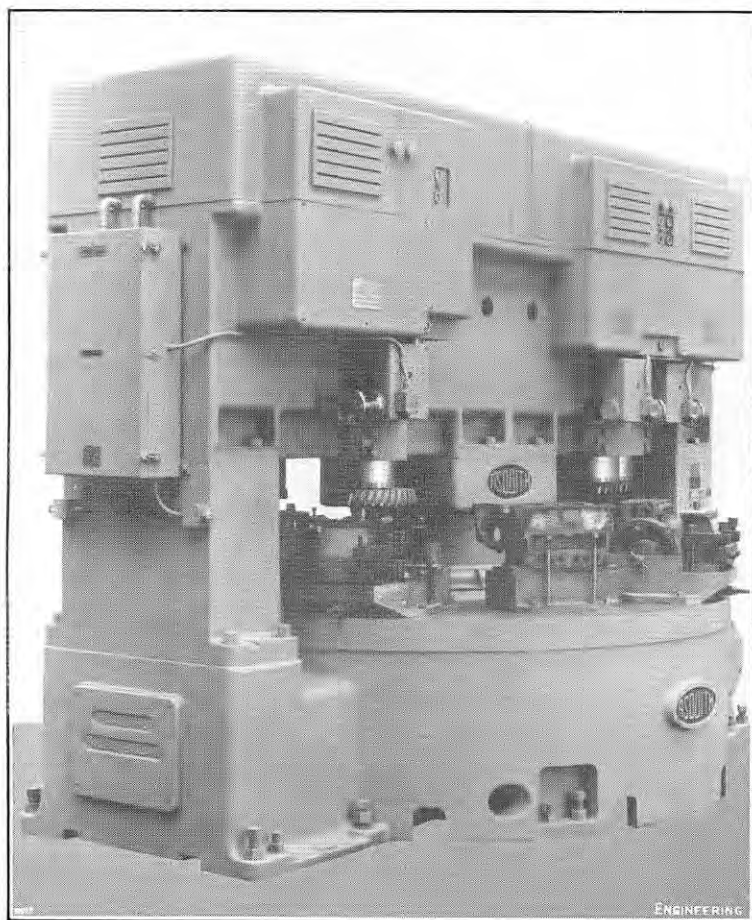


FIG. 6. CONTINUOUS ROTARY MILLING MACHINE; WILLIAM ASQUITH, LTD.

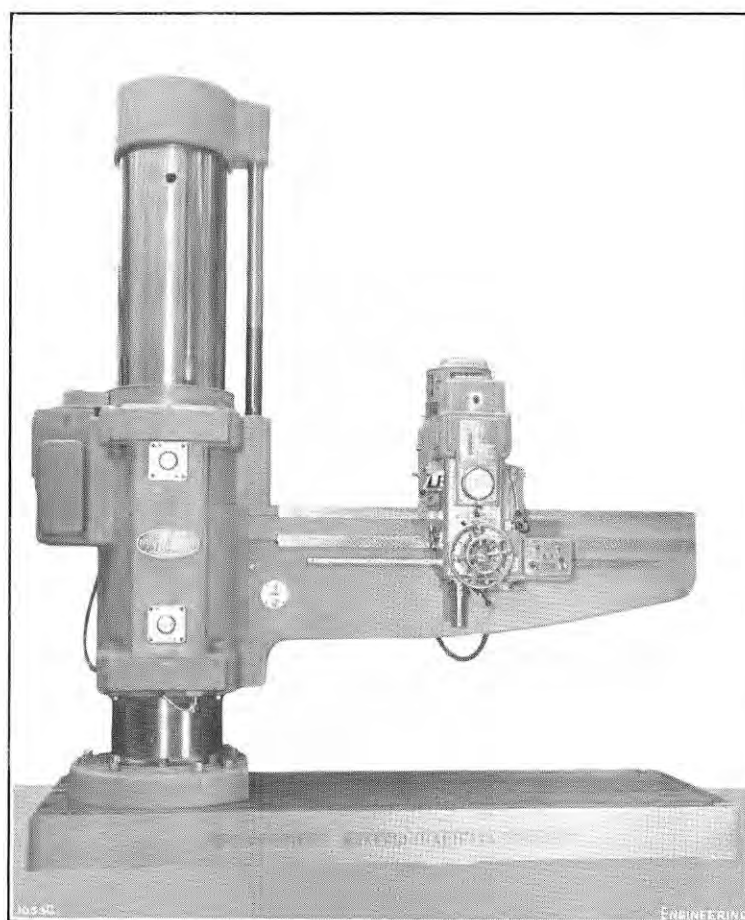


FIG. 7. O.D.4 RADIAL DRILLING MACHINE; WILLIAM ASQUITH, LTD.

EXHIBITS AT THE INTERNATIONAL MACHINE TOOL EXHIBITION.

(For Description, see Page 324.)

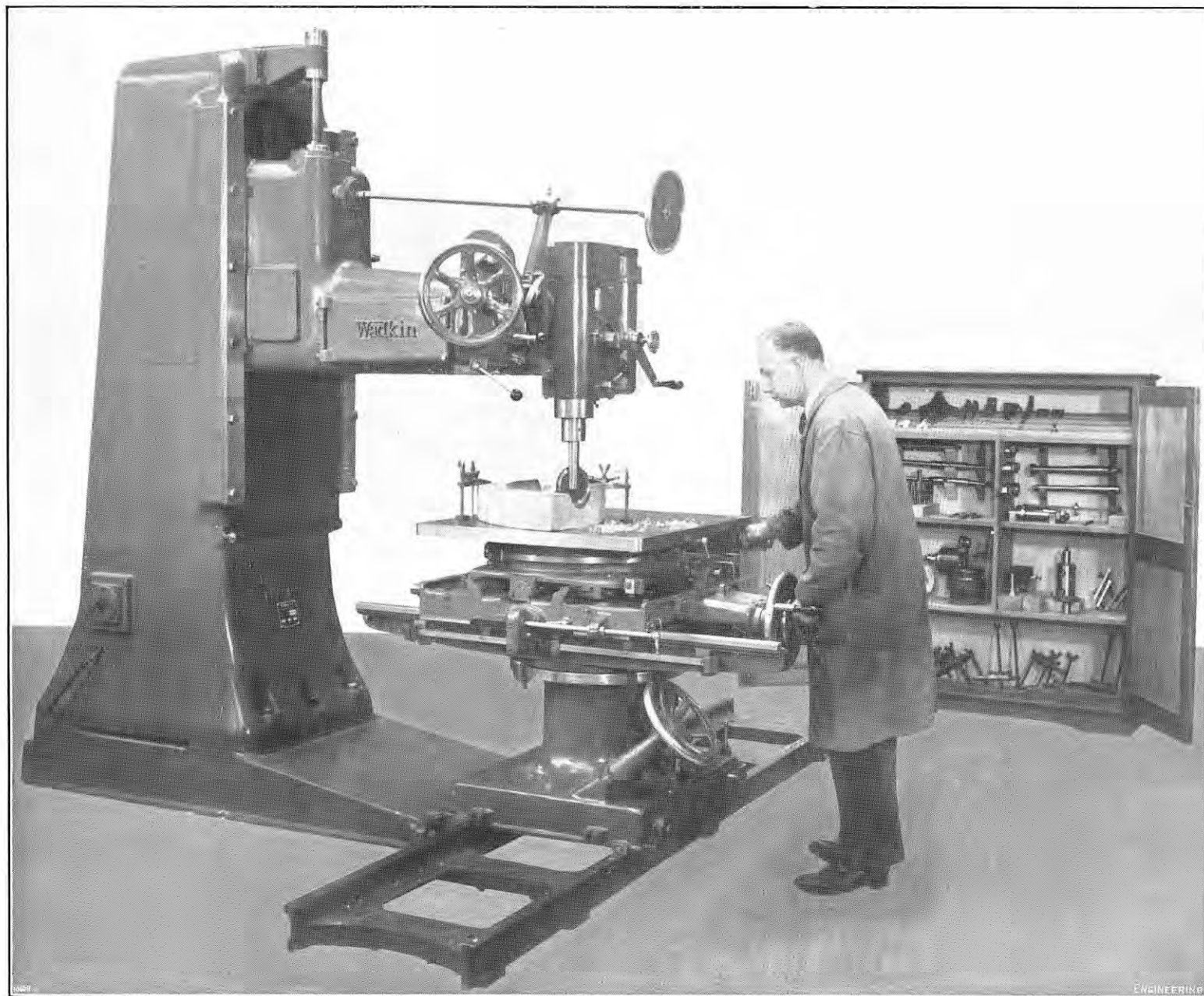


FIG. 8. UNIVERSAL PATTERN MILLER; WADKIN, LTD.

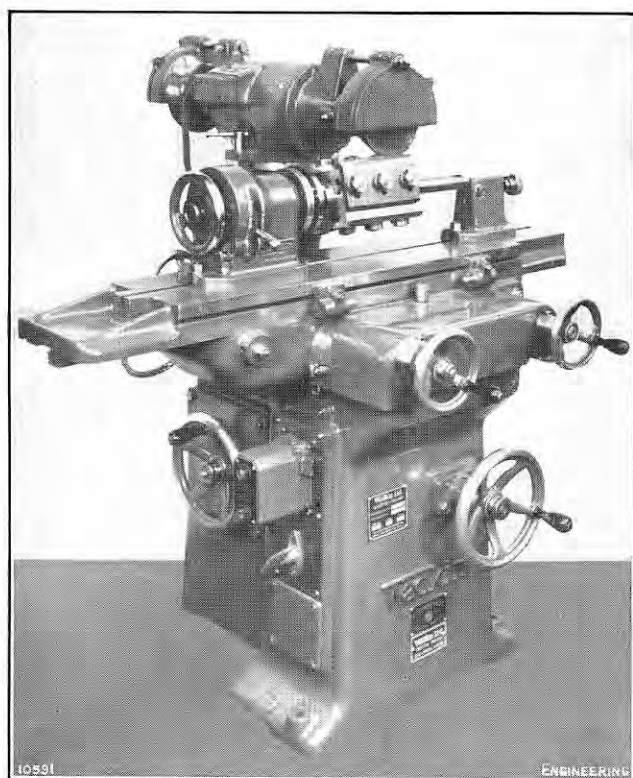


FIG. 9. UNIVERSAL GRINDER FOR WOODWORKING CUTTERS; WADKIN, LTD.

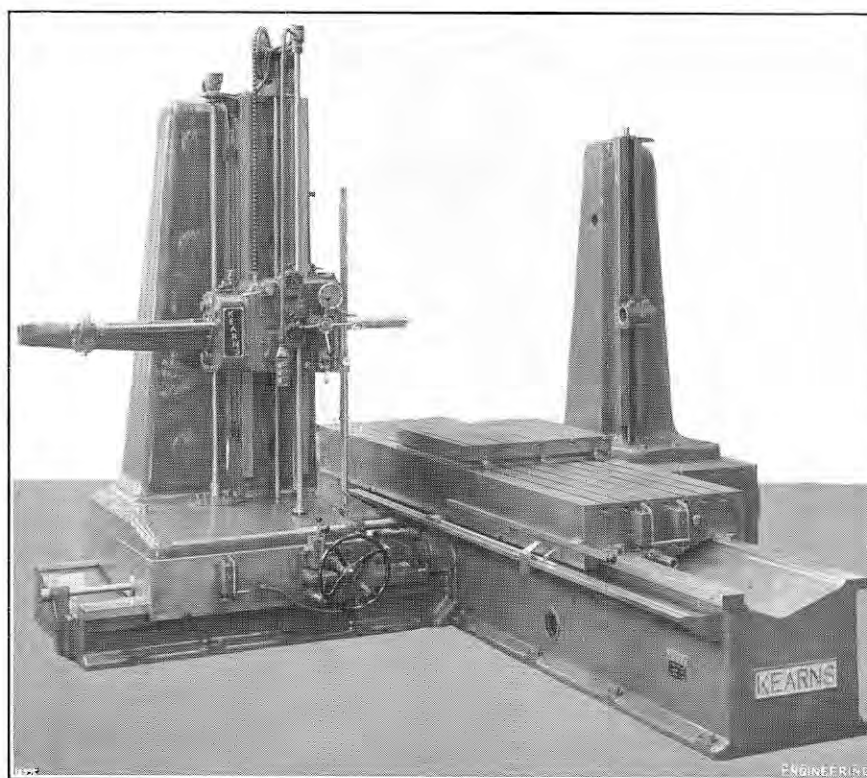


FIG. 10. PLANNER-TABLE HORIZONTAL BORING MACHINE; H. W. KEARNS AND CO., LTD.

EXHIBITS AT THE INTERNATIONAL MACHINE TOOL EXHIBITION, OLYMPIA.

(For Description, see Page 326.)

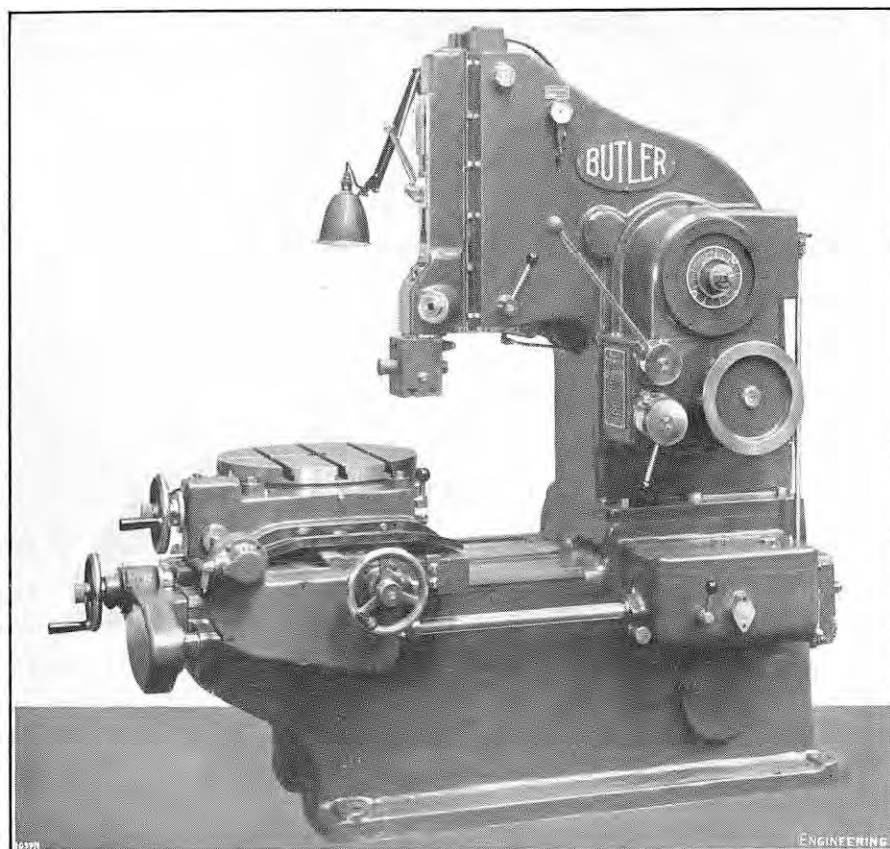


FIG. 13. PRECISION TOOL-ROOM SLOTTER; BUTLER MACHINE TOOL CO., LTD.

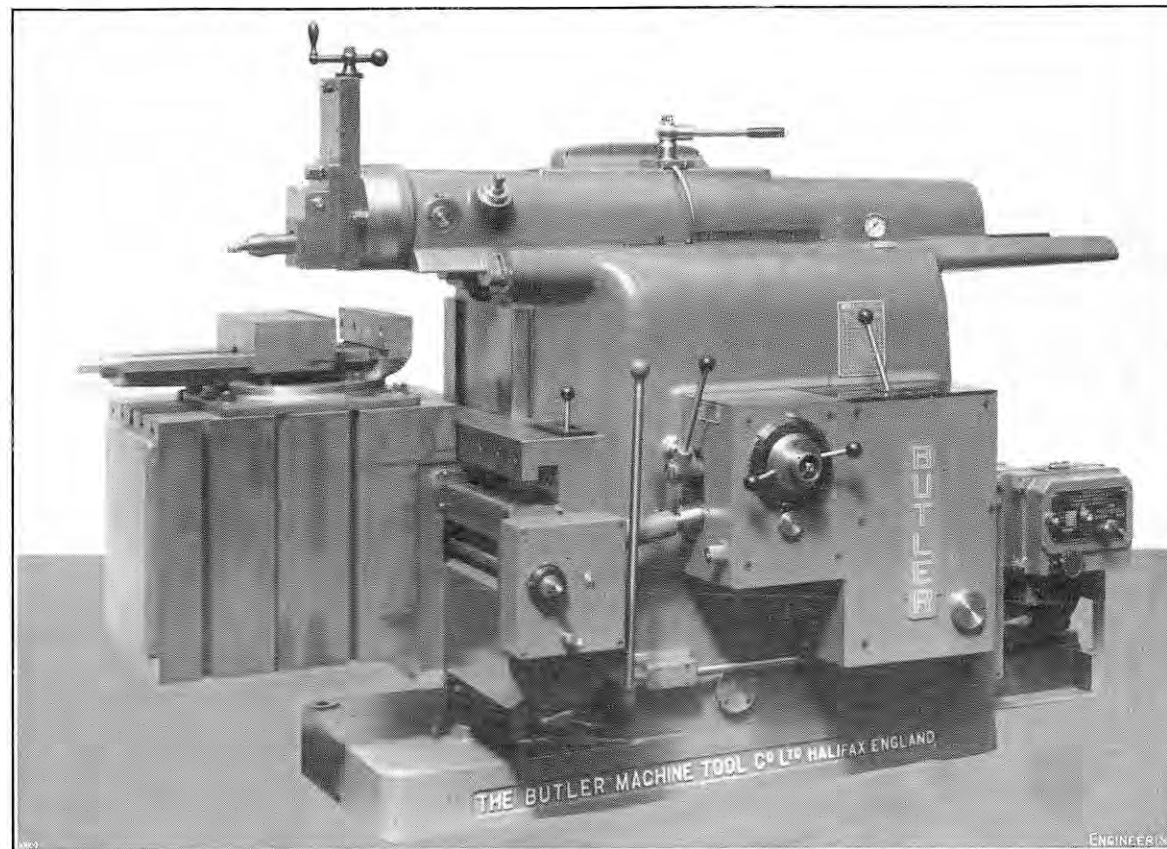


FIG. 14. PROTOTYPE 26-IN. SHAPER; BUTLER MACHINE TOOL CO., LTD.

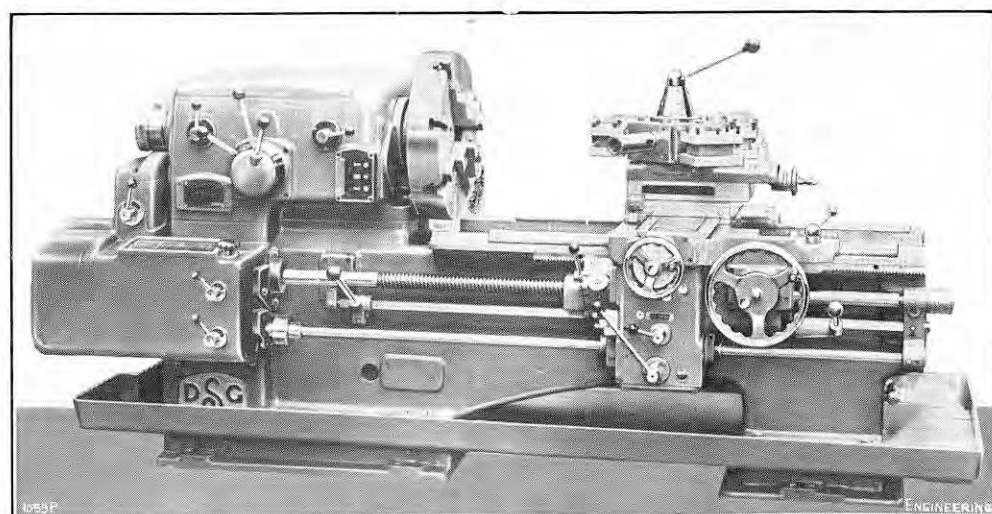


FIG. 15. 17-IN. SWING TOOL-ROOM LATHE; DEAN, SMITH AND GRACE, LTD.



FIG. 16. AUTOMATIC MULTI-TOOL LATHE; DRUMMOND BROTHERS, LTD.

EXHIBITS AT THE INTERNATIONAL MACHINE TOOL EXHIBITION.

(For Description, see Page 327.)

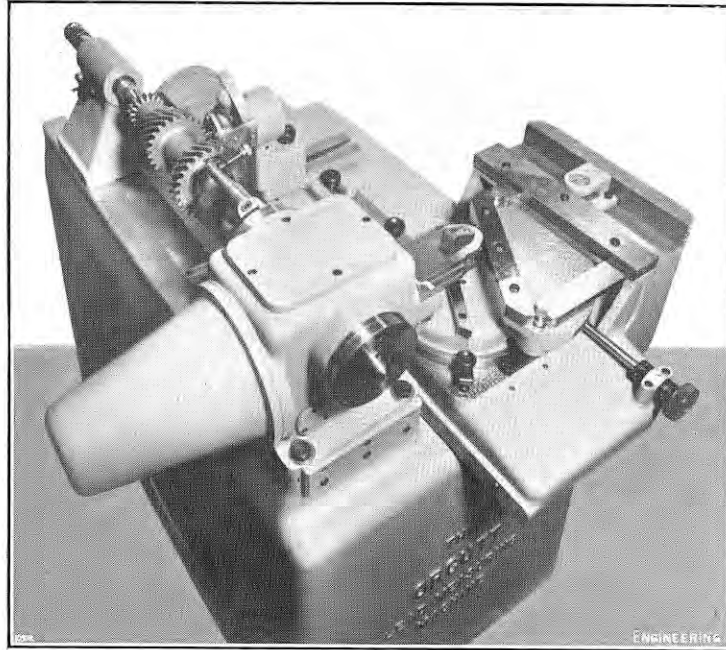


FIG. 17. MACHINE FOR MEASURING LEAD OF HELICAL GEARS; GEAR GRINDING CO., LTD.

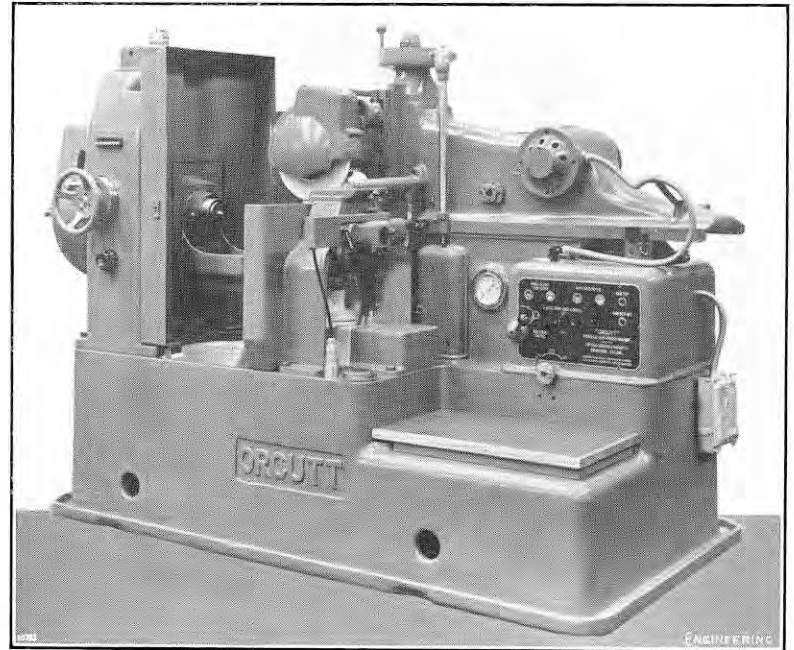


FIG. 18. AUTOMATIC SPUR-TOOTH GRINDING MACHINE; GEAR GRINDING CO., LTD.

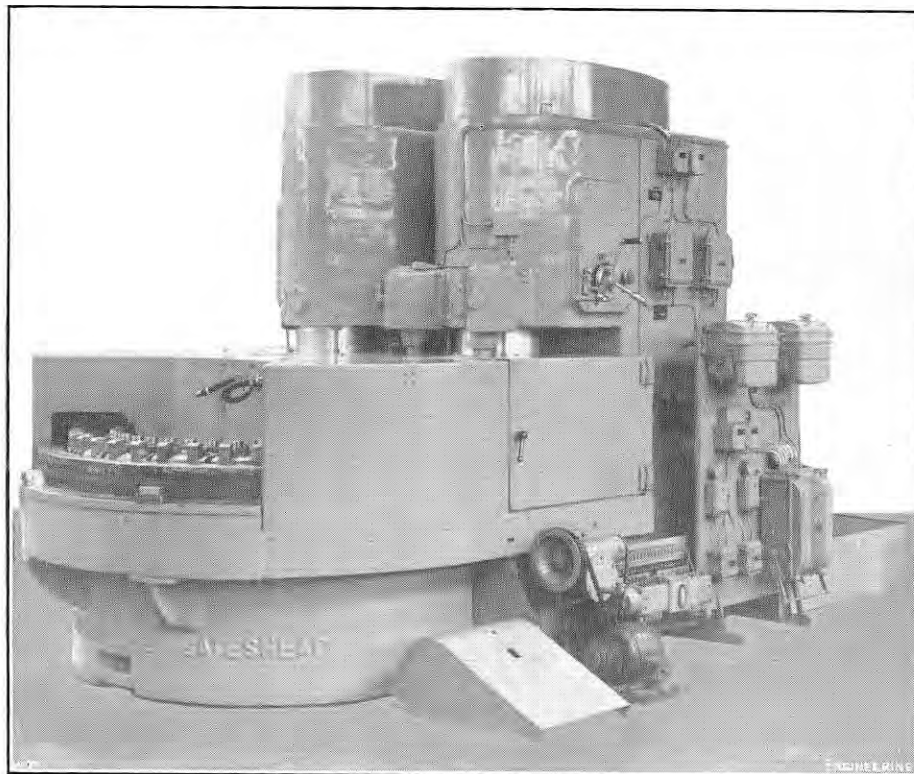


FIG. 19. ROTARY-TABLE CONTINUOUS GRINDING MACHINE; LUMSDEN MACHINE CO., LTD.

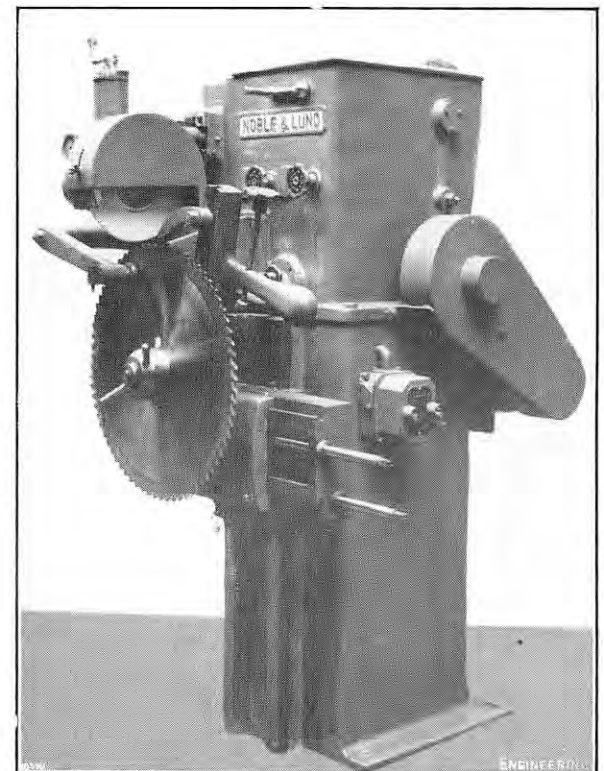


FIG. 20. AUTOMATIC SHARPENING MACHINE FOR CIRCULAR SAWS; NOBLE AND LUND, LTD.

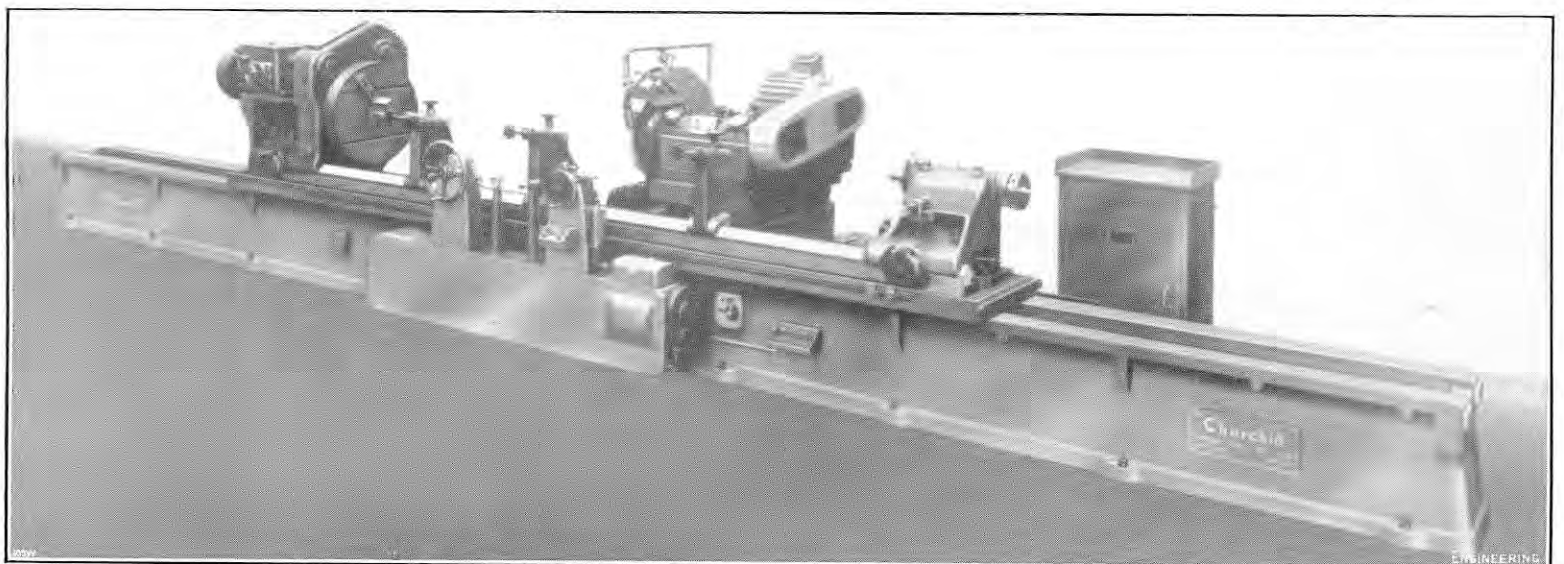


FIG. 21. 36-IN. BY 168-IN. PLAIN GRINDING MACHINE; CHURCHILL MACHINE TOOL CO., LTD.

THE INTERNATIONAL MACHINE TOOL EXHIBITION.

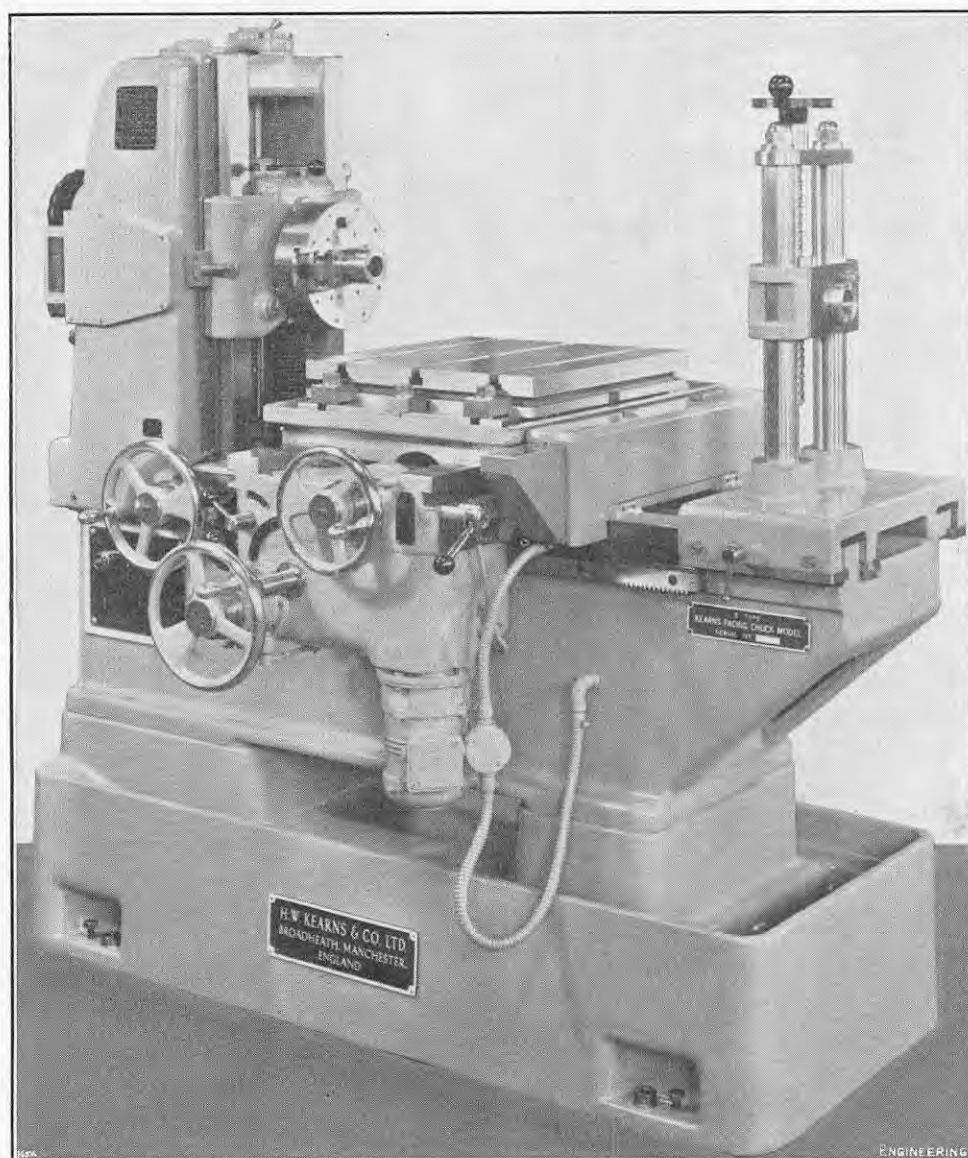


FIG. 11. TOOL-ROOM BORING MACHINE WITH OPTICAL MEASURING SYSTEM;
H. W. KEARNS & Co., LTD.

end of the spindle has six solid splines, ensuring easy sliding motion with freedom from wear. The spindle end is bored No. 5 Morse taper. A noteworthy feature of the new design is that the swivelling movement of the head is now controlled by worm and wormwheel. This mechanism incorporates a spring-loaded friction clutch to prevent damage to the plunger locating the head at the principal angles. These improvements in design, as well as some new operating conveniences, are intended to add to the labour-saving capabilities of the machine and increase still further its value in the pattern shop. It can also be used for machining metal patterns.

UNIVERSAL GRINDER FOR WOODWORKING CUTTERS.

The other Wadkin machine we illustrate (in Fig. 9, on Plate XVI) is their universal cutter grinder, type NH, which is suitable for re-grinding the various cutters used on modern high-speed woodworking machines. It will deal with all types of multi-knife cutter heads, as well as cutters for square or circular blocks, thick or thin planing knives up to 12 in. long, either in the blocks or separately. It is also capable of re-grinding tungsten-carbide tipped saws from 8 in. to 18 in. in diameter, tenoning-machine cutter blocks and drills. The double head, which is driven by a 2-h.p. squirrel-cage motor, can be fitted with 6-in. diameter taper cup grinding wheels, 7-in. diameter dish wheels, or diamond-impregnated wheels. The wheels run at 2,800 r.p.m., and the maximum length of knife that can be ground is 12½ in.

The mounting for the cutter-block to be ground embodies a dividing head, which ensures that each knife is accurately ground in relation to the others. A self-contained dust collector of the filter-sleeve type can be provided.

PLANNER-TABLE HORIZONTAL BORING MACHINE.

Messrs. H. W. Kearns and Company, Limited, Broadheath, near Manchester, will exhibit a number of horizontal machines for boring, milling, drilling and tapping, including the two illustrated here, namely, the planer-table horizontal boring machine (Fig. 10, on Plate XVI) and the tool-room boring machine with an optical measuring system (Fig. 11, on this page). Both these machines are fairly recent additions to the company's range.

The No. 0 planer-table machine consists of a main bed carrying a work-table, with a substantial upright on one side and a boring stay on the other. The upright supports the main spindle slide, and the boring stay carries the bearing for boring bars. The spindle slide provides a mounting for the spindle bearings, and also incorporates the change-speed gears and feed mechanism together with their controls. The travelling spindle, of high-tensile steel, slides in bronze bushes within a sleeve of forged steel which rotates in precision ball and roller bearings. The spindle mounting can be adjusted for wear, if necessary. The spindle sleeve is slotted across the face and is arranged to carry mandrels for milling cutters, a facing attachment or other available equipment. Axial thrust on the travelling spindle and the sleeve is taken by ball washers or dual-purpose bearings. The spindle and sleeve

rotate together as one unit. Sixteen reversible speeds are available, ranging from 10 to 400 r.p.m., and their selection is controlled by two levers only. The feed mechanism embodies a patented arrangement, whereby two complete ranges of feeds are available. The drive for one range is from the spindle sleeve and gives eight feeds in cuts per inch. The other is from the first-motion drive shaft and gives eight feeds, independent of the spindle speed, in inches per minute. It is thus possible to obtain very fine finishes by combining the higher spindle speeds with slow rates of feed. The travelling spindle is arranged with quick and fine hand traverses, and automatic feeds can easily be chosen from ranges of 8 to 96 cuts per inch or 0.8 to 9.6 in. per minute. The spindle slide traverses vertically and is balanced by a weight hanging inside the upright. Automatic feed is provided to the vertical traverse, the ranges being 24 to 288 cuts per inch and 0.26 to 3.2 in. per minute. Hand adjustment and rapid power traverse are also available.

The upright is of substantial construction, well reinforced to take the thrust set up when boring or drilling. The base is arranged to slide on an auxiliary bed. Automatic feeds of 24 to 288 cuts per inch and 0.26 to 3.2 in. per minute are provided. Hand adjustment and rapid power traverse are also available. The main bed is long enough to give full support to the work-table in all positions. The auxiliary beds for the upright and boring stay are bolted to it, thus forming a rigid base for the complete machine. The table is adjustable by either hand or rapid power motion. The surface is planed accurately within fine limits and is T-slotted. Automatic feeds of 24 to 288 cuts per inch and 0.26 to 3.2 in. per minute are also provided. The machine is thus fully automatic and capable of milling either vertically or horizontally. The boring stay is a sturdy casting similar to the upright and carried on a wide base which is arranged with hand adjustment on an auxiliary bed at right-angles to the main bed. The bearing is of the hinged-cap type, so that boring bars and bushes can easily be placed in position. It is arranged to rise and fall simultaneously with the spindle slide. The auxiliary beds are set so that the centres of the travelling spindle and boring-stay bearing are in line, and means are provided for correcting the alignment in the vertical direction, if necessary. The main drive to the spindle is from a built-in electric motor continuously rated at about 950 r.p.m. It is carried in the base of the upright, and power is transmitted to the change-speed gears by a vertical shaft. The change-speed gears are of heat-treated alloy steel, carried on splined shafts which run in ball and roller bearings. The whole of the gearing is enclosed and automatic lubrication is provided. The main drive motor is controlled by an automatic contactor direct-on-line starting panel with interlocked isolator. Simplicity of control has been achieved. The operating levers are conveniently grouped, and adjustments of speed and feed can be made with the work in full view of the operator. Rapid power traverse is provided to the motions of the table and upright and simultaneously to the vertical motions of the spindle slide and boring-stay bearing. All gears run in oil and flanges are fitted to carry oil to the bearings. The slides and traverse screws for the main and auxiliary beds are oiled by a hand-operated force-feed system. A measuring system can be fitted to enable the spindle and work to be set in the desired relative positions. This employs vernier scales, giving readings to 0.001 in. and fitted to the vertical traverse of the spindle slide and boring stay and the traverse of the table.

TOOL-ROOM BORING MACHINE WITH OPTICAL MEASURING SYSTEM.

The other Kearns' machine, shown for the first time in this country, is the Optimetric horizontal tool-room boring machine, type S. It is made in two forms: a collet model and facing-chuck model, the latter of which is shown in Fig. 11, on this page. It incorporates a patented optical measuring system for the vertical and transverse motions of the machine. Settings to 0.001 in. can be made with an error of not more than 0.00025 in., or to 0.01 mm. within 0.005 mm. when the machine is fitted with a metric measuring system. The large screen, measuring 4 in. by 1½ in., is

extremely easy to read and completely avoids the eye-strain caused by peering through a microscope, and as both the rule and vernier are projected on to the same side of the screen, parallax errors are impossible. The glass scales are almost indestructible and are not subject to wear. By passing the projected light through the glass scale a brightly illuminated screen is obtained. Both mountings are adjustable and therefore readings can be set at zero or the nearest whole number. As this measuring system is built into the machine, no end rods, gauges or dials are required, thus saving time and reducing the possibility of errors.

SPIRAL-ELECTRIC PLANER.

Planers, a slotter, and shapers will be exhibited by the Butler Machine Tool Company, Limited, Mile Thorn, Halifax. The planers will include that illustrated in Fig. 12, herewith, and described below; also a hydraulic open-side planer with a stroke of 6 ft., and an open-side crank planer with a stroke of 36 in. The slotter will be the 8-in. tool-room machine shown in Fig. 13, on Plate XVII, and described below; and the shapers will comprise the prototype 26-in. Super shaper shown in Fig. 14, on Plate XVII, and described later, as well as an 18-in. Super shaper and an 18-in. hydraulic shaper.

The spiral-electric planer (Fig. 12) is the firm's No. 6 machine with a planing length of 12 ft., and a permissible width of 4 ft. 6 in. It is one of a range of such machines from 3 ft. to 9 ft. 6 in. wide and with any length of table, and is fitted with two tool-boxes on the cross-slide and a side tool-box on each upright. It is driven by a patent forced-field reversing motor of 45 h.p., with auxiliary electrical equipment comprising a 4-h.p. variable-speed feed motor, a 2-h.p. cross-slide elevating motor, a $\frac{1}{2}$ -h.p. cross-slide locking motor and a $\frac{1}{2}$ -h.p. pump motor. It also has a patent feed and power-traverse unit, solenoid-operated relieving motions for all tool-boxes, electric tachometer equipment for registering the table speeds (which range from 20 to 200 ft. per minute cutting and 110 to 220 ft. per minute return), and a portable pendant control switch for start, stop, inch forward, and inch return to the table and forward and reverse for the power traverse.

The range of machines of this type has been re-designed to bring them into line with modern practice as regards appearance, performance and ease of control. Particular attention has been paid to the lubrication system to make it as fool-proof as possible. The table is driven by a steel worm which meshes with a cast-iron rack. The worm is mounted at one end of a shaft, arranged diagonally, the other end of which carries a hollow-faced phosphor-bronze wormwheel; the latter is driven by a nickel-chromium worm which is connected to the motor through a flexible coupling. The advantages of this system are: it is entirely enclosed, takes up the minimum of floor space and is on floor level; from five to seven teeth are in constant mesh with the rack; the reversing components are reduced to a minimum, thereby improving acceleration and deceleration; and power consumption is less, both under load and at reversals.

PRECISION TOOL-ROOM SLOTTING.

Fig. 13, on Plate XVII, illustrates the Butler 8-in. precision tool-room slotter. In common with the 4-in. and 12-in. machines of this type, it is guaranteed to a maximum error of 0.0005 in. for the ram alignment and table traverses. The drive is by a 3-h.p. constant-speed motor mounted inside the base and driving through enclosed V-ropes and a dry-plate clutch to a four-speed gearbox in which the gears are of heat-treated nickel-chromium steel. The single-helical stroke wheel has a new design of driving block enveloping the V-slide and providing a larger diameter driving pin, while the slotted link incorporates the ram balance weight. The ram, which is arranged to tilt forward up to a maximum of 5 deg. and is located vertically against a dead stop, carries a steel tool-box which can be swivelled through 360 deg. The tool-box has a built-in relieving motion which will operate with the tool in both the vertical and horizontal positions. The stroke can be altered with the ram in motion or at rest, the length being indicated on a dial. The

THE INTERNATIONAL MACHINE TOOL EXHIBITION.

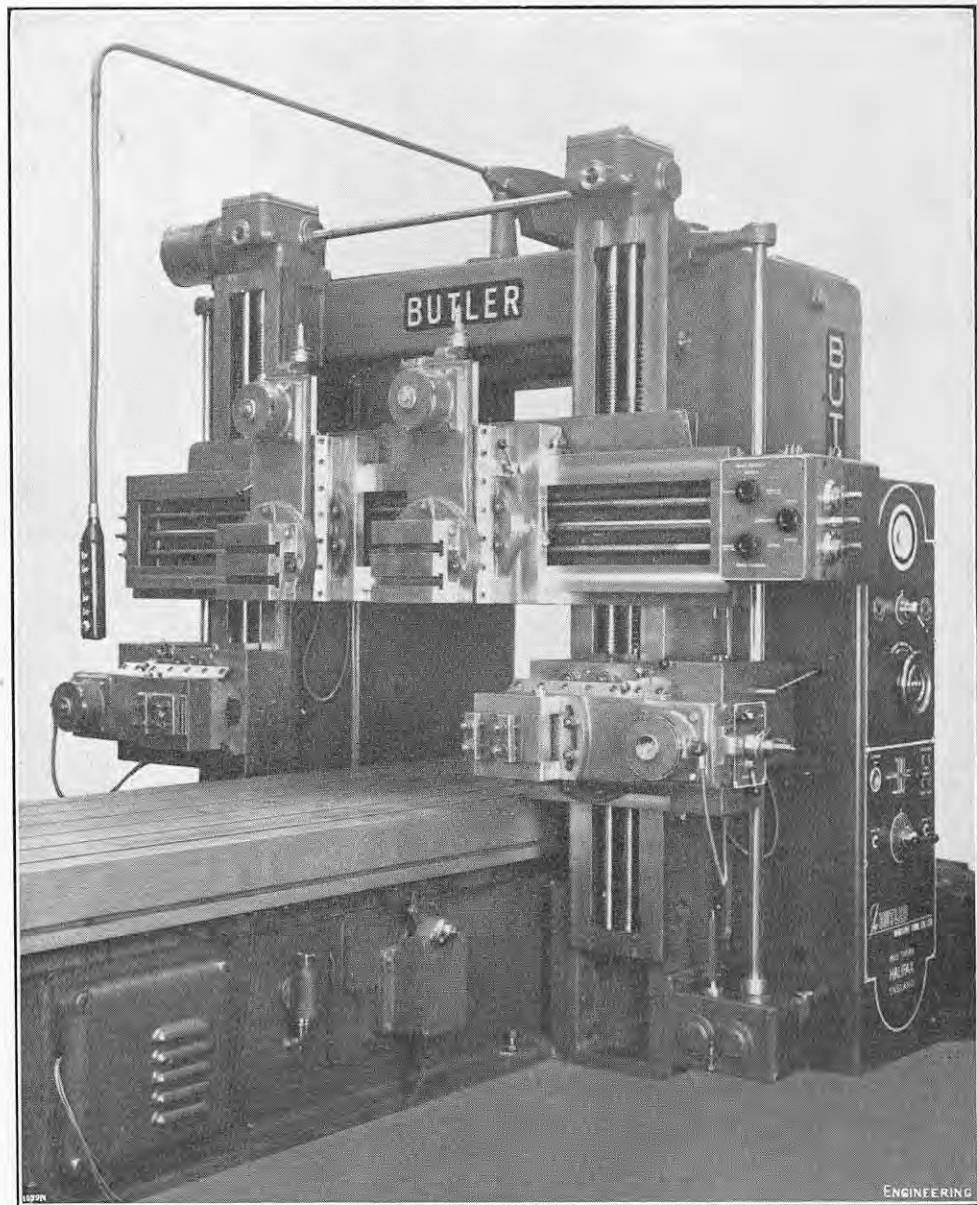


FIG. 12. SPIRAL-ELECTRIC PLANER; BUTLER MACHINE TOOL CO., LTD.

position of the stroke can be adjusted from a squared hole in the ram.

Feeds are selected from the slotted disc and engaged or reversed from the front of the machine, the direction of feed being selected from the clutch levers on the individual screws. The circular table is provided with a driving mechanism through 12 divisions, operated by a plunger built into the front of the square slide. The feed worm can be disengaged to facilitate hand operation. Micrometer collars are fitted to all feed movements. Lubrication of the drive and ram is by gear pump and the nipple system is used for the feed motion and table slides. Four speeds cover a range of 40, 54, 75 and 105 cycles per minute. The travel of the table is 20 in. across and inwards and the table is 20 in. in diameter. The ram has an adjustment of 10 in.; the maximum admittance, ram to table, is 16 in.; and the ram face to the frame horizontally is 19 in.

PROTOTYPE 26-IN. SHAPER.

The Butler 26-in. Super shaper (Fig. 14, on Plate XVII), the most recent design on this stand, has a table measuring 25 in. by 18 in. at the top, and 19½ in. by 19¾ in. at the sides, and has a horizontal travel on the slides of 30 in. The vertical travel is 14 in. and the maximum height admitted is 17 in. The drive is by a friction clutch and V-ropes to an eight-speed gearbox, and the gears are of heat-treated nickel-chromium steel. The sliding members mounted on a six-spline shaft. The stroke wheel is of single-helical construction and rotates around a large fixed bearing in the body, with an extra

bearing for the spindle. The machine has a patented cam-operated feed which can be changed with the ram in motion or at rest; this system also incorporates horizontal power traverse of the table. An automatic down-feed is provided on the tool-box.

A gear pump supplies filtered oil to the gearing and gearbox bearings, the link motion, stroke-wheel bearings, ram slides and feed motion, and the correct functioning of the system is shown by an oil pressure gauge. The table has machined T-slots on three sides. The supplementary slide between the saddle and table is not fitted unless it is specially requested. Special designs of swivelling or combined swivelling and tilting tables can be supplied instead of the rectangular table. Standard equipment includes a parallel-jaw vice on a graduated swivelling base. A 12-h.p. motor is normally fitted. It is mounted on a welded steel baseplate attached to the base of the shaper and drives the clutch pulley through enclosed V-ropes. Eight shaping speeds, from nine to 100 cycles per minute, are provided.

17-IN. SWING TOOL-ROOM LATHE.

Messrs. Dean, Smith and Grace, Limited, Keighley, Yorkshire, are to have a stand devoted entirely to their range of lathes; seven models are to be on exhibition, including five motor-driven centre lathes with swings varying from 13 in. to 26 in. diameter and able to take a maximum of between 42 in. and 132 in. between centres. The 22-in. and 25-in. swing models can be supplied with lengths up to 240 in. between centres. Each machine has available a wide range of spindle speeds,

shown on a distinctive speed-indicating dial with large figures for easy reading, and is driven through a totally-enclosed quick-change gearbox. All the machines are arranged for screw-cutting and two of the models to be shown, the 13-in. and 25-in., are fitted with a taper-turning attachment; the largest machine is also equipped with an electrically-driven traverse to the saddle. In Fig. 15, on Plate XVII, we illustrate the 24-in. diameter motor-driven surfacing and boring lathe, fitted with a hexagon turret on a compound slide. (We regret that the caption on the Plate, which went to press earlier than this page, refers to the firm's 17-in. swing tool-room lathe. We intend to illustrate and describe this machine in next week's issue). Most of these machines are fitted with the company's patent Fastlock spindle nose, which affords a means of fixing chucks and faceplates quickly and securely to the spindle. Cylindrical hardened plungers, spring and cam controlled, project into holes formed in a steel ring fixed to each chuck and faceplate. The plungers are operated by inserting a square-ended key and a slight turn securely locks the chuck or faceplate to the spindle. The beds of all the machines are made from a semi-steel mixture having a Brinell hardness of approximately 200; the diagonal ribbing ensures adequate stiffness of the bed, and the spacing between the ribs provides for ample chip clearance. The leadscrew is protected from falling chips by a protruding lip on the front of the bed.

AUTOMATIC MULTI-TOOL LATHE.

Messrs. Drummond Brothers, Limited, Ryde's Hill, Guildford, will be exhibiting their full range of Maximinor lathes, Maxicut gear shapers, and a new version of their Maximatic automatic multi-tool lathe, on the Drummond-Asquith (Sales) stand, to which further reference is made later in this article. The Maximatic machine, designed for turning medium-size components at high speeds, is available in three sizes, 18 in., 30 in., and 42 in. between centres, with a maximum swing over the saddle of 18 in. and over the slides of 12 in. in each size. The 42-in. lathe is illustrated in Fig. 16, on Plate XVII. On taking over the machine from the tool setter, the operator has to make only a sequence of simple movements in order to maintain output; the press-button control located beneath the headstock enables the machine to be set for the run, and thereafter the only control that requires to be handled is the starting handle. The operator's duties are confined to loading and unloading the workpiece in and out of the chuck and positioning the tailstock, and in this respect he is assisted by the low loading position, only 36½ in. from floor to mandrel, and the total absence of projections in front of the machine. The usefulness of a machine of this type depends to a great extent on the adaptability in the settings of the cross-slides, and in the "Maximatic" every effort has been made to cover the widest range of work without resorting to expensive fitments. Each cross-slide is operated independently by flat former plates; the operating pins carrying the rollers that engage the former plates are provided with positive stops to ensure accurate sizing, and to avoid any tendency of the slide to twist these stops are located centrally on the slide. The mountings of the tailstock and headstock have been so arranged that the traverse of the saddle can be extended in front of these two units, thus widening the scope of the standard machine so as to accommodate work of an unusual nature.

MACHINE FOR MEASURING LEAD OF HELICAL GEARS.

The Orcutt machine tools to be shown on the stand of the Gear Grinding Company, Limited, Cranmore Boulevard, Shirley, Birmingham, include one for grinding splines in shafts up to 20 in. in length, an involute-measuring machine, an automatic spur-tooth grinding machine, and a lead-measuring machine. The two latter are here described and illustrated. In addition, the company will display a range of Fellows-Orcutt gear-shaper cutters.

The Orcutt lead-measuring machine, illustrated in Fig. 17, on Plate XVIII, was re-designed during 1950 with the assistance of the National Physical Laboratory, and although in basic principle the

machine remains the same, considerable improvements were made in details. The whole machine has been considerably strengthened in order to avoid any distortion, so that accurate measurements can always be repeated. Gears up to 13 in. in diameter can be measured, and a 5-in. lead is the minimum that can be checked, either left-hand or right-hand. The maximum rotational travel of the work is $\frac{3}{8}$ of a revolution. The length permissible between the centres is 18 in. The machine consists of two main elements: a generating head carrying the tape bar and the slide carrying the datum straight-edge and generating sine-bar. A single tape is clamped to the tape bar and to the spindle, with a tensioning device, so that backlash can be eliminated. Both the tape bar and the spindle are mounted on special bearings to ensure the minimum resistance. The generating turntable has two pins, of equal diameter and a known distance apart, which are used for the correct angular setting. Two sets of gauge blocks are used, and there is no central pivot, so that the setting becomes purely angular. The generating sine-bar is set on the turntable against the two pins and is, therefore, exactly parallel to them. The gauge blocks are inserted between the pins and the datum straight-edge and the turntable held against the gauge blocks by means of a spring, so that constant tension on the blocks is obtained before the turntable is locked in position. The work is held between dead-centres. The tailstock has a large parallel centre lapped to fit into a hardened bush, and a simple locking device is used so that it cannot move.

In order to check the accuracy of the machine itself, the latest available methods are employed. Firstly, it is necessary to obtain the effective circumference of the generating circle, and this is done by the following method. A 40-sided polygon is mounted on the spindle and an auto-collimator is focused so that a facet can be brought into the collimator eye-piece. A graduated linear scale is placed on the tape bar, and a microscope, above the scale, is attached to the body of the generating head, through which readings to 0.00005 in. may be taken. The nominal effective circumference of the generating circle is 8.640 in. (or $2\frac{3}{4}$ in. diameter); therefore, by advancing the tape bar $8.640 \div 40$ (0.2160 in.), the next facet on the polygon will be brought into view in the collimator eye-piece. This advancing of the tape bar is continued, in equal increments, throughout the full travel of the bar and the errors are noted. From this, the exact effective circumference of the generating circle is obtained, and this determines the constant for the machine setting. It should be pointed out that an advance of 0.0001 in. of the tape bar imparts a rotational movement of 15 seconds to the polygon (at this radius), and in this way it is possible to check the accuracy within very fine limits. The mounting of the generating head, together with the centre bracket, tailstock and slide, on the body of the machine, is simply a matter of parallel alignments which are checked by means of a Société Gènevoise dead-beat indicator, to 0.0001 in. Finally, the accuracy of the whole machine is checked by a master scroll which has been calibrated and certified by the National Physical Laboratory. This scroll is held between the centres and a reading is taken on the machine indicator. A limit of 0.0001 per inch of face width is the maximum permissible error. An alternative method for checking the overall accuracy of the machine is more laborious and was used before the master scroll was available. In this method, the scale is placed on the slide with the microscope mounted on the body of the machine and the polygon is held between centres. The sine-bar is set, by means of the gauge blocks, to any desired lead. Then a linear travel of the slide, equal to one-fortieth of this lead, will rotate the polygon through one facet.

AUTOMATIC SPUR-TOOTH GRINDING MACHINE.

The other Orcutt machine illustrated in this article—in Fig. 18, on Plate XVIII—is an automatic spur-tooth grinding machine, the latest addition to the company's range. It is fitted with an automatic cycle control, which reduces the work performed by the operative to loading, unloading and starting only. By this means, the production

rate is increased considerably above that previously expected, with greater consistency of product. The automatic cycle control is operated electrically, with cam-applied feeds at each revolution of the gear. The number of wheel dressings, and the stages at which these are applied, are selected to suit the work being ground. Though each cam gives a fixed depth and number of feeds applied, it is found in practice that each cam will cover a range of components. When changing is necessary, the easy access given by the design keeps the setting time to a minimum. In a desire to improve further the quality of work produced, a new design of plain bearing has been applied to the wheel spindle and its motor drive with satisfying results.

By giving due consideration to the preparation of the gear teeth before hardening, the grinding of teeth becomes an attractive economic proposition. The use of a correctly designed hob, or cutter, gives a tooth form that requires grinding on the flanks only and which leaves a smooth blend with the root form. The clearing of the root with its slow feeding, normally a large part of the grinding time, is thus removed. Higher feeds, correctly controlled by the cam, enable the fullest use of the pre-forming to be taken and thus reduce the production times even further. The machine capacity is for gears 24 in. in diameter, and it is interesting to note that it can be adapted for the grinding of gears and pinions between centres with a maximum diameter of 10 in. and a length of 10 in., the maximum grinding length being 8 in.

ROTARY-TABLE CONTINUOUS GRINDING MACHINE.

The machine illustrated in Fig. 19, on Plate XVIII, will be exhibited by the Lumsden Machine Company, Limited, Hawks-road, Gateshead, 8. It is known as the No. 91-MLN vertical-spindle rotary-table twin-head continuous grinding machine. The work passes under the wheels once only at a slow speed for each operation. A portion of the table is exposed at the operator's position, and at this point the ground pieces are turned over for grinding the other side, and the finish-ground pieces, i.e., those that have been through twice and had both sides ground, are removed and fresh pieces placed. The work can be held on jigs operated by cams as the table moves round, or on magnetic chucks which become demagnetised at the loading position. There are two spindles and two grinding wheels, which may be arranged in a staggered position so that one wheel grinds at one level and the other wheel at a different level. They may also be used both at one level, and would be so used on castings where the grinding allowance is too great to be taken off by one wheel. Four speeds are provided to the table, though by altering V-pulleys any reasonable speed may be obtained. Each spindle has an electronic sizing device. As the work increases in thickness due to wheel wear, the wheel is automatically fed down to grind at the correct level. The sensitivity of this device is about 0.0005 in. Apart from these special points, the well-tried Lumsden spindle construction is used with, in this case, a multiple V-rope drive. This is an advantage as it enables a suitable grinding wheel speed to be used by selecting appropriate pulley sizes. The feed-box gives a wide range of adjustment for the electronic control. The table motor drives through reduction worms. Lubrication is fully automatic, and the machine is provided with guards, a coolant pump and tank; the latter can be equipped with a magnetic clarifier. The switchgear is mounted on a complete panel with push-button control to all motors.

AUTOMATIC SHARPENING MACHINE FOR CIRCULAR SAWS.

Two machines will be exhibited on the stand of Messrs. Noble and Lund, Limited, Gateshead, 10, namely, the automatic circular-saw sharpening machine illustrated in Fig. 20, on Plate XVIII, and a Fluifed cold circular-sawing machine with a 22-in. diameter saw. The latter machine, which was introduced recently, incorporates a number of new features; it was described on page 333 of *ENGINEERING*, March 14, 1952. The sharpening machine will deal with segmental saws of the type used for cutting iron, steel and non-ferrous metals, gold, between minimum and maximum diameters of

11 in. and 60 in., respectively. The full contour of the tooth is generated by the motions of the grinding wheel and the saw, and the motions are adjustable to suit various pitches. The mounting for the saw is adjustable vertically to provide for different diameters, and horizontally to obtain varying cutting angles for hard or soft materials. One grinding wheel, which runs on ball bearings, will complete all the operations on any one saw. A straight-line up-and-down motion of the grinding wheel is provided by means of a slide in place of the usual swinging arm, thus ensuring a perfectly square tooth. Two speeds are available for this motion: 38 and 64 strokes per minute, the faster being suitable for saws up to 28 in. in diameter. The grinding wheel is actuated by a cam which is enclosed in a gearbox. For the bevelling of alternate teeth a horizontal adjustment is provided for the grinding wheel. The machine can be driven by a 1-h.p. motor or from a line shaft, and a dust-exhaust fan and collector bag are fitted.

"FULCRO-SIZER" PLAIN GRINDING MACHINE.

The Churchill Machine Tool Company, Limited, Broadheath, Manchester, will be displaying nine machines on their stand, including no less than four which are new and being exhibited for the first time, while all the remainder, although basically older machines, have had improvements added to them. Of the new machines, the smallest is the model OW 4-in. by 12-in. Fulcro-Sizer fully-automatic plain grinding machine, illustrated in Fig. 22, on this page. This machine has been specifically designed for the purpose of externally grinding small diameter components to the extremely close limits that are required in the manufacture of scientific instruments and Diesel injection equipment; it is claimed that automatic sizing to ± 0.00005 in. is possible on long production runs. A maximum grinding capacity of 4 in. diameter with a length between centres of up to 12 in. is available on the machine; the 14-in. diameter grinding wheel is considerably larger than those normally used on machines of this capacity. The Fulcro-Sizer operates on a fully-automatic cycle, feeding the work on to the grinding wheel instead of feeding the wheel to the work. After the workpiece has been placed on the cradle the tailstock moves in automatically and picks up the component between centres; rotation of the work commences and simultaneously the worktable tilts forward towards the grinding wheel, until the size position is reached. In this position, the table dwells, if desired, to achieve a high finish, after which the control unit again comes into operation, returning the table to its original position, when the machine automatically unloads the component. To ensure uniformity of production, special arrangements have been made to maintain a constant speed of cycle time. The OW model is the smallest cylindrical grinding machine ever built by the company and, in addition to the Fulcro-Sizer model, the machine is also being built as a non-automatic plain grinder.

36-IN. BY 168-IN. PLAIN GRINDING MACHINE.

In contrasting size to the OW model is the FB model, a plain grinding machine with a worktable 36 in. by 168 in., mounted on a bed which is 432 in. long. It is shown in Fig. 21, on Plate XVIII, and, although a large and heavy machine, it is light and sensitive to control and easy to operate. All the controls are conveniently grouped in a natural operating position and power motions are incorporated in the table and wheelhead traverse motions to eliminate fatigue of the operator. The workhead is of the dead-centre type, operating at speeds varying from 12.5 to 75 r.p.m. The worktable traverse gear is driven from a three-speed motor through a five-speed gearbox, thus giving 15 table traverse speeds between 5.69 and 123 in. per minute. The final drive to the table is through a sturdy rack and pinion. The slideways, which are permanently protected by flexible fabric covers, are lubricated by a new hydrostatic lubrication system.

Other exhibits on the Churchill Company's stand will include the BW, with a work capacity of 10 in. by 20 in. between centres, and a plain grinder, the CW model, with a capacity of 16 in. by 120 in. between centres. Two versions of their new HBG

THE INTERNATIONAL MACHINE TOOL EXHIBITION.

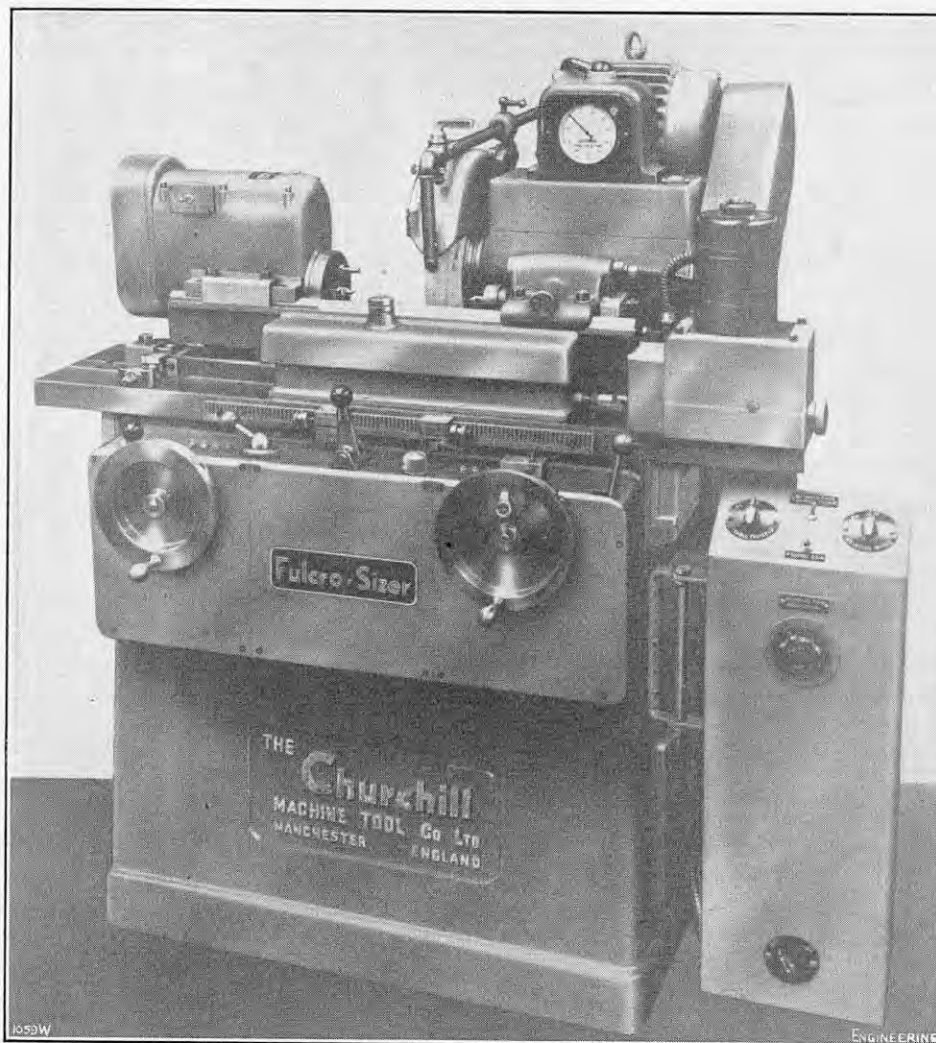


FIG. 22. "FULCRO-SIZER" PLAIN GRINDING MACHINE; CHURCHILL MACHINE TOOL CO., LTD.



FIG. 23. S.R.50 PNEUMATIC MOTOR; DESOUTTER BROS., LTD.

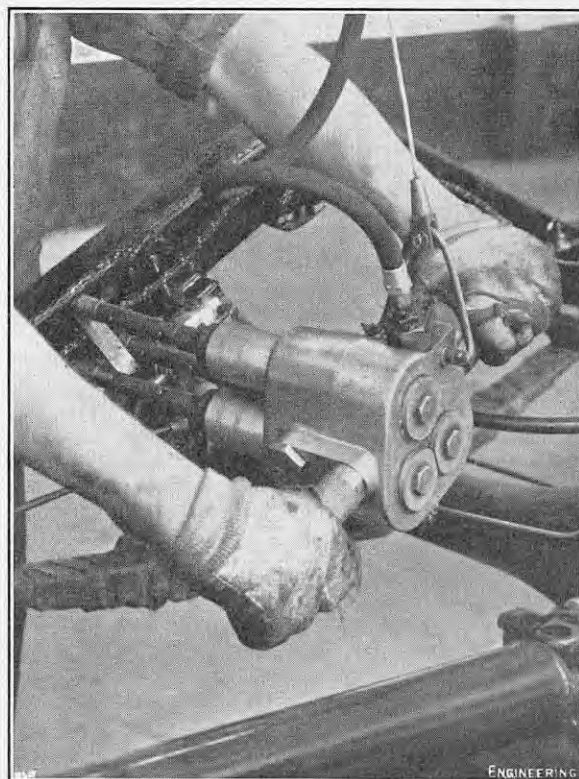


FIG. 24. GROUP OF PNEUMATIC MOTORS; DESOUTTER BROS., LTD.

automatic sizing internal-grinding machine are also to be shown, one adapted for short bore grinding by the plunge method and the other will be shown

ready for grinding long bores by the traverse method. To complete the range of their exhibits, there will be a new centreless grinding machine,

THE INTERNATIONAL MACHINE TOOL EXHIBITION.

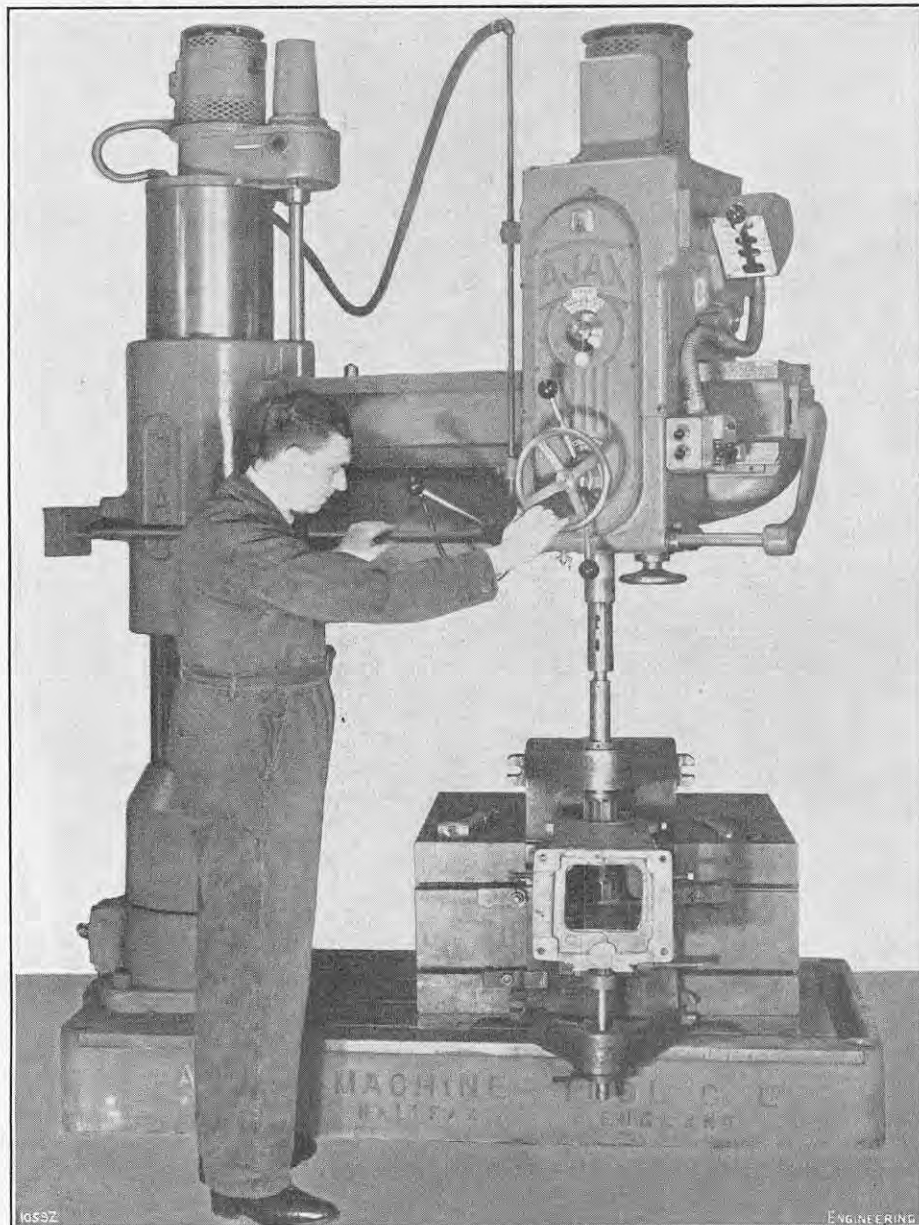


FIG. 25. RADIAL DRILLING, BORING AND TAPPING MACHINE; AJAX MACHINE TOOL CO., LTD.

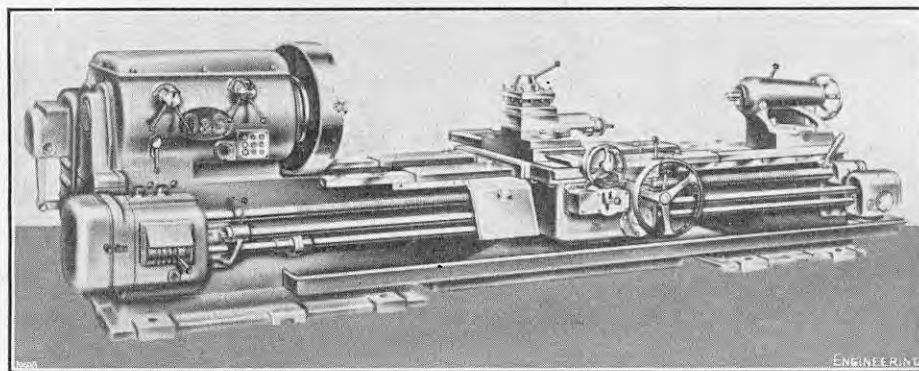


FIG. 26. O. & S. HEAVY-DUTY CENTRE LATHE; DRUMMOND-ASQUITH (SALES), LTD.

model EC No. 2, a fully automatic machine with a hopper feed.

S.R.50 PNEUMATIC MOTOR.

The chief exhibit of interest on the stand of Desoutter Brothers, The Hyde, Hendon, London, N.W.9, is to be their new S.R.50 pneumatic motor, which is intended to improve mass-production methods by making for greater speed where multiple nut and stud runners are practicable on the assembly line. The motor, shown in Fig. 23, opposite, is only 1½ in. in diameter by 6½ in. long and weighs

2 lb. 9 oz.; it develops nearly ¾ h.p. at a torque of 500 inch-lb. and, by its compactness and light weight, provides a convenient power unit where group mounting is possible, and makes practicable the multiple tightening of closely grouped nuts. The motors may be grouped together at as little as 2-in. centres and the low weight makes a multiple-headed tool, as shown in Fig. 24, easy to handle, the operator feeling little torque reaction. That the motor stalls against a controlled air pressure is the most important feature of the design, since it ensures uniformity of tightening torque. Also

on show on this stand will be the firm's wide range of heavy-duty electric drills and screw guns, the former with speeds up to 5,000 r.p.m., together with reversing and non-reversing miniature screw-drivers, specially produced to deal with the rapid assembly of 3 B.A. to 10 B.A. screws and nuts, and Desoutter standardised die-sets.

RADIAL DRILLING, BORING AND TAPPING MACHINE.

The equipment shown by the Ajax Machine Tool Company, Limited, Johnson-street, Halifax, will include the 5-ft. radial drilling, boring and tapping machine illustrated in Fig. 25, herewith. This has been designed to meet the demands imposed by the use of high-speed steel and carbide-tipped tools and, as a consequence, is of exceptionally rigid construction. It is of the internal-pillar type, the pillar being fitted inside the vertical sleeve, a design, it is claimed, that gives good rigidity and better locking arrangements. The sleeve is machined from an iron casting and has a diameter of 13 in.; it is suspended from the upper end of the internal pillar, the thrust being taken by a heavy ball bearing. The lower portion of the sleeve is of larger diameter and contains the locking gear, the action of which secures the sleeve to the pillar, thus making the two into a single column. The arm is an iron casting of box form and is designed to contain the switchgear. The saddle also is a box-section iron casting, the lower portion of which has a V-slide bedded to the radial arm to give true alignment to the spindle. The weight of the saddle is taken by rollers fitted with ball-bearing spindles, which travel along machined surfaces integral with the arm. Adjustment of the saddle along the arm is effected through rack-and-pinion gearing in the normal manner, the rack being bolted to the arm.

A single lever serves to lock the saddle to the arm and the sleeve to the pillar simultaneously. The arm cannot swing in the locked position but it can be raised and lowered, thereby enabling the drilling position to be retained. An electric motor mounted directly on the saddle drives the drilling spindle, and the arm is raised and lowered by an auxiliary electric motor situated at the top of the column, both motors being designed to withstand the repeated reversals imposed by high-speed tapping. The spindle is 1½ in. in diameter and is bored No. 4 Morse taper. It is of high-tensile steel and rotates within phosphor-bronze bearings, end thrusts in both upward and downward directions being taken by ball thrust bearings. Over-feeding of the spindle in both directions is prevented by an automatic trip motion which can be adjusted for drilling to predetermined depths when several holes of equal depth are required. There is 14 in. of feed and the spindle is supported throughout its travel by a hardened-steel sleeve which has a rack cut in its outer surface that engages with a pinion for transmission of both power and hand feeds. A special slow feed for fine adjustment is provided, however, and this is operated by a handwheel.

There are eight speeds in a choice of three ranges. Speed changes are made by a single lever which operates within a gate, the selected speed being retained by means of a plunger stop. Four feed rates are available for each of the eight speeds. Start, stop, reverse and inching motions are controlled by a specially-designed switch installed on the saddle, the number of reversals per minute being limited solely by the skill of the operator and the cutting speed of the taps. Elevation and lowering of the arm are controlled from the same switch, the auxiliary motor for this motion driving the elevating screw through gearing. The elevating screw engages with a phosphor-bronze nut, and a cast-iron safety nut comes into operation automatically should the bronze nut fail for any reason. A friction safety device is also incorporated to prevent over-running when elevating or lowering. Three lengths of arm are available and these permit a maximum distance of spindle from the centre of the column of 4 ft. 6 in., 5 ft. and 5 ft. 6 in., respectively, the corresponding saddle traverses being 2 ft. 8 in., 3 ft. 2 in. and 3 ft. 8 in. The vertical adjustment of the arm remains constant at 2 ft. 4 in. The capacity of the machine when drilling is 3-in. diameter in cast iron and 2½-in. diameter in mild steel and, when tapping, 1½-in. diameter Whitworth and 2½-in. diameter gas.

The total height of the machine measured from the floor to the top of the column is 9 ft. 4 in. and the maximum distance between the spindle and the baseplate is 4 ft. 6 in. The minimum distance between the spindle and the baseplate is 1 ft. The maximum arm projection is 5 ft. 10 in. for the 4 ft. 6 in. model, 6 ft. 4 in. for the 5-ft. model and 6 ft. 10 in. for the 5 ft. 6 in. model.

O. & S. HEAVY-DUTY CENTRE LATHE.

Messrs. Drummond-Asquith (Sales), Limited, King Edward House, New-street, Birmingham, 2, are showing exhibits on a number of stands on behalf of the different companies that they represent. Two products of the W.S. Manufacturing Company, Limited, Birmingham, are shown: the Hi-ton presses and Pitchmaster thread-rolling machine. The Hi-ton presses are made in 14 sizes varying between 1 and 250 tons capacity, although many other variations are possible, such as multiple-ram units, to suit the customers' particular requirements. Meta degreasing machines, rotary washing machines and automatic cylinder-block cleaning machines, as manufactured by Messrs. Dawson Brothers, Limited, will also be exhibited. In Fig. 26, on page 229, we illustrate a new heavy-duty centre lathe, made by Messrs. Oldfield and Schofield Company, Limited, Halifax; suitable for medium-heavy duties, the lathe is of robust construction and is equipped for surfacing, facing and screw-cutting operations. The A-type lathe, as it is called, is normally built in two sizes, i.e., 12½-in. centre for heavy-duty work and 15-in. centre for medium duty. The gap bed is of heavy section with diagonal ribbing, and is mounted on separate legs, with a swarf tray clamped between the bed and legs. This eliminates loose-fitting trays and the risk of coolant leaking on to the floor. The fast headstock is designed to give 24 speed changes from 7 to 500 r.p.m., and all the layshafts revolve on ball journal bearings. The hollow spindle is mounted on pre-loaded Timken taper bearings. The gears are of heat-treated high-tensile steel, and are mounted on splined shafts; ample provision is made for lubricating the gears and shafts. The feed-reverse and coarse-pitch screwcutting motions are incorporated in the headstock. The drive is by 15-h.p. motor through V-belts to the headstock. A friction clutch operated from the front of the head, or from the saddle, provides for starting and stopping the spindle. The motor and all control gear are fitted inside the bed.

The saddle has ample bearing surface on the bed, and is fitted with a taper gib for taking up wear. A four-station turret is fitted and micrometer dials are provided on all hand motions. The apron, which is a special feature of the machine, is of robust construction, and the sliding, surfacing and screwcutting motions are operated by a single lever, all the motions being interlocked. Quick power longitudinal traverse is provided by a 1½-h.p. flange-mounted motor situated at the loose-head end of the bed. The motion is engaged by the apron handwheel. The sliding and surfacing motions are engaged by multi-V tooth clutches, for instantaneous operation. The feed box is of the Norton type, giving 28 changes of feed and screw-cutting. The ranges for the feeds are: sliding, 16 to 224 cuts per inch, and surfacing, 35 to 488 cuts per inch. The screwcutting range is from 2 to 28 threads per inch. The foregoing ranges are multiplied by nine when using the coarse-pitch motion on the slow-speed range only. The loose headstock is split for taper-turning and the spindle is bored to take a No. 5 Morse-taper centre. A bracket carrying a rack pinion is fitted for traversing the headstock along the bed.

MANURHIN AUTOMATIC LATHE.

The import-export division of Messrs. Drummond-Asquith (Sales), Limited, Halifax House, Strand, London, W.C.2, will exhibit a number of machines of German and French manufacture. These will include Ohler hydraulic sawing machines; a Waldrich Coburg long thread-cutting machine, a new model which is claimed to have an exceptionally high production rate; two types of Kreuse fine boring machines, one with a single downward feed spindle, the other with six working spindles operating with an upward feed; and also a range of

THE INTERNATIONAL MACHINE TOOL EXHIBITION.

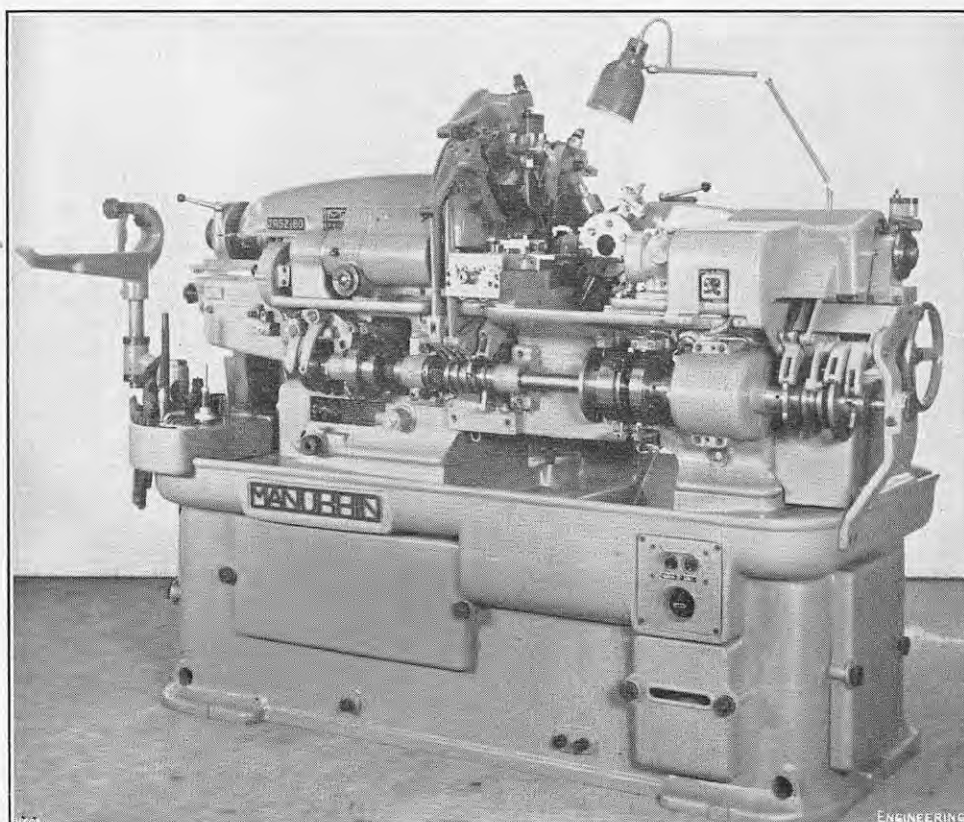


FIG. 27. MANURHIN AUTOMATIC LATHE; DRUMMOND-ASQUITH (SALES), LTD.

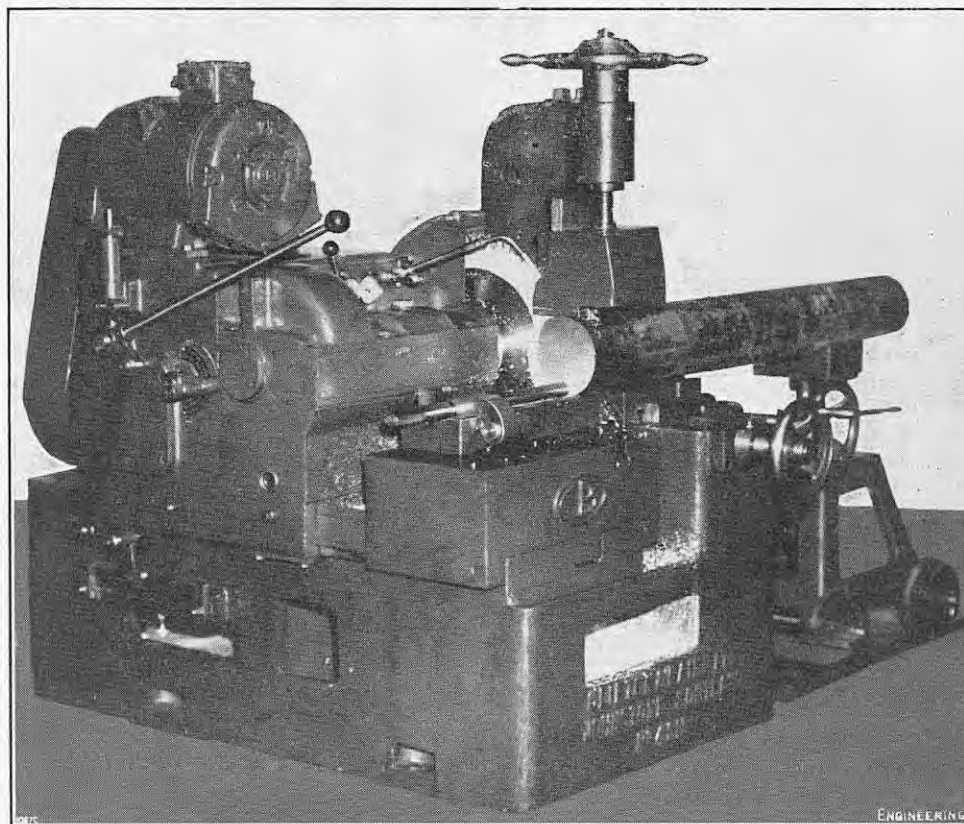


FIG. 28. HIGH-SPEED COLD-SAWING MACHINE; CLIFTON & BAIRD, LTD.

Nassovia die-sinkers, cutter-grinding machines and a precision filing and sawing machine. To complete the range of Drummond-Asquith exhibits there are six machines, three automatic lathes by Manurhin (France and Switzerland) and three turret lathes by Pittler (Germany), all of which are characterised by the large number of combinations of tool positions which are available so that standard tools can be made to do what would otherwise require special tools. In the case of the Pittler machines, in the larger models the turret head has 16 tool sockets, while the small machines have 12 such sockets;

by the use of special tool-holders turning may also be done off the turret simultaneously with drilling or threading operations. In Fig. 27, on this page, we illustrate the Manurhin TR 52/60 automatic lathe. This lathe, which has a maximum admissible bar diameter of 52 mm. (2 in.) and is suitable for the high-quality production of a wide variety of components for the aircraft, automobile and instrument industries, is equipped with five cross-slides, one of which turns longitudinally, an independent swing stop and a turret capable of carrying six tools. An extremely efficient thread-chasing

EXHIBITS AT THE INTERNATIONAL MACHINE TOOL EXHIBITION.

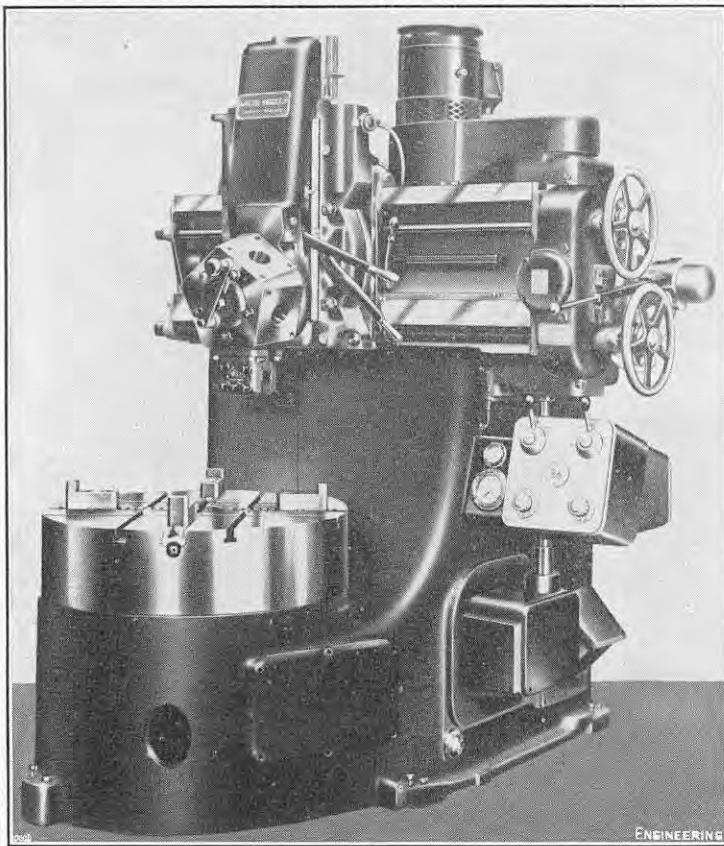


FIG. 29. VERTICAL BORING AND TURNING MILL; WEBSTER & BENNETT, LTD.

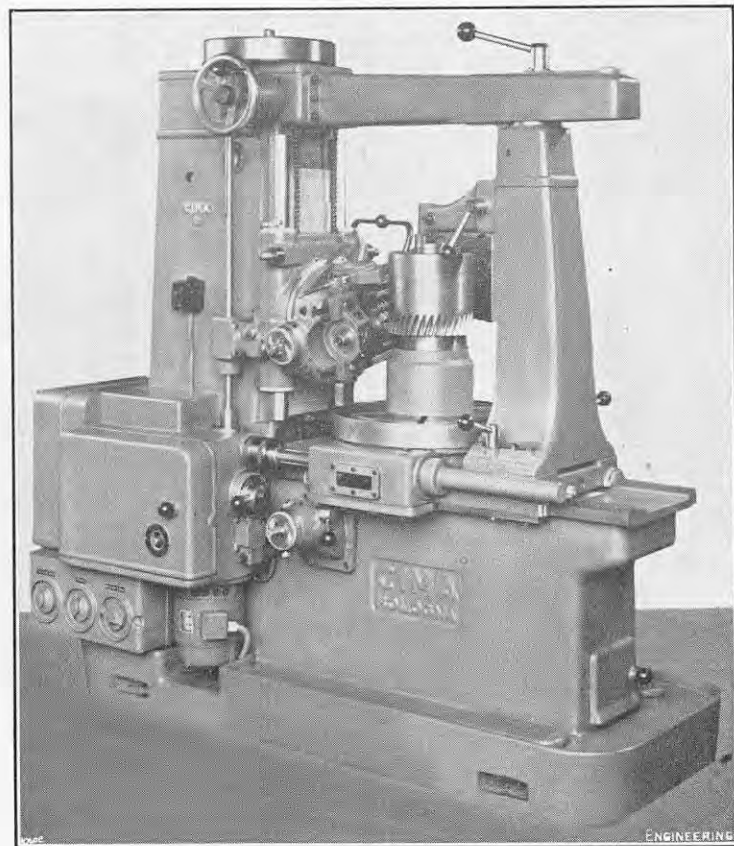


FIG. 30. C.I.M.A. AUTOMATIC UNIVERSAL GEAR HOBBER; ACBARS, LTD.

attachment can be fitted to all sizes of TR models, as well as a special high-speed drilling attachment which is necessary when the normal turning speed does not give sufficient peripheral speed for drilling. The main camshaft comprises two sections. The first part arranged in front of the machine, carries the cams operating the transverse tool slides; the second, set at right angles to the first and connected to it by a spiral-bevel gear drive, carries the cams controlling the turret and the slide with the longitudinal motion.

HIGH-SPEED COLD-SAWING MACHINE.

Messrs. Clifton and Baird, Limited, Empress Works, Johnstone, Scotland, are to show examples of their metal-sawing machines, together with their machines for sharpening circular saws. In Fig. 28, opposite, we illustrate the smallest of the company's new range of cold-sawing machines, which is suitable for cutting solid sections up to 5½ in. diameter and structural sections up to 10 in. by 6-in. rolled-steel joists. This machine is designed for circular saws of between 14 and 18 in. diameter, working at 30, 44 or 60 ft. per minute peripheral speed, which is suitable for cutting all classes of steel, including the alloy steels now in common use. The drive is through V-belts and gearing from a 5-h.p. constant-speed motor mounted on the saw saddle. The hydraulic pump and control valves for the saw feed are contained in a compartment of the saddle, the cylinder being integral with the saddle and travelling with it. During the cutting stroke pressure is maintained on both sides of the piston so as to ensure a controlled feed which varies infinitely up to 25 in. per minute. The vertical and horizontal vices are adjusted by handwheels, the former rigidly holding the work on either side of the blade to ensure burrless cutting, while the horizontal vice is fitted with a universal work anvil which will accommodate round, square or structural sections. Alternatively, an angle-faced vertical vice and swivelling horizontal vices can be fitted, enabling skew cuts to be undertaken; in order that this may be accomplished and the work be kept in line with the shops, the manufacturers recommend mounting the entire machine on a turntable base, so economising in floor space.

As complementary equipment to the company's sawing machines they are also exhibiting their range of saw-sharpening machines which contain all the necessary adjustments for dealing with normal tooth pitches. Dust from the grinding process is extracted by a fan situated in the column and collects at the base, from where it can be removed as necessary.

VERTICAL BORING AND TURNING MILL.

Webster and Bennett, Limited, Foleshill, Coventry, will show one of their 36-in. series-DH vertical boring and turning mills. Its machining capabilities will be demonstrated by machining speed-box covers from aluminium castings. Fig. 29, on this page, shows the machine, which is the smallest in the range of mills for which the firm are well known; the others in the range are the 36-in. duplex machine, the 48-in. single and duplex machines, and the 60-in. single machine. Such machines have been widely used for a number of years in railway locomotive and carriage and wagon workshops, where they are particularly suitable for machining tyres, axleboxes, wheels, piston heads and rings, vacuum-brake cylinders, etc. We have received from the makers copies of tool layout drawings, with explanatory notes, for several operations of this kind, as well as similar particulars for the workpiece which is to be used for demonstration purposes at Olympia. It will be bored, faced, reamed, etc., using seven positions of the turret head.

The 36-in. vertical boring and turning mill has a single column integral with the base, a fixed cross-slide and a single turret head, which experience has shown provides the maximum rigidity. This is an important feature when the maximum use of tungsten-carbide cutting tools is required. The speed and feed ranges, rapid power traverse, clutch and brake, are all hydraulically operated and, in addition, an automatic positive speed-change device ensures correct gear-meshing. The 12 speed changes (in geometrical progression) and 12 feed changes, are controlled by direct-reading hand dials, each range being reversible and interlocked. The chuck is of robust construction and has four hardened independent and reversible jaws mounted on slippers and actuated by protected screws. This design

obviates the necessity of screw-cutting the jaws and is more economical when special jaws are required. The chuck spindle, made from a steel forging, has a double row of pre-selected roller races mounted on its outside diameter. These features contribute to the considerable reduction in operating fatigue, and the hydraulic compensated clutch reduces maintenance costs. The pentagonal turret is also made from a steel forging and has an efficient indexing and locking mechanism. Narrow guides are fitted to all slides. The swivelling head is positive and actuated by suitable gearing on the saddle of the machine. A rapid power traverse is available in all directions, and tool adjustment is made by handwheels and dials calibrated in thousandths. All gears are of steel, hardened and ground, or phosphor bronze; main shafts and most secondary shafts have solid-ground splines. The motor drive is by V-belts through a multi-plate lubricated clutch and geared transmission. Extensive use of anti-friction races is made throughout the geared transmission.

C.I.M.A. AUTOMATIC UNIVERSAL GEAR HOBBER.

An extensive range of Swiss and Italian machine tools will be shown by Acbars, Limited, Cecil House, 57A, Holborn Viaduct, London, E.C.1. The Italian machines on view will include a universal gear hobber manufactured by C.I.M.A., Bologna. This machine, which is illustrated in Fig. 30, above, is of robust construction, the base consisting of a box-section iron casting provided with diagonal ribs to give the requisite stiffness. It is driven through V-belts from an electric motor located at the base of the machine, the speed of the hob being selected by means of a gearbox fitted with hardened and ground gears and installed on the front of the machine. The bevel gears transmitting the drive from the motor to the hob are generated by the Gleason system and a large flywheel mounted on the top of the vertical splined shaft aids in making the machine quiet running. The milling head is fitted to an adjustable carriage sliding within V-guides formed in the vertical column, and the head is swivelled to the required angular position by means of a worm gear, the inclination being indicated on a vernier scale. The spindle runs in bronze bushes

and is adjustable both radially and axially. The work-table carriage is located in V-guides formed on the base of the machine and can be traversed either by hand or mechanically. The dividing mechanism consists of a bronze wormgear and an adjustable endless screw, the complete mechanism being arranged so that it operates in an oil bath. The milling head is provided with vertical and tangential automatic feeds and the work table with an automatic traverse, stops being incorporated in each case. Both the head and table, however, are easily disengaged for hand control, the levers being located at a central point. The mechanism for the differential is driven through a set of change gears and is arranged to impart supplementary movement to the endless screw of the work table in the normal manner. Its use enables helical gears of any angle, wormgears and endless screws to be cut, the mechanism being designed so that it can easily be put out of operation when cutting spur gears. The maximum diameter of spur and helical gears that can be cut with this machine is 550 mm. (21.65 in.). The diameter of the work table is 460 mm. (18.11 in.), and the maximum and minimum distances of hob axis to table-spindle axis are 290 mm. (11.42 in.) and 20 mm. (0.79 in.), respectively. The maximum diameter of hob is 120 mm. (4.72 in.), the maximum length of hob 150 mm. (5.91 in.), and the maximum traverse of the tangential slide 170 mm. (6.69 in.).

72-IN. HORIZONTAL DISC GRINDER.

The Geo. Jackman Machine Tool Company, Limited, 29, Derby-road, Enfield, Middlesex, are to show five disc-grinding machines, a type of machine on which they concentrate. Two of the models exhibited are horizontal discs. We illustrate the No. 29 model in Fig. 31, on this page; this model is being shown for the first time. Two exhibits are double-end disc grinders with 30 in. and 18 in. diameter wheels, and the fifth model is a duplex machine, arranged for the simultaneous grinding of both ends of compression springs or similar components. The model in the illustration is the largest in the company's range and has a grinding disc diameter of 72 in.; it is ideal for grinding the mating faces of large foundry boxes and other similar large castings. The principal features are a heavy rigid base, a compact V-belt drive from a totally-enclosed 25-h.p. motor to a roller mounted spindle, an improved guard ring and dust-extraction equipment, and a built-in dressing device which enables the disc to be trued quickly and simply. Although not exhibited, their catalogue lists smaller models in the same line, with a horizontal grinding disc of only 30 in. diameter, but otherwise built with the same characteristics. The grinding wheel normally fitted to these horizontal disc machines is a fast, cool-cutting corrugated abrasive, $\frac{1}{2}$ in. thick, available in the full range of grinding wheel gradings. Made in four or six segmental sections, they are simply fitted by a central screwed boss, and it is claimed that, under normal production conditions, they may be relied on for an abrasive life of between three and five months.

All the company's disc grinders are arranged with dust outlets to connect up to the works' exhaust systems or to separate dust-collector units. These units have been designed to give a compact installation of ample capacity, so enabling the machines to be placed anywhere in the works. They comprise a totally-enclosed steel cabinet, built-in high-efficiency motor-driven fan, a low air-velocity fabric filter with shaking handle, and a removable dust box.

FLUTE GRINDER.

The stand occupied by Messrs. E. P. Barrus (Concessionaires), Limited, 12-16, Brunel-road, London, W.3, will be devoted to the products of the many United States firms whom they represent. There will be a wide selection of the Aro Equipment Corporation's pneumatically-driven hand tools for grinding, burnishing and polishing; powered drills screwdrivers and nutsetters will also be shown. Among the heavier machine tools on this stand is a crankshaft regrinder and a valve regrinder, both by the Van Norman Company. A flute grinder by the Edward Blake Company is illustrated in Fig. 32, herewith; this machine, which an unskilled operator can easily learn to operate, is suitable for sharpening

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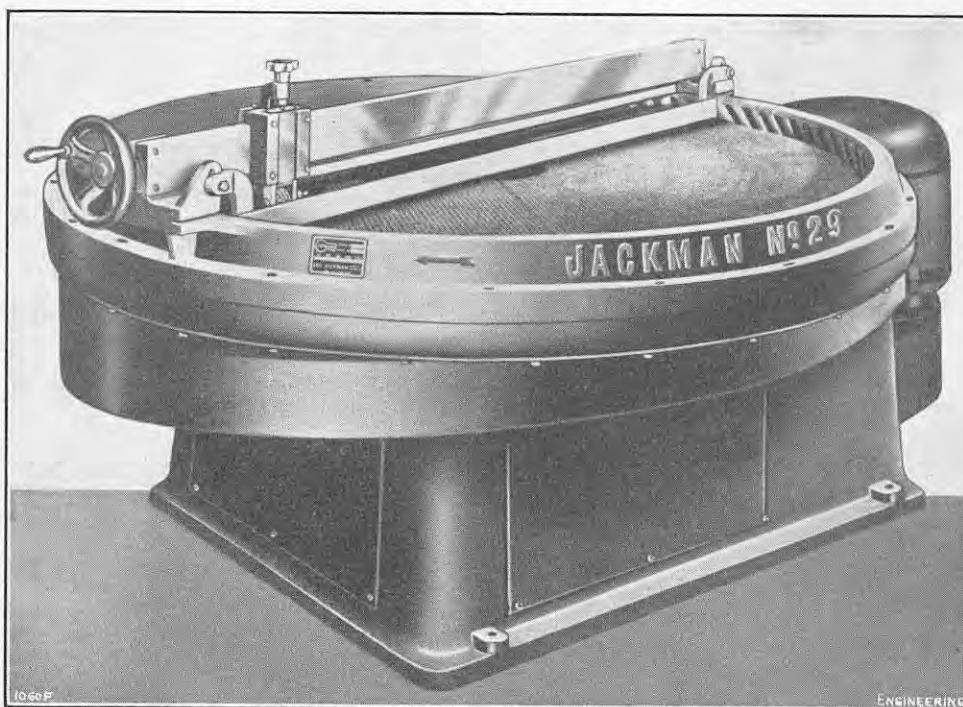


FIG. 31. 72-IN. HORIZONTAL DISC GRINDER; GEO. JACKMAN MACHINE TOOL CO., LTD.



FIG. 32. FLUTE GRINDER; E. P. BARRUS (CONCESSIONAIRES), LTD.

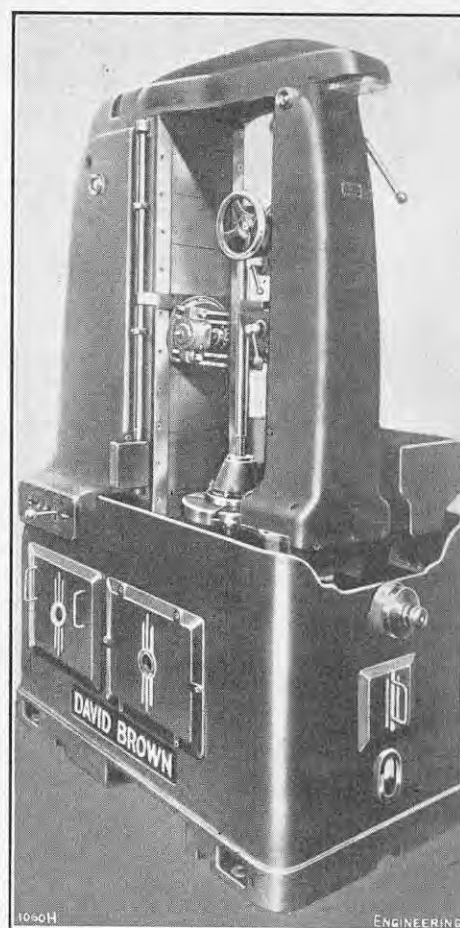
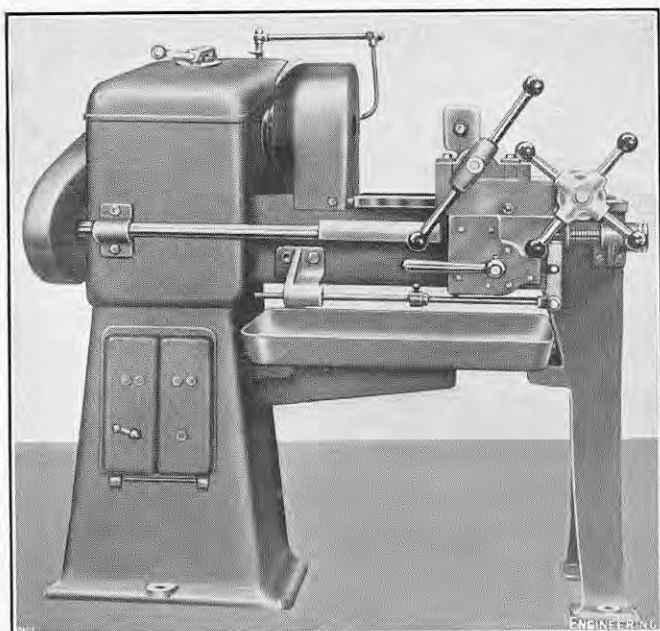
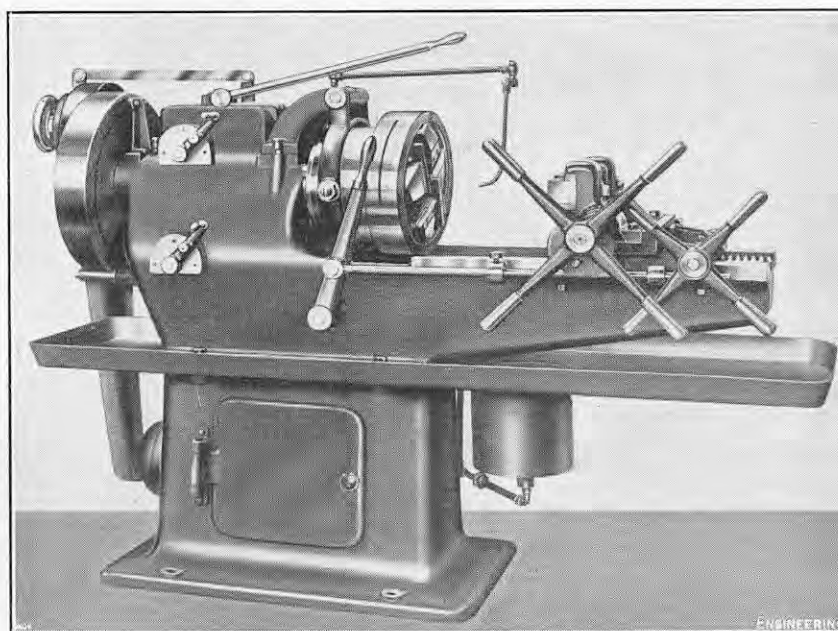


FIG. 33. SPLINE-HOBGING MACHINE; DAVID BROWN MACHINE TOOLS, LTD.

both straight and helical flutes of taps, countersinks, drills and similar tools, up to a diameter of $\frac{3}{8}$ in. Special care has been taken to achieve accurate indexing and good control of the rake angle. To ensure clean and sharp grinding, vibration of the tool that is being sharpened must be prevented; in this machine the shank of the tool is held in a draw-in collet which is just sufficiently tight to keep the tap from turning. The tail end is then supported by back-rest bushings. Mounting of the grinding wheels is so arranged that they may be readily changed for different work. The diamond truing

device is mounted on the same cross-slide as the spindle and the wheel may always be dressed during working operations, if necessary. In a somewhat different class from the greater part of the exhibition is an item also produced by the Blake Company, a specimen set of ground steel surfaces contained in a suitable felt-lined walnut box. The set consists of 23 stainless-steel blocks, each having a machine-cut surface of predetermined roughness value, indicated on the side of each block. Such standard sets are invaluable for the rapid assessment of roughness of a given surface, or in deciding a

EXHIBITS AT THE INTERNATIONAL MACHINE TOOL EXHIBITION.

FIG. 34. 2-IN. TANGENTIAL BAR-TAGGING MACHINE;
MAIDEN AND CO., LTD.FIG. 35. 2-IN. TANGENTIAL THREADING MACHINE;
MAIDEN AND CO., LTD.

degree of finish to be specified. The company also produce a pocket set of these surface-finish standards containing 20 specimens.

SPLINE-HOBGING MACHINE.

Five hobbing machines, ranging in capacity from 15 in. to 60 in., and a gear-shaving machine capable of handling gears up to 25 in. in diameter, have been selected for display by David Brown Machine Tools, Limited, Britannia Works, Sherborne-street, Manchester, as modern examples of the company's unrivalled experience in manufacturing gear-cutting machinery. Of the hobbing machines displayed, one—the MT-V spline-hobbing machine, illustrated in Fig. 33—is of entirely new design and has not been exhibited before. This machine, which is a logical development from the company's MT 15 hobber, has been designed primarily to cut splined shafts up to 35 in. in length, but it is also capable of generating spur and helical gears up to 15 in. in diameter. Contrary to normal practice, splines are cut in the vertical position, this unusual arrangement being made possible by mounting a tall, rigid, upright section to receive and hold the work. The machine is compactly built on a standard MT 15 base with overall dimensions of 68 in. by 49½ in. and with a total height of 90 in. The other hobbing machines exhibited are the latest versions of the MT 15 (both standard and universal types), the MT 30 universal and the MT 60. The MT 15 will generate spurs and helicals up to 15 in. in diameter with a face width of 10 in., and will generate worms by the tangential-feed method; the version exhibited is an improvement on earlier models by virtue of an over-arm support for the work-steady bracket, and a re-modelled hob slide. The display will also include a comprehensive selection of the company's hobs and other gear-cutting tools.

2-IN. TANGENTIAL BAR-TAGGING MACHINE.

As makers of tube and bolt-screwing machines, bar-tagging machines and bar-chamfering machines, Messrs. Maiden and Company, Limited, Hyde, Cheshire, will show a number of machines from their extensive range. In addition to the machines illustrated on this page and described below, there will be a 2½-in. bar-chamfering machine, which is used to prepare the ends of bars so that they do not damage the feed fingers and collets of capstan lathes and automatics; and three screwing machines with capacities ranging from ½ in. to 8 in. The latter machines are designed for various production requirements, including quantity production and the needs of small factories, and one of them is

equipped for screwing taper threads as well as parallel threads.

The 2-in. tangential bar-tagging machine (Fig. 34)—a new design, to be introduced at the exhibition—reduces the ends of bars preparatory to passing them through the dies of draw-benches and wire-drawing machines. Work of this description demands a simple and robust design, capable of hard and continuous work and requiring the minimum of maintenance. The most interesting feature is the cutter head. Four accurately-machined holders ensure that the tools, which have been previously set for length, are rigidly held in position. Each holder is individually swivelled on to a setting bar which is the size of the work in its reduced state; two nuts are tightened to prevent any further movement. This simple method of setting-up ensures correct results. The head is an integral part of the spindle, being mounted in replaceable phosphor-bronze bearings which are spaced so as to provide rigidity and long life. In the past, the tools have tended to confront the user with the only, but rather serious, maintenance problem. By changing from a radial type to a tangential type they become a simple tool which can be easily ground by inexperienced operators, and there is no longer any necessity for each one to be ground exactly the same length as the others. A three-speed gearbox is now an integral part of the main casting, and alternative speed ranges are available according to the type of material being machined. Generally speaking, the 150, 215, 385 r.p.m. range is recommended for ferrous materials, while the 225, 322, 576 r.p.m. range is more suitable for non-ferrous. Each range has been selected to cover, as closely as possible, each type of material which will be used on the range of ½ in. to 2 in. diameter.

Two feeds to the saddle are available. Fixed centres have been arranged, so as to simplify setting-up. Previous experience has shown that a large variety of feeds is not required. By balancing tool life against production times the best results are obtained from feeds of 0.045 in. and 0.080 in. per revolution. The saddle is of robust construction with a narrow guide to give direct thrust and minimise the wear which takes place on the saddle and bed. Felt wipers are fitted to protect the bearing surfaces. The self-centring vice fitted is operated by left-hand and right-hand square threads, and serrated hardened grips provide ample gripping force. A lever at the front of the saddle operates a split nut which brings the feed screw into operation. A pre-set stop is so arranged that, on completion of the required length of tag,

the feed motion is released. Should the operator omit to set the stop, a safety device is provided, so that the feed nut is automatically released as the saddle approaches the cutter head. Alternatively, should it be necessary to discontinue the cut for any reason, hand release is also available.

2-IN. TANGENTIAL THREADING MACHINE.

The other Maiden and Company exhibit (Fig. 35) is one of a new range of threading machines, the design of which is based on the firm's existing "P.R." and "12E" types, but with the substitution of Gustav Wagner tangential die-heads in place of radial heads. The machine illustrated has a capacity of ½ in. to 2 in. Whitworth or British Standard pipe threads, but all the P.R. machines can be so fitted and the 12E machines up to the 6-in. size. The body of the tangential die-head is flange-bolted to the spindle of the machine. Four hardened and ground pins are inserted, on which the chaser holders pivot; hardened steel guides prevent longitudinal movement of the chasers. The bore of the spindle is 2½ in. When lengths of work in excess of the complete saddle traverse are required, the grips are released, allowing the head to continue to rotate and the saddle is moved backwards; once the grips are retightened threading continues. The chaser holders are controlled in one direction by the main body of the head, while in the other direction they operate on a hardened and ground steel cam. On each holder is fitted a hardened steel pad, shaped so that with the rearward movement of the cam the holders are automatically released by means of a spring-loaded pin. The cam itself is adjusted by a small pinion, controlled from the front of the head by a key.

The external ring on which the cam is fitted, in addition to incorporating a release movement, allows the cam to be withdrawn to a position where the chaser holders can be quickly removed and inserted, as required. Accurate setting of the chasers is essential where good results are required; this is ensured by providing a setting gauge, of simple design, using a clock for setting purposes and thus providing extremely accurate results. The die-head is provided with nine speeds, 28 to 150 r.p.m., covering the requirements of the range of work for which the machine is designed. The change-wheels are of hardened steel and carried on splined shafts. Power is provided by a 3-h.p. motor through V-belts to a friction clutch, which is operated by a hand lever. Automatic release is provided so that, by setting a stop to give a determined length of thread, the chasers are released.

(To be continued.)

CONSTRUCTION OF THE CORYTON OIL REFINERY.

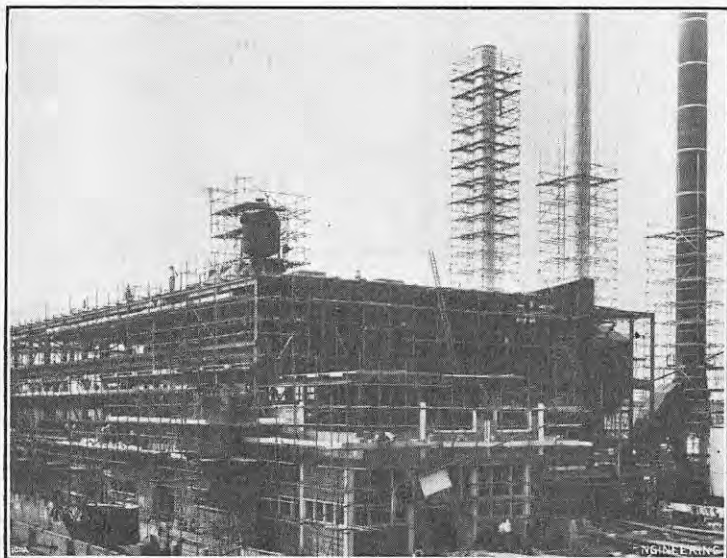


FIG. 1. POWER HOUSE.

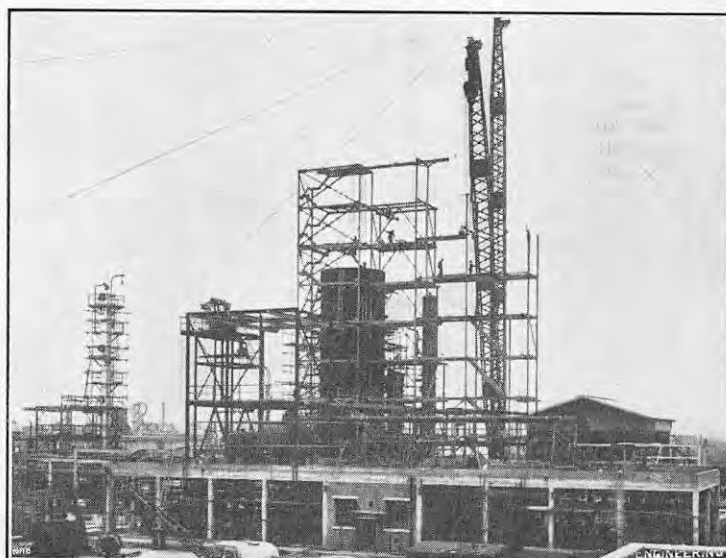


FIG. 2. VACUUM DISTILLATION TOWER.

CORYTON OIL REFINERY
OF THE VACUUM OIL
COMPANY.

Good progress is being made with the construction of the Vacuum Oil Company's new oil refinery at Coryton, Essex, and after two years' work on a virgin site the project has now reached the stage where its final form is discernable. The first major unit to come into operation will be the power plant. This will consist of three boilers which will supply steam to three 5,000-kW turbo-generators. The first boiler has already passed its hydrostatic test and at present is in process of being dried out in preparation for steam raising and, if all goes according to plan, the first turbo-generator is expected to be put on load within a few weeks. In addition to supplying steam to the turbo-generators, the boilers will also provide all the process steam used throughout the refinery area. The main fuel used in them will be propane tar, a refinery by-product with few other uses. Fig. 1, above, shows the boiler and power house in course of erection, and it will be noted that the three steel chimney stacks are in position and that the buildings have reached an advanced stage of construction.

The refinery has been designed to process approximately 900,000 tons of oil annually, and it will be appreciated that such an output will call for large quantities of cooling and processing water. Apart from that used in the boilers, the water will be obtained from the Thames and will be supplied to the site by electrically-driven vertical-spindle pumps installed on a concrete jetty. The jetty is already in position and work on the concrete bridge linking it with the mainland is well advanced. This jetty was constructed at Gravesend and Tilbury, after which it was floated down the Thames and sunk in position. Details regarding the design of the jetty and the methods employed in placing it in position were given on page 332 of our issue for March 14 this year. When in commission, the jetty will be equipped with three pumps, each capable of delivering 15,000 gallons per minute, two of which will be operated by 650-h.p. vertical electric motors and the third by a 650-h.p. horizontal condensing geared steam turbine. There will also be three pumps, each rated at 6,360 gallons per minute, two of which will be driven by 200-h.p. electric motors and the third by a 200-h.p. horizontal steam turbine.

The main refinery units will include a two-stage distillation unit, a catalytic-cracking plant and a thermal reformer. Considerable progress has been made during recent weeks with the two-stage distillation unit. The shell of the atmospheric tower was delivered to the site by road towards the end of July and it already has been erected and much of the interior work completed. The other

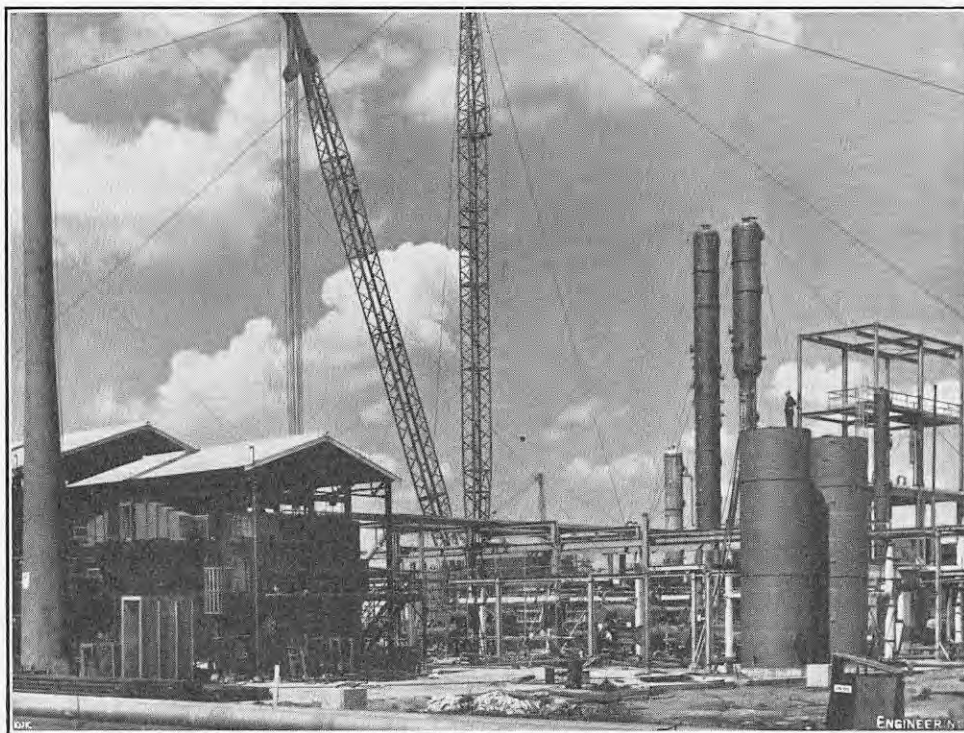


FIG. 3. FURFURAL SOLVENT UNIT; LUBRICATING-OIL SECTION.

distillation tower, namely, the vacuum tower, was too large to be transported to the site as a complete unit and is therefore being built *in situ*. It is shown in course of erection in Fig. 2. The complete distillation unit is expected to go on stream this autumn. Good progress is also being made with the thermal-reforming unit and this too is expected to be in service later in the autumn.

Work has also commenced on the catalytic cracking plant, which, it is hoped, will be brought into production in 12 months time. Known as the Thermofor air-lift catalytic cracker, the new plant will be the first of its kind in the United Kingdom, and the second in Europe. The unit gets its name from the fact that the regenerated catalyst is blown by air through a pipe over 200 ft. high to the top of the reactor, after which it flows through the system by gravity. It is claimed that the unit is easier to operate than other types and has greater flexibility, thus enabling a wider range of stocks to be handled. As it will have a total height of 272 ft. when completed, the foundations have called for special attention. In all, 380 steel-and-concrete piles have been sunk; 130 of these were of the pre-cast type and had to be driven approximately 60 ft. into the ground before a solid

bed was reached. The foundations have been completed and work has started on the main structure.

The lubricating-oil plant will include a propane de-asphalting unit, a furfural treating unit, a Mek dewaxing unit and a percolation unit. When complete, it will enable the Vacuum Oil Company to produce in the United Kingdom for the first time stock oils for Mobiloil, Delvac, Sorac and Gargoyle. Work has started on the propane de-asphalting and furfural units, and the progress made with the latter will be seen from Fig. 3, herewith, which shows the present stage of construction. All four lubricating-oil units are expected to be on-stream by early spring of next year.

When completed, the Coryton refinery will have cost over 12,000,000 pounds sterling, and will represent an outstanding example of Anglo-American co-operation. Socony-Vacuum of New York are providing the technicians to design and supervise the construction, but the whole labour force is British and British industry will provide 95 per cent. of the equipment. Capital for the project has been provided in equal shares by the Powell-Duffryn Group of Great Britain and Socony-Vacuum of New York.

THE BRITISH ASSOCIATION MEETING IN BELFAST.

For the fourth time in its history, the British Association has held its annual meeting this year in Belfast, which has been the capital city of Northern Ireland since the creation of the country as a separate area of government in 1921. The meeting, the 114th the Association has held, commenced on Wednesday, September 3, and concluded on Wednesday last, September 10. The previous Belfast meetings were held in 1852, 1874 and 1902, so that this year's meeting may be regarded both as a centenary and a jubilee. The presidents for the three previous Belfast meetings of the Association were General Sabine, Professor Tyndall and Professor (afterwards Sir James) Dewar. Professor A. V. Hill, C.H., O.B.E., F.R.S., is President for the current year.

Belfast, as is well known, is famous for its ships and its linen, but has several other important industries, including milling, bacon-curing and distilling, which are all linked with the agricultural hinterland of the city. During the course of the meeting, members had ample opportunities for inspecting these industries and everywhere experienced the hospitality for which the community of Northern Ireland has an enviable reputation. Incidentally, it may be mentioned, nearly one-third of the total population of Northern Ireland is included in the County Borough of Belfast, the most recent official figure for the Borough being 443,670. The attendance at the meeting this year was well over 4,000.

A notable feature of the meeting was the presence of H.R.H. the Duke of Edinburgh, who, it will be remembered, was President of the Association for the Edinburgh meeting last year, and who carried out his duties as Past-President in an efficient manner that was greatly appreciated by officers and members alike.

GRADUATION CEREMONY.

The first general assembly of the members was held on Wednesday evening in the Sir William Whitla Hall of the Queen's University, but as the attendance was greater than could be accommodated in this hall the whole proceedings were relayed to the Whitla Hall of the Methodist College, which is situated in Malone-road, a short distance from the University. The inaugural meeting was preceded by a graduation ceremony at which the Chancellor of the University, Field Marshal the Viscount Alanbrooke, K.G., G.C.B., O.M., occupied the chair. On behalf of the University, the Chancellor welcomed the Duke of Edinburgh and asked him to convey their respectful greetings and humble duty to Her Majesty the Queen. Professor J. L. Montrose, Dean of the Faculty of Law, then conferred the honorary degree of LL.D. on Dr. D. W. Bronk, President of the American Association for the Advancement of Science, and on Professor A. V. Hill, President of the British Association. Honorary degrees of Doctor of Science were then conferred upon Professor E. D. Adrian and Sir William Slater, the ceremony being performed by Professor R. A. R. Gresson, Dean of the Faculty of Science of Queen's University. Finally, in the absence of Professor A. H. Naylor through illness, the honorary degree of Doctor of Science was conferred upon Sir Richard Southwell by Professor K. G. Emeleus.

INAUGURAL MEETING.

At the conclusion of the graduation ceremony, the members of the Association were welcomed to Belfast by the Lord Mayor of the City, Councillor James Henry Norritt, J.P., F.C.I.S., and on behalf of the University by the President and Vice-Chancellor, Dr. Eric Ashby, D.I.C. Professor Hill then delivered his address, entitled "The Ethical Dilemma of Science," which has been reprinted, in abridged form, in this and last week's issues of *ENGINEERING*. Before proposing the vote of thanks to the President, H.R.H. the Duke of Edinburgh read the following message from Her Majesty the Queen: "I am very glad to send, through my husband, this message of good wishes to the members of the British Association for the Advancement of Science. I well know that the

strength of our country and Commonwealth depends more and more on the skilful application of scientific discoveries to the many problems that beset us to-day. With this in mind, I am happy to extend my Patronage to the British Association, whose meetings afford to scientists, old and young, such inestimable opportunities of freely exchanging their knowledge and their ideas."

In his vote of thanks, the Duke said it seemed to have been the general custom in the past for the presidential address to deal with some aspect of the work of scientists. He had expected to hear from Professor Hill something about the work on muscular action for which he was justly famous and which had gained him a Nobel Prize 30 years ago; but this year the President had made a notable departure from this custom. He had told the meeting, ably and fearlessly, what responsible scientists were thinking. He had stated their problem clearly and courageously, and in his conclusions had demonstrated that integrity of thought which was the hallmark of all great scientists. He was sure that the address would be welcomed by scientists throughout the world as sound common sense and wise counsel. To the layman and good citizen the President had made clear the issues and responsibilities. He had spoken of the strict principles which governed scientific thought and action, without which no progress of any value would be achieved. In exactly the same way, the Christian principles should govern the thoughts and actions of the community at large. In fact, the compelling duty of the good citizen was to apply those principles to all the problems of modern life, whether they be personal, social, political, or scientific. The meeting had been privileged to hear an address which, he had no doubt, would go down in the annals of the British Association as one of the most important discourses made from the chair in recent times. He hoped it would prove to be controversial, for it was only by the clash of opinions that lasting judgments could be made. At least, it had given prominence to a problem which had bothered many people, both scientists and laymen, for some time. All were most grateful for what the President had done for the cause of science.

(To be continued.)

15-MW GAS-TURBINE ALTERNATOR SET AT TRAFFORD POWER STATION.

THE first gas-turbine driven generator to go into commission for the British Electricity Authority was put on load for the first time at the Trafford power station, Stretford, near Manchester, on Wednesday, August 6. It is a 15-MW unit, installed in an engine-room adjoining the existing steam-plant room, and has been built by the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester.

The gas-turbine plant operates on an open compound cycle. The flow of air, or gas, is through a low-pressure compressor, an intercooler, a high-pressure compressor, a heat exchanger, a main combustion chamber, a high-pressure turbine, a reheat combustion chamber, and a low-pressure turbine, the exhaust then passing back through the heat exchanger before it is discharged to the chimney stack. At the outlet of the high-pressure compressor the pressure is 143.33 lb. per square inch (absolute) and the temperature is 167 deg. C. (332 deg. F.). At the outlet from the heat exchanger to the chimney the pressure is 14.79 lb. per square inch (absolute) and the temperature is 234 deg. C. (450 deg. F.). The air, fuel and gas flows are shown in Fig. 4, on page 336. Fig. 3 is a plan of the layout, and Figs. 1 and 2 show the plant under erection and completed.

The low-pressure turbine is directly coupled to the low-pressure compressor and to the 15-MW generator; it runs at a constant speed of 3,000 r.p.m. under the control of a speed governor regulating the fuel admission to both combustion chambers. The high-pressure turbine and the high-pressure compressor are coupled together and run at a speed determined by the load conditions; at full load it is 5,500 r.p.m. The combined length of

the two units is 80 ft., and, with an intervening space of 16 ft. occupied largely by the reheat chamber, the overall length is 96 ft. The plant is designed for a gas-inlet temperature to both turbines of approximately 1,200 deg. F. and an overall pressure ratio of 10 to 1. It is largely experimental, and no doubt detail modifications will be made in the light of experience.

Before the incoming air is admitted to the low-pressure compressor, it is passed through a Precipitron electrostatic filter, which removes solid impurities that might impair the efficiency of the compressor blading. The stack to which the exhaust gases pass on leaving the heat exchanger is constructed of reinforced concrete, and is 250 ft. high. At first, gas oil will be used as the operating fuel, but it is hoped to modify the plant later to use heavier oils. On starting, the high-pressure line is rotated by a 400-h.p. alternating-current direct-coupled starting motor, and fuel is gradually admitted to the main combustion chamber; the motor is disengaged on reaching a speed of about 3,000 r.p.m. During this time the air drawn through the low-pressure compressor, and the gas discharge through the low-pressure turbine, slowly rotate the low-pressure line, and as fuel is gradually admitted to the reheat chamber the speed of the low-pressure line and the generator increases to 3,000 r.p.m. During idle running the high-pressure line runs at about 3,000 r.p.m.

COMPRESSORS AND TURBINES.

Both compressors, which are illustrated in Figs. 5 and 6, on Plate XIX, are similar in general construction, the low-pressure machine having 14 stages and the high-pressure 15 stages. The stators are of fabricated construction and the rotors are high-tensile chromium-alloy forgings. The stainless-steel blades are held in circumferential serrated grooves. The high-pressure turbine (shown in Figs. 7 and 8, on Plate XIX) has two expansion stages. The stator and diaphragms are of austenitic material, and the nozzles of both stages are of Nimonic 75 alloy. The rotor is a molybdenum-vanadium forging having blades of Nimonic 80A, held in axially-serrated grooves. The low-pressure turbine (Figs. 9 and 10, on Plate XX), which has six stages, has an austenitic stator, with diaphragms and nozzle blades for the first three stages of like material and for the last three stages of $\frac{1}{2}$ per cent. molybdenum steel. The low-pressure rotor body is a molybdenum-vanadium forging with axially-serrated blade roots, holding blades of Nimonic 80A for the first row, of austenitic steel for stages 2 and 3, and of $\frac{1}{2}$ per cent. molybdenum steel for the final three stages.

Each compressor is connected to its turbine by a coupling of the flexible-plate type. The low-pressure compressor and the alternator are connected by a semi-flexible coupling. The whole plant is lubricated by means of a gear pump, mounted on the inlet-end pedestal and gear-driven from the main shaft of the low-pressure turbine. For starting up and for barring after shutting down, an auxiliary lubricating-oil pump is provided, motor driven and having the same capacity as the main pump. When the speed of the low-pressure line is sufficient, the auxiliary pump automatically cuts out and the main pump meets the duty. Barring of the high-pressure line is effected by means of the starting motor. The low-pressure line is barred by a separate barring motor mounted on the turbine pedestal and driving on to the shaft coupling through a double-reduction worm gear.

INTERCOOLER AND HEAT EXCHANGERS.

The intercooler consists of four nests of wire-wound Still-type brass tubes, each nest containing 232 tubes 12 ft. long between brass tubeplates. The tubes are 1 in. in outside diameter and 18 s.w.g. thick. The casing is of welded steel construction and the water headers of cast iron. The water inlet and outlet are at the top of the cooler, giving a two-flow circulation through the tubes. The bottom header is of the floating type, and thus no difficulty arises owing to relative expansion of the tubes and shell. The total weight of the intercooler is 27 tons.

The heat exchangers are six in number and are mounted vertically; the construction of them is shown in Figs. 11 and 12, on Plate XX, and they are visible at the back of Fig. 13, on page 337.

15-MW GAS-TURBINE ALTERNATOR SET AT TRAFFORD POWER STATION.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, MANCHESTER.

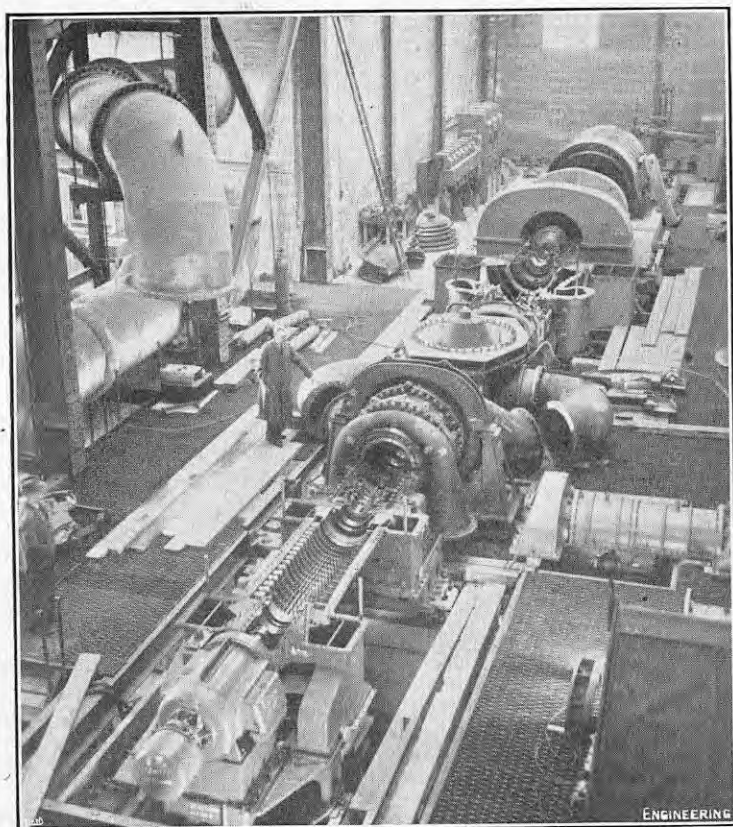


FIG. 1. SET IN COURSE OF ERECTION.

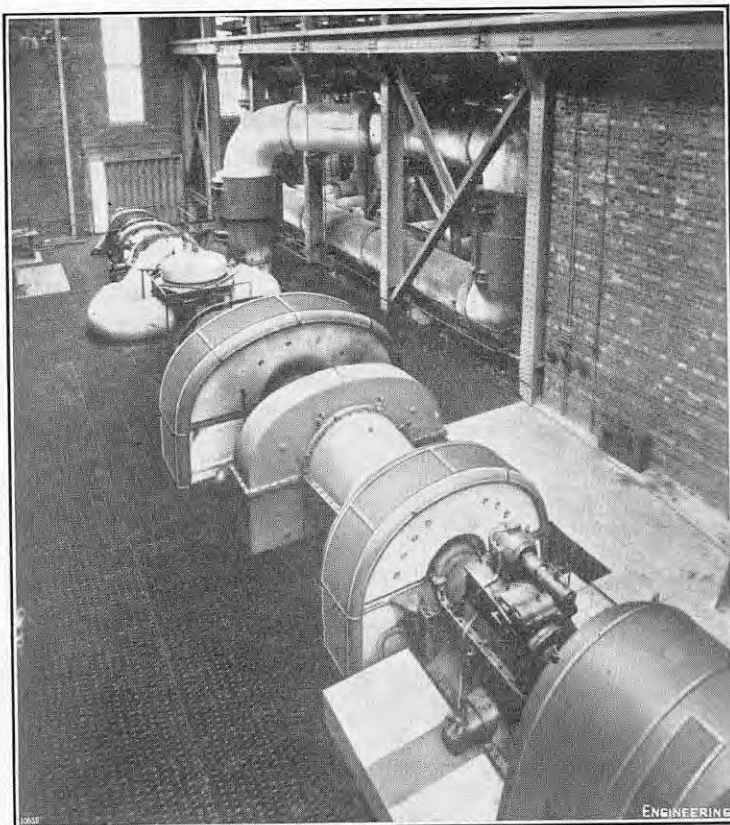


FIG. 2. GAS TURBINE FROM LOW-PRESSURE END.

Each contains 2,005 mild-steel tubes 1 in. outside diameter and 16 s.w.g. thick, the distance between tubeplates being 21 ft. The total tube surface is 66,100 sq. ft. The arrangement very closely approaches contra-flow, the air entering the top and leaving the bottom of the casing, and the hot gas entering the tubes at their bottom ends and leaving at the top. An internal liner fitted with spaced rings, shaped to register with the outer tubes, confines the air flow in the tube nest (Figs. 11 and 12); a gland is fitted between the shell and the internal liner for the same purpose. The tubes are expanded into steel tubeplates at both ends, relative expansion of the tubes and shell being met by means of a gland between the tubeplate and shell at the top end. Tube spacing is maintained throughout the length by transverse corrugated strips (shown in Fig. 11), which also facilitate the replacement of individual tubes.

The heat exchangers have an overall height of 24 ft. 5 in. and a diameter of 5 ft., and weigh 23 tons each. They are each mounted on four radial foundation guide-plates to allow for expansion while maintaining their exact location.

COMBUSTION CHAMBERS AND DUCTING.

The main combustion chamber is mounted in a vertical duct (seen on the right of Fig. 13), connecting the top heat-exchanger air 'bus-main and the high-pressure turbine inlet. It consists of an outer casing of mild steel 42 in. in diameter and an inner primary-chamber wall of stainless steel. The inlet air is admitted to, and gradually mixes with, the products of combustion through a series of apertures in the inner wall. The fuel jet operates with down-stream injection and consists of four main burners and one auxiliary or idling burner, the latter being sufficient to idle the plant.

The reheater chamber is differently constructed in view of the higher inlet-gas temperature. The gas is caused to swirl as it enters the main cylindrical body through two side openings; the release of this rotational motion causes effective mixing of the combustion products with the incoming gas. Only one burner—a combined main and ignition jet—is used in this chamber.

The ducting between the main combustion cham-

Fig. 3. GENERAL ARRANGEMENT OF 15-MW GAS-TURBINE GENERATOR.

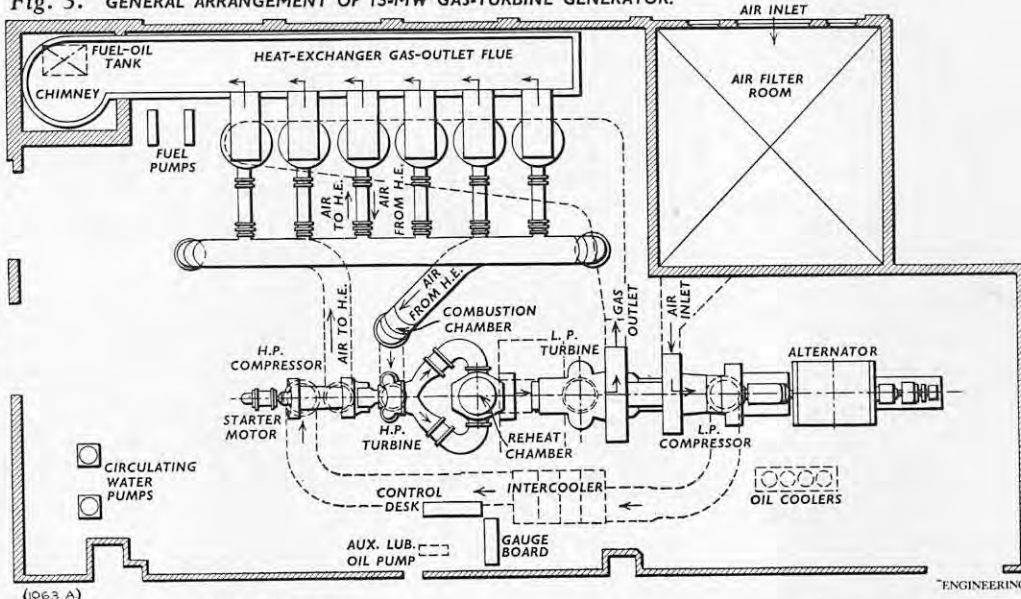
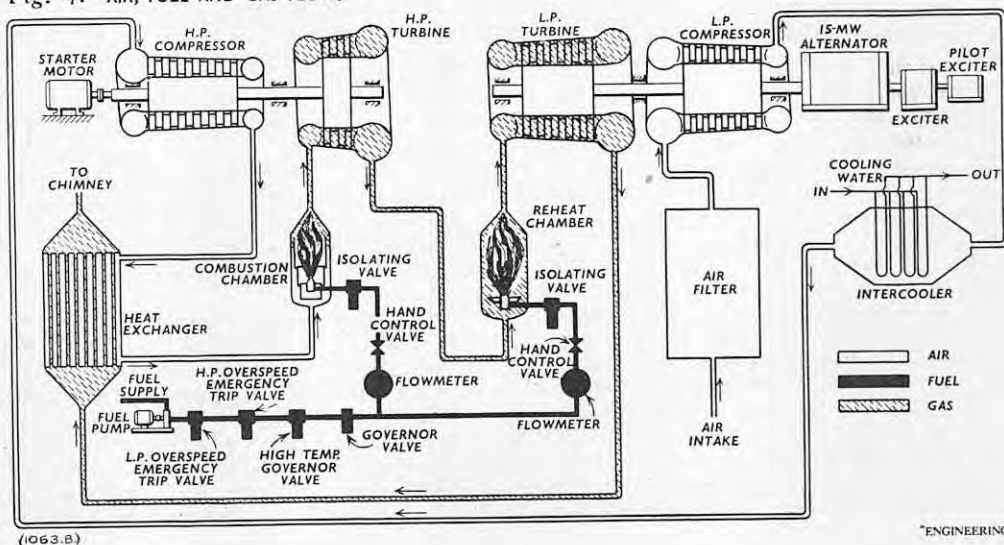


Fig. 4. AIR, FUEL AND GAS FLOW.



15-MW GAS-TURBINE ALTERNATOR SET AT TRAFFORD POWER STATION.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, MANCHESTER.

(For Description, see Page 335.)

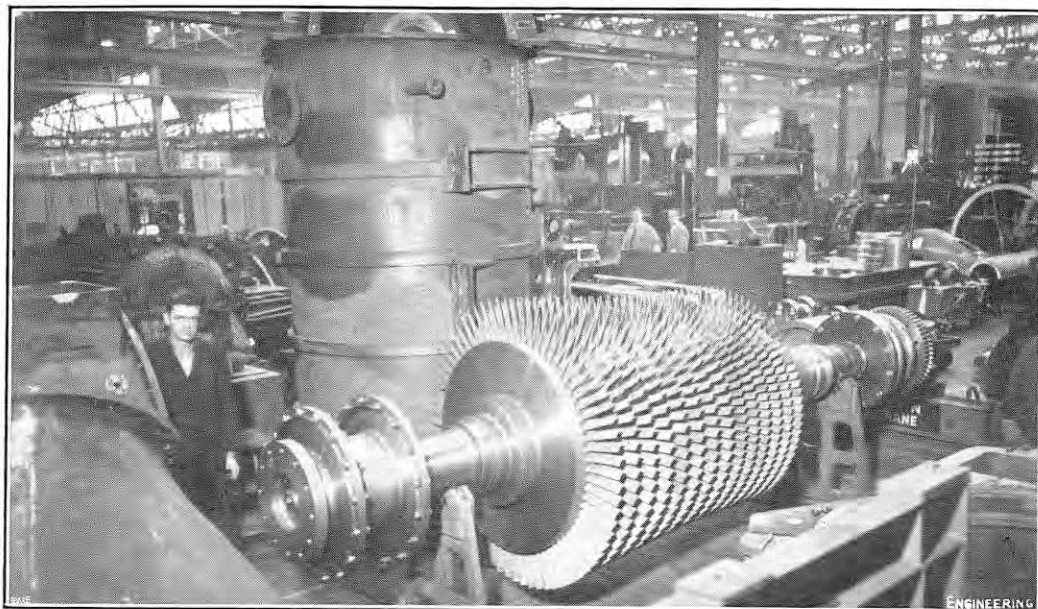


FIG. 5. ROTOR OF LOW-PRESSURE COMPRESSOR.

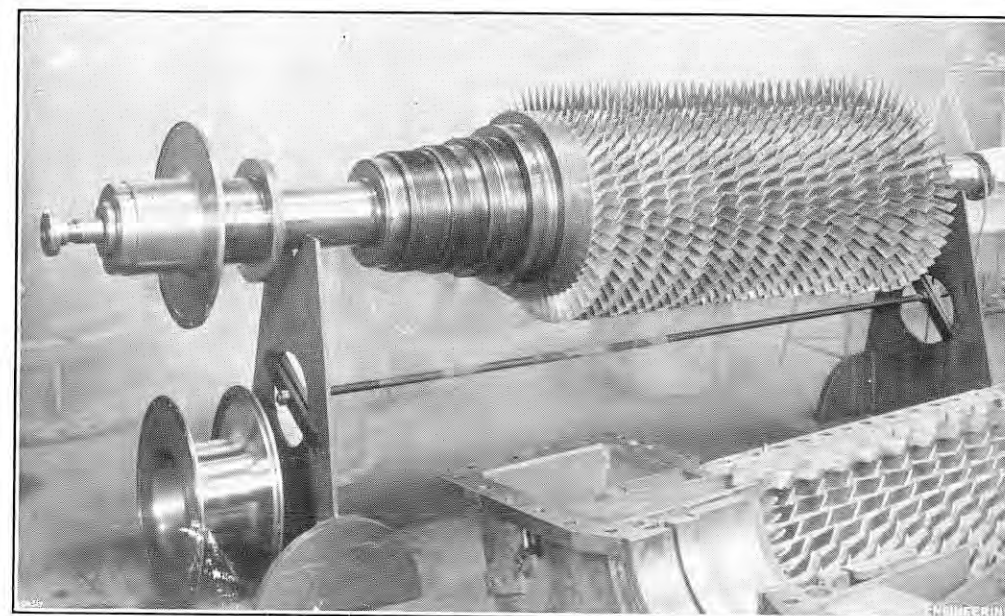


FIG. 6. ROTOR AND PART OF CYLINDER OF HIGH-PRESSURE COMPRESSOR.

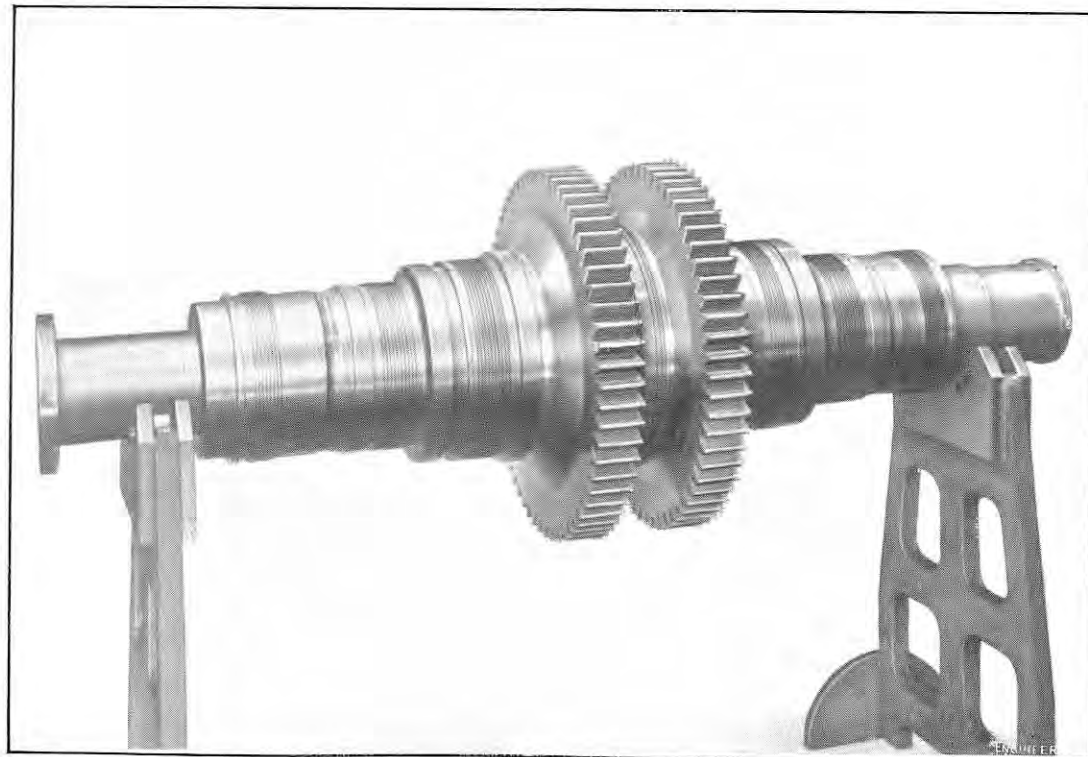


FIG. 7. ROTOR OF HIGH-PRESSURE TURBINE BEFORE BLADING.

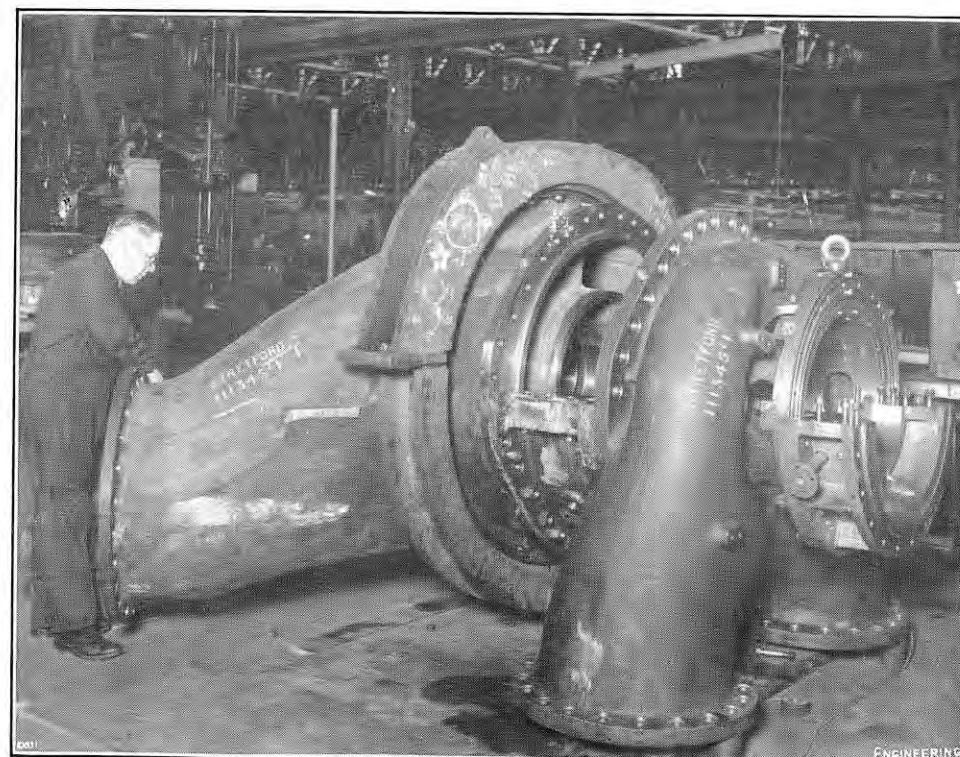


FIG. 8. HIGH-PRESSURE TURBINE DURING ASSEMBLY.

15-MW GAS-TURBINE ALTERNATOR SET AT TRAFFORD POWER STATION.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, MANCHESTER.

(For Description, see Page 335.)

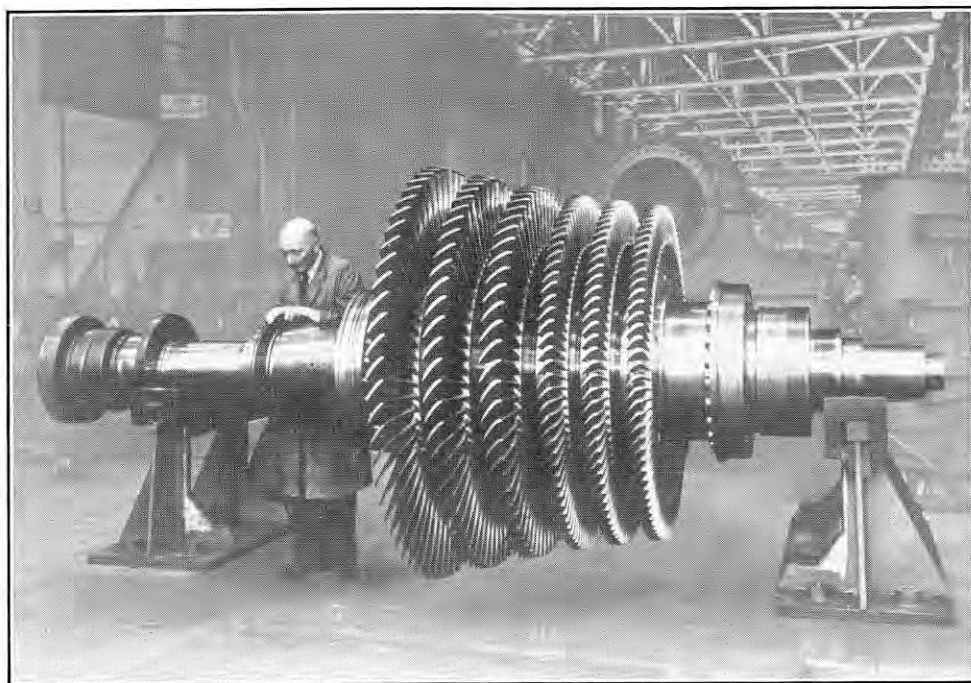


FIG. 9. ROTOR OF LOW-PRESSURE TURBINE.

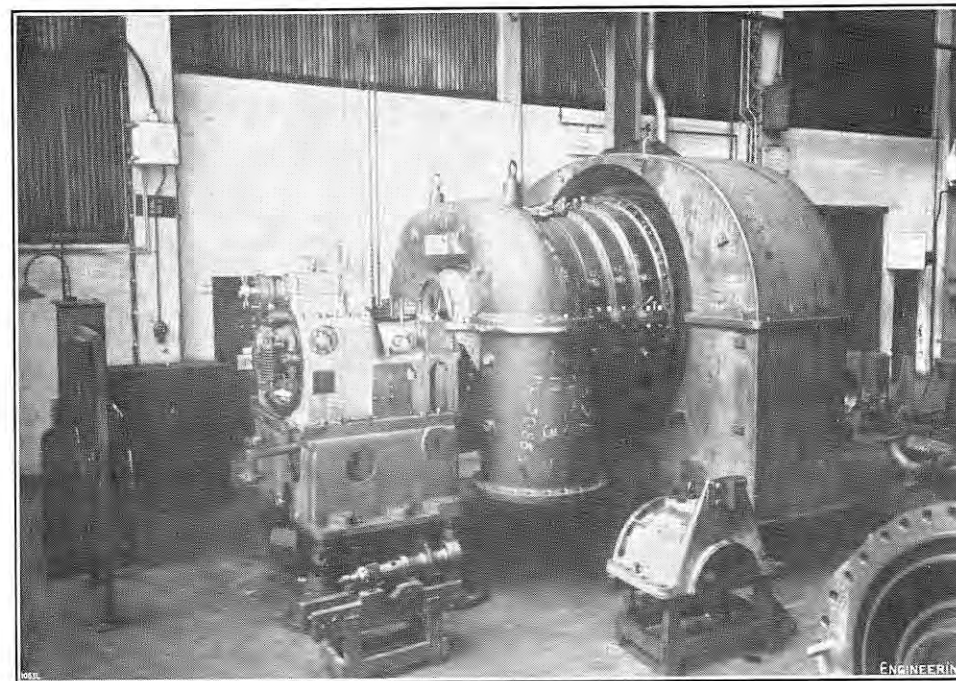


FIG. 10. LOW-PRESSURE TURBINE ASSEMBLED.

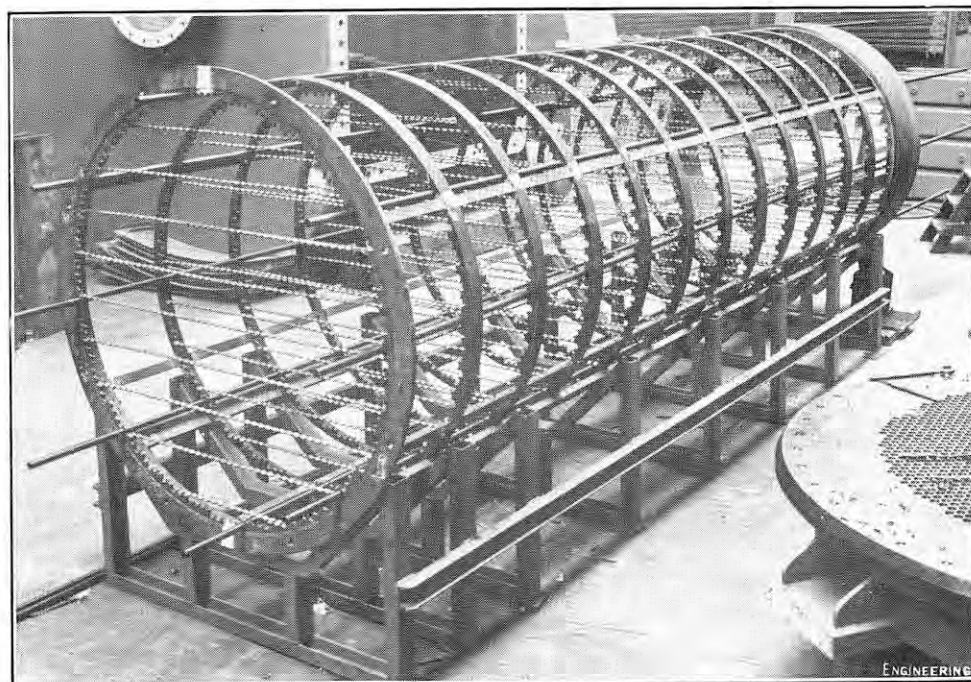


FIG. 11. INNER FRAME FOR TUBE NEST OF HEAT EXCHANGER.

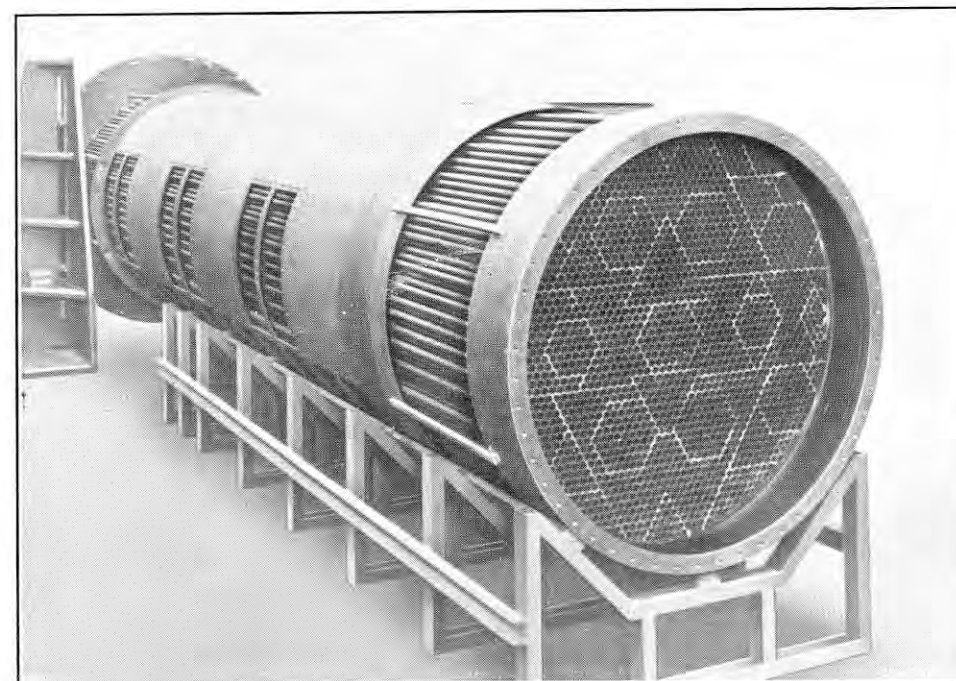


FIG. 12. HEAT-EXCHANGER INNER FRAME TUBED AND SHEETED.

15-MW GAS-TURBINE ALTERNATOR SET AT TRAFFORD POWER STATION.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, MANCHESTER.

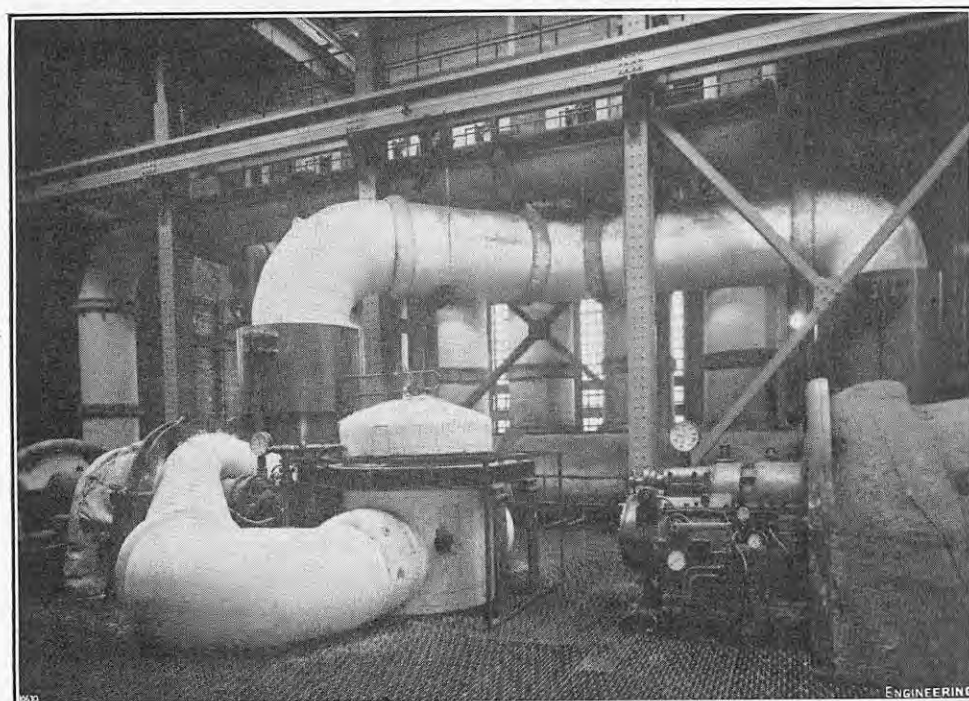


FIG. 13. HIGH-PRESSURE END, REHEAT COMBUSTION CHAMBER, AND LOW-PRESSURE END.

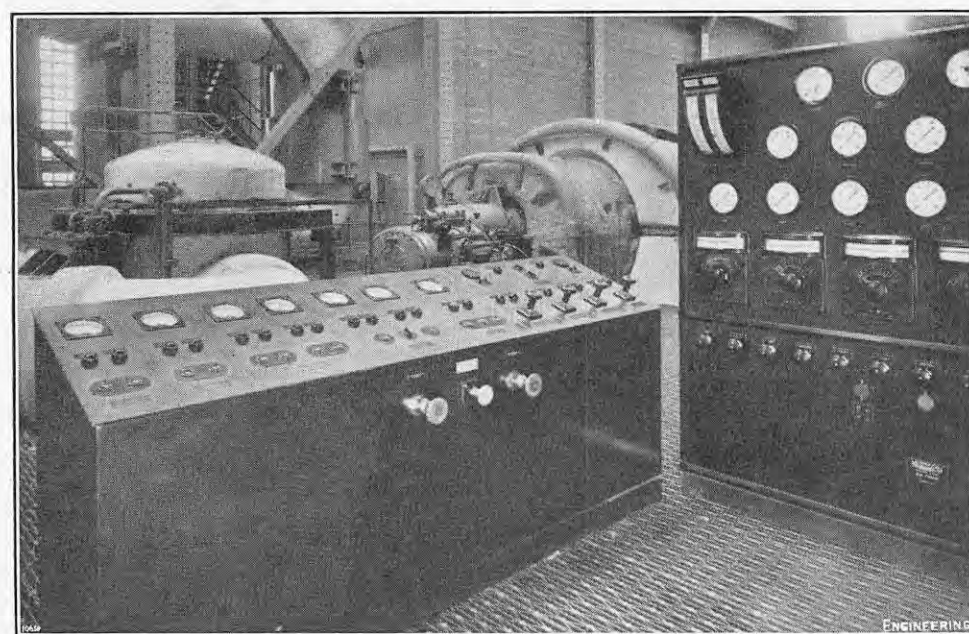


FIG. 14. CONTROL DESK AND INSTRUMENT PANEL.

ber and the high-pressure turbine, and that between the reheat chamber and the low-pressure turbine, are lagged both internally and externally. In large gas-turbine installations, one of the major problems is the provision of adequate flexibility in the large ducts. They are often of considerable length, and, besides being subject to extreme changes of temperature, they have to cater for considerable axial movement of the plant components. For the Trafford installation, where a duct diameter of 54 in. is used, Metropolitan-Vickers have introduced a new type of flexible expansion piece, a cross-section of which is shown in Fig. 15. It consists of two annular discs of steel plate which are pivoted at the inner edges to the duct itself and at the outer edges to an intermediate ring; these form a flexible collar, annular discs of thin flexible metal effecting the necessary gas seal at the pivoting points. The duct can flex by straining the annular discs to concave or convex formation as required. The maximum stress in such a construction is, for equal flexure, far less than would occur in a conventional corrugated section.

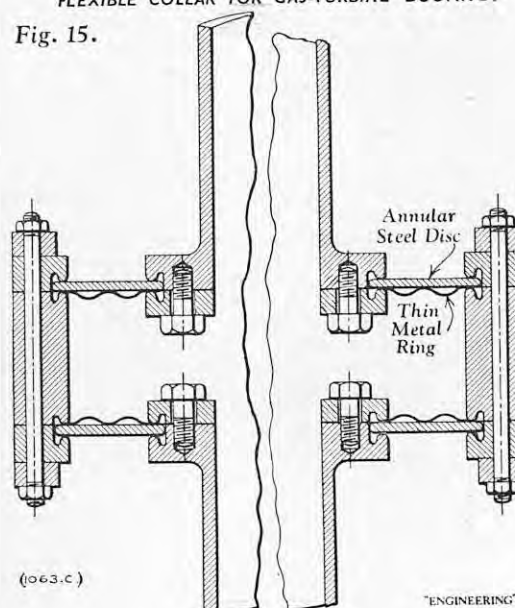
FUEL SYSTEM.

The fuel storage tanks are situated on the remote side of an adjoining canal, and a smaller service tank is accommodated in the foundation of the stack adjoining the engine-room. A float-operated switch maintains a suitable level of fuel in the service tank by starting and stopping a motor-driven pump near the storage tank. The fuel system is extremely simple and very flexible from the control point of view; it has been designed for use on distillates such as gas oil, and on pre-heated residual fuels. It is shown in the flow diagram, Fig. 4. From the service tank, fuel flows by gravity through filters to two motor-driven fuel pumps. These pumps are of Towler manufacture, and each is capable of delivering 1,686 gallons per hour against a pressure of 1,000 lb. per square inch. One pump alone is sufficient to meet the requirements of the plant; the other, a reserve, is brought in automatically if the fuel pressure drops.

From the pumps the fuel passes through two over-speed emergency trip valves, one for each turbine. These follow normal steam practice, the

FLEXIBLE COLLAR FOR GAS-TURBINE DUCTING.

Fig. 15.



fuel valves being held open by lubricating-oil pressure and tripped by the release of this pressure in the event of over-speed through either of the turbine governors. From the emergency trip valves the fuel passes to the temperature-control fuel valve, the purpose of which is to regulate the fuel admission so as to prevent excessive gas temperatures in the turbines. The fuel then passes to the constant-speed governor valve, which is of the balanced needle type and is operated directly from the speed-governor arm, the considerable force available rendering the use of a relay mechanism unnecessary. The governor is gear-driven from the low-pressure turbine spindle and is mounted on the inlet-end pedestal near the main oil pump. The needle of the fuel valve is profiled to give a straight-line relationship between the load and governor-arm travel.

From the governor valve the fuel divides, one line going to the main combustion chamber and the other to the reheat chamber, the fuel in each instance passing through flowmeters, which can, however, be isolated when residual fuels are used. The main fuel supply to each chamber passes through a hand control valve and an isolating valve, a tapping upstream from the hand control valve of the main chamber supplying fuel to the auxiliary burner. Between these valves connections are taken to pressure gauges fitted with electrical contacts, so arranged that if the hand valves are in the open position during an attempted start, the build-up of pressure will cause the contacts to break and render the start ineffectual. Thus the set cannot be started with the hand valves open, which would result in premature admission of fuel to the main burners. To simplify the control system further, these hand valves are located in the control desk (illustrated in Fig. 14), and thus remote-control mechanisms are obviated. The isolating valves are controlled by magnetic valves, which when switched on admit pressure oil to the operating servo-cylinders and thus open the isolating valves. The switching-off of the magnet valves and the closing of the isolating valves release the fuel in the pipe-line to the drain tank. A number of interlocks are provided to safeguard against a wrong sequence of starting operations.

Generator.—The alternating-current generator is rated at 17,650 kVA 6.6 kV three-phase 50 cycles per second, and is directly coupled to the gas turbine. It is of standard Metropolitan-Vickers construction with a welded stator frame. The stator winding is of the involute type, and a closed-circuit ventilation system is provided, with a water-cooled air cooler mounted in the foundation below the machine. Cooling air is re-circulated by means of fans mounted on the ends of the rotor. Excitation is obtained from a main exciter and a pilot exciter.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

CLYDE NAVIGATION TRUST STATISTICS.—The revenue of the Clyde Navigation Trust, for the year ended June 30 last, reached a record total of 1,824,374l., it was disclosed at a meeting of the Trust in Glasgow on September 2, when the accounts were approved. The tonnage of vessels arriving at, and departing from, the port during the year was 13,412,358, an increase of 171,200 tons on the preceding year, and the tonnage of goods imported and exported was 6,010,369, an increase of 354,941 tons. In the case of foreign imports, the largest increase was in iron ore, which rose by 206,000 tons. The main decrease was in coal from America, which declined by 72,000 tons.

COAL EXPORT INDUSTRY.—Scottish coal exports during July amounted to 102,398 tons, the highest total for that month since the resumption of the trade in 1948. Exports during the first seven months of the present year aggregated 516,831 tons, as compared with 435,947 tons in the corresponding period of 1951.

CLOSING OF COLTNESS COMPANY'S WORKS AT NEWMAINS.—After meeting representatives of the management and employees to discuss the impending closure of the Coltness Iron Company's works at Newmains, Mr. J. Henderson Stewart, Joint Parliamentary Under-Secretary of State for Scotland, said on September 3 that the decision was one of the management in which the Government could not intervene. The Ministry of Labour, however, would do everything in their power to place redundant persons in other employment, and no great difficulty was expected as regards skilled operatives.

NEW WORKS AT BARONY COLLIERY.—The first coal from the new No. 3 shaft at Barony colliery, Auchinleck, a major project designed for an output, in conjunction with the two existing shafts, of 1,000,000 tons a year, was wound on September 4. The present output is 1,700 tons a day, which, it is hoped, will be stepped up to at least 4,000 tons within the next few years. The new shaft is concrete-lined and is 21 ft. 7 in. in diameter. When the installation of new winding gear is complete, four-decked cages will bring up 10 tons of coal at each wind. The productivity is expected to rise from the present 24 cwt. per man-shift to 36 cwt. The total workable reserves have been estimated at 115,000,000 tons.

PROGRESS AT GLENOCHIL COAL MINE.—Good progress is reported with driving operations at the new coal mine at Glenochil, Tullibody, Clackmannanshire, stated to be the biggest surface-drift project in the country. Commenced at the beginning of the year, a roadway, sloping down an incline of one in five, has now been driven a distance of 200 yards. The rate of advance has been expedited since the introduction of a "slusher," which is said to be capable of discharging five tons of spoil in a little over 10 minutes.

ROAD DIVERSION AT PRESTWICK.—Work on the loop diversion on the main Ayr-Glasgow road at Prestwick Airport, rendered necessary for the extension, towards the sea, of the main runway, is expected to commence next week. County engineers have been experimenting with new types of road-making material to be used in the 2,000-ft. long development, which is scheduled to be completed in three months.

CONNEL FERRY RAIL-ROAD BRIDGE.—A meeting of North-Argyll industrialists and farmers held at Oban last week under the chairmanship of Colonel R. M. T. Campbell-Preston, managing director of Alginat Industries, Ltd., Barcaldine, decided to send a memorandum to Scottish M.P.s, the Secretary of State for Scotland, and the Minister of Transport, requesting the abolition of toll charges on the Connel Ferry rail-road bridge, near Oban. Strong complaint was made during the meeting about the "serious effect" the lack of a non-toll road bridge had on the development of industry in North Argyll.

CLEVELAND AND THE NORTHERN COUNTIES.

MORE SKILLED MEN NEEDED.—A shortage of 200 skilled men at the Heaton works, Newcastle-on-Tyne, of C. A. Parsons & Co. Ltd., was mentioned by Sir Claude D. Gibb, chairman and managing director of the firm, at the works' annual open day when relatives of the employees were allowed to tour the works. Sir Claude said that the firm had enough contracts to last until 1958 and could get still more orders if they had the skilled men to cope with them.

TEES-SIDE WATERWORKS.—Developments planned by the Tees Valley Water Board were referred to last week when members of the Tees-side Industrial Development Board toured the Water Board's works. Alderman C. W. Allison, the chairman, said that within two years the Water Board would be able to supply an additional 32,000,000 gallons of water weekly from the Broken Scar plant and 7,000,000 gallons more from a new pipeline from Lartington to Barnard Castle. The new Selsel reservoir was estimated to cost 5,000,000l., but this was likely to be much higher by the time the work was commenced (in two or three years' time), owing to increasing costs of labour and materials.

DEVELOPMENTS AT SOUTH BANK IRONWORKS.—Eston Urban Council, Yorkshire, are to meet representatives of Dorman, Long & Co., Ltd., to discuss the firm's development plans at South Bank Ironworks. Outline plans providing for new coke-oven plant of 150 to 170 ovens and a stockyard of 60,000 tons of coal have been submitted to the Council. Later, more ovens and another stockyard of 50,000 tons are proposed. A subsequent development provides for two extensions, each of 250,000 sq. ft., at the by-product plant.

TEES TRADE STATISTICS.—At a meeting of the Tees Conservancy Commission, held last week at Middlesbrough, it was reported that imports in July amounted to 279,822 tons and exports to 138,847 tons. Compared with the June figures, imports were down by more than 69,000 tons, due mainly to reduced iron ore imports, but exports were up by 22,000 tons. The largest export increase was 9,900 tons of coal. Less castings, machinery and bunker coal, were exported than during June.

TRANSFER OF REDUNDANT COLLIERIES.—Owing to the closing of two seams at Woodhorn Colliery, Northumberland, about 100 miners, who will become redundant, are to be transferred to the nearby Lynemouth Colliery where extensive developments are in hand.

REORGANISATION AT A COLLIERY.—A meeting has been held between the National Coal Board and the consultative committee at Ryhope Colliery, County Durham, to discuss a reorganisation plan at the colliery which would mean that about 250 miners would become surplus to the requirements. They would have to be transferred to nearby collieries or become unemployed. The meeting was adjourned to allow the matter to be discussed further with the men's union. Some of the displaced miners would be transferred to Washington "F" pit, Wardley Colliery and Usworth Colliery.

THE MIDLANDS.

STEEL SUPPLIES.—Evidence of an improvement in the steel supply position can be found in various parts of the Midlands. Steelworks are prepared to accept orders on a larger scale for the fourth period of the year than for any of the previous three periods, and re-rollers have reported some improvement in supplies of semi-finished steel. Two Wednesbury firms have been able to regain some lost production as a result of the improved steel supply position. H. J. Barlow & Co., Ltd., have ended the short-time working which they introduced in June, and Clifford Products, Ltd. have been able to re-engage some of the employees who were dismissed in the early part of the year.

WESTERN REGION BRANCH RAILWAY TO CLOSE.—The branch railway line from Leominster to Bromyard, which has been threatened with closure for more than a year, will cease to carry traffic on September 15. The line, is 13 miles long and is part of a connecting link between Leominster and Worcester via Bromyard. The section between Worcester and Bromyard is to remain open. Strong opposition to the proposed closure was encountered from local residents and organisations, but the West Midland Area Transport Users' Consultative Committee, by a majority vote, upheld the Railway Executive's proposal. Road passenger services in the area will be augmented on the day the railway closes.

TECHNICAL COLLEGE EXTENSIONS.—An expenditure of 103,000l. has been authorised by the Minister of Education for the building of the second part of the Walsall-Staffordshire Technical College. A four-storey building is to be erected adjacent to the recently completed workshop block. It will contain accommodation for students of electrical and automobile engineering, electronics, and the building and general engineering trades. The College, which is situated at Walsall, will receive a 60 per cent. Government grant, and the remainder of the expense will be met by the county borough of Walsall and the Staffordshire County Council.

COURSE IN ELECTRONIC ENGINEERING.—Coventry Technical College has introduced a full-time course in electronic engineering, which is claimed to be the first of its kind in the Midlands. The course, which will extend over three years, has been established at the request of the Ministry of Education and the Radio Industries Council.

REFRESHER COURSE FOR WORKS AND PLANT ENGINEERS.—A refresher course on "Heat and Power" for senior works and plant engineers will be conducted, in the New Extension Block, Department of Civil and Mechanical Engineering, University of Nottingham, weekly on Tuesday evenings for a period of 19 weeks commencing on October 28. The course has been organised by a committee, under the chairmanship of Mr. E. G. Phillips, O.B.E., M.I.Mech.E., M.I.E.E., which includes representatives of local industries and institutions in collaboration with the Regional Council for Further Education, the University of Nottingham and the East Midlands Kindred Engineering Societies. The principal subjects will include: fundamentals of heat and power, the internal-combustion engine, the gas turbine, back-pressure and pass-out turbines, the steam engine, fundamentals of heat transfer, grates and stokers, boilers, economisers and superheaters, distribution and economic use of process steam, and instrumentation. The fee for the course is 4l. 4s. 0d., and the honorary secretary, from whom further information can be obtained, is Dr. H. K. Lloyd, Department of Civil and Mechanical Engineering, University of Nottingham, University Park, Nottingham.

LANCASHIRE AND SOUTH YORKSHIRE.

COLLIERY MODERNISATION.—A new coal-winding shaft is being brought into operation at Barnsley Main colliery to supply a new washing and screening plant, which is part of a 250,000l. reorganisation scheme at the colliery. The new coal washer is designed to deal with 200 tons of coal an hour. Barnsley Main employs about a thousand men and has an output of 8,000 tons a week.

EXTENSIONS AT AN IRONWORKS.—A modernisation scheme at the works of the Renishaw Iron Co., Ltd., near Sheffield, is designed to double the output of pig iron, which is 100,000 tons a year at present. The foundations are being laid for a new modern blast furnace which will have an annual capacity of 150,000 tons of pig iron, while the charging operations are to be completely mechanised. Other extensions are projected and an old furnace is to be relined. Production in the foundries and machine shops will be increased.

HOUSES FOR RESEARCH WORKERS.—The first of 30 semi-detached houses, each costing 1,800l., will shortly be completed by the United Steel Companies Ltd., on the Allendale and Sitwell estates, Rotherham. The houses are intended for research workers at the new Swinden laboratories of the firm. Many of the 200 research workers live in Sheffield and others had homes at Stocksbridge when the transfer to Rotherham began. A Government subsidy was granted for the 30-house scheme which is expected to be completed in January.

SOUTH-WEST ENGLAND AND SOUTH WALES.

BRIDGE BUILDING IN WALES.—Shortage of steel, which has been holding up work on the new bridge over the River Neath at Briton Ferry, has been overcome for the present. The date of completion will depend on the continued availability of raw materials, but the Ministry of Transport anticipate that it should be finished within the next two years. The bridge is part of a scheme for providing a new trunk road which will halve the present journey between Briton Ferry and Swansea. As a result of a discussion on the Newport development plan, the East-Wales Committee of the Board for Industry has supported the proposal to build a second bridge over the River Usk.

PROPOSED OPEN-CAST MINING AT CWMBRAN.—Cwmbran Urban Council have received a letter from the Ministry of Fuel and Power stating that the Ministry propose to enter a total of 174,189 acres of land adjoining the designated area of Monmouthshire's new model town of Cwmbran for open-cast mining. The land affected covers virtually the whole western boundary of the urban district. Protests have been made that the comparatively small quantity of coal likely to be obtained would not have any momentous effect upon the economic state of the country, compared with the adverse effect which its working would have upon the new town. In reply to protests, the Ministry of Fuel and Power have invited the Council to send representatives to a conference at which the whole question can be discussed.

NOTICES OF MEETINGS.

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

INSTITUTE OF METALS.—Monday, September 15, to Friday, September 19, 44th Annual Autumn Meeting. Monday, September 15, 8.30 p.m., Sheldonian Theatre, Broad-street, Oxford. Autumn Lecture: "On the Foot-hills of the Plastic Range," by Professor H.W. Swift. Tuesday, September 16, and Wednesday, September 17, 9.30 a.m., Clarendon Laboratory, Parks-road, Oxford, various papers for discussion. Thursday, September 18, 9.30 a.m., Clarendon Laboratory, informal discussion on "Grain Boundaries." Various visits and excursions will take place on the afternoons of Tuesday, Wednesday and Thursday, and all day on Friday. For further particulars, see page 223, *ante*.

INCORPORATED PLANT ENGINEERS.—*Liverpool and North Wales Branch*: Monday, September 15, 7.15 p.m., Radiant House, Bold-street, Liverpool. "Amenities in Industry," by Mr. H. S. Crump. *Glasgow Branch*: Tuesday, September 16, 7 p.m., Engineering Centre, 351, Sauchiehall-street, Glasgow, C.2. "Mechanical Handling Equipment and Methods," by Mr. F. T. Dean. *Edinburgh Branch*: Tuesday, September 16, 7 p.m., 25, Charlotte-square, Edinburgh. "Heat Transfer from Steam," by Mr. R. A. Brecknell. *St. Albans Branch*: Tuesday, September 16, 7.30 p.m., Peahen Hotel, St. Albans. Discussion Group. "Radio and Television Interference," by Mr. C. E. Hollingworth. *Western Branch*: Wednesday, September 17, 7.15 p.m., Grand Hotel, Bristol. "Energy from the Atom," by Mr. A. F. Posnett. *South Yorkshire Branch*: Thursday, September 25, 7.30 p.m., Grand Hotel, Sheffield. Discussion on "Hazards and Regulations in Steelworks." *Birmingham Branch*: Friday, September 26, 7.30 p.m., The Imperial Hotel, Birmingham. "Modern Factory Lighting," by Mr. F. Jamieson.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*North-West London Branch*: Monday, September 15, 7.30 p.m., Prince of Wales Hotel, Kingsbury, Middlesex. "Electronically-Controlled Driving Equipment," by Mr. F. Ralph. *Manchester Branch*: Wednesday, September 17, 7.30 p.m., Engineers' Club, Manchester. Film on "Wire Ropes." *South-West London Branch*: Wednesday, September 17, 8.15 p.m., Guild House, 32, Worpole-road, Wimbledon, S.W.19. "Lighting, Power, Heating and Thermocouple Cables," by Mr. G. E. D. Redman.

INSTITUTE OF MARINE ENGINEERS.—Tuesday, September 16, 5.30 p.m., 85, The Minories, E.C.3. Presidential Address, by Lord Howard de Walden.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—*Liverpool Branch*: Tuesday, September 16, 6.30 p.m., Radiant House, Bold-street, Liverpool. Chairman's Address on "The Training of a Heating and Ventilating Engineer," by Mr. J. W. Winning. *Birmingham Branch*: Wednesday, September 24, 6.30 p.m., Imperial Hotel, Birmingham. "Radiant Heating," by Mr. F. R. L. White. *Yorkshire Branch*: Wednesday, September 24, 7.30 p.m., Hotel Metropole, Leeds. Film Evening. *Scottish Branch*: Tuesday, September 30, 6.30 p.m., Engineering Centre, 351, Sauchiehall-street, Glasgow, C.2. Annual Meeting.

NEWCOMEN SOCIETY.—Wednesday, September 17, 5.30 p.m., Science Museum, South Kensington, London, S.W.7. Special General Meeting, followed by: (i) "History and Particulars of the Brass Battery Process," by Mr. B. de Soyres; (ii) "Memorials to Engineers and Men of Science," by Eng. Capt. E. C. Smith; and (iii) "Twenty Problems" on the identification of "some bygone gadgets," exhibited by Mr. James F. Parker.

INSTITUTION OF PRODUCTION ENGINEERS.—*Birmingham Section*: Wednesday, September 17, 7 p.m., James Watt Memorial Institute, Birmingham. Discussion on "Examples of Economy in Materials Usage." *Edinburgh Section*: Wednesday, September 17, 7.30 p.m., North British Station Hotel, Princes-street, Edinburgh. "Social Functions of Industry," by Dr. A. Roberts. *Derby Section*: Monday, September 22, 7 p.m., College of Art, Green-lane, Derby. "Starting a New Factory," by Mr. A. R. Northover. *Manchester Section*: Monday, September 22, 7.15 p.m., College of Technology, Sackville-street, Manchester, 1. "Measurement of Productivity," by Mr. B. H. Dyson. *Sheffield Graduate Section*: Tuesday, September 23, 6.30 p.m., Royal Victoria Station Hotel, Sheffield. "Preventive Maintenance," by Mr. J. R. Widdowson. *Coventry Section*: Tuesday, September 23, 7 p.m., Geisha Café, Hertford-street, Coventry. "Applications of Operational Research to Production Engineering Problems," by Mr. M. J. Moroney. *South Essex Section*: Wednesday, September 24, 7.30 p.m., South-East Essex Technical College, Barkingside. "The Urgency of Simplification," by Mr. T. H. Windbank. *South Wales and Monmouthshire Section*: Thursday, September 25, 6.45 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Recent Developments in the Use of Materials," by Mr. M. H. Le Vie.

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—*North-West Centre*: Wednesday, September 17, 7.30 p.m., Adelphi Hotel, Liverpool. "Heavy Haulage," by Mr. E. Skelton. *North-East Centre*: Thursday, September 18, 7.30 p.m., Hotel Metropole, Leeds; and Tuesday, September 23, 7 p.m., King's Head Hotel, Darlington. "Some Factors Influencing the Choice of a Crankcase Lubricating Oil," by Mr. A. Towle. *Western Group*: Thursday, September 25, 7.30 p.m., Grand Hotel, Bristol. "Dieselisation," by Mr. D. Poole.

INSTITUTION OF WORKS MANAGERS.—*Notts and Derby Branch*: Friday, September 19, 8 p.m., Welbeck Hotel, Nottingham. Open Discussion Meeting. *Northampton Branch*: Monday, September 22, 7 p.m., Franklins Gardens Hotel, Northampton. Discussion on "Computing Overheads or Costings." *Glasgow Branch*: Monday, September 22, 7.15 p.m., 39, Elmbank-crescent, Glasgow, C.2. Annual Meeting. "Impressions of American Industry," by Mr. J. C. Campbell.

INSTITUTION OF MINING AND METALLURGY.—Monday, September 22, 5 p.m., Royal Institution, 21, Albemarle-street, W.1. Third Sir Julius Wernher Memorial Lecture on "Radioactivity in Mineral Dressing," by Professor A. M. Gaudin.

BRITISH INSTITUTION OF RADIO ENGINEERS.—*West Midlands Section*: Tuesday, September 23, 7.15 p.m., Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton. "A Pulse Tester for Coaxial Cables," by Mr. N. S. Dean and Mr. E. Carey.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—Wednesday, September 24, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. Presidential Address, by Mr. C. M. Cock.

INSTITUTION OF MECHANICAL ENGINEERS.—*North-Western Industrial Administration and Engineering Production Group*: Thursday, September 25, 6.45 p.m., Engineers' Club, Manchester. "Basic Engineering Standards and Their Place in Design," by Captain G. C. Adams. *East Midlands Branch*: Thursday, September 25, 7.30 p.m., Grand Hotel, Leicester. Address by the branch chairman, Mr. W. N. Bray.

ILLUMINATING ENGINEERING SOCIETY.—*Leicester Centre*: Monday, September 29, 6.30 p.m., Offices of East Midlands Electricity Board, Charles-street, Leicester. "Horticultural Lighting," by Mr. J. J. French. *Cardiff Centre*: Tuesday, September 30, 5.45 p.m., Offices of South Wales Electricity Board, Cardiff. Centre chairman's address by Mr. A. J. Dalton.

CONTRACTS.

THE MARCONI INTERNATIONAL MARINE COMMUNICATION CO., LTD., Chelmsford, Essex, are supplying radio equipment and aids to navigation now being fitted on board the 8,600-ton single-screw cargo motorship *Burutu Palm*, built for the West African trade of the Palm Line, Ltd., at the Pallion shipyard of SHORT BROTHERS LTD. An "Oceanspan" transmitter with "Mercury" and "Electra" receivers will form a complete telegraphic communication unit capable of world-wide transmission and reception. A medium-wave "Reliance" auxiliary transmitter is also installed. The vessel's aids to navigation comprise a "Lode-stone" direction-finder and a "Seagraph" recording echometer, while a "Vigilant" auto-alarm is fitted for safety of life at sea purposes. An "Oceanic" sound-reproducing system, consisting of a receiver and seven loud-speakers, is also provided.

During August, the British Electricity Authority have placed contracts for equipment for power stations, transforming stations, and transmission lines, amounting, in the aggregate, to 6,665,970l. The principal contracts include: for Woolwich power station, the boiler-house structural steelwork, with REDPATH, BROWN & CO. LTD.; for Brighton "B" power station, two 320,000-lb. per hour boilers, with BABCOCK & WILCOX LTD.; for Littlebrook "C" power station, Dartford, Kent, coal-handling plant, with the Fraser & Chalmers Engineering Works of the GENERAL ELECTRIC CO. LTD.; for Connah's Quay power station, near Flint, two 300,000 lb. per hour boilers, with INTERNATIONAL COMBUSTION LTD., also foundations to the coal-handling plant and ancillary works, with the YORKSHIRE HENNEBQUE CONTRACTING CO. LTD., and 132-kV 2,500-MVA switchgear, with FERGUSON, PALLIN LTD.; for Doncaster power station, auxiliary-power, control and alarm cables and connections, with ENFIELD CABLES LTD.; for Stella North power station, near Newcastle-upon-Tyne, the steel-frames for the turbine house, boiler house, workshop and store buildings, with CLEVELAND BRIDGE AND ENGINEERING CO. LTD., also six boiler feed pumps, with G. & J. WEIR LTD.; similarly for Stella South power station the steel-frames for the turbine house, boiler house, workshop and store buildings, with CLEVELAND BRIDGE AND ENGINEERING CO. LTD., also boiler feed pumps, with SULZER BROS. (LONDON) LTD.; and, finally, the Staythorpe, Newark to Drakelow, Burton-on-Trent, 275-kV twin 0.4 sq. in. transmission line, with W. T. HENLEY'S TELEGRAPH WORKS CO. LTD.

PERSONAL.

MR. HENRY NIMMO, M.I.C.E., M.I.MECH.E., M.I.E.E., chairman of the Southern Electricity Board and a part-time member of the British Electricity Authority, who has been chairman of the General Council of the Engineers' Guild Ltd., Abbey House, 2, Victoria-street, London, S.W.1, for the past two years, has now been elected President of the Guild. He succeeds Mr. ROBERT CHALMERS, O.B.E., B.Sc., M.I.C.E., M.I.MECH.E., whose term of office expires on September 30.

MR. A. E. WOODWARD-NUTT, M.A., F.R.Ae.S., has been appointed principal director, research and development (aircraft), Ministry of Supply. He will supervise and co-ordinate the work of the following four directorates: military aircraft research and development (R.A.F.), of which AIR COMMODORE G. SILYN ROBERTS, C.B.E., A.F.C., M.Sc., F.R.Ae.S., has been appointed director; the corresponding (R.N.) directorate, of which CAPTAIN (E) C. W. JONES, M.I.Mech.E., A.F.R.Ae.S., R.N., has been appointed director; civil aircraft research and development, which remains under Mr. J. M. GRAY; and aircraft servicing research and development, as director of which, as stated on page 303, *ante*, AIR COMMODORE W. A. OPIE, C.B.E., is to succeed AIR COMMODORE G. B. M. RHIND, B.A.

MR. J. D. PEARSON, Wh.Sc., B.Sc.(Eng.) (Lond.), M.I.Mech.E., A.F.R.Ae.S., M.I.P.E., has been appointed chief executive of the Aero Division of Rolls-Royce Ltd., Derby. MR. A. F. KELLEY, B.Sc., A.M.I.C.E., A.M.I.Mech.E., M.I.P.E., who became an assistant general manager (Aero Division) in 1950, has now been appointed general manager (manufacturing) for this division.

MR. T. R. B. SANDERS, C.B., who was on the staff of the Ministry of Supply from 1944 until 1951 and was concerned with the technical development of a wide range of service equipment, has been appointed engineering adviser to the British Standards Institution, 24, Victoria-street, London, S.W.1.

MR. J. G. DETCHON, O.B.E., engineer commodore of the fleet of the British Tanker Co., Ltd., has retired after 41 years of service at sea, 30 of them with the British Tanker Co. He was made engineer commodore in September, 1949.

MR. ROY C. ORFORD, M.Sc., C.P.A., A.M.I.E.E., has been appointed patents manager to Power Jets (Research and Development) Ltd. He joined the firm in March, 1951.

MR. K. G. LEACH, M.A. (Cantab.), A.M.I.C.E., A.M.I.E.E., has been appointed manager of plant and apparatus, (South-Western area) of the sub-office, at 25, Baldwin-street, Bristol, of the British Thomson-Houston Co., Ltd., Rugby. Mr. Leach took up his new appointment on September 8.

MR. F. A. ROSS, A.C.A., has been appointed secretary-accountant of Edgar Allen & Co. Ltd., Imperial Steel Works, Sheffield, 9, in succession to Mr. H. L. Wyneken, who is leaving to take up a similar appointment with L. J. Harris & Co., Ltd., Stoke Prior, near Bromsgrove.

DR. EDGAR C. BAIN, vice-president for research of the United States Steel Co., has been awarded the 1952 "Grande Médaille de la Société Française de Métallurgie." The medal was first awarded in 1949 and bears the effigies of Floris Osmond and of Henry Le Chatelier in alternate years. This year the award will be a Le Chatelier medal, which will be presented on October 25, during the Journées Métallurgiques d'Automne in Paris.

MR. A. DAWES ROBINSON is retiring from the post of Board of Trade Controller, East and West Ridings Region, on September 30, and is taking up an industrial appointment. He will be succeeded by Mr. J. PATERSON, United Kingdom Trade Commissioner in Montreal.

MR. W. G. MARSKELL has succeeded Mr. J. CUNNINGHAME as chairman of the Scottish Section of the Institute of Fuel, 18, Devonshire-street, London, W.1. MR. A. H. PINDER has been appointed honorary secretary of the Midland Section of the Institute following the departure of Dr. G. F. EVESON to take up a new appointment in the North-East of England. MR. L. M. JOCKEL has resigned from the Council of the Institute on removal to Scotland after retirement from the service of the British Electricity Authority.

MR. C. C. P. MACNALLY, B.Sc., of Belfast, has been appointed to the Colonial Engineering Service in Northern Rhodesia.

The publicity department of the MOND NICKEL CO. LTD., and of HENRY WIGGIN & CO. LTD., formerly at 35, Park-street, W.1, was transferred, as from September 8, to Thames House, Millbank, London, S.W.1. (Telephone: VICTORIA 3888.)

A new company, DAVID BROWN (AUSTRALASIA) PROPRIETARY LTD., 82, Pitt-street, Sydney, Australia, has been formed. MR. P. J. CLIFFORD, former export sales manager, David Brown Tractors (Engineering) Ltd., Meltham, Yorkshire, has been appointed manager of the new company.

FLYING DISPLAY OF BRITISH AIRCRAFT.

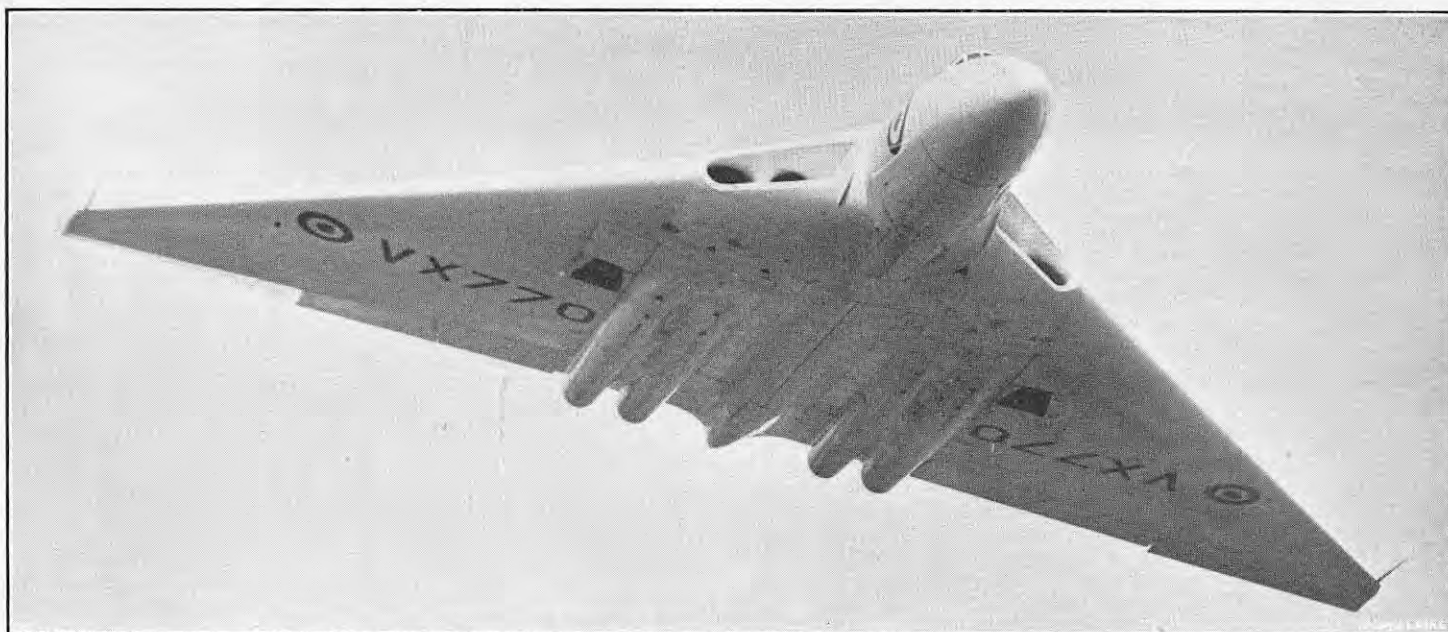
(For Description, see Page 346.)

FIG. 10. AVRO 698 BOMBER AEROPLANE; A. V. ROE AND COMPANY, LTD.

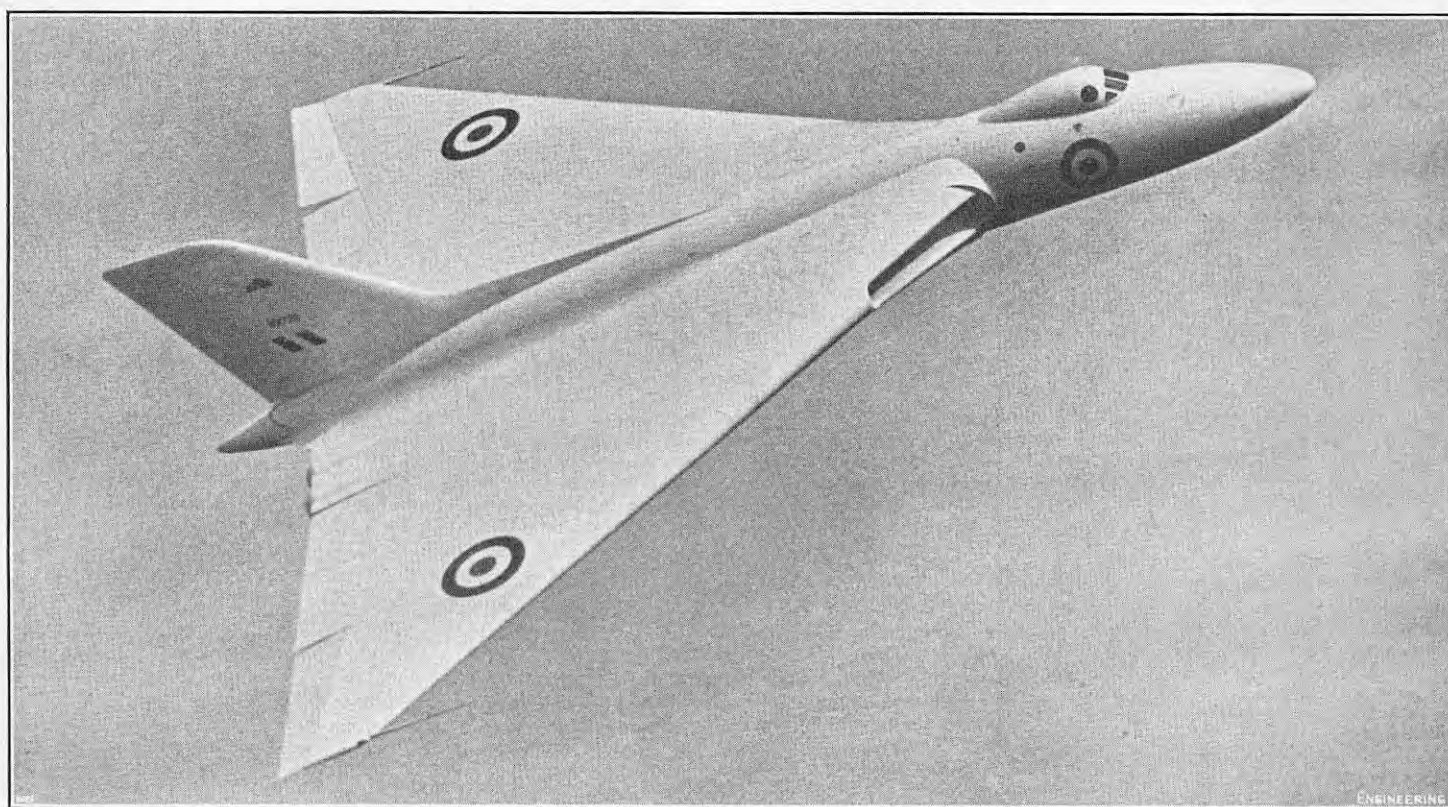


FIG. 11. ANOTHER VIEW OF THE AVRO 698 BOMBER AEROPLANE.



FIG. 12. "MARATHON" NAVIGATION TRAINER AEROPLANE; HANDLEY PAGE, LTD.

ENGINEERING

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LONDON, W.C.2.

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

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

TIME FOR RECEIPT OF ADVERTISEMENTS.

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

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

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

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ENGINEERING

FRIDAY, SEPTEMBER 12, 1952.

VOL. 174.

No. 4520.

ANGLO-AMERICAN COUNCIL ON PRODUCTIVITY.

THE reports of the various teams which have been sent to the United States under the auspices of the Anglo-American Council on Productivity have been appearing with such regularity, and over what seems, in retrospect, to have been such a long time, that many students of them have come to regard the periodical publication of a new report as a regular feature of the British industrial scene, and can hardly remember when and how the practice began. Now, however, that the Council has ceased operations, the time has obviously come for a review of its activities, even though some of the reports have still to be published. The organisation was set up, in fact, in the autumn of 1948, as the result of discussions between the late Sir Stafford Cripps, then Chancellor of the Exchequer, and Mr. Paul Hoffman, who was the Economic Co-operation Administrator in the United States; and its purpose, as explained in the Final Report,* recently issued, was "to promote economic well-being by a free exchange of knowledge in the realm of industrial organisation, method and technique, and thereby to assist British industry to raise the level of its productivity." It was composed of representatives of management and of labour, drawn from both the United States and the United Kingdom, the British organisations concerned being the Federation of British Industries, the British Employers' Confederation, and the Trades Union Congress. The intention (which has been adhered to) was that the Council should cease to function on the termination of the Marshall Aid plan; this date was June 30, 1952, and, accordingly, the

* Final Report of the Anglo-American Council on Productivity, Published by the United Kingdom Section of the Council, 21, Tothill-Street, London, S.W.1. [Price 3s. 6d., including postage.]

Council was wound up on that date. To deal with the publication of the reports still outstanding, however, the United Kingdom Section continues in being, *pro tem.*, and eventually will be absorbed into the proposed British Productivity Council.

The final report now issued consists of a general survey of the Council's aims and activities; a section describing its organisation, committees, staff, etc., and the four sessions which it held as a body—the first and third in London, and the second and fourth in New York; a more detailed section devoted to its work, and that of the committees; and a section on the important subject of costs. There are also appendixes devoted to a report on procedure, the impact of the published reports on industry, distribution figures for the reports published so far, "other activities"—mainly concerned with publicity in one form or another, and the membership of the main Council and of its American and British sections. In sum, therefore, it is a document of considerable value to the student of industrial economics and of current events.

Altogether, 47 teams from various industries and 19 specialist teams or expert groups visited the United States, their membership comprising 885 men and 26 women—a total of 911; and between them they visited 2,000 American plants or "places of business." The initial scheme was that American teams should pay similar visits to the United Kingdom and, in fact, teams did come from America to study the British cotton-textile, pressed-metal and electricity-supply industries; but, as the prime object was to increase British productivity there was not the same incentive for American industries to study British methods, so that, in practice, the traffic across the Atlantic was predominantly westward. The scheme was devised for the benefit of British industry as a whole, but a glance down the list of the 47 teams shows that by far the greater part were associated, directly or indirectly, with engineering trades and production. This characteristic is not quite so marked in the case of the 19 specialist teams, but even there the engineering interest was evident in more than half of the subjects or branches studied. This is the more notable in view of the fact that the Council did not attempt to decide which industries should send teams; a general invitation was issued for applications to be made by industries which might wish to do so, and only on receipt of the applications were the arrangements put in train.

All things considered, the total expenditure involved cannot be regarded as excessive, even when it is borne in mind that a great deal of expense must have been incurred by American industry which does not appear in the accounts included in the report. The total came to about 844,500l. sterling (say, 2,364,600 dollars), of which the United Kingdom Section, and the British industries concerned, contributed roughly 320,400l., or rather less than 900,000 dollars. Of the British expenses, not quite 180,000l. was met by a grant-in-aid from the United Kingdom Treasury and by contributions from the British organisations represented on the Council. An additional, 141,000l. was contributed by the industries directly concerned in sending teams to the United States. There were, however, further charges upon British industry which do not figure in the accounts, as the firms continued to pay the wages and salaries of their employees who formed the teams and, in many cases, provided them with additional funds to meet incidental expenses. An analysis of the costs, given in the report, shows that the expenditure accounted for represents an average of 287l. per head of the team members, of which the Government grant-in-aid amounted to 132l. per head. About 55l. per head of the total of 287l. was expended in preparatory travel and "briefing" within the United Kingdom.

Up to June 1, 1952, 34 of the 47 industry teams and 15 of the 19 specialised teams had had their reports published. Of the 34 team reports, an aggregate of 333,658 copies had been distributed, mainly by sales; and the circulation of the specialist teams' reports had reached 169,560 copies, making a grand total of 503,218. The report which had sold most extensively was that on "Building," of which 39,861 had been disposed of. The next largest distribution was that of the report on "Coal" (25,863 copies). No other industry report reached a 20,000 circulation, but two of the specialist reports—on "Management Accounting" and "Materials Handling in Industry," respectively—exceeded that figure with totals of 23,568 and 22,843. The smallest distribution in the two lists, taken together, was that of the industry report on "Brushes" (4,269); but it will be realised that these totals provide no measure of the ultimate value to British industry as a whole of any particular report, as there are such great variations between the respective outputs, personnel and general scale of operations. Nor can any useful comparison be made between the influence of one report and another in promoting productivity; in some industries, marked improvements may be made with relatively little capital expenditure, whereas in others the economic conditions may be so widely different that any extensive reorganisation can only be undertaken on a long-term basis.

Frequently, the question has been asked, What practical benefit has resulted in any of the industries concerned, that can be traced directly to the experience gained by the teams in their visits to the United States? As the report points out, "it has been found impossible to discriminate clearly between action taken as a result of a productivity team's visit, and what has happened as a part of normal development in the post-war period"; though it is added that "the industrial organisations concerned, and many firms, have no doubt about the value of the reports in accelerating action—largely in the field of production techniques." Appendix 2 to the report, however, gives examples of development in seven industries which sent teams to America; and five of the seven are industries of a predominantly engineering character. The five reports concerned are those on steel founding, drop forging, grey-iron founding, internal-combustion engines, and Diesel locomotives. In the case of the first of these industries, it is stated, several foundries have increased their output per man-hour since 1949 by 10 to 15 per cent. It is estimated that overall productivity in the industry has been increased by about 15 per cent. since 1949, and in some foundries the increase has been as much as 30 per cent. In the drop-forging industry a number of benefits have accrued from the team's report and the action taken upon it by the National Association of Drop Forgers and Stampers; specifically, to quote the report, "a number of drop forgers report . . . up to 40 per cent. increases in the output per man-hour of hammermen." In the grey-iron founding industry, mechanisation is being quite widely extended . . . with resultant increases in productivity of direct production workers of sometimes more than 50 per cent. since the team's visit." Among the makers of internal-combustion engines, "nearly all companies . . . report increases in output and productivity over the last few years of amounts varying up to 50 per cent.," though it may be that these are not entirely attributable to the report by that industry's team; and the builders of Diesel locomotives have been particularly impressed by the recommendations, in their report and that on welding, in favour of unit construction and a greater use of welding in association with it, and, in some cases, by these means, "have reduced erection time to a matter of a few hours."

SAFETY IN CHEMICAL WORKS.

THE number of factory accidents resulting in death or serious injury is much smaller than the numbers of road accidents having similar results. The reason for this may be that in factories some control can be exercised over the activities of the operatives, while on the roads such control is impracticable and all too many road users are either incompetent or reckless. An additional factor in the situation is that while factory managements pay much attention to questions of safety and spend large sums in installing safeguards of one kind and another, the authorities responsible for roads do little to eliminate sources of danger; their activities are largely limited to propaganda. It is frequently stated that the country cannot afford the engineering works which would help to reduce the suffering and financial loss caused by road accidents, but industry is never asked if it can afford the protective measures called for.

Although, as suggested, workpeople in factories can be to some extent controlled, they cannot be regimented and the total of industrial accidents would be greatly reduced if those for whom safety measures are introduced did not frequently ignore, and sometimes deliberately defeat, them. At a recent conference concerned with safety in chemical works a case of what may be charitably described as nonchalance in the face of danger was quoted. It was amusing, but illustrated the troublesome personal aspect of the problems with which those concerned with safety in industry have to cope. The incident related to men working inside a vessel into which a leakage of gas was possible. The regulation was that a cage of canaries should be taken into the vessel and if after a time the birds began to show signs of distress, the men should leave at once. On one occasion, the safety officer found the cage of canaries outside and the men working inside the vessel. On inquiring why the canaries were outside, he received the reply, "Well, the birds weren't looking well so we put them out in the fresh air."

This story was told by Mr. J. Davidson Pratt, Director of the Association of British Chemical Manufacturers, at a conference held in Buxton in May. The conference, which was concerned with safety in chemical works, was organised by the Association. A report* of the papers read and the discussions to which they gave rise has now been published. One of the items in the three-day meeting was a Brains Trust, in the course of which it was asked if expenditure on safety measures was justified on purely economic grounds. This question might profitably be addressed to the authorities responsible for the roads of the country. According to Sir Alker Tripp, the loss caused by road accidents amounts to some 100½ million per annum, from which it would appear that considerable expenditure on safety measures would be justified "on purely economic grounds."

On the first day of the meeting, an introductory address was given by Mr. H. W. Cremer, President of the Royal Institute of Chemistry, in the course of which he said that of all the industrial organisations of which he had knowledge, the Association of British Chemical Manufacturers was the one that had really made the study of works safety an "integral, sincere, and fully accepted part of its life's work." The holding of these conferences may be taken as some evidence of this. Mr. Cremer was, however, far from pretending that all was well in the chemical world and that there was nothing more to be done. A matter which he particularly

stressed was that far more attention should be given to inculcating in students a knowledge and appreciation of the physiological properties of chemical substances. The university-trained chemist was "so anxious to unleash his science on an unsuspecting world that he had little, if any, time to think of its ultimate effect on his fellow men." Possibly the Association could do something to persuade writers of text-books to indicate that a knowledge of the physiological properties of chemical substances was as essential as knowledge of their physical and chemical properties.

The validity of this contention was indirectly illustrated in a paper entitled "Safety in the Laboratory and on the Plant," presented by Dr. L. J. Burrage. This paper dealt in considerable detail with the particular dangers associated with the great range of substances handled in chemical research departments and in works. The physiological effects of, say, concentrated alkalis and the methods of dealing with cases of injury are the same in a commercial plant as they are in a laboratory and the full information given by Dr. Burrage about the practice in the laboratory over which he presides is directly applicable to industry. Great stress is laid on the training of beginners and assistants and on the maintenance of orderliness and cleanliness. A detail point, illustrative of many which are made, and which bears on practice in commercial life equally with that in his laboratory, is that all safety appliances are painted green and fire-fighting appliances red. The use of the latter colour for fire-protection arrangements is common, but its efficacy is weakened if its use is not restricted to that service.

The conference naturally was mainly concerned with chemical works and laboratories, but many of the matters discussed are of importance in a wider sphere. This applied, for instance, to the papers on "Toxic Dusts in Industry," by Mr. J. S. Evans, and "The Relation between Plant Strength and Dust Explosion Relief," by Dr. Donald Matheson. The chairman, introducing Dr. Matheson, said that he had started work at a university on "a comparatively harmless material such as nitroglycerine," but now, in the Factory Department, was concerned with "more sinister explosives such as sugar, starch, babies' cooling powders and so forth." This playful remark had a serious side, and it is certain that many people, and firms, handling light organic powders have little or no knowledge of their explosive possibilities. The subject of the paper is indicated by its title; it contained the information that work on the explosive properties of some commercial dusts was being carried on at the Mines Research Station. The matter of toxic dusts has also received great attention in the coal-mining industry and, although it has not been neglected in industries in which, for instance, metallic dusts are produced, it is probable that a knowledge of the effects of such dusts is not so widespread as is desirable.

Another paper which was of interest to a more extensive audience was one entitled "Safety in Plant Maintenance" contributed by Mr. C. A. Beaton. In addition to questions of chemical hazards, it dealt in informative detail with such matters as the corrosion and erosion of pressure vessels, joints on pressure vessels and mechanical hazards of many kinds arising from the use of hand tools, grinding wheels and machinery. The last paper at this interesting and useful conference concerned "The Safe Transportation and Storage of Chemicals." It was presented by Messrs. I. E. Baggs, P. D. Moll and C. W. Richards on behalf of the Works Safety Committee of the Association. Chemicals of all kinds in course of transport may have to be handled by individuals ignorant of their properties. Apart from questions of packing, it is very desirable that containers should be labelled so as to give some indication of their contents.

* *Fourth Conference on Chemical Works Safety, Palace Hotel, Buxton, 2nd-4th May, 1952, Proceedings.* Association of British Chemical Manufacturers, 166, Piccadilly, London, W.1. [Price 7s. 6d., post free.]

NOTES.

THE PRICE OF PROGRESS.

THE annual air displays organised at Farnborough by the Society of British Aircraft Constructors have acquired a world-wide renown as exhibitions of the capabilities of British aircraft, but hitherto, although always spectacular as demonstrations of flying, they have been free from serious accident. The memory of this year's display, however, has been overshadowed by a tragedy without parallel in the record of British flying meetings. On the afternoon of Saturday, September 6, a de Havilland 110 jet-propelled fighter aircraft, after diving from a height of about eight miles, broke up in the air while circling the airfield at reduced speed and comparatively low altitude, causing the death of the pilot, Mr. John Derry, and his observer, Mr. Anthony Richards, and killing 25 spectators in the public enclosure. About 65 people were injured, three of whom have since died, making the total death-roll 30. Mr. Derry, who was the first man in this country to fly at a speed exceeding that of sound, had done so in this aircraft on a number of occasions; and, to judge from his messages by radio telephone to the control van, evidently had no reason to suspect any defect on this dive. He flattened out at about 10,000 ft. and came down to make a circuit of the airfield. This he had just completed when, as he was turning into the airfield, in a direction across the runway, fragments were seen to fly from the machine. Almost immediately, the aircraft disintegrated, the starboard engine falling harmlessly beside a car park and the port engine into the closely-packed public enclosure. Suggestions have been made that the disaster may have been precipitated by an over-rapid change of altitude as the aircraft began to climb while turning; but a member of our editorial staff, who was present, is emphatic that the manoeuvre was in no way exceptional. A statement issued jointly by Mr. A. A. Hall, Director of the Royal Aircraft Establishment, and Mr. E. C. Bowyer, Director of the S.B.A.C., and repeated at the inquest, said that this machine, which was a prototype, had exceeded the speed of sound on more than a hundred occasions. It was, in fact, the aircraft in which Mr. Derry first accomplished that feat, four years previously, to the very day. An official inquiry is being conducted at present by Sir Vernon Brown, Chief Inspector of Accidents in the Ministry of Civil Aviation, and, pending his report, speculation on the cause would be out of place. Whatever the eventual findings may be, however, they cannot affect the profound sympathy that the whole nation feels with the victims of this unexampled disaster, their relatives, and the designers and builders of the aircraft, who have paid such a grievous price for their contribution to Britain's progress in the achievement of air supremacy.

A NATIONAL POLICY FOR FUEL AND POWER.

The eagerly-awaited report of what has come to be known as the Ridley Committee was published this week by H.M. Stationery Office [price 6s. 6d. net.] The committee was appointed just over two years ago by the then Minister of Fuel and Power "to consider whether any further steps can be taken to promote the best use of our fuel and power resources, having regard to present and prospective requirements and in the light of technical developments." With terms of reference so wide and implications so intricate, it is not surprising that it was found necessary to hear evidence from more than 60 organisations and individuals and to consider over 200 memoranda; nor that the report proper should cover some 70 pages and be accompanied by another 160 pages of appendices. Broadly speaking, the committee have accomplished their task by enunciating the problems of a fuel and power policy and considering both the demand for fuel and the prospects of satisfying it. The domestic and non-domestic uses of fuel and power are next analysed and considerable space is devoted to the possibility of their co-ordination. As a result, certain general conclusions have been reached upon which 40 agreed recommendations are based. In the domestic field, these recommendations include

the suggestion that new standards of performance, based on achieving a room efficiency of about 40 per cent. with coal, should be determined for solid-fuel room-heating appliances; that the production of high efficiency fires, capable of installation in existing openings, and of devices for insertion in existing flues to restrict the chimney throat should be encouraged; and that financial incentives towards the installation of the new standard fires and the improved insulation of houses should be provided. In the industrial field, more energetic steps, it is considered, should be taken to ensure greater fuel efficiency by setting up an advisory service and by financial assistance; and Government departments and other public authorities should take the lead in promoting this improvement. The Railway Executive is advised to plan for increased fuel efficiency and to accelerate trials of new forms of traction. A number of recommendations for improving the present position by modifying their tariff structures are made to the Electricity and Gas Boards; and it is suggested that a specialised Tariffs Advisory Committee should be established to assist the Minister in his general control over the price policies of the nationalised fuel and power industries. Finally, it is recommended that the Minister should set up a Joint Fuel and Power Planning Board.

CONSTRUCTION AND EQUIPMENT OF DRY DOCKS.

A special committee of the Institution of Civil Engineers, on which members of the Institutions of Mechanical Engineers, Electrical Engineers and Naval Architects, as well as representatives of the Admiralty and the United Kingdom Chamber of Shipping also sat, has issued a memorandum on the construction and equipment of dry docks. This memorandum, which correlates the many problems which have to be solved before the design and construction of a new dry dock can be undertaken, is divided into six main sections: classification; dimensions and siting; dock structure; caissons and gates; mechanical and electrical equipment; and miscellaneous equipment. It is suggested that dry docks should be classified by size, and that there should be a uniform system of quoting their dimensions. The section on dock structure deals with the floor, walls and entrances, and the arrangements which should be made therein for equipment and services, such as pumps, gates and cranes. The various types of caissons and gates are dealt with in the next section, after which descriptions are given of the different patterns of main and auxiliary pumps, capstans and operating machinery with the methods of controlling them. The miscellaneous equipment dealt with in the final section includes keel and bilge blocks of various types, as well as docking towers, centring devices, bollards and fairleads. Copies of the memorandum can be obtained from the secretary of the Institution of Civil Engineers, Great George-street, London, S.W.1, at a price of 7s. 6d., post free, paper-covered edition, and 10s. 6d., post free, cloth-bound edition.

BRITISH WATERWORKS ASSOCIATION.

The forty-first general meeting and annual conference of the British Waterworks Association opened in Edinburgh on Wednesday, September 10, and closes to-day (Friday, September 12). The proceedings began with a civic welcome from the Lord Provost of Edinburgh (the Rt. Hon. J. Miller), after which the annual report was presented. The President (Provost A. Wallace) then delivered his address, in which he pointed out that the Census of 1951 disclosed that some 2½ million persons, or about 4·5 per cent. of the population, had no piped water supply in their houses. The Census also showed that in this respect the most rural parts of the country were the worst off and that in the eastern counties of England nearly 40 per cent. of the rural households were without a supply. The figures further suggested that 5½ million households, out of the 14½ million in Great Britain, had no fixed baths. It was clear therefore that the domestic needs of the people of the country for water was by no means yet satisfied. In fact, the twin problems of extending the supplies in rural areas and of finding water to meet the generally increasing demand for domestic purposes would be enough to occupy fully the energies of the authorities, apart from the

difficulties associated with the day-to-day running of these undertakings. On the afternoon of Wednesday, September 10, a paper was read by Mr. G. Baxter, in which he described the organisation, practice and works of the Edinburgh water undertaking, of which he is the engineer. The area served had recently been extended to 366 square miles with a population of 588,000, of whom about 488,000 were in the city. Supplies, which were obtained from five sources, amounted to 33·5 million gallons per day over the three driest consecutive years, and, of the average daily consumption, 21·5 million gallons were for domestic purposes. A number of new works, of which a description was given, were being undertaken. In a second paper, the works of the Stirlingshire and Falkirk Water Board were described by Mr. E. W. Denholm.

NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD.

The North of Scotland Hydro-Electric Board, by re-designing part of their Glen Moriston hydro-electric scheme, have been able to save about 1,400 tons of steel and 25,000 tons of cement. The original scheme, which was passed by Parliament in 1949, proposed the construction of four reservoirs and five power stations. In lower Glen Moriston there were to be a small reservoir, aqueduct and power station at Dundreggan, a larger reservoir from which water was to be led by a tunnel two miles long to a power station at Invermoriston, and a subsidiary power station at Livishie. It has now been decided to dispense with the lower dam, the aqueduct and the original power station at Dundreggan. The station which was to have been built at Invermoriston will be built underground, almost vertically below the Dundreggan dam, with the turbines discharging into a tunnel leading to Invermoriston. The subsidiary generating station at Livishie, near the lower Moriston dam, will now be situated above the Dundreggan dam, with the turbines discharging into the new loch formed by it. It will not now be necessary to construct a 132,000-volt line between Dundreggan and Invermoriston, and the flooding of a considerable belt of timber on either side of the River Moriston will now be avoided. The designed annual output of about 214,000,000 units will not be affected. In upper Glen Moriston, where there will be two reservoirs and two power stations, work has begun on the construction of dams at the outlets of Loch Cluanie and Loch Loyne, and the driving of the tunnel from Loch Cluanie to a power station near the Ceannacroc. As the main 16,000-kW turbo-alternator at the Ceannacroc power station is to be a duplicate of the two machines at Invermoriston, the Board have also decided to build this power station underground.

WATER SUPPLY IN GLASGOW.

The report of the chief engineer and general manager (Mr. Stanley D. Canvin) of the Glasgow Water Department for the year ended May 31, 1952, discloses that during the period under review there was an increase in consumption from 84·7 to 86·4 million gallons per day, which corresponds to a rise from 69·61 to 70·8 gallons per day per head of population. This was due to the fact that new housing schemes necessitated the installation of no less than 26,119 extra connections and that the arrangements over the whole water area of 90 sq. miles had been improved and strengthened. It is not, therefore, surprising to learn that steps are being taken to supplement the water from Lochs Katrine and Arklet, from which the greater part of the city's requirements have been taken for nearly a century, by drawing on the resources of Glenfinlas. A survey of the site chosen for this purpose was completed and, as noted on page 302, *ante*, it is hoped that constructional work will begin in the early part of next year. The scheme which has been adopted is a modification of one which was put forward earlier and will, it is estimated, result in a saving in capital expenditure and safeguard the city's water supply during the next ten years. During the period under review, the route for the west main under the River Clyde was approved. In all, some eight possible routes for this tunnel were investigated before two were found which gave a possibility of agreement with the proprietors of the land.

OBITUARY.

MR. H. S. HUMPHREYS.

It is with regret that we note the death of Mr. Herbert Septimus Humphreys in the Royal Northern Hospital, London, N.7, on September 5. Mr. Humphreys, who was chief engineer superintendent of the British Tanker Company, Limited, the shipping organisation of the Anglo-Iranian Oil Company, Limited, was born on December 27, 1889. He was educated at Margate College and at Clarence College, Gravesend, and, in August, 1905, entered upon a five-years' apprenticeship with Messrs. A. W. Robertson and Company, Limited, Royal Albert Docks and Lea Shipbuilding Yard, London. During this time he studied at Stratford and East Ham Technical Colleges, and obtained the Board of Trade certificate in engineering. At the conclusion of his apprenticeship, Mr. Humphreys joined the Atlantic Transport Line in August, 1910, as a junior engineer. He was torpedoed while serving as second engineer in the s.s. Mineapolis during the war of 1914-18 and, in March, 1916, obtained a commission as an engineer-lieutenant in the Royal Navy. After serving in H.M.S. Bellerophon and other ships, he was demobilised in May, 1919, and for a number of years held the rank of engineer-lieutenant-commander in the R.N. Special Reserve.

In July, 1919, Mr. Humphreys was appointed ship and engineer surveyor on the staff of Lloyd's Register of Shipping, at Belfast, but 18 months later, on January 1, 1921, he entered the British Tanker Company as assistant engineer superintendent. Promotion to the post of chief engineer superintendent came in 1942. During the war of 1939-45, Mr. Humphreys took a prominent part in the preparation of specifications for oil tankers suitable for war-time construction and service, and was subsequently responsible for the supervision of war-time tanker construction on the Clyde. He was also largely responsible for the development and construction of prototype fireproof life-boats for tankers. Since 1945, he had been in charge of the design, technical development and construction of a large number of new oil tankers, increasing in size to the 32,000-ton deadweight capacity geared-turbine steam tankers now under construction. Mr. Humphreys was awarded the Gold Medal of the North East Coast Institution of Engineers and Shipbuilders in 1935 and the Denny Gold Medal of the Institute of Marine Engineers in 1936. He was a member of the Institution of Naval Architects and served as chairman of the Council of the Institute of Marine Engineers in 1936. He was also on several technical and scientific committees and was a member of Council of the Shipping Federation.

MR. A. BRAMMER.

We also regret to record the death of Mr. A. Brammer, which occurred after a long illness at Cockfosters, Hertfordshire, on August 30, at the age of sixty. He was general secretary of the Association of Supervising Electrical Engineers.

Albert Brammer was born in Burslem on November 20, 1891, and was educated at Middleport Day School and Burslem Technical School. After holding various commercial posts he was appointed assistant to the general secretary of the National Union of Clerks in 1917, a position which he occupied for the next four years. In 1921, he became general secretary of the Association of Supervising Electrical Engineers and was still occupying that office at the time of his death. During his long tenure of this appointment the Association developed from very small beginnings to a place of importance in the electrical engineering industry, and with the rise in membership a corresponding increase in the duties—administrative, technical and educational—which the general secretary had to perform. These duties were made the more onerous by a number of war and post-war difficulties, but were nevertheless promptly and painstakingly carried out. Mr. Brammer was elected a Companion of the Institution of Electrical Engineers at the beginning of the present year.

EIGHTH INTERNATIONAL CONGRESS ON THEORETICAL AND APPLIED MECHANICS.

THE Eighth International Congress for Theoretical and Applied Mechanics was held at Istanbul from August 20 to 28, 1952, the host being the University of Istanbul. The technical meetings took place in the newly-erected building of the Faculty of Science of the University. This was the third Congress to be held since the war, the others being in Paris in 1946, and in London in 1948. The natural attractions and the historical associations of Istanbul are well known, but the technological status of present-day Turkey is probably appreciated less widely. It is a measure of the growing importance of this virile nation in matters of science and technology that the considerable undertaking of organising such a Congress should have been accepted; and it may be said at once that the Congress was a great success, a result that was due largely to the excellence of the organisation.

Bearing in mind the geographical situation of Istanbul, it is of interest to note, from the list of members attending, that their total number was nearly 500, apart from "associate members" belonging to the families of the active participants. A rough analysis of the list shows that they came from the following countries: Turkey, 81; British Commonwealth, 43; United States, 138; France, 63; Germany, 33; Italy, 17; Japan, 16; The Netherlands, 16; Sweden, 14; Yugoslavia, 9; Belgium, 8; and Switzerland, 8. Four members or fewer came from each of the remaining eleven countries, namely, Austria, Czechoslovakia, Denmark, Egypt, Finland, Greece, Iran, Israel, Mexico, Norway, and Spain. Though the official languages used were limited to English, French, German and Italian, the representation of the membership shows how universal is the activity now going on in scientific work.

The Congress opened in the evening of August 20 with a reception, in the main building of the University, by the Rector, Professor Dr. K. I. Gürkan. The members heard, to their great regret, that the President of the Organising Committee, Professor Kerim Erim, had suffered a breakdown in health and was unable to be present. Later in the proceedings, however, Professor Erim recovered sufficiently to preside, to the general satisfaction, at the Congress banquet, held on August 26. Other evening receptions were given, respectively, by the Minister of National Education (His Excellency Tefvik İleri) and by the Rector of the Technical University of Istanbul (Professor Dipl.-Ing. Emin Onat); and a farewell reception was held on August 27 at the Baltalimani Biological Station. On Sunday, August 24, the members were taken on a day excursion by steamer to see the Bosphorus and the Princes Islands in the Sea of Marmora. On certain other days there were visits to the mosques and the museums of the city, and an excursion to the Golden Horn. The social events were both numerous and well arranged, and offered ample opportunity for the many informal meetings and discussions which are often the most valuable facilities afforded by such an international gathering.

The serious work of the Congress was divided among five Sections: I, Elasticity, plasticity and rheology; II, Fluid mechanics, aerodynamics and hydrodynamics; III, Mechanics of solids, including ballistics, vibrations, friction and lubrication; IV, Statistical mechanics, thermodynamics and heat transfer; and V, Mathematics of physics and mechanics, and methods of computation. The Sections (and, in some cases, sub-sections) worked in parallel. Altogether, more than 300 papers were presented; and the proceedings of the Congress, when published, will provide a comprehensive survey of the state of current knowledge in this wide field of work—a field upon which many engineering developments are being, and will be, based. The time allowed for the presentation of individual papers was restricted to 20 minutes each, an allowance which, as it had to cover both paper and discussion, was much too short in most cases to

permit of detailed consideration. With the wealth of material presented, however, no other course was open to the Organising Committee. A most praiseworthy feature of the meetings was the accuracy of the time-keeping throughout; this made it possible for a member to pass, without difficulty or confusion, from one Section to another as his interest might lead him. Those with any extensive experience of international (or even of national) congresses know how rarely the time-keeping reaches such a high level. Praise should be given also to the projection and other equipment provided; when it is remembered that there were sometimes seven meetings in progress simultaneously, this alone is no small matter of organisation.

In addition to the contributions made in the form of papers, there were "General Lectures" delivered on the successive days. Professor J. C. Hunsaker, of the Massachusetts Institute of Technology, lectured on "Social Aspects of Aeronautics"; Sir Geoffrey Taylor, F.R.S., on "Hydrodynamic Theory of Detonating Explosives"; Professor John von Neumann, of the Institute for Advanced Study at Princeton, New Jersey, on "Automatic Computation and Hydrodynamics"; Professor Richard Courant, of the University of New York, on "Reciprocal Variational Problems Connected with Solutions of a Simple Non-Linear Equation"; Professor Arthur Kantrowitz, of Cornell University, on "Physical Phenomena Associated with Strong Shock Waves"; Professor W. Tollmien, of the University of Göttingen, delivered a lecture entitled "Über Schwingungen in Laminaren Strömungen und die Theorie der Turbulenz"; and Professor A. Lichnerowicz, of the Collège de France, spoke on "Méthodes Tensorielles en Mécanique."

Sectional addresses were given by Professor A. Signorini, of the University of Rome, on "Quelques Recherches Récentes de Dynamique des Solides"; by Professor G. Temple, of the University of London, on "The Dominant Derivative Method in Aerodynamics"; by Professor J. M. Burgers, of the Institute of Technology, Delft, Holland, on "Some Statistical Problems Connected with Solutions of a Simple Non-Linear Equation"; by Dr. F. N. Frenkiel, of Johns Hopkins University, Baltimore, Maryland, U.S.A., on "Turbulent Diffusion"; by Professor N. T. Minorski, formerly of Stanford University, California, "Sur la Méthode Stroboscopique et ses Applications"; by Mr. Maurice Roy, Membre de l'Institut de France, "Du Combustible à la Propulsion"; by Professor W. Prager, of Brown University, Providence, Rhode Island, on "The General Theory of Limit Design"; by Professor M. Picone, of the University of Rome, "Sur une Méthode pour le Calcul des Valeurs Propres et des Fonctions Propres, et sur son Application à l'Equation de Schrödinger"; and by Professor Markus Reiner, of the Hebrew Institute of Technology, Haifa, Israel, on "Rheology of Second Order Effects in Elasticity and Hydrodynamics." These lectures and addresses will provide, in the published volume of *Proceedings*, a further fund of advanced and original knowledge.

The first days of the Congress coincided with the hottest weather that had been experienced in Istanbul for five years. Whether or not this was in any way responsible, the speeches at the opening meeting were commendably concise; and later, at the banquet, which was held in the open, with a more comfortable temperature, all that needed to be said was well and briefly expressed. As a result of the excellent organisation, the members of the Congress, many of whom were visiting these beautiful and historic surroundings for the first time, were able both to obtain the maximum benefit from the Congress and to enjoy the many amenities of Istanbul and of Turkey.

PROJECTED HIGH-SPEED INTER-CONTINENTAL AIR LINER.—Handley-Page Ltd., Cricklewood, London, N.W.2, have issued preliminary details of a project for a high-speed long-distance air liner with a load-carrying capacity of 50,000 lb. It is to be powered by jet engines, of unspecified type and number, and will be capable of carrying 117 passengers directly between London and New York in 17½ hours. The maximum seating capacity will be for 150 persons. A two-deck layout is to be adopted. Freight holds will be provided, with a capacity of 1,000 cub. ft.

CENTENNIAL OF AMERICAN ENGINEERING.



MUSEUM OF SCIENCE AND INDUSTRY, CHICAGO.

CENTENNIAL OF AMERICAN ENGINEERING.

For the past ten days, the city of Chicago has been the scene of what is claimed to be the largest single gathering of professional engineers ever to take place. The claim is unlikely to be disputed, for, since September 3, over 30,000 engineers from all parts of the world have converged on the city. The primary reason for this great convention, which is due to end tomorrow (Saturday, September 13), has been the celebration of the foundation, 100 years ago, of the American Society of Civil Engineers, the first professional engineering body to be formed in the United States. To do honour to the eldest of their number, over 60 other leading associations of engineers in America have come to Chicago for the period of the celebrations, and by so doing have given a convincing demonstration of the essential unity which prevails among engineers of all denominations. That this kindred spirit is world-wide has been shown by the readiness of engineering societies in countries far removed from the American continent to send representatives to Chicago to join with their American brethren. Great Britain is well represented, those who travelled from these shores to Chicago including the Presidents of the Institutions of Civil, Mechanical and Electrical Engineers.

The Centennial of Engineering, however, has been more than a joyous celebration and a demonstration of unity. It has presented those who have taken part with an opportunity to review the achievements of the past century, to take stock of the present state of engineering knowledge, and to discuss the probable trend of engineering in the future. Each of the constituent societies, besides participating in the general programme of celebrations, has staged a series of meetings devoted to its own specialist activities, and at these over 1,000 papers dealing with almost every branch of engineering and every subject of direct interest to engineers have been presented. The papers delivered at the Centennial, however, have not all been addressed to specialists, for it was an avowed aim of the organising committee to use the event to foster a better understanding of the engineering profession among laymen. Thus the specialist activities have been supplemented by a series of public addresses forming a symposium on aspects of engineering of high importance to the community at large, as well as to industry and commerce. These addresses have been given by leading experts in various professions.

That Chicago should have been chosen as the venue for the centenary celebrations was particu-

larly appropriate since the city is itself a monumental tribute to civil engineers, to the triumph of man, aided by science and engineering, over his environment and to the spectacular growth of industrial power in the United States during the past century. Little more than 100 years ago, Chicago, now America's second city and the fourth largest in the world, was a small town on the mud flats by the Chicago River, where the latter enters Lake Michigan. The story of the ceaseless campaign against the all-pervading mud is well known, and of how the inhabitants, in 1856, after due deliberation, embarked on the prodigious task of raising the level of the wooden-planked streets of their town by 12 ft., thereby converting the ground floors of their dwellings into underground cellars. Tragedy, however, was to descend upon them in 1871, when fire swept through their city, destroying over 17,000 buildings in the space of 27 hours, and leaving one-third of the populace homeless. The holocaust, however, presented the authorities with a unique opportunity to rebuild their city on improved lines. Modern Chicago, with its 29-mile frontage on Lake Michigan, its regular pattern of streets, its many imposing buildings—the skyscraper is said to have originated there—and its spacious parks, is a tribute to enlightened civic planning as well as to engineering skill and human endeavour.

It is not only civil engineering, however, that is to be found in Chicago. Situated within easy reach of one of the world's richest reserves of iron ore, the city was early a centre of engineering and industry. In 1864, Pullman built his first railway sleeping car there. Three years later, the Western Electric Company started a great telephone-making industry in the city. At the present time, Chicago, with more than 4,000,000 inhabitants and 12,000 industries, includes among its activities meat packing, the preparation of food products, iron and steel making, the manufacture of machinery and electrical equipment of all kinds, railway engineering, petroleum refining, paint and chemical manufacture, the production of agricultural equipment, the manufacture of aircraft components, plastics and building materials, as well as a host of smaller industries.

The headquarters of the Centennial have been the Museum of Science and Industry, a splendid building in the classical style, originally erected to house exhibits at the World's Fair Exposition, held at Chicago in 1893, but modified and improved upon subsequently. At the present time, its scientific section contains a remarkably fine and skilfully arranged permanent collection of exhibits

which illustrate fundamental scientific principles and their applications in a vivid manner. During the period of the Centennial, the permanent exhibits have been supplemented by a special Centennial of Engineering exhibits, covering 10,400 sq. ft. of floor space, which has been designed to trace briefly the history of engineering in one industry—in this case, the machine tool industry—and also to illustrate the application of modern engineering in a variety of industries. Particular subjects illustrated have included the use and advantages of aluminium as a structural material, the significance of mechanised farming, the importance of lubrication in modern machinery, the history of illumination, and a display of recently developed electric-lighting units, including a 50,000-watt lamp, and the world's smallest electric lamp, made for use in surgery. Access to the exhibits has been facilitated by the installation of an electric escalator, presented by the Westinghouse Electric Corporation, which was dedicated on the opening day of the Centennial and will remain a permanent feature of the museum. Another special attraction at the museum during the celebrations has been a musical review entitled "Adam to Atom," which was designed to portray the advance of mankind through the ages with particular reference to scientific discoveries and engineering developments.

The Centennial began on Wednesday, September 3, which was designated International Day in honour of the many foreign visitors attending the celebrations. There was no official opening ceremony, but in the afternoon of the opening day the occasion was marked by the laying of a special corner stone at the Museum of Science and Industry, after which a reception for foreign visitors was held within the museum. Major Lenox R. Lohr, President of Centennial of Engineering, 1952, Inc., the organisation formed by members of the American Society of Civil Engineers to arrange the Centennial, Mr. D. M. MacMaster, director of the Museum of Science and Industry, and Colonel C. S. Proctor, President of the American Society of Civil Engineers, officiated at the ceremony. In a central cavity in the one-ton block of granite which formed the corner stone, there was placed a Monel metal box, in which, surrounded by an atmosphere of helium, at a pressure slightly greater than atmospheric, were a number of physical and chemical materials, including radioactive materials, arranged as a series of long-term experiments, which, it is hoped, will advance scientific knowledge and, on occasion, prove or disprove certain current theories. It is intended that the box shall be opened after 100 years have elapsed.

Among the contents of the box are small quantities of dry hydrogen and oxygen in contact, in the proportions in which they combine to form water. The object of this experiment is to determine whether combination will, in fact, occur in the absence of any catalyst. Scientists are divided on the matter, some holding that no reaction will take place and others expecting a very slow reaction. In another sealed capsule are a number of oriental lotus seeds, which are traditionally associated with longevity. It is hoped that, when the box is opened, scientists will have more accurate data on which to predict the ability of seeds to maintain their germination properties. Another experiment included is an investigation of slow crystallisation to determine whether different crystalline structures can be obtained if the crystal formation is extremely slow. The box also contains a small lead block coated on one face with an extremely thin layer of a radioactive isotope of lead which has a half-life of 22 years. The object, in this instance, is to determine the depth to which the radioactivity will have penetrated into the block after a century and to measure the amount of radioactivity remaining in the material. An experiment to determine the age-hardening of a recently developed metal alloy has also been included.

Several varieties of biological moulds, including that used to produce penicillin, have also been inserted in the box. These moulds will be in a state of suspended activity during their century of incarceration and, if they survive, will be allowed thereafter to resume their biological activity. Several varieties of virus and bacteria are also being tested. The passage of the years will be recorded by means of a thermostatic clock, which will record successive annual extremes of temperature. The clock will register once when the ambient air temperature reaches 85 deg. F., and will not register again until the temperature falls below 15 deg. F. These values are expected to lead to single annual indications of the summer and winter seasons in spite of the wide fluctuations of temperature in Chicago.

(To be continued.)

FLYING DISPLAY OF BRITISH AIRCRAFT.

(Concluded from page 310.)

THE 1952 display of the Society of British Aircraft Constructors, which was held at Farnborough, Hampshire, and ended on Sunday, September 7, was marred by a tragic accident. On Saturday, September 6, the first prototype D.H. 110 all-weather night fighter aeroplane (the first British fighter to exceed the speed of sound), constructed by the de Havilland Aircraft Company, Limited, Hatfield, Hertfordshire, fell to pieces in the air over the aerodrome. The aircraft had taken off from Hatfield, and its arrival at Farnborough was heralded by the sharp explosive noises, similar to heavy gunfire, that sometimes accompany a dive at supersonic speed. The aircraft itself then came into view and, after pulling out from the dive, turned into the airfield and completed a high-speed run parallel with the runway. The pilot then turned away from the aerodrome, and when the aircraft again came into view, approaching from the north, as if to fly across the runway, it did not appear to be travelling at high speed.

It was as the aircraft approached the boundary of the airfield that the break-up occurred, and the exact sequence of events, which happened rapidly, is not clear. Several observers have confirmed our impression, however, that some objects were seen to fall from the aircraft, and that the latter assumed a nose-up attitude before the tail-booms parted from the fuselage and the structure disintegrated. The momentum and power of the engines carried them a considerable distance, and one landed on an area of rising ground that was densely packed with spectators. The other engine fell beyond the spectators. Parts of the fuselage also landed within crowded enclosures, and caused further casualties. Altogether, 30 people lost their lives, including the pilot, Mr. John Derry, and the observer, Mr. Anthony Richards, and many

people were injured, some seriously. An official inquiry into the cause of the accident is being held. After a brief interval, it was decided to continue the display, and most of the spectators stayed to watch the flying, which included another demonstration of a dive at supersonic speed by the Hawker Hunter, followed by an extremely fast low-level run. We refer to the accident on page 343.

Fig. 13 shows the second prototype D.H. 110 (which appeared in the display on the first four days) in a vertical turn, revealing clearly the swept-back twin-boom configuration. It is powered by two Rolls-Royce Avon engines; the wing-root air intakes are provided with boundary-layer bleeds. Each boom carries a swept-back fin and rudder, and the tailplane is mounted between the fins, above the efflux from the two jets. A tricycle undercarriage is fitted. The D.H. 110, it may be recalled, was built to the same specification as the Gloster Javelin, as a long-range interceptor fighter fitted with comprehensive radar search equipment. During the first five days, Mr. Derry had given impressive displays of rapid manoeuvres, handling the aircraft as if it were a single-seat fighter.

FLYING DISPLAY OF BRITISH AIRCRAFT.

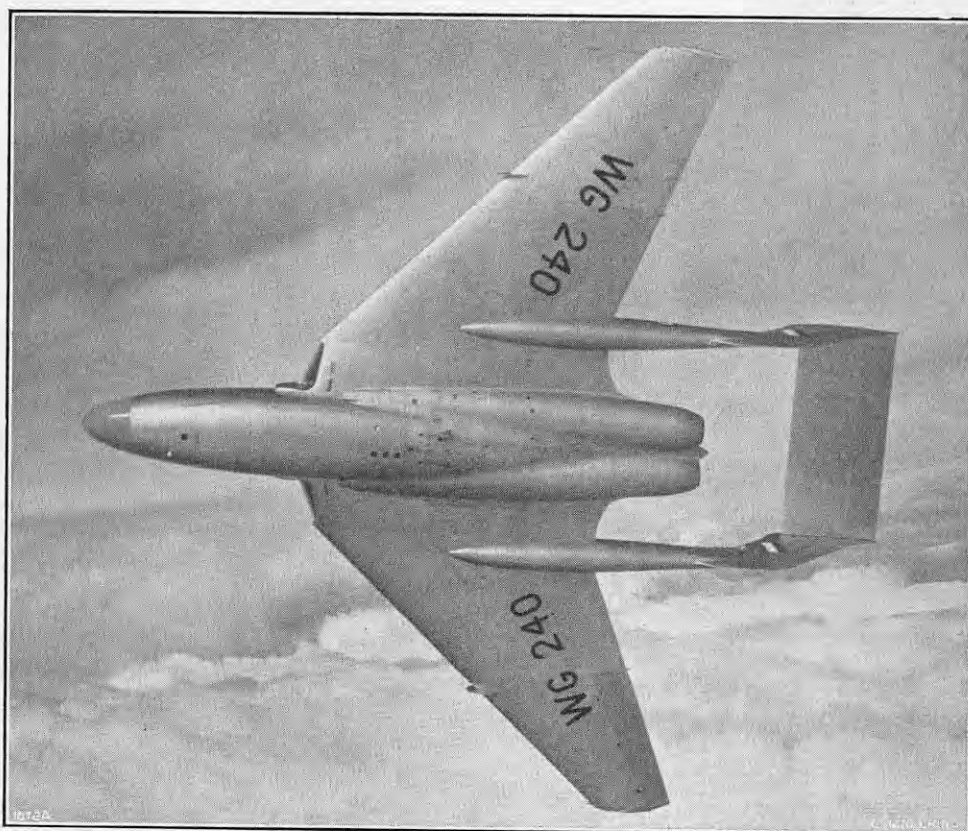


FIG. 13. SECOND PROTOTYPE D.H. 110; DE HAVILLAND AIRCRAFT CO., LTD.



FIG. 14. SKEETER HELICOPTER; SAUNDERS-ROE, LTD.

AVRO 698 BOMBER.

The prime exhibit of the display was perhaps the four-engine delta-wing bomber aeroplane, the Avro 698, designed and constructed by Messrs. A. V. Roe and Company, Limited, Greengate, Middleton, Manchester. The Minister of Supply, Mr. Duncan Sandys, has recently stated that an appreciable number of Avro 698 aircraft have been ordered for the Royal Air Force. "The dart-like form of this new machine," he said, "offers the important advantage of reducing wing-loading and drag, and provides much increased stowage space for fuel or payload. This will enable it to attain a speed approaching the speed of sound and to carry a very large bomb-load over great distances. It is, moreover, designed to fly at altitudes which will give it a considerable degree of immunity from ground and air defences." This aircraft, believed to be the first of its kind in the world, with a performance greatly in advance of any known existing aircraft designed for similar duties, flew for the first time on Saturday, August 30. During the flying display, it was based at Boscombe Down, Wiltshire. As the Avro 698 approached Farnborough, from Bos-

FLYING DISPLAY OF BRITISH AIRCRAFT.

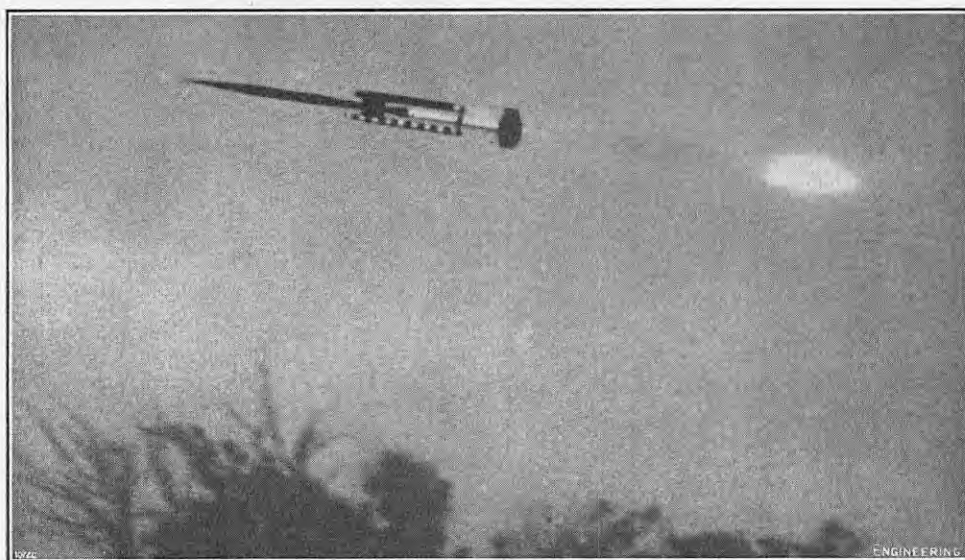


FIG. 15. AT START OF FLIGHT.

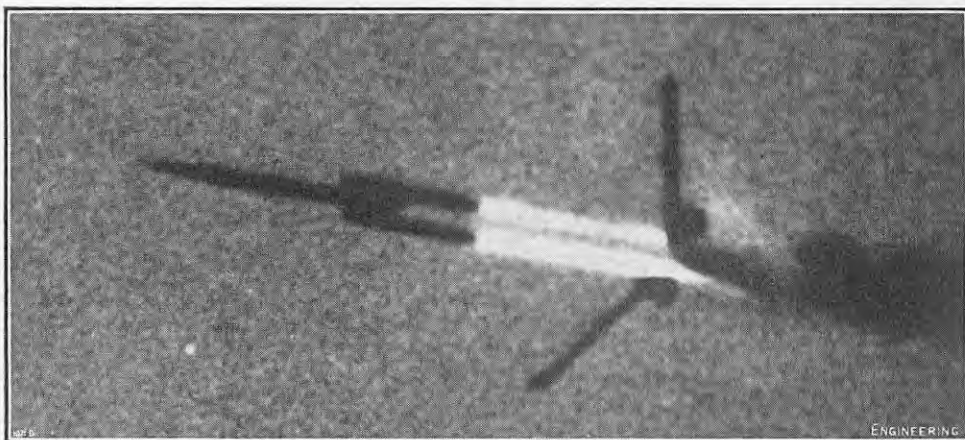


FIG. 16. END OF BOOST PHASE.

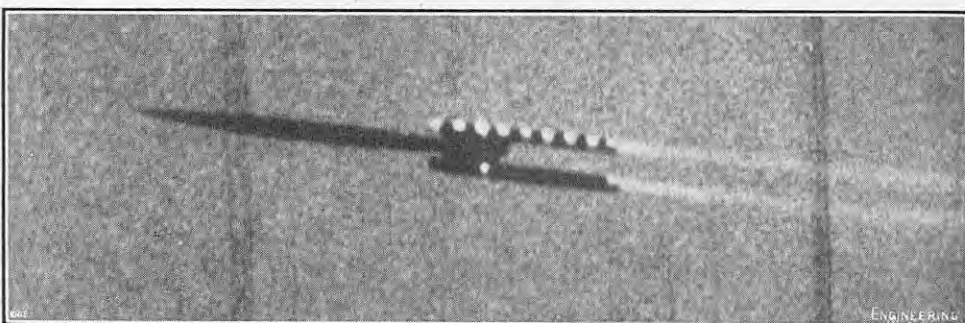


FIG. 17. UNDER RAM-JET PROPULSION.

FIGS. 15-17. RAM-JET TEST VEHICLE; BRISTOL AEROPLANE CO., LTD.

combe Down, it could be seen that on either side of the great white triangular bomber were flying two small "triangles," one red and one blue, the Avro 707A and 707B, respectively, on which the research flying which led to the construction of the 698 was carried out.

As may be seen in Figs. 10 and 11, on page 340, the four Rolls-Royce Avon jet engines which power the Avro 698 are grouped closely about the centre line of the aircraft; the air intakes in the wing roots have a boundary-layer fence at the inboard end. Control is by rudder, ailerons and elevator flaps, no tailplane being fitted. Air brakes are provided above and below the wings. A tricycle undercarriage is fitted, comprising four-wheel bogie main units and a twin nose-wheel. In order to demonstrate the simplicity of the new bomber, no crew members other than the pilot were carried on the demonstration flights. Although the machine had only been flying for a few hours, the pilot

brought the aircraft in low over the aerodrome and gave a convincing demonstration of its controllability.

HELICOPTERS.

Among several helicopters taking part in the display, the 10/13 seat helicopter, designed for short and medium ranges, and constructed by the Bristol Aeroplane Company, Limited, Filton, Bristol, made its first public appearance. A description of this machine, the Bristol 173, was given on page 33 of our 173rd volume (1952), at the time of its maiden flight. It may be recalled briefly that it has twin rotors, one at each end of the fuselage, driven by two Alvis Leonides LE 25 HMV radial engines, each developing 525-545 brake horse-power. Both rotors may be driven by either engine. It is hoped that the Bristol 173, which is now undergoing its development flights, will go into service with British European Airways in about two years' time.

The Skeeter helicopter was first demonstrated in

the 1949 flying display by the Cierva Autogiro Company, Limited. When the latter firm was dissolved, Messrs. Saunders-Roe Limited, Eastleigh, Hampshire, took over the development of the Cierva helicopters, and this year they showed in the static park their developed version of the Skeeter, the Mark 5, a side-by-side two-seater single-rotor machine, suitable for private flying, training, or military duties, with a single three-blade rotor and a torque-balancing tail rotor, which also provides lateral control. The Skeeter is illustrated in Fig. 14. The rotor is driven by a 180-h.p. Blackburn Bombardier air-cooled engine. The main rotor diameter is 32 ft., the overall length is 31 ft. 2 in. and the overall width is 28 ft. 2 in. With the blades removed, the machine is 28 ft. 5 in. long and 7 ft. 5 in. wide. The height, over the tail rotor, is 9 ft. 10 in., and with the tail rotor removed, 7 ft. 4 in. The Skeeter 5 has an all-up weight of 2,000 lb., with a disposable load of 550 lb. The forward part of the cabin is constructed in light-alloy sheet, with large Perspex windows giving a good view all round. Behind the cabin, the engine, mounted athwartships, and the rotor transmission gearbox and shafting are supported on a welded-steel tubular structure, covered with detachable light-alloy panels giving easy access for servicing. A tricycle undercarriage with a steerable nose wheel is fitted, the main units being attached to the centre section structure. The performance with the Bombardier engine is not disclosed, but the Mark 3 Skeeter, which took part in the flying display, and is powered by a 150-h.p. de Havilland Gipsy engine as originally fitted, has a speed of 94 m.p.h. at maximum continuous power at sea level, and 80 m.p.h. at maximum weak-mixture power at sea level. The range, on 25 gallons of fuel, is 295 miles.

The Westland Sikorsky S.51 helicopter, fitted with an Alvis Leonides 550-h.p. engine, has been a familiar feature of the flying display for some years now, and a description of the machine was given on page 317 of our 168th volume (1949). In service with the Royal Air Force and the Royal Navy, it is known as the Dragonfly. This year the Dragonfly Mark 3, constructed by Westland Aircraft, Limited, Yeovil, Somersetshire, appeared for the first time. It differs from earlier marks in that it has all-metal rotor blades and power-assisted controls. The metal blades consist of an extruded light-alloy leading edge bonded to thin-gauge light-alloy trailing-edge sections. It has an all-up weight of 5,870 lb. The main rotor diameter is 49 ft., and the overall length is 41 ft. 1½ in. The height is 12 ft. 11 in.

An interesting exhibit on the stand of the Fairey Aviation Company, Limited, Hayes, Middlesex, was a scale model of their projected 40-seat Rotodyne helicopter, which is being designed to carry a useful load of 13,000 lb. at a high cruising speed of 200 m.p.h., with an endurance of two hours. The all-up weight is estimated to be 31,000 lb. It has a five-blade reaction-driven rotor, 80 ft. in diameter, and is also provided with fixed wings which provide most of the lift during horizontal flight. A conventional tailplane with two fins is fitted. It is powered by two gas-turbine units, located above the fuselage, driving auxiliary compressors, which supply compressed air to pressure jets at the rotor-blade tips, and also to two turbine units driving propellers, one in each fixed wing. The compressed-air supply is controlled by valves; in vertical flight, the full power is absorbed by the rotor. During cruising, most of the power is taken by the propeller turbines. This system of propulsion eliminates complicated mechanical transmissions and the need for torque-reaction rotors or propellers. The Rotodyne, with its large unrestricted fuselage, should have possibilities as a freight carrier.

RAM-JET RESEARCH VEHICLE.

On view in the static exhibition, and illustrated in Figs. 15, 16 and 17, on this page, was an early version of a supersonic ram-jet test vehicle, for studying the behaviour of ram jets in free flight, constructed by the Bristol Aeroplane Company, Limited, Filton, Bristol, to a design by the Royal Aircraft Establishment. It comprises twin ram jets, each 6 in. in diameter, and a body housing the fuel supply, fuel system controls, and automatic measuring and radio transmitting equip-

ment. A pair of 7.5-in. cordite rocket booster motors are mounted in tandem with the vehicle, which is launched from a twin-railed ramp. The booster motors are free to slide away aft at the end of the boost phase; by this time, the vehicle is travelling at a velocity well beyond the speed of sound, and the ram-jet motors are working efficiently, accelerating the vehicle still further. Fig. 12 shows the test vehicle at the beginning of its flight, under propulsion by the rocket motors. In Fig. 13, the rocket motors can be seen dropping away at the end of the boost phase, and in Fig. 14 the vehicle is in flight under ram-jet power.

NAVIGATIONAL-TRAINING AEROPLANE.

A navigation-trainer development of the Marathon I, illustrated in Fig. 12, was demonstrated by Messrs. Handley Page (Reading), Limited, Woodley Aerodrome, Reading, Berkshire. The original airliner version of this aircraft was described on page 250 of our 168th volume (1949). The Marathon, having a still-air range of nearly 1,300 miles, is particularly suitable for advanced navigational-training flights to such places as Malta and Gibraltar. Each aircraft will carry an instructor navigator and two student navigators, in aft-facing seats, with a pilot and signaller. An astrodome and "pear-drop" windows are fitted for taking sights. The equipment carried includes Rebecca Mark 4, Gee and radio compasses. There are two versions of the navigation trainer, the Marathon I and IA, powered respectively by de Havilland Gipsy Queen 70-3 and 70-4 engines. The Mark I has a maximum continuous speed of 199 m.p.h. at 8,600 ft., whereas the Mark IA develops its maximum continuous speed, 206 m.p.h., at a lower altitude, 5,800 ft. The maximum continuous speeds at sea level are 179 m.p.h. for the Mark I and 192 m.p.h. for the Mark IA. The climb to 10,000 ft. is carried out in 17 minutes by the Mark I aircraft, 14 minutes by the Mark IA. At the maximum all-up weight, 17,535 lb., both versions of the aircraft will take off and clear a 50-ft. obstacle in 900 yards. The disposable load is 4,177 lb. The speed for maximum range, at 5,000 ft., is 160 m.p.h.

Many other aircraft appearing in the display, including several of considerable significance, have been described in previous issues, and lack of space renders it impossible to refer to them individually. We should, however, mention another incident that occurred on Saturday. In order to demonstrate its remarkable take-off characteristics, the Pioneer five-seat light aircraft, built by Scottish Aviation, Limited, Prestwick, Ayrshire, took off across the main runway, and in doing so, hit the port elevator against one of the runway lights, tearing it from its outboard hinges and leaving it suspended from a single hinge, trailing behind at an angle of some 70 deg. from the normal. The pilot, nevertheless, was able to continue the take-off, complete the circuit and land, on the starboard half of the elevator, without any apparent difficulty. The Pioneer was described on page 218 of our 170th volume (1950).

It is inevitable that the main impression created by the 1952 display is that knowledge of the loads imposed on high-speed aircraft and their ability to withstand them has lagged behind developments in performance. Within a week, two prototype aircraft, the D.H.110 and the P.120, have collapsed in the air. The P.120 delta-wing research aircraft, constructed by Messrs. Boulton Paul Aircraft, Limited, Wolverhampton, which was intended to take part in the display, broke up in the air on Saturday, August 30. In this case, however, the pilot escaped safely by parachute. *The Times* (Monday, September 8) has suggested that experimental aircraft should not be publicly demonstrated; it is sincerely to be hoped that the authorities do not adopt this viewpoint. It may, however, be suggested that in future displays pilots should be instructed to approach the airfield only along the direction of the runway.

On page 309, *ante*, an illustration of an Avon-engine tail-pipe appears over the caption "Tail-pipe of Reheat Avon Engine; Armstrong Siddeley Motors, Limited." In fact, as is well known, the Avon engine is constructed by Rolls-Royce, Limited, Derby, and we offer our apologies for the error.

LABOUR NOTES.

As on previous occasions, economic and political problems covering a wide field were discussed by the Trades Union Congress at its 84th session at Margate last week. A statement issued by Sir Vincent Tewson, the general secretary of the T.U.C., on the eve of the opening, announced that the total number of persons affiliated to the organisation at the end of December last year had reached the record figure of 8,020,079, an increase of 192,134 on the total for December 31, 1950. Included in the total for 1951 were 1,317,759 women. The Congress was opened on September 1 with an address by the President, Mr. Arthur Deakin, C.H., C.B.E., to which a brief reference was made in these columns last week. An important point re-emphasised by Mr. Deakin in this address was that this island was no longer exclusively the workshop of the world. Other nations, which had received the benefit of exports and services from Great Britain, had used them to develop their own resources and many of them at the present time were competing with Britain in the world's markets. Many of this country's economic troubles arose from that source. These difficulties would in no way be lessened, Mr. Deakin stressed, if trade unions pursued a policy which inevitably increased production costs and compelled British exporters to require higher prices for their products.

Arising out of a section in the General Council's report, dealing with negotiations with bank and insurance firms, a delegate from the Guild of Insurance Officials protested against the domination and control exercised by employers in connection with the type of organisation, known as house unions, which was being established in the banking and insurance professions. He was assured from the chair that the General Council would keep this matter under review and that it would take what action it could. A resolution was moved on behalf of the Fire Brigades Union requesting the General Council to initiate a campaign to defend the trade-union movement from attempts being made to set up so-called non-political trade unions and associations in certain industries and services with a view to weakening *bona fide* trade unions, and wrecking established negotiating machinery. This resolution was eventually remitted to the General Council for its consideration.

Re-armament formed the main subject of discussion at the session on September 2. Two composite motions were laid before the meeting, both of which, Mr. Deakin warned the delegates, were to be regarded as rejecting the General Council's report on this question. The first demanded that the General Council should oppose the preparation for war, which re-armament entailed, while the second called for international action to reduce armaments and assist the economic development of backward countries. Both were defeated by majorities of three to one, as also was an amendment to the second motion. This "twilight amendment," as one delegate described it, recognised the necessity for re-armament but requested that Britain's participation in it should be reduced to take into account the country's economic position. Finally, on a fourth vote, the General Council's report affirming that a simple curtailment of the re-armament programme would not provide an immediate solution of economic problems and recommending the maximum measure of re-armament, within the limits of Britain's power to find the means, was carried by 5,597,000 to 1,450,000 on a card vote.

Previously, at the same session, a resolution asking for the restoration of a free national health service was adopted unanimously. The delegates also accepted a motion requesting the establishment of a comprehensive occupational health service. The afternoon of September 3 was devoted to the State ownership of industry. At the close of a rather noisy debate, the meeting carried a resolution which instructed the General Council to draft proposals for the extension of "social ownership" to further industries and services, particularly

those subject to monopoly control, and to take into account the plans of the Confederation of Shipbuilding and Engineering Unions for the engineering industry, as well as suggestions submitted by other affiliated organisations. Efforts to have this motion remitted to the Council were unavailing.

Elections to the new General Council, the number of members of which had been increased from 33 to 35, were announced at the morning session on September 4. All members of the existing Council were declared re-elected. A debate on wages and profits occupied the greater part of that day's programme. It resulted in the acceptance, by a majority of over six million votes, of the Council's statement in its annual report. This referred to the seriousness of the country's present economic situation and contained firm warnings regarding the consequences of substantial wage increases being conceded. The trade-union movement, the Council affirmed, had a vital responsibility to ensure that it did not worsen an already precarious position by its own actions. In a somewhat contradictory mood, the delegates also approved, almost unanimously, a long all-embracing resolution asking unions to reject attempts to restrict justifiable wage increases necessary to ease the burden of the rising cost of living. It had been previously accepted by the Council.

On the other hand, a motion sponsored by the Electrical Trades Union, which referred to the "substantial" profits made by industry and gave support to unions defending the living standards of their members by the submission of wage claims, was heavily defeated. In opening this debate, Mr. Lincoln Evans, general secretary of the Iron and Steel Trades Confederation, made the point that it was misleading to allow trade-union members to believe that all pay increases could be met out of profits. If that were true, the recent increases in the cost of coal and transport would not have been necessary. Broadly, he stated, the position was that trade unionists paid one another's wage increases.

On Friday, September 5, the last day of the Congress, delegates gave unanimous approval to a resolution requesting that joint consultations should take place immediately to apply the principle of equal pay for women to all sections of Government employment. A motion asking that the expenses incurred by employees, living on housing estates outside town areas, in travelling to and from their employment should become a charge on national funds was rejected. At a subsequent meeting of the new General Council, Mr. T. O'Brien, M.P., was elected chairman.

Five members of the T.U.C. General Council, including Mr. O'Brien, met the Prime Minister, Mr. W. S. Churchill, at 10, Downing-street, last Monday, to inform him that the annual congress had taken the view that the dispute between the Scottish printing firm of Messrs. D. C. Thomson and Company, Limited, and the printing trade unions, now four and a half months old, involved the vital trade-union principles of freedom of association and the right to organise. The T.U.C., therefore, had set up a special committee to consult the trade unions directly involved in any further action against the firm and to advise on what action would be advisable to effect a satisfactory settlement.

In reply, Mr. Churchill said that, since the Minister of Labour informed the House of Commons on August 1 that Messrs. Thomson had agreed to abandon their non-union policy subject to certain safeguards, with which the printing unions concerned were in agreement, the Minister had been in constant touch with the various parties to the dispute in any endeavour to arrange an amicable solution. Among other matters, he had drawn their attention to the principles embodied in the International Labour Convention No. 98 of 1949, regarding the right to organise and bargain collectively. Having been asked by the Minister on August 28 to consider this carefully, the firm had replied that it would no longer insist that any one should sign an agreement not to belong to a union.

THE SHAPE OF WINGS TO COME.



FIG. 1. HUREL-DUBOIS HD10. ASPECT RATIO 32.5.

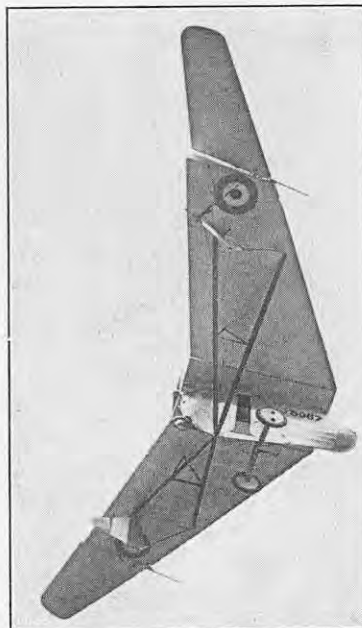


FIG. 3. HILL PTERODACTYL OF 1925.

Fig. 5. SUCTION-WING AEROFOIL SECTION.

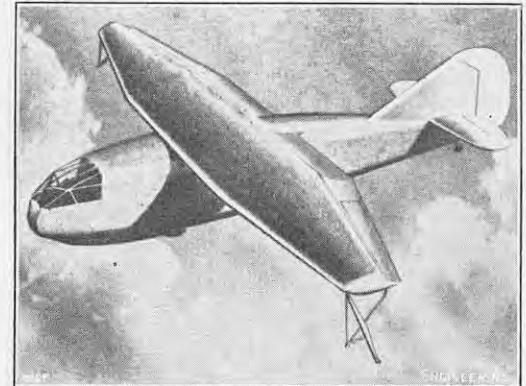
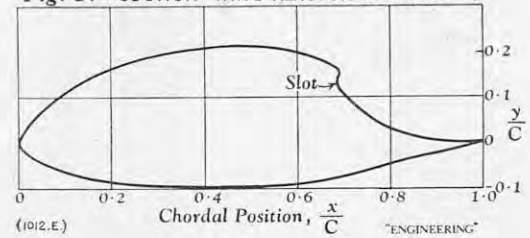
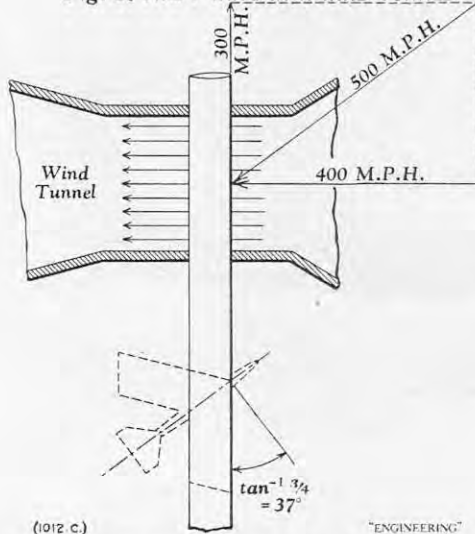


FIG. 6. AUSTRALIAN SUCTION-WING GLIDER.

Fig. 2. SWEEP WING IN A WIND TUNNEL.



THE SHAPE OF WINGS TO COME.*

By D. KEITH-LUCAS, B.A., M.I.Mech.E.,
F.R.Ae.S.

BETWEEN 1939 and 1945 we, in the United Kingdom, were too busy winning the war to do as much fundamental research in aerodynamics as we ought to have done. The Germans, rather curiously, found time to do much more basic research and if the war had continued much longer we should have found ourselves in a difficult position against the rocket-propelled swept-wing fighters which were just beginning to come from the German aircraft industry. War always provides a stimulus to technical advancement but in this country the biggest strides in the aerodynamic field have been taken since the war and were the direct consequence of jet propulsion, which made it possible to fly at higher speeds and enhanced the importance of being able to do so. Germany had reacted sooner than we to the challenge of jet propulsion and we owe a lot to the lead given to us by the German research work. It is healthy, if a little frightening, to recall that Lippisch in Germany was working on a high-speed Delta design even before the last war.

In this paper I want to review the reasons which have led to the swept-back, crescent and Delta wing forms and try to see where these developments are leading us. I shall speak mostly about high-speed aircraft, although recent researches have

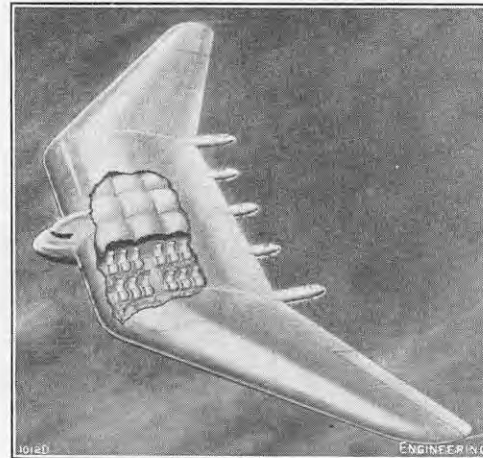


FIG. 4. ALL-WING AIRLINER PROJECTED IN 1945.

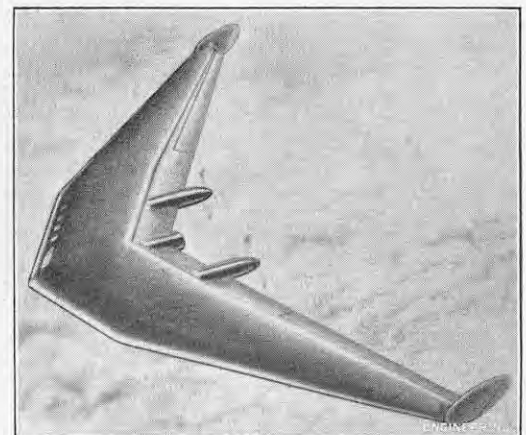


FIG. 7. PROPOSAL FOR SUCTION-WING AIRLINER.

led to at least one rather intriguing shape for low speeds, namely, the Hurel-Dubois light plane which is shown in Fig. 1. As will be seen from the figure, the wing of the Hurel-Dubois has a very large span and small chord. Its aspect ratio, that is, the ratio of the span to the mean chord, is $32\frac{1}{2}$ compared with a maximum of about 12 on the war-time bombers and about four on modern fighters. It is possible that it may be the forerunner of others like it, and it is included here to show how low-speed aircraft are developing in comparison with high-speed types. Before the war the difference between a high-speed and a low-speed aircraft was mainly one of degree. They were both flying at subsonic speeds and the aerodynamic laws were the same for both. The high-speed aircraft therefore had more power and less drag, but was not necessarily very different in outward shape from one designed for low speed. To-day the picture is quite different, because by "high speed" we have come to mean that the aircraft flies at supersonic or, at least, very high subsonic speeds and, by passing through or even approaching the speed of sound, it has entered a new regime of aerodynamics. It is a natural corollary that the aerodynamic shapes have to be different, and as aircraft speeds increase we can expect a continuing divergence between the design of "low-speed" and "high-speed" types.

The Purpose of Sweepback.—The outstanding development in high-speed aircraft is the swept wing in its different guises. It is often stated that sweepback enables a wing to "slide" through the air in rather the same way as a bread knife or a scythe is drawn across what it is cutting. This,

of course, is the principle of the guillotine, which always had a swept-back or "Delta" blade; but we are talking of air, which behaves differently from bread, grass or the human neck. Indeed, the analogy is dangerous, for, at low speeds, the drag of a swept wing is no less than that of a straight one.

Perhaps the best way to illustrate the purpose of sweepback is to take a rather far-fetched example from a wind tunnel. Let us suppose that we have an untapered wing which spans the tunnel and, if you like, sticks out a bit on each side. The tunnel speed is 400 m.p.h., and the pressure distribution round the wing is, clearly, appropriate to its incidence to the airstream and to the speed. Now let us suppose that the wing is made much longer so that it sticks out a long way from one side of the tunnel, as shown in Fig. 2, and that we proceed to push it through the tunnel at 300 m.p.h. at right angles to the air-flow. Apart from some slight corrections due to skin friction the pressure distribution over the wing is unaltered. But if we consider any one point on the wing it is, by simple vectors, in an air stream of 500 m.p.h., to which the wing is swept back at about 37 deg. The flow round the wing is therefore behaving like that round a straight wing at 400 m.p.h., whereas the actual speed is 500 m.p.h. An aircraft with swept wings can therefore fly much faster than a corresponding one with straight wings before meeting the compressibility troubles which, on a straight wing, occur at and around the speed of sound. These troubles include increase of drag, loss of lift, changes of trim, deterioration in stability and control, and the possibility of unpleasant buffeting.

This explanation really amounts to no more than saying that we can resolve the velocity into two

* Paper read before Section G of the British Association at Belfast on Monday, September 8, 1952. Abridged.

components, one at right angles to and the other along the wing, and that we can then neglect the flow along the wing. For some strange reason most people find the wind-tunnel analogy easier to visualise. In practice, due to boundary layer and end effects, the advantage which can be realised is only about half of that indicated by this over-simple treatment. But, in spite of that, sweepback has two very important contributions to offer. In the first place, it reduces the adverse effects of compressibility and in this respect a swept wing behaves in much the same way as a much thinner straight wing. In the second place, sweepback postpones the compressibility effects to higher speeds and, if the angle of sweep is sufficient, can even postpone them to speeds well above the speed of sound, which is something which thinness by itself cannot do. Both contributions are important, but the second one is particularly important if the aircraft is designed for a maximum speed anywhere between, say, 80 per cent. and 150 per cent. of the speed of sound, i.e., for a Mach number between 0.8 and 1.5.

All-Wing Aircraft.—Now sweepback was first introduced into aircraft design for quite a different reason. With the development of cantilever monoplanes, designers began to think in terms of thicker wings and explored the possibility of using aerofoil sections of up to 25 per cent. thickness : chord ratio. As the size of aircraft increased it became tempting to try to submerge the fuselage by putting it athwartships in the wing, so saving the weight and drag of the fuselage. It also reduced the bending moments at the wing roots, arising from the upward lift forces, by spreading the load more uniformly across the span. The obvious development of this idea was to dispense with the tail, because there was no longer anything to support it. The longitudinal stability and control of the aircraft was then restored by sweeping the wings back and, in effect, carrying the tailplane on the wing tips.

The Hill Pterodactyl of 1925 was a pioneering effort in this direction and is shown in Fig. 3, from which it will be seen that, though there is still a fuselage, it is only a small one. Fig. 4 shows an example of a design which was projected by Short Brothers in 1945 as a trans-Atlantic air liner to much the same specification as the Brabazon. With a wing of 22 per cent. thickness : chord ratio it had to be a very large aircraft to provide sufficient headroom in the cabin. On paper it showed an advantage in payload and speed over a conventional design, but the passengers' view would have been poor and the stability and control problems needed further investigation.

Boundary Layer Suction.—One of the objections to using the thick wing sections demanded by this sort of design is that the drag of the wing becomes unduly high. A thick boundary layer of relatively stagnant air builds up round the wing and is shed as a wake from the trailing edge. The drag can be very much reduced if this boundary layer is sucked away near the trailing edge of the wing and it becomes possible to use very thick sections, such as that shown in Fig. 5, without incurring any penalty in drag over normal thin sections. The engineering difficulties are considerable, as the quantity of air which has to be removed is very large, but it can be done and it makes the all-wing design both feasible and attractive. Fig. 6 shows an experimental glider developed and flown by the Australian Aeronautical Research Laboratories. It has a wing section of $31\frac{1}{2}$ per cent. thickness : chord ratio, with boundary-layer suction. In a lecture before the Third Anglo-American Aeronautical Conference, Mr. T. S. Keeble explained that the experiment was directed towards an all-wing air liner and that, basing the design on the results of the glider tests, he calculated that such an air liner could carry 40 per cent. more load and would be 40 per cent. faster than one designed on conventional lines, while still consuming no more fuel for the same range. Fig. 7 shows the general arrangement of Keeble's air liner. It is an attractive proposition and looks like a high-speed aircraft, although in fact it cruises at under 300 miles per hour. Alternatively, the same devices may be used to obtain wings of very high aspect ratio like the Hurel-Dubois, but without the need for the strut. The great problem with such slender wings is to provide sufficient

stiffness and strength in the wing structure without making it too heavy and so cancelling the aerodynamic advantage. The thicker sections possible with boundary-layer suction make the idea more practical and it becomes very attractive for low-speed long-range aircraft; especially for those which require long endurance as opposed to range, as, for example, Coastal Command aircraft engaged on anti-submarine patrol.

Tailless Aircraft.—We have got so used to the conventional arrangement of aircraft with a straight wing, a long slender fuselage and a tail that we are apt to look on a tailless design as something of an unnatural freak. But if we observe nature carefully we notice that seagulls and ducks and many other birds are, in effect, tailless at least in straight flight, and bats are tailless at all times and are probably the most manoeuvrable of all fliers. Gulls use their tails in manoeuvring but, as far as one can see, more as air brakes than as elevators and, incidentally, they use their feet in the same way. There is a strong argument for a tailless design on structural grounds. In a pull-out from a dive or in a high-speed turn there is a large upload on the wing and usually, a down-load on the tail. On a conventional tailed aircraft with swept-back wings the moments due to these loads cancel each other out only through the long path up the fuselage and the wing to the centre section. With a tailless design, on the other hand, the down-load of the tail occurs at the wing tips and so we not only avoid the need for a structurally-strong and stiff fuselage, but reduce the bending moments in the wings also. There is therefore a potential gain in structure weight as well as in drag, which must be offset against the fact that the tailplane, if we may call

it that, has a shorter moment arm and therefore has to be larger.

Delta or V Wings.—Even without boundary-layer suction there is a good case for the all-wing and tailless aircraft. In America, the controversy between that type of design and the high-aspect ratio wing with a long slender fuselage has been dubbed the "Big Wing" against the "Big Stick," and long-range bombers have been developed to both formulae. Both types of aircraft were designed for relatively low speeds. As the speeds of military aircraft have increased, the old controversy has died away and a new one has come to take its place. The new argument is between the different shapes of swept wings and the Big Wing and Big Stick appear now as the Delta wing (Fig. 8) and the swept-back or V wing as used on the Boeing B.47 (Fig. 9) and B.52 and on the Consolidated B.60. There are all sorts of considerations which lead to one choice or the other. What to do with the engines; where to put the fuel; what wing area is needed for landing or for manoeuvrability at operating altitudes; how heavy will the structure be and how is the wing going to distort or deflect at high speed? This last is one of the big problems of sweepback on high-speed aircraft because of its effects on stability and control.

Aero-Elastic Effects.—We have already seen how sweepback was first introduced as a means of providing longitudinal stability and control on tailless aircraft. The odd part of the story is that nowadays we are concerned by the ill effects of sweepback on stability, both longitudinal and lateral. It seems as if it had turned about and was now "kicking for the other side"; but still, if we keep a careful eye on its behaviour, it is very well

THE SHAPE OF WINGS TO COME.



FIG. 8. AIRCRAFT WITH DELTA WING : AVRO 707.

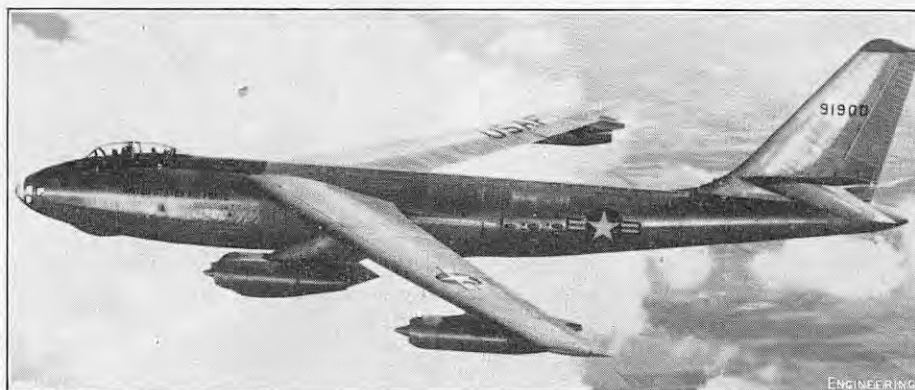


FIG. 9. AIRCRAFT WITH V-WING : BOEING B.47.

THE SHAPE OF WINGS TO COME.

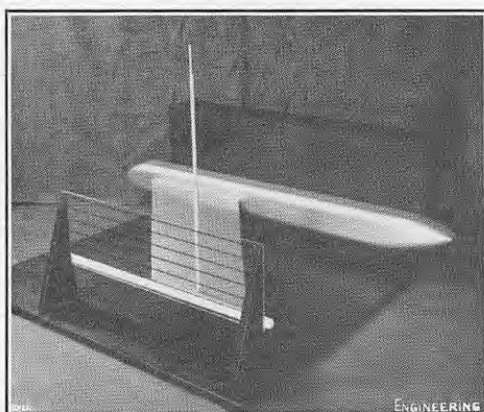


FIG. 10. UNDEFLECTED.

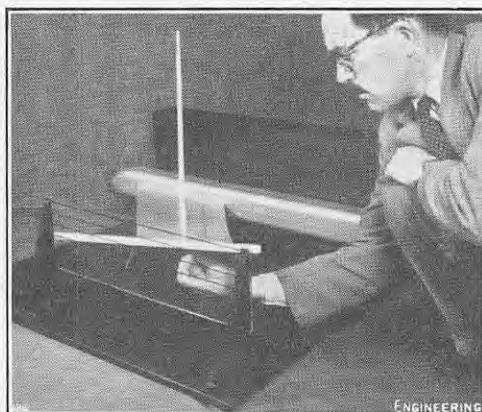


FIG. 11. UNTWISTED, BUT WITH LOSS OF INCIDENCE AT TIP.

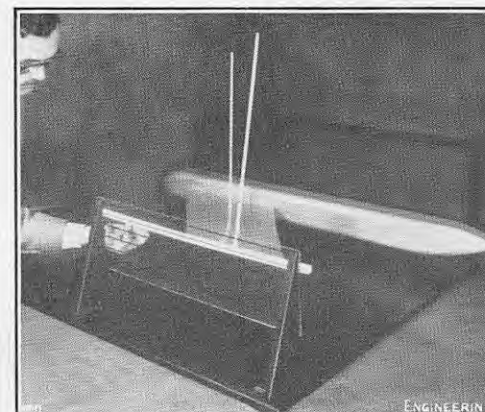


FIG. 12. NO LOSS OF INCIDENCE AT TIP, BUT WING IS TWISTED.

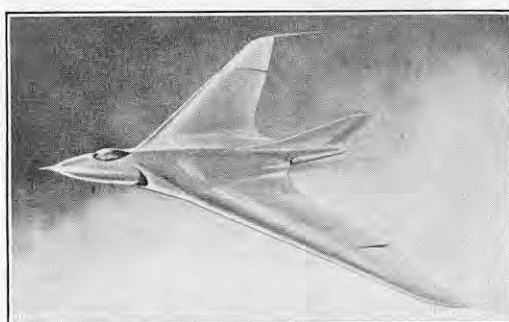


FIG. 13. AIRCRAFT WITH ROTATING WING-TIP CONTROLS.

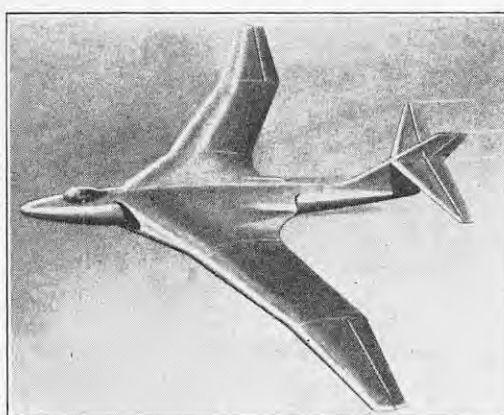


FIG. 14. CRESCENT WING.

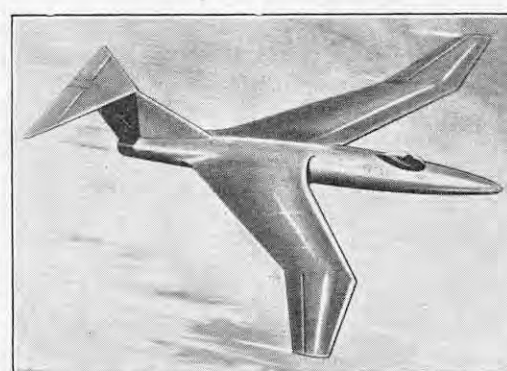


FIG. 15. SWEEP-FORWARD CRESCENT WING.

worth its place in the team for its high-speed qualities. The instability in its character shows itself in various ways, of which the most pernicious are aero-elastic effects, tip stalling and rolling moment due to sideslip. It is the aero-elastic effects, the aerodynamic effects of structural distortion in flight, which often have the biggest influence on the choice of wing-plan form. The fact that sweepback is employed to allow high-speed aircraft to fly at still higher speeds is, in itself, a fair indication that we are likely to meet severe aero-elastic problems, because at high speeds quite small distortions may give rise to large aerodynamic forces.

Aileron Reversal.—An example of the sort of problem which I have in mind is the designer's old bugbear of aileron reversal. Consider, say, the starboard wing of an aeroplane on which the aileron is deflected downwards with the intention of increasing the lift on that side and making the aircraft roll to port. On a perfectly rigid wing the resultant rolling moment would increase as the square of the speed, but in practice wings cannot be perfectly rigid and the behaviour is more complicated. The air loads due to the downward aileron produce a twist in the wing, up at the trailing edge and down at the nose, so that the wing loses incidence and loses lift and so produces a rolling moment which is in the opposite direction to that due to the aileron itself. The amount of the twist increases with speed because the air loads become greater in comparison with the elastic restraint of the wing structure. Finally, there comes a speed at which the rolling moment due to the twist equals that due to the aileron and the ailerons become totally ineffective. At still higher speeds the effect of the twist exceeds that due to the ailerons and the aircraft rolls in the opposite direction to that intended by the pilot.

The designer has to see that the "aileron-reversal speed" falls well outside the operating speed range of the aircraft and to do this he may have to make the wing much stiffer in torsion than would otherwise be necessary. Aileron reversal is a problem which was well known in the days of straight wings, but sweepback has made it a more subtle enemy. Not only must we now consider the stiffness of the wing in torsion, but also we must

see that the bending deflections do not cause a loss of aileron power. It is not immediately obvious why this should be, although it is really nothing more than simple geometry.

The best way to see it is by deflecting an actual model. Figs. 10, 11 and 12 show a model of a swept-back wing. The pointer at the tip shows the incidence of the wing in the line of flight. The two vertical rods show whether the wing is twisted along its span. In Fig. 10, the wing is undeflected and untwisted. In Fig. 11, a load applied centrally at the tip has deflected the wing while leaving it untwisted, but, as the pointer shows, there is a severe loss of incidence at the tip. This, in turn, means a loss of lift which opposes the intended effect of the aileron. This characteristic of swept-back wings may, as we have seen, produce a serious loss of aileron power but cannot, by itself, produce aileron reversal, because the effect dies away to nothing as the aileron power diminishes. Fig. 12 shows no loss of incidence at the tip, but the wing is twisted.

Washout Due to Flexure.—The loss of tip incidence which results from wing flexure has another very important effect on the handling qualities of swept-wing aircraft. Let us take the case of a pull-out from a high-speed dive. The pilot pulls the stick back so as to raise the nose of the aircraft and increase the incidence of the wing. He expects that, if he then holds the stick fixed, the aircraft will pull-out at a constant normal acceleration; that is, in a flight path with a constant radius of curvature. But let us see what happens. After he has pulled the stick back, it takes a moment before the aircraft attitude can change and the lift build up on the wing. When this happens the wings bend slightly upwards and, as we have seen, shed lift at the tips. On a swept-wing aircraft, the tips are well behind the centre of gravity and this loss of lift therefore means a nose-up change of trim, tending to make the aircraft tighten in to the manoeuvre. In other words, an increase in lift causes a further increase in lift; there is, therefore, a loss of stability which could have serious consequences on a highly swept wing of high aspect ratio. As we shall have occasion to refer to this effect

again, I shall call it "washout due to flexure," the term "washout" being in common usage to describe a reduction in incidence of the tip of a wing as compared with the root. Some washout is often built into a straight wing to improve the stalling behaviour.

The Aero-Isoclinic Wing.—If we return to the model of the swept-back wing and apply the load farther forward, it is obvious that we shall produce a nose-up twist which will counteract the washout due to flexure and, if we choose precisely the right point at which to apply the load, we can bend the wing with no change of incidence along the span. This is shown in Fig. 12. One way of doing this is to place the torsion box well back in the wing so that the air loads acting at about the quarter-chord line have a considerable moment arm about the torsion box. Even so, the torsional stiffness of the wing may have to be less than usual so as to get the right relationship between twist and flexure. Problems of aileron reversal then have to be faced and it is probably necessary to use either rotating wing-tip controls in place of conventional ailerons or else to use "spoilers" of some sort. My preference is for rotating wing-tip controls because, if used as elevators as well as ailerons, they offer a means of overcoming tip stalling by the simple expedient of increasing the washout as the wing incidence increases. They can also be expected to provide excellent control at high Mach numbers. This solution to the aero-elastic problems has been advocated by G. T. R. Hill, who calls it an "aero-isoclinic" wing to indicate that the incidence or inclination to the airflow remains constant along the span in spite of flexural distortion. Fig. 13 shows the possible appearance of such an aircraft with rotating wing-tip controls.

The Crescent Wing.—Another solution to the problem is to crank the wing tips forward from the rest of the wing so that the load on the tips is forward of the axis of the wing. This is the "crescent wing," which was pioneered by Arado in Germany and has since been developed by Handley Page in England and is shown in diagrammatic form in Fig. 14. It is quite an attractive solution because it also lessens the tendency to tip stalling by reducing the sweepback over the critical tip portion. There is neces-

THE SHAPE OF WINGS TO COME.



FIG. 16. GANNET IN FLIGHT.

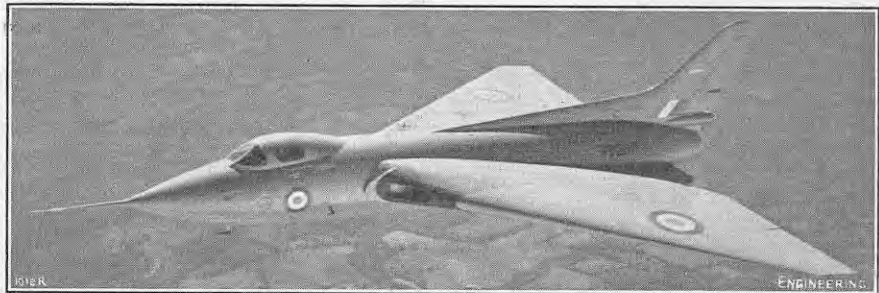


FIG. 17. AVRO 707.

Fig. 20. POSSIBLE PLAN-FORMS FOR SUPERSONIC AIRCRAFT.

Fig. 18. LARGE DELTA AIRCRAFT.

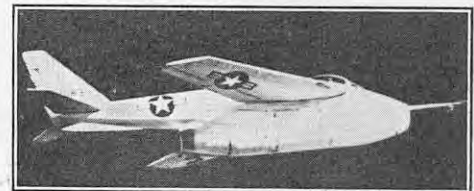
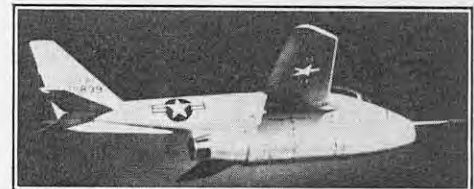
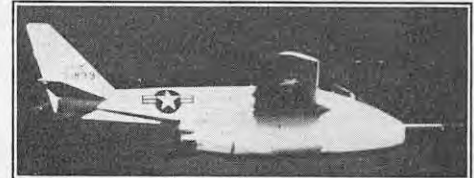
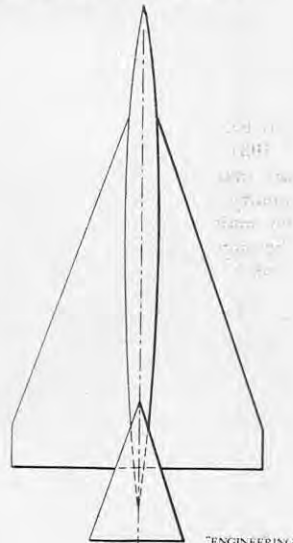
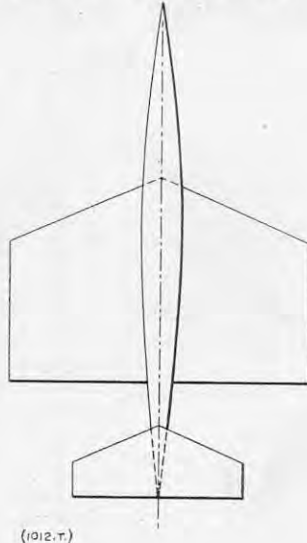
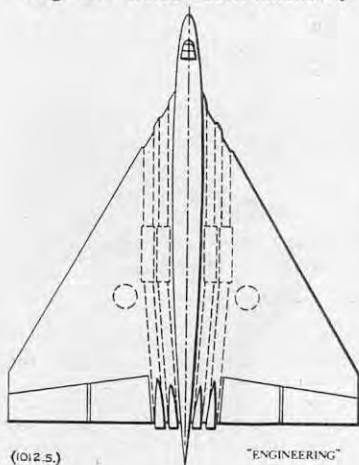


FIG. 21. BELL X-5, SHOWING SWEEPING OF WINGS IN FLIGHT.

Fig. 19. EFFECT OF SWEEPBACK ON DRAG.

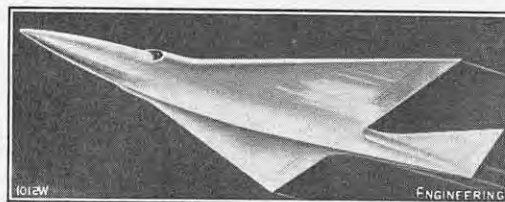
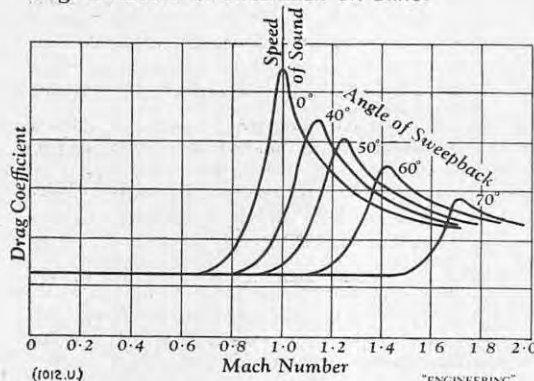


FIG. 22. PROPOSED SUPERSONIC FLYING BOAT.

what was a decrease in incidence is now an increase. At first sight it would appear that the increase in incidence forward of the centre of gravity would have the same effect on stability as a decrease in incidence aft. In fact, it is much more pernicious because the process tends to be self-energising; an increase in lift causes an increase in incidence which causes a further increase in lift which causes a further increase in incidence, etc., etc., and at some speed the wing will fail by having its "neck wrung," which is the phenomenon known as "wing divergence."

Now, on a swept-back wing, there is usually no danger of wing divergence because of the washout due to flexure. It is only when we try to correct the washout by using a crescent wing or some other artifice that wing divergence can possibly occur and then only if the correction is overdone—which it obviously must not be. With forward sweep we could also use a crescent wing, as shown in Fig. 15, so as to overcome wash-in due to flexure as well as wing divergence. In this case we must be careful not to under-correct, the penalty for over-correction being only an increase in stability.

It is perhaps surprising that no designer has yet, at least to my knowledge, tried this variant of the crescent wing. Taken a little farther, the idea leads to an M wing which has certainly been tried by Nature if not by man as this photograph of a gannet in flight, reproduced in Fig. 16*, bears witness. But we must remember that the gannet is not designed for trans-sonic speeds, so the reason for the sweep is not the same even though the aero-

* I am indebted to Mr. J. Barlee for the photograph from which Fig. 16 has been reproduced.

sarily some weight penalty on the structure due to the crank but it need not be much, particularly as the crank is fairly near the tip. Another slight disadvantage is that the tips have to be very thin in order to make up for the loss of sweep. The aero-isoclinic wing and the crescent wing enable the designer to use higher aspect ratios than would otherwise be possible, and they show to the greatest advantage when the design conditions are such as to demand high aspect ratios.

Forward Sweep.—The tendency to tip stalling of swept-back wings is a problem which the designer of every swept-wing aircraft has to face and do something about. One possible solution is to sweep the wings forward instead of back and so get the stall to start at the wing root. It would then be accompanied by the same unstable nose-up pitching moment which we get with swept-back wings, but would be free from the loss of aileron control and sudden wing drop which occurs when the tips stall first. It sounds quite an easy solution and has certain other advantages, including the opportunity for a long tail arm without a long fuselage. The objection is again that of aero-elasticity. Flexure of a swept-forward wing produces an increase in incidence at the tips in exactly the same way as flexure of a swept-back wing causes a decrease in incidence. It is easily visualised by thinking of our model of the swept-back wing and imagining it to be flying in the opposite direction;

elastic problems may be similar. As a matter of fact, I imagine that the M wing on the gannet is as much to facilitate wing folding as to overcome aero-elastic effects.

The Delta Wing.—On the evidence of the aircraft which are now flying, designers throughout the world are concentrating on sweepback to the complete exclusion of sweepforward. After our brief excursion we will therefore return to sweepback and to the problem of aileron reversal and wash-out due to flexure. The simplest solution of any is to make the wing really stiff by keeping the aspect ratio small. The Delta wing exemplified by the Avro 707 (Fig. 17) is the logical result and it offers very considerable structural advantage over other shapes. There is plenty of room to house a really satisfactory structure and to place the spars just where and how the designer wants them.

Subsidiary advantages are that the small aspect ratio has the property of reducing the effects of compressibility and of making the tendency to tip-stalling less severe; moreover, there is room in the wing to house the engines, fuel and undercarriage. Also, the cut-outs, which are necessary to allow the under-

carriage to retract, are not nearly so serious as on a narrow wing. On the Boeing B.47, with its very slender wing, it is interesting to see that the undercarriage is housed, tandem fashion, in the fuselage and the engines are slung externally on struts below the wing. How much neater to tuck everything tidily away inside the wing and keep the fuselage as small as possible! But, in spite of that and for all its virtues, the Delta wing is not the answer to all our troubles. Strut-mounted engines may look untidy, but they are the favourites of the maintenance engineers. The crews of combat aircraft may also be partial to them on the grounds that the consequences of an engine fire are less serious. Engines buried in a Delta wing may present a beautifully clean installation, but the jet pipes and/or the intake ducts are undesirably long, especially when the aircraft is large, and there must be some weight penalty and loss of efficiency as a result (see Fig. 18).

What is more important, however, is that, when altitude requirements demand a wide span, the wing area of a Delta becomes unnecessarily large and it has to be paid for in the most precious of aeronautical currency, namely, drag and weight. The weight saving on the basic structure can easily be nullified by the weight of the skin sheeting to cover so large an area plus the weight of the large chordwise ribs and, most serious of all, the weight of fuel burnt in overcoming the skin-friction drag of the additional wing area. The conclusion which can be drawn is that there is a strong case for the Delta wing in the smaller sizes and especially when the sweepback is 60 deg. or more. On very large aircraft of, say, 200,000 lb. and upwards, the Delta becomes uneconomical and a V wing, probably with strut-mounted engines, is then the obvious choice. At intermediate sizes around 100,000 lb. the choice is not so simple and the best solution may be a V wing with engines buried in the wing roots, which can be enlarged if necessary, as on the Valiant.

Supersonic Shapes.—The drag coefficient of an aircraft wing is almost constant at subsonic speeds, but peaks up to a very much higher value at transonic speeds and then settles down again to an intermediate value at supersonic speeds. The precise values are not easily obtained, because the ordinary wind-tunnel techniques break down at transonic speeds. The effect of sweepback, as we have already seen, is both to reduce the drag rise and to delay it to higher speeds. Fig. 19 shows the sort of pattern we get for wings of various angles of sweep. As an example, let us take a Mach number of 1.6 and we see that the wing with the lowest drag is that with the greatest sweep, but that the next lowest is a straight wing.

For very high speeds, where the degree of sweep required would be impracticable, it may therefore be better to have no sweep at all. Put another way, we must either have enough sweep to delay the compressibility troubles to speeds beyond the range in which we are operating or else we can hurry on the troubles by using no sweep at all, so that all is well again at the operating speeds. What we must not do is to fly in the troubled region of mixed subsonic and supersonic flow. If we favour the straight wing we must make it very thin, because the wing will then be working in pure supersonic flow where the drag penalty for thickness is great. It seems that before long we shall be forced to use thickness: chord ratios as low as 3 per cent. or 4 per cent., and the wing will therefore have to be of small aspect ratio in order to be sufficiently stiff and strong. I imagine that it will be worth while to provide just sufficient sweepback to overcome any tendency to wing divergence. We therefore arrive at the two alternative plan forms shown in Fig. 20. Of the two solutions, the one using acute sweepback is theoretically preferable. There is always the possibility of wanting to fly at lower speeds when climbing, manoeuvring or if damaged in combat, and it is well not to have to worry about forbidden speeds at which the drag is high and there are uncomfortable trim changes.

The Landing Problem.—One of the big problems will be to get such highly swept wings to give adequate lift at low speeds. There are also likely to be some difficulties with longitudinal and lateral stability. It has been said that the hardest part of designing a supersonic aircraft will be to make it

fly slowly, and it is probably true if the designer allows very little compromise with high-speed performance. Take-off may present a problem, but the thrust necessary to fly at very high speeds is likely to be adequate for unassisted take-off unless the wing lift is very poor or the wing loading is very high. If it is not good enough, the take-off can always be assisted by catapulting or by quick-burning rockets. If even these are not sufficient, we can return to the principle of air-launching from a parent aircraft, in the manner that was pioneered by Short Brothers at Rochester and has subsequently been used for supersonic research aircraft in America. The real problem is likely to be in landing, where these aids cannot so readily be used.

Here then is a challenge—all sorts of mad ideas come to mind. Should we "unsweep" the wings for landing as on the experimental Bell X-5, shown in Fig. 21, in which the wings are pivoted about a vertical hinge at the root so that the angle of sweep can be varied in flight? It may be the answer, although it is bound to introduce a penalty in weight and possibly in drag too, but it can be done, as proved by the Bell X-5 and by the Westland-Hill Pterodactyl Mark IV, which flew as long ago as 1931. Birds often use this technique, but Nature can make moving joints with much less weight penalty than we can and without having to consider the maintenance aspect in quite the same way. The engine thrust to achieve the supersonic speeds must be at least comparable with the weight of the aircraft, so we might possibly swivel the engines round to give lift instead of propulsive thrust. It sounds a bit complicated and the control problems are sure to be very involved.

Perhaps the best way out of this difficulty is to avoid it altogether, which we could do if we arranged for the high-speed aircraft to link up with a parent aircraft in flight, using a technique similar to flight refuelling. This is not a very happy idea, as we must be absolutely sure that the parent never goes unserviceable while its chicks are on a mission and, moreover, that it never falls a victim to enemy attack. We might even consider stopping the aircraft in flight by air brakes and forward-firing rockets and then letting it down on parachutes or by a retractable rotor as a helicopter. It is obviously impossible to do the helicopter scheme without fantastic complication, and the parachute would be much too bulky to stow without severe drag penalty. We may then be forced to put up with the high landing speeds by using arrestor gear. This, at least, is a practical suggestion, but it would involve great cost in runways and arrestor gear.

Alternatively, we might put up with the high landing speeds if we make the aircraft into a flying boat and alight on water. Ernest Stout has suggested an aircraft of this type which appears to have very little more drag than an equivalent landplane, and the water will certainly provide the necessary braking force smoothly and effectively. Fig. 22 shows how such an aircraft might look, and we may be able to improve upon it still farther by the use of hydro-skis instead of the planing bottom. It is one of my ideas of "the shape of wings to come," but, in spite of my faith in the future of water-based aircraft, I believe that there will always be a need for landplanes and an alternative solution applicable to landplanes will have to be found.

Atomic Power.—Our discussion so far has been about the foreseeable developments of fixed-wing aircraft, using the types of propulsion which are already familiar to us. We have not even considered helicopters or guided missiles. Just round the corner are much more exciting things, like space ships, artificial satellites and atomic-powered air liners. It is very tempting to plunge into speculation as to the shape of these future craft, but it is doubtful whether there is any value in doing so until our knowledge is on firm enough foundations to support the structure of a logical argument.

The atomic-powered air liner might be a possibility to-day, but it would have to be extremely large and would probably be uneconomical on account of the enormous weight of the screening necessary round the reactor unit. We could argue from that single premise that the aircraft ought to be a flying boat because of the high landing weight which, on a landplane, would mean a heavy under-

carriage and the need for airfields with exceptionally long runways capable of taking very heavy loads. All of this is an expense which the taxpayer would be glad to dodge. The reactor unit and engine would be in the hull of the boat and the passengers would have to be housed in the wing or in the wing-tip floats.

We could now prepare a sketch of the atomic-powered flying boat, but it would not be altogether convincing because it would strike us as old-fashioned. We have, indeed, been applying the old arts of aircraft design to a new form of propulsion, whereas a much more radical approach is needed. The jet fighters of to-day are not the Spitfires or Hurricanes of yesterday with new engines in them, but are of new shapes to suit the new conditions. What shape the atomic-powered aircraft will be is a subject deserving much thought when we know enough about the characteristics of the engine. Will the engine really weigh so much or shall we again find that what we thought was fundamental is no more than a passing phase? Somehow, it seems unlikely that the atomic-powered aircraft will look old-fashioned. It will come as a challenge and a stimulus to new research in structures and aerodynamics, but this time Britain must lead and not wait to pick up the threads from a narrowly-defeated enemy. There must therefore be a close understanding between the atomic research establishments and the aircraft industry. Unnecessary secrecy will deprive the country of the chance to lead in the atomic age.

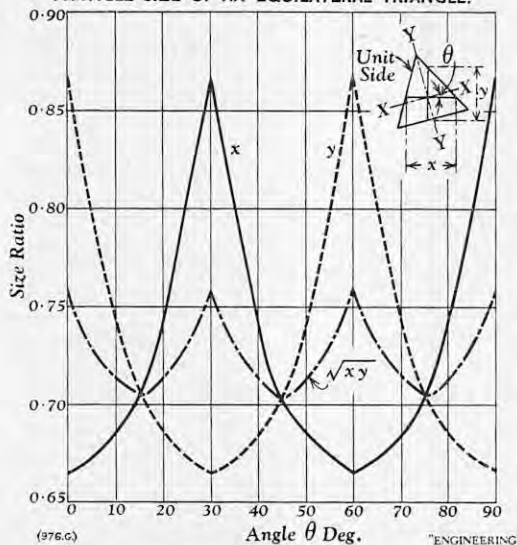
BERTHING OF WARSHIPS IN RESERVE.—The Admiralty announce that, to economise in money and naval manpower, and to improve the efficiency of the Reserve Fleet, a number of H.M. ships, at present moored in the upper reaches of naval harbours, are to be transferred to commercial ports under arrangements made with the Docks and Inland Waterways Executive, and maintained mainly by civilian labour through the agency of local firms. The ports which will be used first are Cardiff, Penarth and West Hartlepool. The new arrangement will release for other duties a number of naval officers and men at present employed on "care and maintenance" duties.

CONFERENCE ON INDUSTRIAL BOILER PLANT OPERATION AND MAINTENANCE.—The Combustion Engineering Association have arranged to hold a conference on "The Operation and Maintenance of Industrial Boiler Plant" at the Grand Hotel, Harrogate, on Tuesday and Wednesday, October 21 and 22, 1952. The Conference will cover shell and water-tube boilers using solid, liquid and gaseous fuels. The titles of the sessions will be: "The Boiler Plant—Its Control and Maintenance," "The Men in the Boiler House," "The Utilisation of Waste Heat," and "Firing." Further information may be obtained from the director, Combustion Engineering Association, 6, Duke-street, St. James's, London, S.W.1.

INDUSTRIAL ACCIDENTS.—Descriptions of accidents which have been notified to H.M. Inspectors of Factories, and suggestions for preventing such accidents, are given in a quarterly periodical, published for the Factory Department of the Ministry of Labour and National Service by H.M. Stationery Office, Kingsway, London, W.C.2, and entitled *Accidents: How They Happen and How to Prevent Them*. The July, 1952, issue, published on September 1, contains notes on 29 accidents. These include fatalities and accidents caused by celluloid, cranes and lifting gear, personal safety equipment, electrical apparatus, molten metal, bad lighting, woodworking machinery, and the careless starting of a motor car. The yearly subscription, including postage, is 3s. 6d. and the price of a single issue 9d. net.

ROAD GOODS VEHICLES.—According to the "Summary of the Annual Reports of the Licensing Authorities for Goods Vehicles for 1950-51," there were over 912,000 road goods vehicles with carriers' licences at the end of 1951. This number, which did not include nationalised road goods vehicles, comprised 103,000 vehicles operating under "A" or "B" licences, some 13,000 working under contract "A" licences, and 796,000 in possession of "C" licences. It is recorded that the standard of maintenance of goods vehicles did not show any appreciable improvement during the period covered by the reports and this is attributed, in part, to the difficulty of obtaining new vehicles. Other contributory causes were the increased cost of maintenance and repair, and the lack of garage facilities. Copies can be obtained from H.M. Stationery Office, Kingsway, London, W.C.2, price 2s. net.

Fig. 6. GRAPH SHOWING VARIATION IN $\sqrt{xy}$ AGAINST VARIATION IN x AND y FOR THE MEAN PARTICLE SIZE OF AN EQUILATERAL TRIANGLE.



SOME RECENT DEVELOPMENTS IN CONCRETE TECHNOLOGY.*

By D. A. STEWART, A.M.I.C.E.

(Concluded from page 315.)

WHEN a very large number of particles have to be examined and their projected areas found, the process becomes somewhat tedious and a more convenient device has to be adopted. This is to determine the "statistical diameter," which is found by measuring the width of the particle along a line bisecting it at right angles to the plane of view, i.e., the plan view. Thus, if a large number of particles are measured in this way as they lie at random on a plane surface, the mean dimension derived can be considered as the statistical diameter of the group determined from a sample. The accuracy will depend upon the number of particles measured. It has been found by experiment that a more accurate value of the statistical diameter can be found by measuring the particle in two directions at right angles to each other, so that each line of measurement bisects the particular particle considered. The two dimensions are then multiplied together and the square-root of the quotient used as a value determining the statistical diameter. Fig. 6 shows the variation arising in measuring an identical particle by the two methods.

In calculations relating to concrete-mix design we are chiefly concerned with the coarse aggregate, because only in this material is it possible to exert any effective grading control. As a rule, the fine aggregate has to be accepted as produced since the expense of a full grading plant would be excessive and, in the bulk of present-day concreting work, quite unjustified. The determination of a suitable maximum size of aggregate would, therefore, appear to depend upon the mean size of the sand particles lying between the two adjacent upper-limit fine aggregate screens, as used in making a mechanical analysis. Other factors, however, also demand the engineer's consideration, since the maximum and mean sizes of the coarse aggregate are clearly influenced by such considerations as the space between shuttering, and the size, distribution and cover of reinforcement. There is no great difficulty in seeing why the thickness of a beam or wall should have a decisive bearing upon the maximum size of aggregate. Clearly, the size of the coarsest particles must not be so great as to preclude them from entering the formwork; moreover, once in, sufficient space must be available to them for manoeuvre so that the relative position of each particle to the other can be adjusted to break down arching and induce an improved packing arrangement.

Fig. 7.

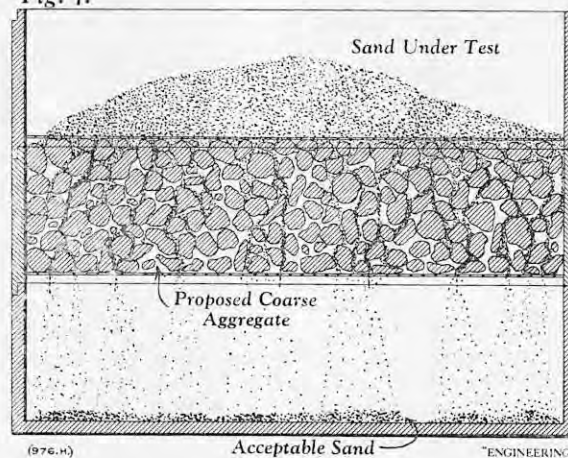


Fig. 9. RATIONAL DESIGN.

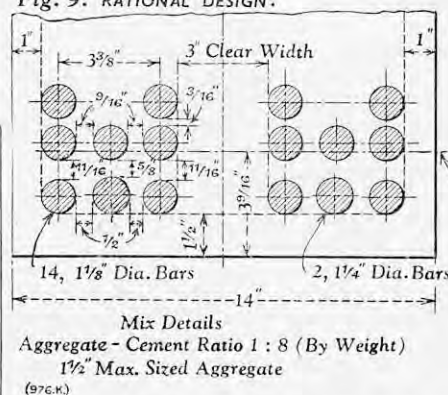


Fig. 8.

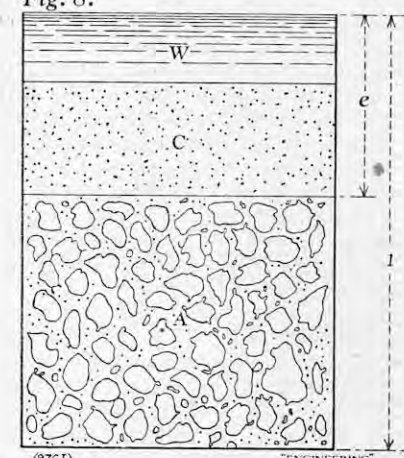
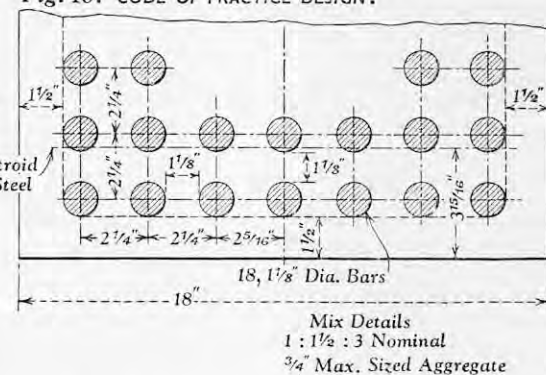


Fig. 10. CODE OF PRACTICE DESIGN.



In theory, the maximum particle is not as important in this connection as the predominant size of the coarsest material; that is, the size of particle having the greatest value for the summation of equivalent spherical diameters divided by the number of particles in question. In practice, a special mechanical analysis may be made, using intermediate sieve sizes and weighing or counting the residues on each sieve. For instance, in the case of $1\frac{1}{2}$ in. to $\frac{3}{8}$ in. material, a representative sample may be divided up on $1\frac{1}{8}$ in., $1\frac{1}{4}$ in., $1\frac{1}{2}$ in., $1\frac{3}{4}$ in. and $2\frac{1}{4}$ in. sieves. Such an analysis, when plotted against either percentage weight or volume of the intermediate size groups, will allow a computation to be made of the mean particle diameter, and this linear dimension may be used for determining the suitability of the aggregate in respect of the formwork spacing; and, if suitable, other statistical data, such as surface area and specific surface, volume of unit statistical void and hence size and quantity of filler, may be derived from it by appropriate measurements. As a rough but satisfactory practical check on the upper grading limit, the space between shutter faces may be divided by 6 and the resulting dimension taken as a measure of the screen size through which 95 per cent. of the coarse aggregate must pass. The method of fixing the maximum-sized aggregate just described applies whether the mix is to be of continuous or gap grading, but where the latter type of grading is to be used, two further problems of size remain to be solved before a preliminary mix design can be made. The first relates to the volume, size and distribution of the reinforcement, and the second to the mean size of the combined grading; this latter gives a measure of the specific surface of the mix and hence the "workability."

There are a number of important points connected with reinforcement and aggregate sizes which many have failed to appreciate in the past, but which have a marked effect upon the structural design as well as the design of the mix. The Code of Practice recommendation is that the spacing of the bars should be at least $\frac{1}{4}$ in. greater than the nominal maximum aggregate screen dimension. The assumption here is that all the aggregates should be able to pass into and through the reinforcing zone. However, an examination of any continuous grading will

show the following conditions to exist. (1) 95-100 per cent. of the coarse material usually pass the coarsest screen, therefore all or nearly all the coarse aggregate must be less than the nominal size; (2) the mean size of the coarse material on a basis of weight must be considerably less than the maximum aggregate size; (3) in passing through the grading screens, the aggregates are restrained in two dimensions, i.e., they possess one degree of freedom only, whereas in filtering into the reinforcement, they possess two degrees of freedom. Hence the effective size of coarse aggregate that can be passed by bars set at 1 in. spacing may be as great as $1\frac{1}{2}$ in. nominal screening size, i.e., the particles may measure 2 in. $\times$ $1\frac{1}{8}$ in. $\times$ $\frac{7}{8}$ in. It is evident that, in relating the size of coarse material to the bar spacing in a reinforced-concrete member, the size to be considered is the mean size. The term "mean size" requires some further definition, since in any grading curve there are several mean sizes. The mean size may refer to a mean value based on weight, surface area, linear diameter, or upon the number of particles. Thus, an aggregate graded from $1\frac{1}{2}$ in. to $\frac{3}{8}$ in. might have 50 per cent. $-1\frac{1}{2}$ in. $+\frac{3}{8}$ in., 25 per cent. $-\frac{3}{8}$ in. $+\frac{3}{8}$ in., and 25 per cent. $-\frac{3}{8}$ in. $+\frac{3}{8}$ in.; in which case, the mean sizes would be 0.75 in. when based on weight; 0.367 in.

when based on surface area $\left(\sqrt{\frac{\sum x^2 dN}{\sum dN}}\right)$; 0.306 in.

when based on linear diameter $\left(\frac{\sum x dN}{\sum dN}\right)$; and between $\frac{3}{8}$ in. and $\frac{1}{2}$ in. when based on a number of particles.

In fixing the mean size of aggregate with reference to the reinforcement of a member, it is the volume distribution that is of importance and hence the weight of material on either side of the mean must balance; therefore, in the grading curve just discussed, the mean aggregate size would be $\frac{3}{8}$ in. In practice, however, owing to the tolerance permitted by B.S. 882, there exists a declination of sizes from the largest to the smallest within any size group, and the actual mean size would approximate more closely to $\frac{1}{2}$ in. We have now two points on our grading curve for the coarse aggregate, the upper limit being decided by the space available between opposite shutters in the formwork and the

* Paper read before Section G of the British Association at Belfast on Thursday, September 4, 1952.

mean size by consideration of reinforcement spacing and density. From these data it is possible to construct a preliminary grading curve and to carry out bulk density and other tests with locally available aggregate which has been screened out and re-combined so as to fit the curve. The question of sand now arises: this has to act as a filler for the coarse material and must be able to filter into the voids therein when the coarse particles are closed up or are in process of closing up. The maximum size of the sand or fine aggregate is, therefore, the admittance size mentioned earlier in this paper. In practice, this size will be found to be $0.125D$, where D is the diameter of the maximum particle size when a gap grading is used, but this would be too coarse in the case of a continuously-graded aggregate. One method of determining whether a sand is suitable or not is to sieve it through four or five layers of tightly-packed coarse aggregate, held between two nesting $\frac{3}{8}$ -in. sieves. This method is illustrated in Fig. 7. The sand should always be as coarse as possible, while still complying with the conditions stated above; consequently, where the coarse aggregates have a maximum size of $\frac{3}{4}$ in. and over, sand having more than 2 or 3 per cent. passing the No. 100 sieve should be avoided, as otherwise the demand for water will be increased unnecessarily in attaining a particular value of "workability."

The coarse and fine aggregates having been selected and tested in regard to their physical and chemical characteristics, the engineer may proceed to design his mix to meet the mixing and placing conditions. His mix design should be based on the assumption that the concrete will be fully compacted and hence unit volume of concrete may be depicted thus. Consider a vessel, Fig. 8, the volume of which is to be regarded as unity, filled, under gentle vibration, with combined coarse and fine aggregate, the upper surface of which is just level with the top edge of the container. Imagine these aggregates reduced to a liquid state so that they collapse, getting rid of all the contained air voids and filling that portion of the container marked A. The space represented by the depth e , divided by the volume of the container 1, gives a value called the Void Ratio. For a fully-compacted concrete which will not develop segregation, this space must be occupied by cement paste, the cement and water being mixed in the appropriate proportions to give a required strength.

For the purpose of our analysis, consider the cement to be melted down to the voidless volume C , in the diagram; then, the liquid part of the paste occupies the space W . Now we have all the ingredients of the concrete separate, but fully compacted—the condition the concrete will attain under the influence of vibration. AC and W are absolute volumes. Let the specific gravity of the three ingredients be as follows:

d_a = mean specific gravity of the combined aggregates (sand and stone);

d_c = specific gravity of the cement;

d_w = specific gravity of the water, usually taken as 1.

The bulk density of the combined aggregates can now be expressed as

$$\frac{(1 - e)d_a}{1} = \frac{A d_a}{A + C + W} \quad (1)$$

Since this is the bulk density of unit volume of material, it will be referred to as the specific bulk density (Sp. B.D.).

Specific Bulk Density.—In designing a mix we have to consider three aspects of the matter and these can be set out as follows and then combined in equation (1):

$y = \frac{A}{C}$ ratio, on which depends the cost of the mix;

$x = \frac{W}{C}$ ratio, on which largely depends the strength of the cured concrete.

y may be expressed as $\frac{A d_a}{C d_c}$ or $A d_a = y C d_c$;

x may be expressed as $\frac{W x l}{C d_c}$ or $W = C d_c$.

The equation for the Sp.B.D. can be written in the form:

$$\text{Sp. B.D.} = \frac{C d_c y}{d_a} + \frac{C d_c}{d_c} + \frac{x C d_c}{1} \quad (2)$$

$$= \frac{C d_c}{d_c} \left(\frac{y}{d_a} + \frac{1}{d_c} + x \right)$$

and

$$\frac{y}{d_a} + \frac{1}{d_c} + x \quad (3)$$

The theoretical quantities calculated by this method require some adjustment in the field because of loss of sand in the mixer and loss of mortar through joints in the shuttering during placing, where vibration is used. The additional quantity of sand which it will be necessary to add must depend upon the mixer performance and on the accuracy and firmness of the shuttering. As a rule, an increase of 10 to 15 per cent. on the calculated sand content is adequate. Thus, if the theoretical quantity of sand is 25 per cent. of the combined aggregates, the actual mix should be worked out on a basis of 27 per cent.

Effect of Reinforcement.—The presence of an appreciable percentage of reinforcement has an interesting effect upon the design of the mix. Where the bars are closely spaced, as they may be when vibration is used, the volume of the bars must be considered as coarse aggregate. As can be seen in Figs. 9 and 10, the close spacing of the bars precludes the coarse gap-graded aggregate from entering an area roughly bounded by the perimeter of either bar group; so it is evident that the volume of coarse aggregate must be reduced by the volume occupied by the bars. The fine aggregate therefore increases as a percentage of the combined aggregates in the mix as delivered from the mixer. The following example will illustrate this particular design consideration.

Suppose that the mix, as determined from the known characteristics of the aggregates, the required crushing strength and aggregate: cement ratio is 112 lb. cement, 220 lb. sand, and 580 lb. stone (dry weights). This mix is to be compacted into a beam of 30 in. depth and 14 in. width having three layers of three $1\frac{1}{2}$ -in. diameter bars in two groups, making 18 bars in all. The steel represents 4.25 per cent. by volume of the bulk space occupied by the coarse aggregate and that material will have to be reduced by this amount.

The mix, therefore, will have the following quantities: 112 lb. cement, 220 lb. sand, and 552 lb. stone. It should be noted that this variation from the original mix design quantities is required only when the reinforcement is grouped so as to preclude the free assembly of the coarse aggregates in the reinforced zone; it does not apply to single layers of bars, since the effect then is as if part of the concrete had been boxed out or displaced by part of the formwork.

Where vibration is employed, advantage should be taken of the appreciable reduction produced in the viscosity of the concrete, enabling it to flow into restricted areas which it would fail to fill if any other method of placing were used. Because of this augmented flow it becomes sound and economic practice to group the bars in the manner illustrated in Figs. 11, 12 and 13. This close grouping allows an appreciable reduction in the overall width of a beam, with a consequent and worthwhile reduction in the dead load of the members. The grouping must be done in such a manner as to permit of the entry of the vibrator into the reinforced zone so that the concrete can be well compacted, thus ensuring a sound bond with the reinforcement. The space provided for the vibrator also serves as a filling space at points where the member is reinforced in its upper parts. In normal reinforcing practice, where top reinforcement is required the concrete has to be infiltrated through the bars. This has the disadvantage of limiting the maximum size of aggregate quite unnecessarily, while preventing the use of an internal vibrator of adequate size.

The introduction of vibration as a means of placing is beginning to have a profound effect upon almost

every aspect of concreting. In the past, the degree of compaction likely to be attained on any job could never be assumed to be constant, nor could a definite value be set upon it in terms of mass per cubic foot; hence, since the percentage of voids present in any concrete has a most important bearing upon its strength and other qualities, no great reliance could be placed upon the finished product, resulting in the use of an undesirably large factor of safety. The correct and adequate use of vibration has greatly reduced the variations in packing that can arise in concrete as placed and thus it has become possible to design a mix so as to possess certain characteristics, both during placing and after curing. The success of a concrete designed for and placed by vibration depends upon two requirements common to all concretes, namely, the provision of raw materials of uniform characteristics and quality, and the combination of these materials in the correct proportion to form a homogeneous mix. Primarily, these conditions can be fulfilled only if suitable plant is available and operated with considerable technical skill. Unfortunately, as regards aggregates many plants are overworked and under-maintained so that, in spite of the wide tolerance permitted by B.S. 882, grading control is almost impossible. Furthermore, many suppliers do not appreciate the importance to the concrete engineer of maintaining their materials at constant values of grading and bulk density. It should be noted that constant grading in itself is not enough to cover an aggregate specification, as a change in particle shape will entirely alter the filler required at a particular water: cement ratio and aggregate: cement ratio. In the same way, the bulk density alone cannot fix the particle sizes and therefore the admittance size of the filler or fine aggregate will be indeterminate.

As the mechanisation of concreting increases, the demand for more precisely controlled raw materials will increase also. It may not be realised that a closely controlled aggregate is worth more money to the contractor, working to a modern specification, than an ill-controlled material, because the difference between the minimum required strength and the average strength can be reduced appreciably where a closely controlled aggregate is used. Thus, if the minimum strength requirement at 28 days is 3,000 lb. per square inch, the contractor using a variable grading may well have to aim at an average strength of 5,000 lb. per square inch employing a 6.5:1 aggregate: cement ratio to attain it, whereas, with a closely controlled gap-graded aggregate, the mean strength need not exceed 4,200 lb. per square inch; a reduction of 16 per cent., which can be attained with vibration placing and a 9.5:1 mix. The difference in cement content per cubic yard of these two concretes is 151 lb.

Cements, too, could be improved in regard to uniformity of performance. At present, cement drawn from a single works varies appreciably from batch to batch and this variation is accentuated when cement is delivered to a contract from two or more works. In these circumstances, variations have been put as high as 40 per cent. However, the reduction in cement variations can be achieved only if running costs are increased and further capital expenditure is undertaken, and, until the variations due to poor grading control and indifferent mixing and placing are overcome, such expenditure is not justified.

The combination of the concreting materials in the mixer, and the delivery from the mixer of these materials in a uniformly mingled state, is one of the major problems and anxieties of the concrete technologist. Some mixers give a better performance than others in regard to a particular type of mix, but most mixers produce a disconcerting degree of segregation when dealing with concretes which are suitable for vibration placing. Where the harsh mixes of low water content, that are particularly suited to vibration placing and the production of high-quality concrete, are concerned, many mixers have the unfortunate habit of retaining the fine aggregate within the mixer at the time of discharge, thus robbing the concrete of a large part of the filler. This loss of filler can be overcome to some extent by adding extra sand, as described earlier in the paper, but there is a danger of intermittent over-sanding taking place when the fines in the drum of

VIBRATED CONCRETE.

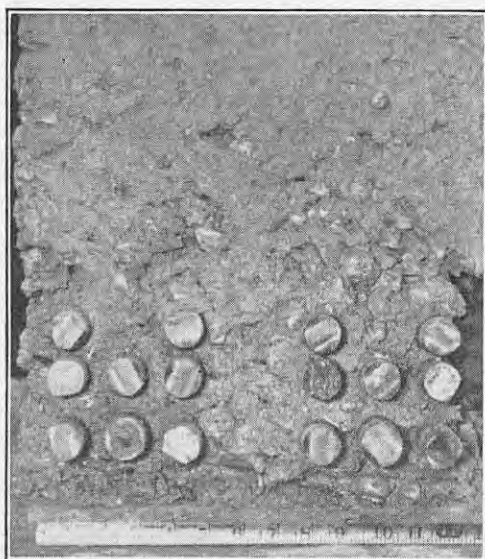


FIG. 11. END OF BEAM, SHOWING PENETRATION OF CONCRETE INTO REINFORCEMENT.

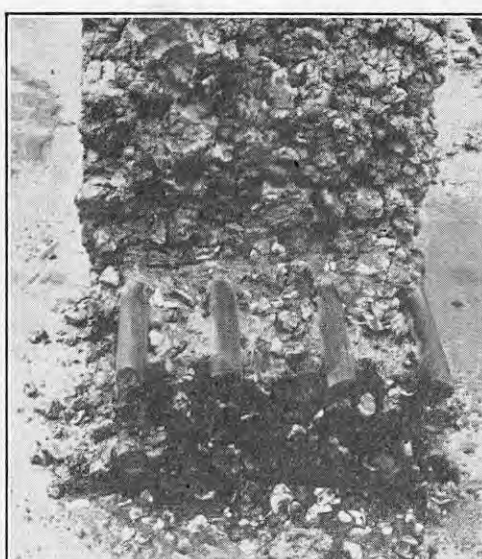


FIG. 12. GREEN CONCRETE OF BEAM BROKEN AWAY TO SHOW BARS.



FIG. 13. SHOWING DENSE PACKING OF CONCRETE ABOUT BARS.

the mixer build up beyond the point where they can be retained. When this condition is reached much of the sand which has been held in the drum for two or three mixes is discharged at a single emptying, resulting in a marked change in the behaviour of the concrete under the influence of the vibrator.

One of the big advantages offered by vibration is the immediate stripping of formwork in either precast or cast *in situ* work. In the case of *in situ* work, which is perhaps the most important, lifts of up to 12 ft. can be placed and immediately stripped which allows the concrete surface to be treated in the green state by trowelling for fair face work, and by scoring where a render and set finish is required. Furthermore, the damage to shutters that are stripped from green concrete is far less than would occur with set concrete, particularly as the working faces of the forms require only hosing and brushing down to make them ready for the next lift.

It is hoped that a further advantage may arise from work that is proceeding at present; that is, elimination of tanking in basements and other structures designed to resist the ingress of water. It has always been possible to make effective water-retaining structures from concrete by the use of rather rich mixes and, in certain instances, the addition of one or other of the well known proprietary brands of sealing agents. However, the danger of the formation of shrinkage cracks, with a resulting seepage, was always present and where, as in the case of a basement, one of the concrete surfaces could not be examined and treated in the event of failure without a considerable amount of excavation, such a risk was not worth taking. The use of vibration in compacting carefully designed mixes, proportioned in such a way as to reduce overall shrinkage to a minimum while at the same time developing a high density, has made it possible to do without asphalt tanking in certain instances, and thus greatly reduce construction cost. As a rule, the mixes employed in this work are leaner than those generally found in reinforced concrete, which in itself reduces the cost of materials. The major saving, however, is due to the reduced excavation costs and the elimination of the asphalt and its protective covering. When vibration is correctly applied it is possible to reduce the frequency of construction joints, not only in road slabs but in other structural works. Where these joints are necessary the cost of their preparation for connection to new work can be reduced appreciably because, with correct mix design, no hacking is required; the only preliminary necessary to the addition of new concrete is hosing down to remove any deleterious matter covering the surface of the hardened concrete.

The development of prestressed concrete has focused the attention of structural engineers upon

high-strength concrete and at the same time brought to notice two characteristics possessed by most concretes, but which have not been included in design calculations in the past. Both shrinkage and creep are of great importance in prestressed design and account for an increased high-tensile steel consumption of from 10 to 15 per cent. It is generally accepted that these two phenomena are associated with the cement paste, that is, with the quantity of water and cement contained in the mix. Recent developments have shown that, by careful mix design and the compaction of the concrete by vibration, strengths normally obtained with aggregate: cement ratios of 5:1 by weight can be attained with concrete as lean as 7:1. These not only contain less cement but less water, and consequently may be expected to develop lower values of shrinkage and creep. It is believed that a gap-graded concrete, having the same proportions as one continuously graded, will shrink and creep less than the continuously graded concrete because, in the former, the coarse aggregates are brought into intimate contact, thus forming a rigid skeleton which cannot shorten with loss of moisture and in which the creep is confined to a large extent to the plastic deformation associated with the rock from which the coarse material is derived.

In conclusion, the author would like to stress the very great need that exists to-day for qualified concrete technologists and certain classes of skilled operatives if the fullest advantage is to be taken of a very valuable engineering material. There is also, as always, the urgent need of laboratory and field research and development, both in regard to concrete itself and to the plant connected with its production.

POST-GRADUATE STUDIES IN TECHNOLOGY, ECONOMICS AND ADMINISTRATION.—A pamphlet recently issued by the Imperial College of Science and Technology and the London School of Economics and Political Science contains information respecting the joint arrangements made by the two schools to enable post-graduate students in technology, economics and administration to take advantage of the combined facilities which these bodies provide. Post-graduate research students accepted by either school will receive guidance and help from both in appropriate cases. Where such a course is deemed advisable, students will be placed under two supervisors, one at each college. Brief reference is made to the post-graduate maintenance grants offered by the Department of Scientific and Industrial Research. Copies of the pamphlet, for which there is no charge, and additional information regarding the joint arrangements for post-graduate research may be obtained from the registrar, Imperial College of Science and Technology, Prince Consort-road, London, S.W.7, or the registrar, London School of Economics and Political Science, Houghton-street, London, W.C.2.

THE ETHICAL DILEMMA OF SCIENCE.*

By PROFESSOR A.V. HILL, C.H., O.B.E., F.R.S.
(Concluded from page 311.)

MUCH scientific and technical advance has led to unexpected dangers and difficulties. Without our present knowledge of bacteriology and preventive medicine, gigantic armies could never be kept in the field, and land war on the recent scale would be impossible: is medical science, therefore, to be blamed for Twentieth-Century war? The indiscriminate use of insecticides, by upsetting the balance of Nature, can quickly do more harm than good. Radio communication may be used for spreading lies and disorder as well as truth and goodwill. Developments in microbiology, in many ways beneficent, may be used in the future for biological warfare, with effects at present unpredictable; and control by international agreement and inspection might be very difficult. The list need not be multiplied; all are aware that every new benefit to mankind provides also its own dangers, either as unexpected consequences or by deliberate misuse. Science is not alone in this: liberty may lead to licence, religion can be used to inflame passions, laws can be exploited to protect wrongdoing. If scientists feel called upon to examine their consciences, so much the better: but they need not imagine that in this they are exceptional.

It has been debated whether "the scientific mind is fundamentally amoral." The real answer is that there is no such a thing as "the scientific mind." Scientists, for the most part, are quite ordinary folk. In their particular scientific jobs they have developed a habit of critical examination, but this does not save them from wishful thinking in ordinary affairs, or sometimes even from misrepresentation and falsehood when their emotions or prejudices are strongly enough moved. Their minds are no more amoral than those of surgeons, lawyers, or scholars. As investigators, most of them realise that their function would be stultified were they to introduce moral data into a scientific argument. A surgeon is not required, or indeed allowed, consider to whether it would be better for the world if his patient died under the operation, he has only to carry it out with skill, care and integrity: but it would be foolish to conclude that the surgical mind is amoral. So it is with scientific people: like all good citizens they must take account of ethical considerations, and the chief of these, as with other good citizens, are integrity, courage and goodwill. Integrity forbids them to allow feelings of any kind to

* Presidential address to the British Association, delivered in Belfast on September 3, 1952. Abridged.

obscure facts, but that does not make them amoral: after all, integrity is the first condition of morality.

In the practical world of to-day, complete abandonment of secrecy, in government and industry, is out of the question. The advantages to international relations, and to general scientific progress, of the greatest possible freedom are evident; to these can be added the impossibility, in a free democracy, of keeping the best people unless the conditions of their work are congenial. The penalty of filling an organisation, governmental or industrial, with second-rate people, cheerfully amenable to unnecessary restrictions, is far too evident in its result on efficiency to be tolerable for long. The cure, therefore, is largely in scientists' own hands. In this, as in many other aspects of their work, moral considerations come in, and the only way to resolve the dilemma which is in so many minds is to discuss it frankly.

It is well that scientists should realise that the prestige of science is not their personal property, but a trust which they have an obligation to pass on uncompromised to their successors. The popularising of genuine science is an important public service; but to use the general prestige of science as a bait to attract attention to pronouncements on other topics is a disservice both to science and the public. As a citizen, I need no more justification than any other citizen in saying what I like about such things: but I have no right to pose as a representative of science in discussing them. If political pressure were applied in any way to force conformity to particular scientific theories, as happened in Germany and is happening now elsewhere, then one's right and, indeed, one's duty would be clear, alike as citizen and as scientist. But the nature of political institutions and the policies of political parties are not scientific questions and how I choose to vote has nothing to do with science.

Some 1,700 years ago there crystallised out, from many centuries of experience of the human problems and ethical necessities of medicine, the so-called Hippocratic Oath. The obligation of integrity and trust; the insistent claim of suffering; the care of mothers and children; solicitude for the old and weak; the sanctity of human life: these are as vital a part of medical tradition as its science and its art. Practice, it is true, may lag behind principles, but at least such failure is regarded as discreditable; and it is hard to imagine any kind of civilisation in which the ethical principles of medicine were disregarded. That is one reason why the future possibility of biological warfare is particularly repugnant. To-day, science finds itself, unexpectedly and without those centuries of tradition and experience, in a position no less important to the community than medicine: and its ethical principles have not yet clearly emerged.

Every candidate for admission to the earliest of American learned associations was required to answer Yes to the question, "Do you love truth for truth's sake, and will you endeavour impartially to find . . . it for yourself and communicate it to others?" That affirmation might have its place in a modern scientific version of the Hippocratic Oath. But again the same dilemma arises—"endeavour impartially . . . to communicate it to others." Apart altogether from considerations of national security, in many fields to-day much of the best research is done, and done increasingly, in industrial laboratories. Those who have seen and admired such work, and the people who do it, cannot but applaud the foresight which made it possible. But if all the results are to be communicated at once and impartially to others, could directors and shareholders be reasonably expected to continue their support? Indeed, if an industry were nationalised, could it afford to give away its secrets to competitors abroad? Not in any real world, in which a nation must remain solvent and industry must depend for success on the rapid application of new knowledge. The dilemma must be met by reasonable compromise, of which, perhaps, the most hopeful sign to-day is that many of the directors of industry come up through research departments.

A graver problem is provided by research under Government, when considerations of security come

in. In the emergency which became evident in 1935, the secret development of radar for purposes of air defence aroused no obvious pangs of conscience; and many other developments come in that class. But the surest of military maxims is that counter attack is an essential part of defence; to limit scientific methods to defensive weapons would be to ensure defeat—indeed, it is quite impracticable. But let us be realists; so long as offensive weapons may be used, the part played by the scientist is no more immoral than that of the engineer, the workman, the soldier or the statesman.

We all bear, as citizens, an equal responsibility. But is it practical to suggest that all scientists in all countries should agree, and hold to their agreement whatever happens, to take no part in research on offensive weapons? Or at least should endeavour impartially to communicate its results to others? The answer is evident. There are individuals in all free countries who find such work intolerable. In those countries, their scruples are respected and they are at liberty to do something else; but let them not imagine that the problem is solved that way, or that those who think otherwise are necessarily stupid or immoral. The first condition of freedom is freedom of conscience, and the scientist has the same right to that as any citizen: but freedom does not extend to giving away other people's property, whether of goods or knowledge.

There seems to be no simple answer to the riddle. All knowledge, not only that of the natural world, can be used for evil as well as good: and in all ages there continue to be people who think that its fruit should be forbidden. Does the future welfare, therefore, of mankind depend on a refusal of science and a more intensive study of the Sermon on the Mount? There are others who hold the contrary opinion, that more and more of science and its applications alone can bring prosperity and happiness to men. Both of these extreme views seem to me entirely wrong—though the second is the more perilous, as more likely to be commonly accepted. The so-called conflict between science and religion is usually about words, too often the words of their unbalanced advocates: the reality lies somewhere in between.

"Completeness and dignity," to use Tyndall's phrase, are brought to man by three main channels; first, by the religious sentiment and its embodiment in ethical principles, secondly, by the influence to what is beautiful in nature, human personality or art, and, thirdly, by the pursuit of scientific truth and its resolute use in improving human life. Some suppose that religion and beauty are incompatible: others, that the aesthetic has no relation to the scientific sense: both seem to me just as mistaken as those who hold that the scientific and the religious spirit are necessarily opposed. Co-operation is required, not conflict: for science can be used to express and apply the principles of ethics, and those principles themselves can guide the behaviour of scientific men, while the appreciation of what is good and beautiful can provide to both a vision of encouragement.

Is there really, then, any special ethical dilemma which we scientific men, as distinct from other people, have to meet? I think not: unless it be to convince ourselves humbly that we are just like others in having moral issues to face. It is true that integrity of thought is the absolute condition of our work, and that judgments of value must never be allowed to deflect our judgments of fact; but in this we are not unique. It is true that scientific research has opened up the possibility of unprecedented good, or unlimited harm, for mankind; but the use that is made of it depends in the end on the moral judgments of the whole community of men. It is totally impossible now to reverse the process of discovery: it will certainly go on. To help to guide its use aright is not a scientific dilemma, but the honourable and compelling duty of a good citizen.

INSTITUTION OF CIVIL ENGINEERS.—A Bayliss prize of 15*l.* has been awarded by the Institution of Civil Engineers, Great George-street, London, S.W.1, to Mr. Stanislaw Bregosz, who obtained the highest marks at the Institution's associate-membership examination, held in April, 1952. Mr. Daniel R. P. Hettiaratchi and Mr. Arthur Clayton Wilson obtained equal marks and were awarded second place in order of merit.

PROGRESS IN AERONAUTICAL SCIENCE AND ENGINEERING.*

By SIR BEN LOCKSPEISER, K.C.B., F.R.S.

(Concluded from page 319.)

I HAVE already indicated the part the metallurgist might play in the evolution of the gas turbine, and many think he holds the key to its immediate future. But there is no doubt of the part he has already played in the evolution of the modern aeroplane. The change from the fabric-covered biplane to the superbly finished metal-covered monoplane is due primarily to the extraordinary advances made in the properties of light alloys and methods of fabrication. When the Wright Brothers flew, aluminium was little more than a scientific curiosity, a low-density weak metal of about 5 tons per square inch tensile strength. Modern aircraft aluminium alloys have a tensile strength as high as 40 tons per square inch with a density one-third that of steel, and the proof stresses of aluminium alloys have been almost doubled since the time of the first World War.

The development of light alloys which could be rolled into sheet of high strength coincided with important advances in structural science and led to the introduction of the cantilever monoplane which created a major revolution in aircraft engineering. The main structural change was the introduction of stressed-skin or monocoque construction. This innovation enabled the surface covering to contribute very substantially to the strength of the structure as a whole. It made the most efficient use of material by placing it as near as possible to the outside surface. The skin now provides nearly all the torsional stiffness, while it also contributes to the bending strength of the wing, thus enabling a reduction in the weight of the main spars to be made. The tail surfaces have developed on similar lines, while the fuselage early lent itself to monocoque construction.

The recently developed magnesium alloys, especially those containing zinc and zirconium, have proved of great value in lightweight castings, such as those for the compressor casings of aircraft gas-turbines, for they have a strength: weight ratio nearly 20 per cent. greater than that of the best aluminium alloys. Magnesium alloys are also becoming available as forgings, extrusions, and rolled sheet with very promising engineering properties. High specific strength is not their only virtue: they can be machined faster and more easily than any other engineering material, and they have completely displaced aluminium alloys in aircraft wheels. Magnesium alloys now account for about one-third of all light-alloy castings supplied to the aircraft and engine industries, and the proportion is growing.

Light alloys based on aluminium and magnesium suffer, however, a rapid loss of strength with rise of temperature. This has for long been a serious drawback in reciprocating engines, where the piston temperature has limited cylinder diameter and power output. In the gas turbine, compression raises the temperature of air leaving a compressor with a compression ratio of 6:1 to well over 200 deg. C., and copper-bearing aluminium-alloy blades are now giving way to those of titanium alloys containing chromium and iron, whose strength characteristics with temperature, compared with those of aluminium alloys and sintered aluminium powder, are shown in Figs. 7 and 8. Titanium alloys which have so far been investigated are twice as strong as aluminium alloys for one and a half times the weight, and further improvements in strength: weight ratio may be achieved. The possibilities ahead in the wider use of titanium alloys, both structurally and for particular use at elevated temperatures, may be great, and justifies a considerable research effort. The cost is at present high—about 5*l.* per lb., as compared with 3*s.* per lb. of aircraft aluminium alloys, but the commercial production of titanium is a recent innovation. The great fall in the price of aluminium from 3*l.* 5*s.* per lb. in 1884 to 1*s.* per lb. in 1935 was achieved by the

* Presidential address to Section G of the British Association, delivered at Belfast on Friday, September 5, 1952. Abridged.

development of new extraction techniques, and it may well be that corresponding advances will be made with titanium. However, the very reactive nature of titanium at the high temperatures which are necessary for its extraction and working present difficult technological problems, but a very great effort will, without doubt, be devoted to the development of a new metal, the ores of which are so plentiful and which has such outstanding properties.

The ratio of the elastic modulus to density for present-day titanium alloys is, however, 10 per cent. lower than the corresponding figure for steel and aluminium alloys, and this relative deficiency may, if it persists, prevent full advantage being taken of the high specific strength of titanium in aircraft structures. The development of the modern aeroplane, particularly as regards speed, has introduced a new criterion in design, namely, structural stiffness, which is now a consideration comparable in importance with strength. A reasonable degree of stiffness is essential on practical engineering grounds, but the main concern is with flutter. This is a complicated aeroelastic phenomenon in which, at a particular speed, dependent on the characteristics of the structure, oscillations occur of progressively increasing amplitude, ending in structural disintegration. The best a designer can do is to ensure, as far as he can, that the flutter speed is well above the highest flying speed.

The design criteria for achieving this are derived primarily from a masterly mathematical analysis by Frazer and Duncan in 1928, working at the time in the National Physical Laboratory. The mass balancing of the wing about its axis of twist, the close aerodynamic balancing of the control surfaces, the addition of weights to bring their centres of gravity close to the hinge lines, and mechanical irreversibility of the control system—all these measures raise the flutter speed. But increased stiffness, both in flexure and torsion, is the principal safeguard as regards the structure itself, and this is the main reason why, as speeds get higher, the need for structural materials of higher ratio of modulus of elasticity to density becomes greater.

In addition to strength and stiffness at the minimum cost in weight, a third criterion—fatigue—has to be taken seriously into account. This is becoming more and more a matter for anxiety as new alloys of higher tensile strength come into use. The demand for economic air transport urges operators to keep their aircraft in use for as long a period as possible, and flying to schedule often involves flying in bad weather. Considerations of fatigue act as a check on both. Aircraft encounter gusts in the atmosphere and the resultant accelerations impose loads on the structure which may be several times the normal figure. The structure is, of course, stressed accordingly, but although structures can be designed, to a large degree of certainty, to deal with failing loads which need only be applied once, it is another matter to deal with repeated loading, particularly when the repetition is irregular, both in time and intensity.

To fill in our knowledge about gusts, many aircraft now carry a counting accelerometer, which counts the gusts encountered and grades them according to severity. Information from air routes at various altitudes all over the world is thus being accumulated which enables the designer to assess, with more and more confidence, the kind of repeated load conditions likely to be encountered. In the structural laboratory complete wings are subjected to a fluctuating load, broadly representative of flight in bumpy weather, until failure occurs. In addition, joints, which are usually the more critical parts of a structure, are tested separately in fatigue-testing machines.

I have done little more than indicate some of the scientific and engineering problems that have been encountered in the development of aircraft, and some of the ways in which these problems have been dealt with. As a consequence of these advances in the several fields of science, technology and design, and with a recognition of the vital part played by the skill of pilots, aircraft speeds have increased steadily with the years and, at an increasing rate, from a maximum speed of 70 miles per hour in 1910 to over 600 miles per hour in 1950 (Fig. 9). High speed, however, carries certain consequences. High flying speeds involve high rates of fuel con-

AERONAUTICAL SCIENCE AND ENGINEERING.

Fig. 9. MATERIALS FOR COMPRESSOR BLADES
VARIATION OF ULTIMATE TENSILE
STRENGTH WITH TEMPERATURE.

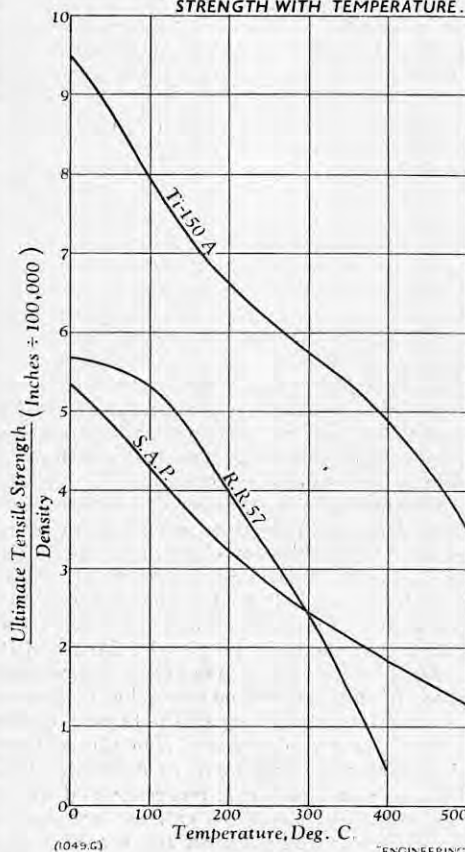


Fig. 10. MATERIALS FOR COMPRESSOR BLADES
STRESS REQUIRED TO PRODUCE 0.1 PER CENT.
TOTAL CREEP STRAIN IN 100 HOURS.

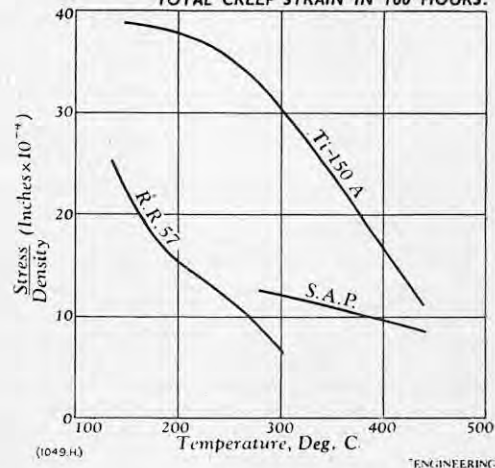
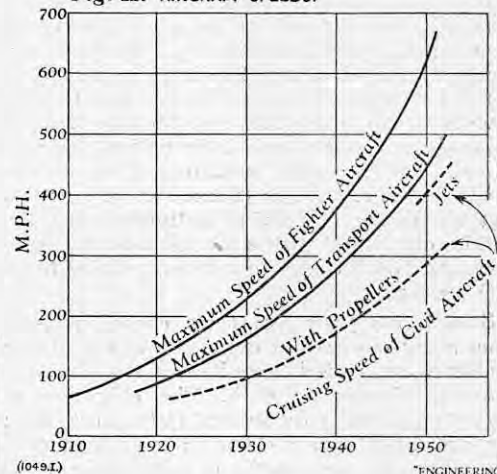


Fig. 11. AIRCRAFT SPEEDS.



sumption, and if we wish to travel fast we have to make it worth while in terms of a reasonable pay load and range. We can get anywhere in the habitable world in hops of about 2,000 miles or so, and, as we pay for speed by fuel consumption, a fast aircraft at the beginning of a 2,000-mile flight is virtually a flying tanker. The all-up weight of the Comet fully laden is about 47 tons of which 46 per cent. is fuel. Further, higher flying speeds involve higher landing and take-off speeds, and fast long-range aircraft are not only inevitably heavy but demand long and expensive runways. Aircraft weight determines the thickness of concrete for a given sub-grade, and take-off speed, for a given acceleration, the length of runway. At the London Airport the longest runway is 3,200 yards, and concrete 12 in. thick is used on a stable gravel base. The airport covers nearly 3,000 acres and its cost to date is 10½ million. Its estimated cost on completion is of the order of 20½ million.

These very heavy runways have led to two interesting developments for decreasing the thickness of construction. The first involves the use of prestressed concrete—a modern technique which has been boldly exploited in many interesting structures. Its application to runways was first tried in 1947 at Orly by the eminent French engineer, Freyssinet. It is 60 m. wide and 420 m. long and is built up of precast plain concrete slabs 1 m. square and 16 cm. thick. Steel wires are threaded through the blocks, transversely to the line of the runway, at 1-m. intervals. These wires are heavily tensioned and anchored to either side of the runway, and so induce transverse compressive stress in the concrete.

The runway is portioned up into large right-angled isosceles triangles and the diagonal joints thus made are closely packed with steel rollers 20 mm. in diameter inserted vertically between adjacent edges to form linear roller bearings. Longitudinal movement is prevented by deep abutments, one at each end, reaching down some 20 ft. or more into the ground. The effect of this is to impose a longitudinal compressive stress of similar magnitude to the transverse stress. The result is a uniform compression of the runway in all directions.

The second development was suggested by

Williams, of the Royal Aircraft Establishment, who proposed to lay concrete slabs on water-bags. These bags under the runway, like the inner tubes of motor-car tyres, need only be flexible and impervious; in neither case are the walls of the inner container required to resist any significant stress. The effect of the arrangement is to convert a concentrated load on the surface of the runway into a uniform pressure on the soil of only 2 to 5 lb. per square inch, a pressure within the bearing capacity of all but the poorest soils.

The flying boat offers a means of escape from large concrete runways and airports. The flying boat always had the advantage of being able to dispense with an undercarriage which, in a modern large aeroplane may account for 6 per cent. of the total structure weight; but this was for a long time more than offset by the excessive size and weight of a hull which had to carry the propellers high above the water to keep them clear of the spray. Jet propulsion has changed all this and a smaller hull, combined with improvements which can now be made in its aerodynamic design, may well tip the balance in favour of a flying boat for all-up weights of 50 tons and above. Flying boats, however, require prepared waterways, and for boats of the size of the Princess and Duchess, docking facilities.

A more radical and, indeed, revolutionary attack on the runway problem has been proposed by Green and Thomlinson, and worked out in considerable detail at the Royal Aircraft Establishment. The modern concrete runway is an expensive nuisance, however it is constructed, and the heavy and elaborate mechanism of the aircraft undercarriage an unnecessary extravagance in weight and an undesirable handicap in structural design. Green and Thomlinson aimed to get rid of both by catapulting aircraft into the air and "belly-landing" them on a tautly-suspended flexible sheet. For landing, the aeroplane is flown level a few feet from the ground, caught on a hook by arrester gear and

MANUAL HOISTING AND WINCHING MACHINE.

C. E. SIMMS ENGINEERING, LIMITED, SHEFFIELD.

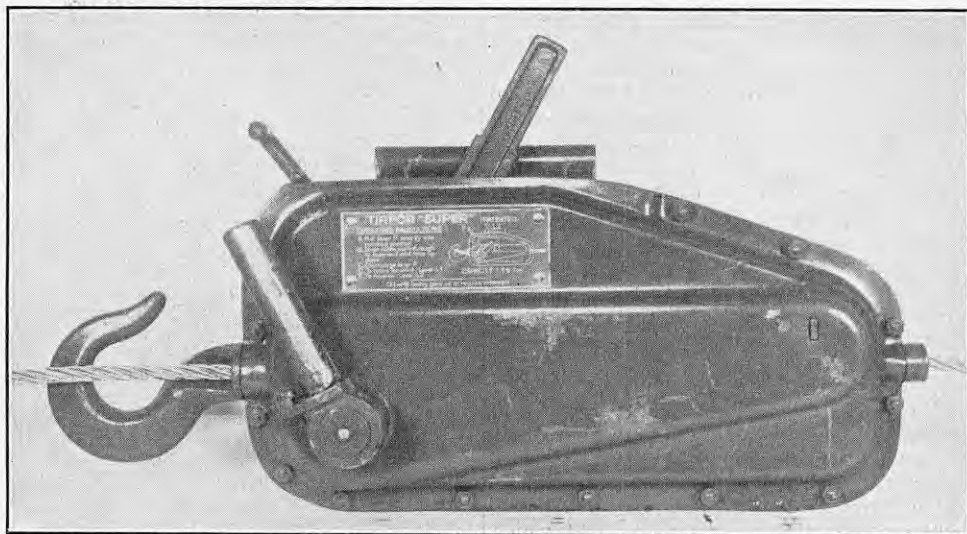


FIG. 1.

Fig. 2.

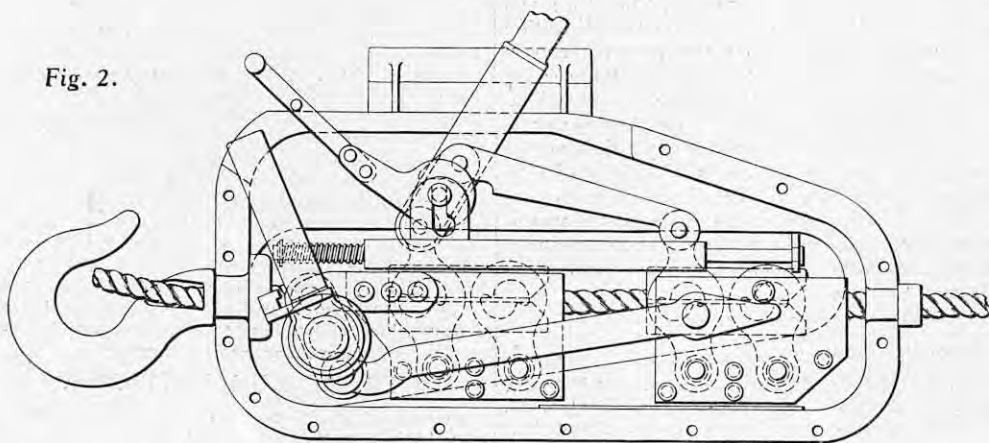
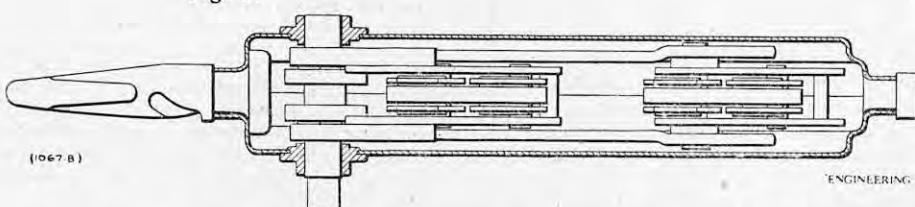


Fig. 3.



dropped on the sheet, which allows a good landing without bounce to be made.

Some structural reinforcement is required for the fuselage, but this is not expensive in weight, and turns out to be small in comparison with that of the undercarriage. Launching by catapult and the use of arrester gear follows standard aircraft-carrier practice, but the idea of placing on the ground, instead of in the aircraft, the means of absorbing the vertical kinetic energy on landing, is entirely new. Much experimental effort has been devoted to developing this idea and that it is quite feasible is shown by the fact that many landings of a Vampire have been made by this method.

The ability to land on and take off from a small space may become one of the urgent problems of the next 20 years. The helicopter can do this already, and that it can do so is the main justification for its existence. From its small operating bases it can travel direct from the heart of city to city. It is not capable of high speeds, as aircraft speeds go, but the Bristol 173 helicopter, which flew for the first time earlier in the year, has been designed to cruise at 120 miles per hour and this is quite sufficient to give it an advantage in door-to-door times for journeys such as between London and Paris. But the helicopter may be cast for a more striking role. It is at present a very complicated and expensive mechanism, but it could be very much simplified by jet propulsion of the rotor, burning

fuel with compressed air at the blade tips. This would involve a higher fuel consumption than at present, but apart from the elimination of the need to balance the rotor torque reaction, the gain in weight saving, simplification and manufacturing costs should be very considerable. A helicopter on these lines has already flown in the United States.

I confess that these thoughts may have arisen from an uneasy feeling I have that aircraft, the most mobile of all forms of transport, are in some danger of surrendering much of their mobility by becoming tied to expensive and extensive aerodromes. The helicopter, courageously pioneered by Sikorsky in the United States, was for long rather an unwanted child in the aeronautical family, expensively brought up on speed. But this child, which has learnt how to operate from a confined space, has yet to grow up. We may see, in the not very distant future, the application of folded and faired-in powered rotors to fixed-wing machines, for use only during take off and landing, without prejudice to top speed; and, perhaps, by removing the restraining influence of landing speed on top speed, actually make higher top speeds possible. But if this comes about, the primary advantage will lie not in the realm of speed but in the realisation of safer and far more economic landing and take-off conditions. The future in the air may well lie in the conquest of the ground.

MANUAL HOISTING AND WINCHING MACHINE.

THE hand-operated hoisting and winching machine illustrated in Figs. 1 to 3, herewith, weighs only 36 lb., yet exerts a smooth, snatchless pull of 30 cwt., is not limited in length of rope (since the rope passes through the machine, not round a drum), and allows the operator to release the load under control. There is also a model which will exert a pull of 3 tons. The Tirfor machine, as it is known, is marketed in this country by Messrs. G. E. Simm Engineering, Limited, East Parade Chambers, Sheffield, 1. It can be used as a semi-portable tool, as, for example, a hoist over a lathe, or as a fully-portable tool for removing pit-props, erecting steelwork, etc. It has been used for loading machines on to low-loading trailers, pulling down trees and removing tree stumps, loading and unloading pipework, tensioning overhead cables, and, in Norway, for operating a ski lift. The wire rope, which is supplied in standard lengths of 66 ft., with a hook on one end and coiled on a reeler, is a hemp-core rope $\frac{7}{16}$ in. in diameter. It is pulled at a rate of 11 ft. per minute.

The hook on the machine is attached to a convenient point, and the rope is paid into the machine, through the hole at the other end, until it projects through the hole in the hook. The load is then applied by means of a telescopic handle on the arm which is fixed to the end of a shaft protruding from the side of the machine. The backwards and forwards movements of the handle cause the rope to be pulled through the machine. Two pairs of split jaws alternately grip and pull the rope and, having released the rope, return to the original position for the next cycle. While one pair is pulling the other is moving freely along the rope in the opposite direction. Fig. 2 shows the arrangement of the lever and the links which couple it to the pairs of jaws (shown in dotted lines). The total movement of the rope during each cycle is $2\frac{3}{4}$ in.

A reversing lever and a release catch are fitted at the top of the machine. Movement of the lever causes the jaws to act in the opposite direction while gripping the rope, thus enabling the load to be lowered or released under complete control and with great accuracy of position. The release catch opens both sets of jaws simultaneously, so that the rope can be pulled through freely by hand. When all the slack has been taken up the release catch is returned to its original position and the jaws are ready for gripping again. The catch cannot be operated when the rope is loaded.

CHANGES IN IRON AND STEEL PRICES.—As a result of the new Iron and Steel Prices (No. 2) Order, 1952—Statutory Instrument 1952 No. 1554, issued by the Ministry of Supply, the prices of certain qualities of alloy-steel and stainless-steel products have been revised to take account, among other factors, of the changes in production caused by measures adopted to conserve nickel and molybdenum; and also to take account of increases in the prices of alloys. The Order is on sale, price 2d., at H.M. Stationery Office.

FAMOUS BRITISH TRAINS.—A 16-page booklet containing ten whole-page photographic reproductions of well-known British railway trains has been published by *The Times Weekly Review*, under the title "Famous British Trains." Among the expresses included in this brochure are the Norfolkman at Norwich, the Thames-Clyde in Nithsdale, the Flying Scotsman, the Cornish Riviera, the Queen of the Scots, the Golden Arrow, and the Royal Scot. Descriptive notes are given respecting each of the trains. Copies, price 1s., may be obtained from The Times Publishing Co., Ltd., Printing House-square, London, E.C.4.

A NEW TYPE OF MOTOR TORPEDO BOAT FOR THE ROYAL NAVY.—The Admiralty announced last Friday that the first two of a new design of motor torpedo boat, the Gay Archer and the Gay Bombardier, had been launched at the Portsmouth shipyard of Vosper Ltd. The ships' hulls, which are almost entirely of wooden construction, incorporate structural members of water-resistant plywood. The vessels have a length of 72 ft. 2 in., a beam of 19 ft. 8 in. and mount two 21-in. torpedo tubes above the water line. Their armament also includes one small gun. The main machinery consists of conventional petrol engines, supplied by Packard Cars, Brentford, Middlesex.

NOTES ON NEW BOOKS.

Principles of Electrical Engineering.

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

IN the thirty years which have elapsed since the first edition of this book appeared the "principles of electrical engineering" have not altered, if that phrase is understood to mean the basic laws of the natural phenomena which it is the business of electrical engineering to utilise in practice. In the preface to the first edition the authors pointed out that study of the book should be followed by "detailed courses in direct-current and alternating-current machinery." To that should now be added "courses in the application of the devices covered by the term electronics." Although the invention of the "thermionic tube, the most versatile device ever produced by man" may not have altered the procedure followed in designing a squirrel-cage motor, it has none the less tended to modify the whole point of view in many branches of electrical engineering and as electronic devices are becoming common in a wide variety of applications, it is desirable that electrical engineers concerned with almost any branch of electrical work should be acquainted with the principles of their operation. This book deals with electronics as a part of its subject, but not at the expense of more long-established branches of electrical engineering. It is stated, however, that, in modifying the treatment to meet new demands, most of the text has been completely rewritten. The book is described as a "substantial first course in . . . the really basic principles upon which modern electrical engineering rests." This claim is justified and the treatise will no doubt continue to receive the support which has been accorded to it from the first. To students who are not acquainted with it, it should be pointed out that the expression "first course" does not mean that this is an elementary book intended for first-year men; a knowledge of the calculus and physics is assumed.

Fluorspar.

Department of Scientific and Industrial Research: Memoirs of the Geological Survey. Special Reports on the Mineral Resources of Great Britain, Vol. IV. Published by H.M. Stationery Office, Kingsway, London, W.C.2. [Price 17s. 6d. net.]

HOME sources of fluorspar were first investigated as part of the programme of examination of the mineral resources of Great Britain during the first World War. The first edition of this report was published in 1915; a second, without revision, in 1917; and the account was brought up to date for a third edition published in 1922. Important changes have taken place in the fluorspar industry since that time. Whereas there was an exportable surplus of production in 1922, home demands subsequently increased until conditions during the second World War revealed an impending shortage for home needs in the steel and chemical industries. A complete re-investigation was therefore carried out and, although the main work was completed by 1942, contact was maintained with further developments, and the fourth edition, published this year, shows the state of the fluorspar producing industry in 1949. The report begins with an interesting introductory chapter on industrial uses, production and prices, mineralogy and origin of fluorite, and mining and treatment methods. Each of the following five chapters deals with one of the five geographical districts where fluorspar is mined or where there is a possibility of obtaining it in useful quantities. The two main centres of production are the northern part of Derbyshire and the western part of Durham, and the accounts of these areas naturally occupy the greater part of the report. Remaining areas are grouped as follows: north-west Yorkshire; Cornwall and Devon; and Scotland. In addition to a general account of fluorspar occurrences in each district, there is a summary of the geological, mining and treatment details known

about each working or abandoned mine. Many references are appended to each chapter and the report contains a wealth of information on home resources of fluorspar.

Die Stanzertechnik in der feinmechanischen Fertigung.

By PAUL GABLER. Carl Hanser-Verlag, Leonard-Eck-Strasse 7, Munich 27, Germany. [Price 21 D.M.]

THE field of the technique of pressing in the manufacture of small parts, which is the subject of this book, is immense, although the examples chosen are mainly components for the electrical engineering industry; nevertheless, the book contains only 200 pages, this condensation being achieved by treating concisely the basic principles of pressing and press tools, and by devoting more space to requirements for the increase of efficiency. Such a treatment obviously must be based on experience of actual manufacture, and, for that reason, may appeal directly to many engineers, designers, and toolmakers who have met with similar problems. The book is divided into three sections of about equal length. In an introduction, the requirements of the components in question are demonstrated on typical examples. In the first section, those methods of press technique are discussed which promise an increase in output, quality, or economy; the same section also reviews the considerations governing the choice of the method to suit a given component, and it also indicates how the utilisation of the material depends on the properly chosen shape of the component. The second section deals with the economics of when to provide a simple tool and when an elaborate one, how to reduce the costs of tooling by appropriately adjusting the shape of the component, and with trends of contemporary machines in the direction of higher economy. The last section is devoted to the manufacture of press tools, both when they are required singly and in large quantities, and also deals with their maintenance.

Forces in Framed Structures.

By T. LYLE MORGAN, M.Sc., A.M.I.C.E., A.M.I.Struct.E. E. and F. N. Spon, Limited, 22, Henrietta-street, Strand, London, W.C.2. [Price 25s.]

THIS book is concerned with that part of the subject of theory of structures that is concerned with the analysis of the forces in the members of statically determinate frames. It is suitable for students preparing for Higher National Certificates or similar diplomas in building or civil engineering and for degree students during the early part of their studies. Worked examples form an important feature of the text. Practically all types of statically determinate frames used to-day have been solved to illustrate the relative applicability of the various methods. The method of joint equilibrium has been developed in great detail, for the author considers it to be the most powerful method available for the analysis of the forces in the members of such frames, particularly for trusses having parallel booms. Chapter Six deals with the method of tension coefficients, this being the most efficient means of obtaining a solution of space frames, and the final chapter is devoted to the problems of influence lines for the forces in members of framed structures.

"A CASE FOR HANDLING."—The part that mechanical handling can play in the factory and workshop is well illustrated in a film, entitled "A Case for Handling," which has recently been prepared under the superintendence of the British Electrical Development Association, 2, Savoy-hill, London, W.C.2; and can be obtained from them on free loan. This film, which is available in the 16-mm. and 35-mm. sizes and has a running time of 32 minutes, shows specifically how the employment of stackers, conveyors and other appliances can be used in place of manual labour so as to increase the efficiency, raise the output and improve the working conditions in a foundry producing aluminium die castings. It points a moral which is, however, wider, for it shows workers, foremen and staff up to the level of works managers "that every time a material is handled something is added to its cost and nothing to its value." Its technical correctness leaves nothing to be desired.

BOOKS RECEIVED.

Problems of Power Transmission at Voltages above 225 kV. By PROFESSOR FRANCOIS CAHEN. The British Electrical and Allied Manufacturers' Association, 36 and 38, Kingsway, London, W.C.2. [Price 5s.]

Die Messwandler. By DR. J. GOLDSTEIN. Second edition. Verlag Birkhäuser, Basle, Switzerland. [Price 29.10 Swiss francs, cloth bound, 24.95 Swiss francs, in paper covers.]

Forest Products Research. Bulletin No. 1. *Dry Rot in Wood.* By K. ST. G. CARTWRIGHT and DR. W. P. K. FINDLAY. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2s. net.]

The Caterham Railway: The Story of a Feud—and its Aftermath. By GEOFFREY SPENCE. The Oakwood Press, Tanglewood, South Godstone, Surrey. [Price 7s. 6d. net in boards, 10s. 6d. net, cloth bound.]

Practical Clock Repairing. By DONALD DE CARLE. N.A.G. Press, Limited, 226, Latymer-court, London, W.6. [Price 30s. net.]

United States Bureau of Mines. Report of Investigation 4883. *Centrifugal Testing Apparatus for Mine-Structure Stress Analysis.* By LOUIS A. PANER. The Regional Director, Bureau of Mines, 4800, Forbes-street, Pittsburgh 13, Pennsylvania, U.S.A.

Selected Government Research Reports. Vol. 10. *Ceramics and Glass.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 25s. net.]

Principles of Human Relations. By PROFESSOR NORMAN R. F. MAIER. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 6 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 48s. net.]

The Final Report of the Anglo-American Council on Productivity. Offices of the Council, 21, Tothill-street, London, S.W.1. [Price 3s. 6d., post free.]

Memorandum on Non-Destructive Methods for the Examination of Welds. British Welding Research Association, 29, Park-crescent, London, W.1. [Price 5s.]

Ministry of Transport. Railway Accidents. Report on the Derailment which Occurred on 25th May, 1952, between Linlithgow and Philipstown in the Scottish Region British Railways. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 6d. net.]

Recommended Domestic Solid Fuel Appliances. List No. 5. July, 1952. The Coal Utilisation Council, 3, Upper Belgrave-street, London, S.W.1. [Price 6d.]

The Structure and Properties of Mild Steel. By PROFESSOR C. A. EDWARDS. Quality Press, Limited, Bouverie House, Fleet-street, London, E.C.4. [Price 20s. net.]

TRADE PUBLICATIONS.

Isolation of Machinery Vibration and Noise.—A booklet published by W. Christie and Grey, Ltd., 4, Lloyd's-avenue, London, E.C.3, describes the basic principles of machinery vibration, the factors involved in isolating vibrations, and the several different systems for which they can supply the mountings, etc., and on the use of which they can advise in connection with particular cases of vibration or noise. The desirability is stressed of taking precautions against vibration and noise before the installation of new machinery. The mountings, etc., include pedestal antivibrators, spring suspension systems, dashpot dampers, and Coresil foundation plates, which are made of cork, impregnated to prevent deterioration, and give a long life.

Hydraulic Systems for Machine Tools.—A manual entitled "Hydraulic Systems and Hydraulic Oils for Machine Tools"—a timely publication, in view of the International Machine Tool Exhibition reported elsewhere in this issue—has been issued by the Vacuum Oil Company, Limited, Caxton House, Tothill-street, London, S.W.1. A brief review is given of the principles of hydraulic operation and of its advantages, particularly ease of control and economy of power. The needs of the practical man—the machine-tool operator and foreman—have been recognised. Leakage, scoring, deposit formation and other troubles are dealt with, and a survey is given of the usefulness of high-quality oils in eliminating these difficulties. American and British machine tools are considered. The manual contains numerous drawings of equipment.

Low-Current Tubular Rectifiers.—A pamphlet, received from Standard Telephones and Cables Ltd., Boreham Wood, Hertfordshire, gives details of the tubular rectifiers they manufacture. These incorporate special high-voltage SenTerCel plates, the design of which enables fewer to be used for a given voltage.

Alternating and Direct-Current Motors and Starters.—We have received from the General Electric Co., Ltd., Magnet House, Kingsway, London, W.C.2, a well-illustrated catalogue dealing with the various types of alternating-current and direct-current motors made by them. In each case the main features of design are described and some points which should be noted in ordering are given. There are also similar data regarding the starters made for use with these motors, the whole forming a useful collection of information for anyone wishing to obtain this type of equipment.