Machinery

NEWALL

THE NEWALL ENGINEERING CO. LTD.
PETERBOROUGH ENGLAND

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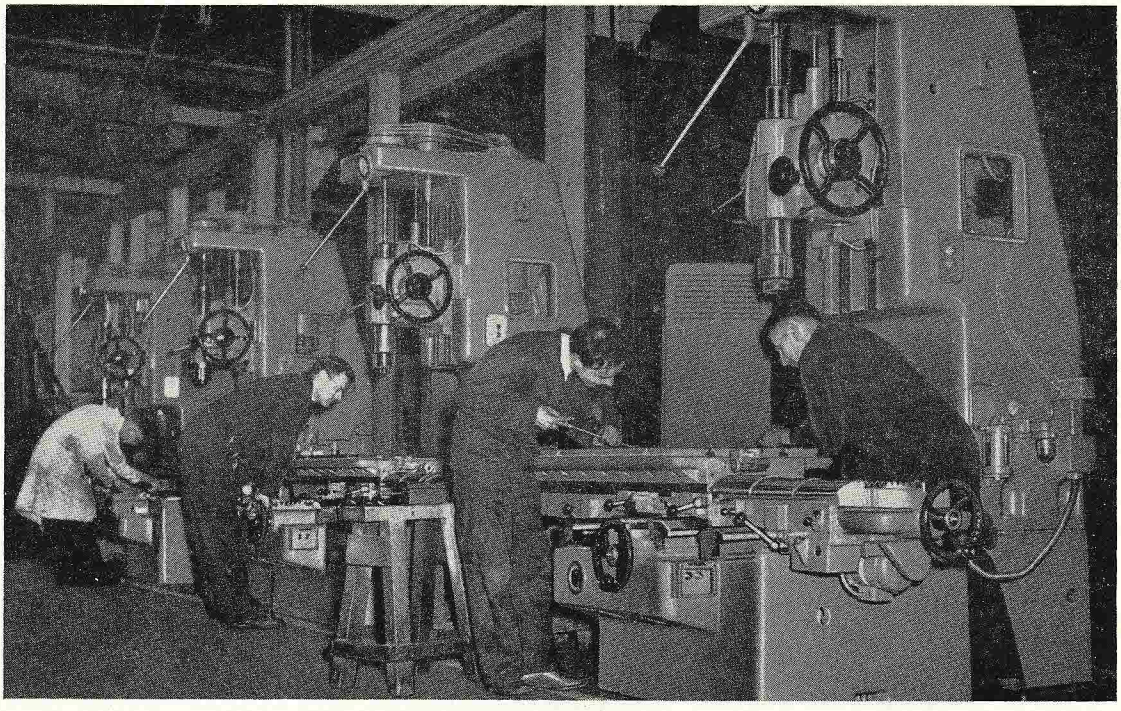
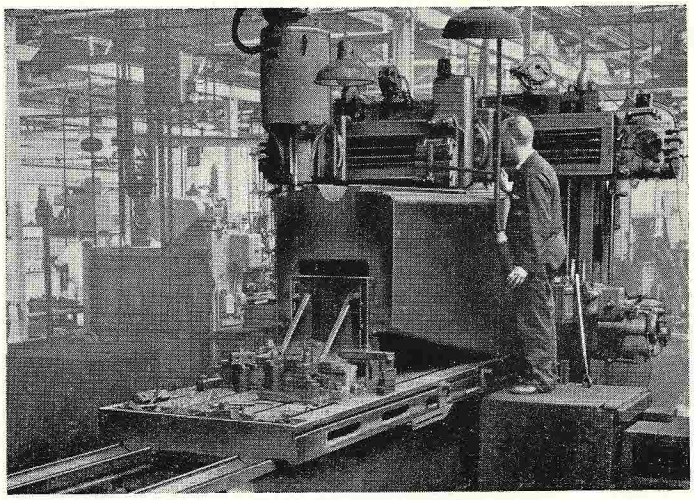


The Newall Engineering Co., Ltd. Old Fletton, Peterborough

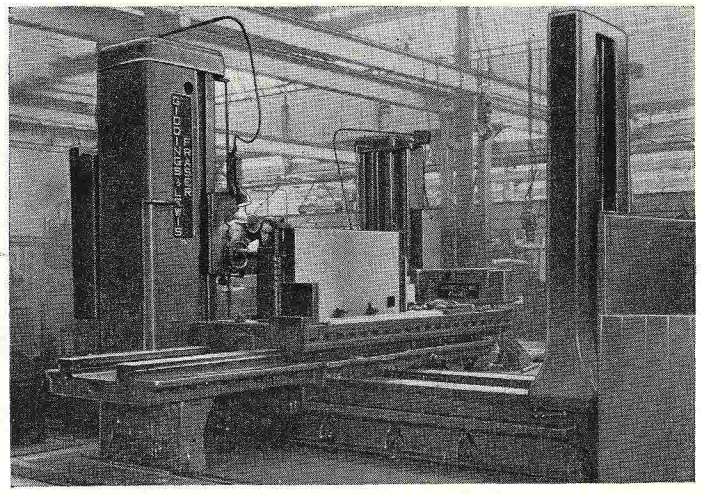
P. A. SIDDERS CHIEF ASSOCIATE EDITOR

The name of Newall has long been familiar to engineers in connection with a widely accepted system of limits and fits, also with machine tools of high precision for jig boring, grinding, and lapping. Founded by Mr. John Walker Newall, The Newall Engineering Co., Ltd., was established as a public company in 1900, and the original factory was located at Featherstone Street, Walthamstow, London. At that time, the company had only a small number of employees, and the early products included a semi-automatic sheep-shearing machine, designed by Mr. Newall to facilitate wool clipping on the rapidly developing sheep stations in Australia. This machine met with considerable success, and served to introduce the company to the problems associated with exporting. As was not unusual at that period difficulties were experienced in supplying spare parts that could be guaranteed to fit the machines for which they were intended, and these difficulties were accentuated when machines were sold overseas.

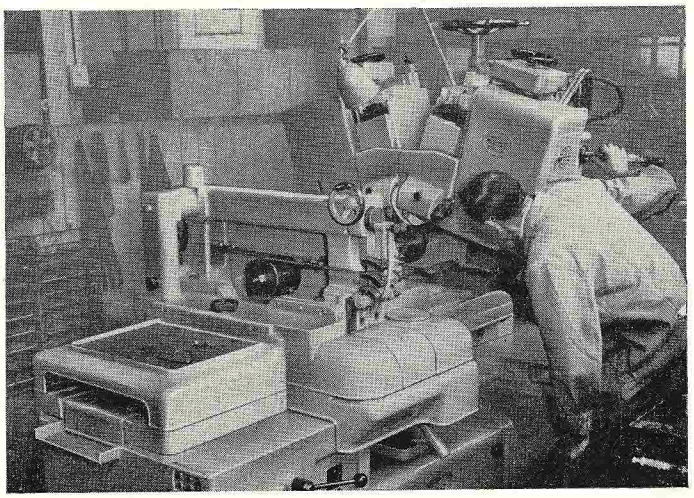
Mr. Newall was a practical engineer of considerable ability, and with a wide range of experience and skill, and he applied himself to the problems connected with the assembly of components without the necessity for fitting operations. After a large amount of theoretical and practical work, he evolved the Newall Standard Table of Limits, and thus established a basis for accurate machining that was without equal at that time, and was widely employed in engineering workshops both in this country and abroad for many



1 *This Bertram machine installed in the planing section of the No. 1 works of the Newall Engineering Co., Ltd., Peterborough, has been converted by the company for heavy-duty plano-milling by mounting a 30-h.p. Futurmill head on the cross-rail. The machine is here seen set up for operations on the column for a Newall type 2657 Spacematic numerically-controlled jig boring and milling machine*



2 *Among the most recently installed horizontal borers at the No. 1 works are these two Giddings & Lewis-Fraser type 340 T machines with outboard supports for the tables. On the machine in the foreground, operations are in progress on the front bed casting for a Newall cylindrical grinding machine of unitized construction*



3 *This Maag type HSS 30 gear tooth grinder is employed for finishing hardened gears for Newall machines. It is seen set up for grinding a spur gear with 63 teeth of 12 d.p., 20 deg. pressure angle, and $\frac{3}{4}$ in. face width, the time required being approximately $1\frac{1}{4}$ hours. A Churchill type SAU 12 gear shaving machine has recently been installed*

years. As a result of the introduction of the Newall system, the company became engaged in the production of precision gauges and measuring machines, and this type of work became the principal activity for a considerable period.

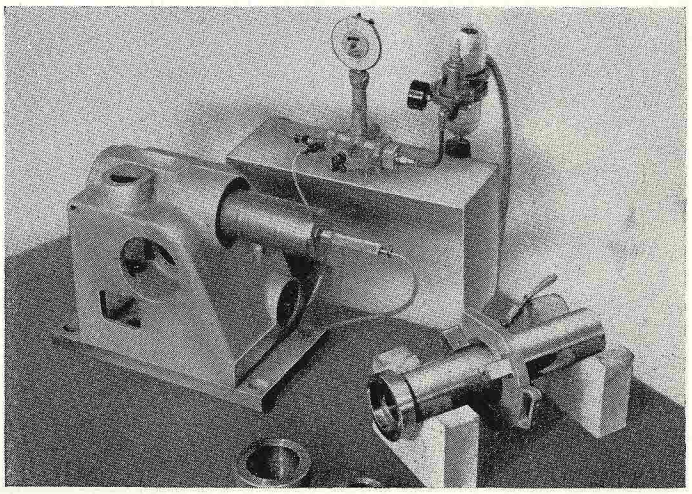
In the years that preceded the first world war the company experienced a number of difficulties, and during this time the business was transferred to Warrington, Lancs., but was later re-established in London. It may be of interest to note that a precision linear measuring machine which was designed and built in 1910 is installed in the present No. 2 factory, and is still capable of measuring to an accuracy of 0·0001 in. The building of grinding machines was started in 1910, and continued until the outbreak of war in 1914. Construction of such machines was then stopped, to enable the company to concentrate on gauges and precision measuring machines, which, by that time, had become the main products.

Although The Newall Engineering Co., Ltd., had enjoyed a high reputation for quality, it continued to operate on a relatively small scale, with a limited range of activities, until the latter part of the 1920's. In 1927, the business was acquired by Mr. Sydney Player, who had joined the firm as works manager some 19 years earlier, but had left and lived for some time in the U.S.A. There Mr. Player had established the Bethel-Player Company, at Westboro, Mass., and had gained wide experience in the design and building of machine tools. It was not until 1932, however, that Mr. Player disposed of his American interests and returned to Great Britain to take an active part in the management of the Newall company.

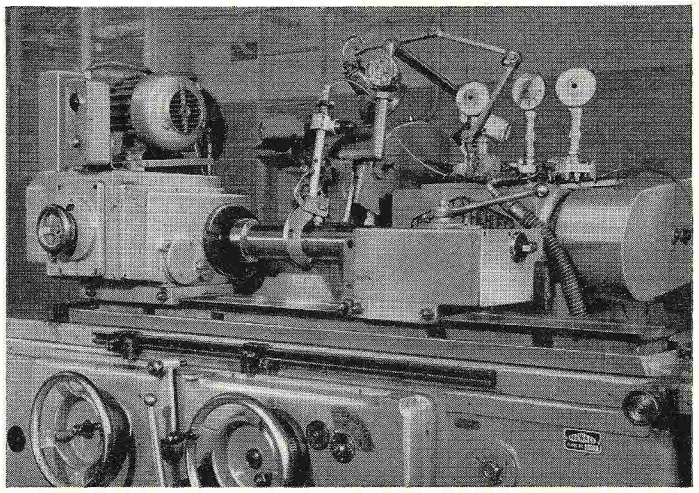
He decided to change the company's manufacturing programme and to engage principally in the building of machine tools, with gauge production relegated to a secondary role, since he foresaw an expanding market for precision machine tools, principally on account of the growth of the motor vehicle and aircraft industries in this country. The correctness of his judgement was soon confirmed and in two years it was necessary for the company to seek larger premises.

The present No. 1 factory at Peterborough was purchased in 1935, and operations were started there with a nucleus of 14 employees from the London works. Lapping, cylindrical grinding, and thread grinding machines—at that time imported principally from the U.S.A., Switzerland, and Germany—were developed, and in 1936, the first Newall jig borer was introduced. This machine incorporated the now well-known Newall system of cylindrical rollers to provide a basis for accurate measurement, and was the first of a long line of machines which has established the company as one of the major builders of jig borers in the world.

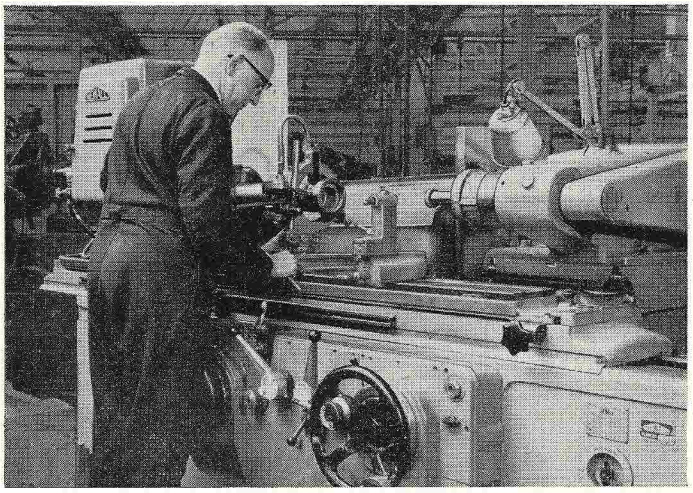
To meet increasing demands, the Peterborough factory was considerably enlarged during the second world war, and because optical measuring equipment could no longer be imported from Germany, the company acquired its first subsidiary—a small optical manufacturing firm at Slough, Bucks. This company was subsequently considerably expanded, and a comprehensive range of optical components and instruments was developed to meet the needs of wartime industry. Later, the firm was renamed Optical Measuring Tools, Ltd., and established in new premises at Maidenhead. Recently, a manufacturing and selling agreement



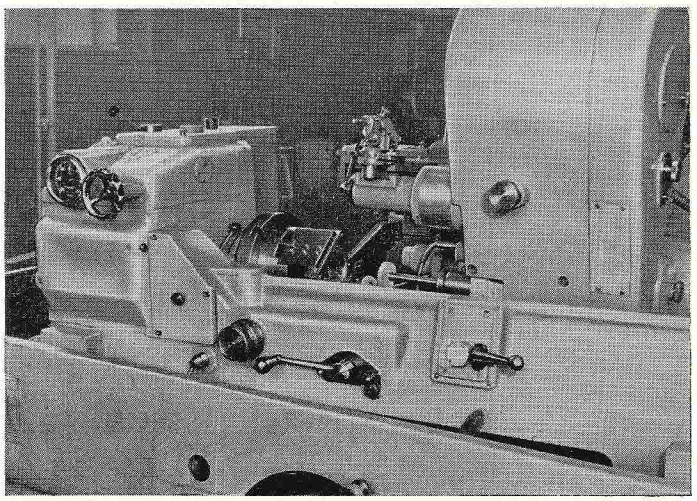
4 *This equipment developed by the chief inspector of the Newall Engineering Co., Ltd., ensures correct mating of jig borer quill cylinders and the associated housings. It incorporates O.M.T.-Etamic air gauging elements and differential comparator. A ring gauge provided with sensing units is applied to a previously-checked quill cylinder, and a plug gauge with similar elements is inserted in the housing at intervals during final honing. The relationship between the two components is indicated on the comparator. Integral supports ensure that the ring gauge is always square to the quill.*



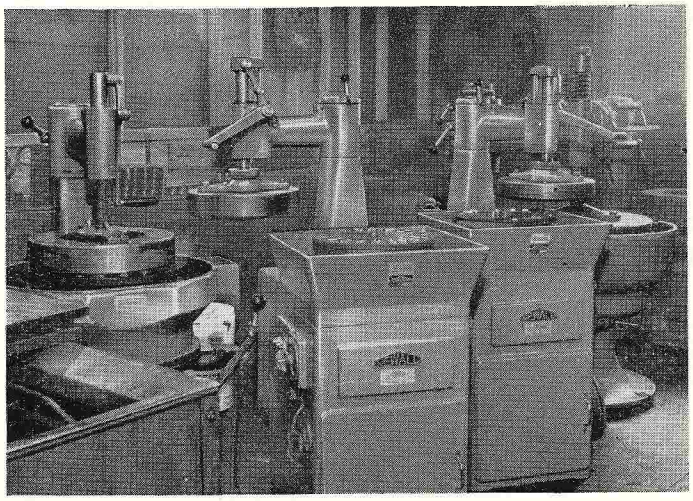
5 *A Newall-Keighley type L 12 cylindrical grinder with special equipment for operations on jig borer quills. The Machine has a plain-bearing workhead, and three O.M.T.-Etamic air gauges are provided for measuring the diameter, taper, and ovality of the work. A quill for a type 1520 jig borer is seen on the machine, and it is ground parallel within 0·00005 in.*



6 *In the cylindrical grinding section of the No. 1 works is installed this Newall type LI machine for operations on quills for the type 1529 jig borers. The machine has a special workhead fitted with SKF roller bearings and provided with oil mist lubrication, the arrangements being similar to those employed on the firm's jig borers. Larger quills are ground externally on a type LA machine, fitted with Sigma air gauging equipment.*



7 *Machines installed in the temperature-controlled precision grinding department of the Newall factory include a number of the company's NL type, which are employed principally for finishing the threads of lead-screws. One of the machines, here shown set up for grinding a special experimental nut, is equipped with an internal grinding head and an auxiliary diamond dressing unit*



8 *Some of the Newall type IOU lapping machines in the temperature-controlled shop for finishing rollers employed for measuring purposes on certain of the company's jig borers. Turned and heat treated rollers are hard chromium plated prior to lapping, and the latter operation is performed in two roughing stages and a finishing stage. An O.M.T. optical projection comparator is installed in the lapping shop for checking rollers, and provides readings to within 0·00005 in.*

was concluded by O.M.T., Ltd., for the production of Etamic high precision air gauging and machine control equipment.

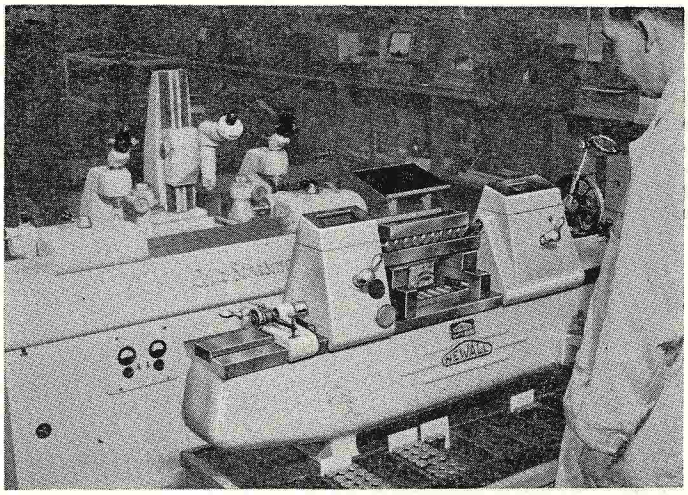
A second subsidiary—now Keighley Grinders (Machine Tools), Ltd.—was purchased later in the war, in order to meet the demand for internal and universal grinders, and a wide range of such machines was built.

Post-war growth

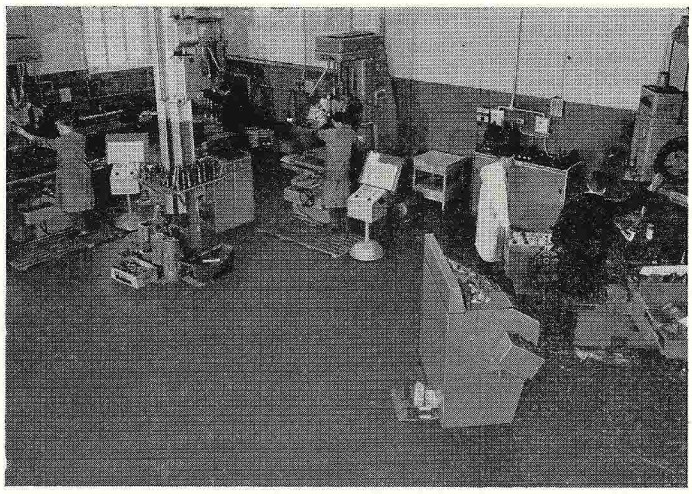
After the second world war, a lessening in the urgency of demand for machine tools enabled the company to embark on the development of a number of new designs and improved versions of existing machines. Crankshaft and camshaft grinders were introduced, followed by semi- and fully-automatic cylindrical grinders with a wide field of application, particularly in the motor car industry. Electronic, hydraulic, and pneumatic systems for machine tool control were investigated, and the most effective arrangements incorporated in the company's products. Mention may be made of the Newall type ANL automatic tap grinding machine which was introduced in 1958, and the type BG precision chucking grinder, for bearing production, in 1960. In the latter year, the company also introduced the type 1520CC Contimatic jig borer, equipped with the A.E.I. Numeritrol system for the control of jig boring, contour milling, and other operations.

Mr. Sydney Player's two sons have been associated with the business for many years, and the elder, Mr. Denis S. Player, succeeded his father as chairman of the Newall Engineering Co., Ltd., and its subsidiaries, in August of this year. He had then been a director of the company for 24 years, and deputy chairman since 1958. Earlier he had been instrumental in the formation of Optical Measuring Tools, Ltd., of which he was the first managing director, and was responsible for the establishment of Newall Group Sales, Ltd. Mr. Sydney Player's younger son, Mr. James C. Player is deputy chairman of the organization and managing director of The Newall Engineering Co., Ltd.

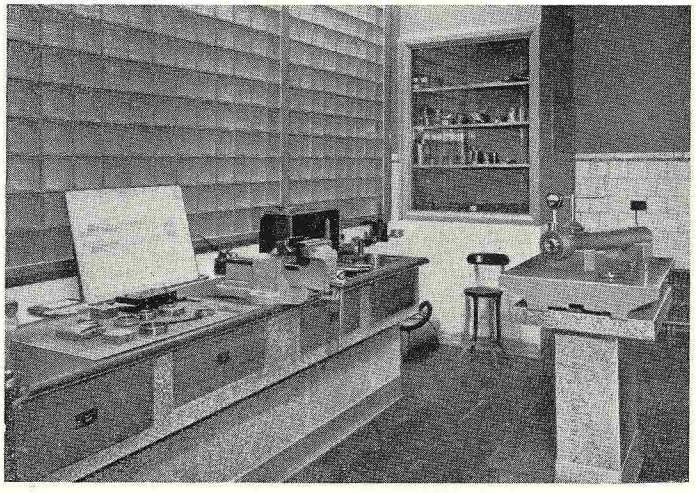
The company now has three factories in the Peterborough area, and the original Old Fletton works (known as No. 1 factory) has been expanded to a floor area of approximately 80,000 sq. ft. Built in 1957, the No. 2 factory has an area of 25,000 sq. ft., and the recently acquired No. 3 factory has a floor space of 30,000 sq. ft. The total number of employees at the two Peterborough works is more than 675. It is the aim of the company to be as self-contained as possible, and an existing foundry, at Bury, was acquired for the production of high quality machine tool castings. Known as The Newall Precision Foundries, Ltd., this subsidiary now provides employment for some 60 people. A mechanical handling division has been established to undertake the design and production of equipment for use on the company's machines. Optical Measuring Tools, Ltd., and Keighley Grinders (Machine Tools), Ltd., have both been expanded during the post-war period, and the total number of employees of the Newall group of companies now exceeds 1,050. In addition to the sales organization to which reference has already been made, the company has established a selling and service subsidiary in Canada, and an associate manufacturing and marketing organization in Australia.



9 *After measuring rollers have been finished-lapped, they are transferred to the central metrology department of No. 1 works, where they are first checked individually for diameter, then sorted into sets of ten and compared on this Newall-built measuring machine against a master set that has been calibrated by the N.P.L. In each set, rollers are selected to give a maximum accumulative error approaching zero. The Leitz-Strasmann universal measuring machine in the background, it is stated, was the first to be installed in this country.*



10 *A view of part of the jig boring department at the No. 1 works, showing four of the seven machines installed. At the right is a Newall type 2657 Spacematic jig boring and milling machine, with A.E.I. positional control equipment. The other three machines seen are standard type 2443 jig borers, two of which have been equipped for milling operations. Machines not shown include a second type 2443 (with optical positioning arrangements), a type 1520 with Airmec positioning control, and a type 2451 with hydraulic table drive for milling operations.*



11 *One end of the temperature controlled assembly department which was originally provided for assembling jig borer quill units. The department is supplied with electrostatically filtered air at a pressure that is slightly above atmospheric. The floor is covered with "granolith" tiles, and the benches and supports for surface plates are faced with the same material. One of the glass brick walls which ensure a high standard of natural illumination may be seen at the left.*

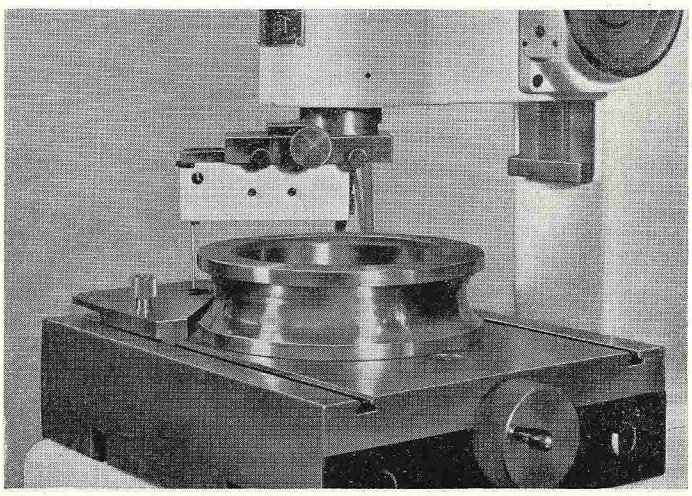
Machine tools built by the company at the Peterborough factories include the Spacematic 2657 jig boring and milling machine, equipped with the A.E.I. measuring and control system for automatic co-ordinate positioning; the type 2451 jig boring and milling machine; the type 2443 and 1520 jig borers; the three latter machines being equipped with the patented Newall roller measuring system. The Newall hydraulically-operated fine boring machine is available in single- and twin-head designs. Cylindrical grinders include the LA range with capacities for work up to 120 in. long, and fully-automated type LA machines can be supplied for incorporation in link lines for mass-production operations. Type UG machines, of unit construction, are available with automatic loading, unloading, and work conveying equipment, and the type MAC multi-wheel machine is intended for grinding several diameter steps on components at one set-up, and is widely employed for cam and crankshaft journals. In addition, specialized machines are made for grinding crankpins (type HAC), camshafts (the Autocamatic) and turbine blades (type 3D).

Other machines built at the Peterborough works include the Rigidlap universal lapping machine, and the type NL thread grinders, which are available in universal high precision form for toolroom work; for normal production operations; and arranged for fully automatic loading and operation, for the high speed grinding of taps and other threaded workpieces. It may be mentioned here that some 28 per cent of the company's machines are exported, and it is planned substantially to increase the proportion, which has been steadily rising for a number of years.

Production facilities

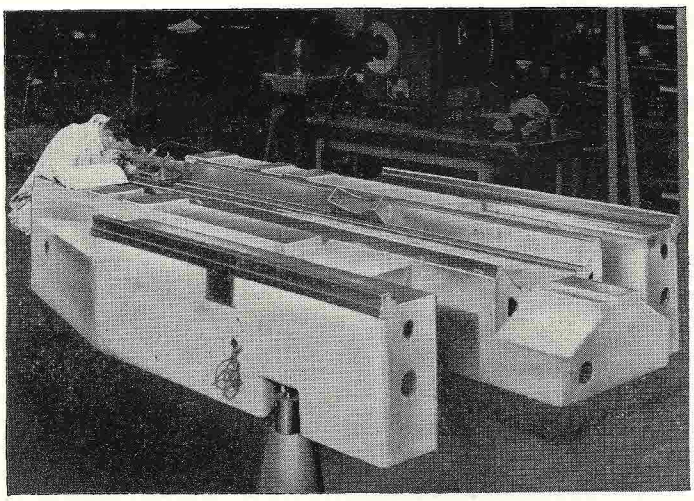
The main production shop at the No. 1 works is divided into three sections lengthwise, which provide for light machining, heavy machining and sub-assembly. Each machining section has an independent inspection department, which is controlled from a central metrology department. Gauges are issued with each batch of work, and when the batch has been completed, they are returned to the metrology department and checked before being used again. In the heavy machining section there is a number of planers by Butler—of which the latest is a double housing machine of 20 by 6 by 6 ft. capacity—Stirk, Planers (Huddersfield), Boehringer, and Bertram, the latter being fitted with a Futurmil heavy-duty milling head. A Kendall & Gent CVM 60 plano-milling machine is also installed in this section. Machines for boring and similar operations include a Webster & Bennett 60-in. vertical turning and boring mill, and two recently-installed Giddings & Lewis-Fraser type 340T horizontal machines, also a number of Kearns borers.

For milling operations in the light machining section there are machines by Kearney & Trecker-C.V.A. and Cincinnati, also two Huré machines with universal swivelling heads. An extensive range of machines for the production of gears and similar components includes Maxicut 2A and 3A shapers, a Sykes hobber and a rack shaper, a recently-installed Churchill SAU 12 gear shaver, a Rigidhobber by the same maker, and a Hey tooth-rounding machine. A Maag type HSS30 gear grinder is employed for finishing operations, and a Maag type PH 60 universal gear tester and a Goulder No. 2 rolling gear tester are installed in a

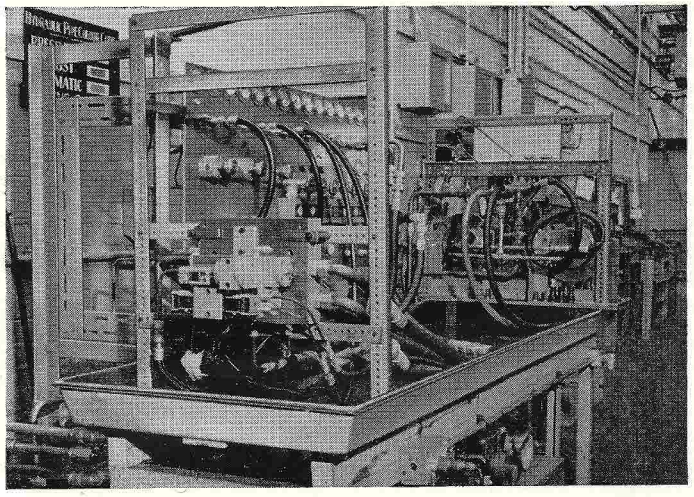


12 *Close up view of a set-up on an O.M.T. roundness measuring machine, fitted with a Foxboro recording instrument, which is installed in the central metrology department of the Peterborough works. This set-up provides for checking the dimensional accuracy and roundness of the track in a ball bearing inner race. Another set-up on the same machine serves for checking the circularity of cross-section of the track, and for this purpose the inner race is supported in a vice type fixture with its side faces vertical*

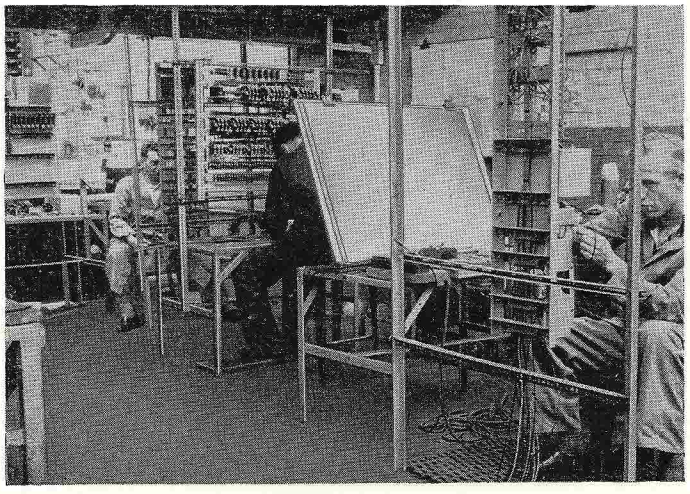
13 *In addition to the assembly bay for type 1520 and 2443 jig borers, seen in the heading illustration, there is a temperature controlled department, at the No. 1 works, for the assembly of Newall type 2657 Spacematic auto-positioning jig boring and milling machines. This department also provides for assembling special types of jig borers. Extensive use is made of auto-collimators for checking purposes during assembly, and an inspector is here seen using an instrument for determining the accuracy of alignment of the guideways on a base casting*



14 *This rig in the hydraulic test bay of the Newall works is employed for checking all bought-out equipment, the valves made by the company, and complete assemblies, in order to eliminate testing on the machines. The rig permits specific delivery and exhaust conditions to be stimulated, in accordance with data determined from investigation of the machine circuits. Reference letters on the test bed and on the units and assemblies facilitate making connections. A wheelhead control unit for a Newall HAC crankpin grinder is here seen being checked*



15 *A special department for the building of electrical control panels from proprietary units has been established at the No. 1 works. To facilitate building, the panels are supported on vertical frames made from drilled steel angle section, and cable is drawn from reels mounted above the frames. A Meddings universal radial drilling machine is provided for the production of fixing holes in the panels, and there is a test bay at one side of the department. It may be of interest to mention that there is approximately 5 miles of wiring in a Spacematic jig borer*



cubicle adjacent to the section. Orcutt and Parkson testers are used for checking operations on the section floor. A Whirlmatic thread-whirling machine is included in the gear-cutting group for operations on leadscrews and feedscrews. Certain screws are finished on this machine, but the majority are ground.

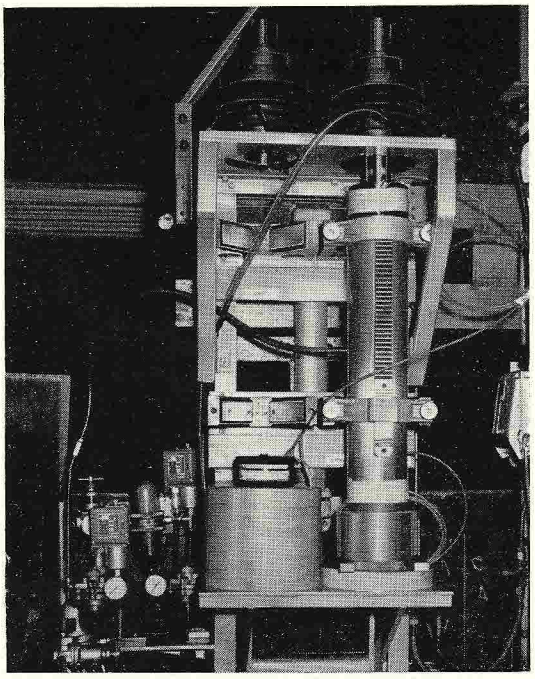
A number of surface grinders is installed, including two large Snow machines (OS 54 and OS 96) and a vertical spindle, circular table machine by the same maker, also machines by Jones & Shipman and Norton. The company employs Newall machines for cylindrical grinding operations, and the group for this work includes certain units with experimental features and special equipment. For example, there is a machine with a special workhead, which has SKF roller bearings and oil mist lubrication for the spindle, the arrangements being similar to those employed on the company's jig borers.

There is a special precision grinding shop with a number of Newall machines including a battery of type NL thread grinders, one of which has an internal grinding head. These machines are used principally for finishing operations on leadscrews. Mention may also be made of a Newall-Keighley type L12 machine which has been specially equipped for grinding quills for the company's jig borers. The machine has a plain-bearing headstock, and three OMT-Etamic air gauging units are provided—two reading to 0·000025 in. and one to 0·0000125 in.—for measuring the diameter, taper, and ovality of the workpieces. Larger quills are ground on Newall type LA machines with Sigma air gauging equipment, which is of the contact type, in contrast to the OMT-Etamic units which are of non-contact design.

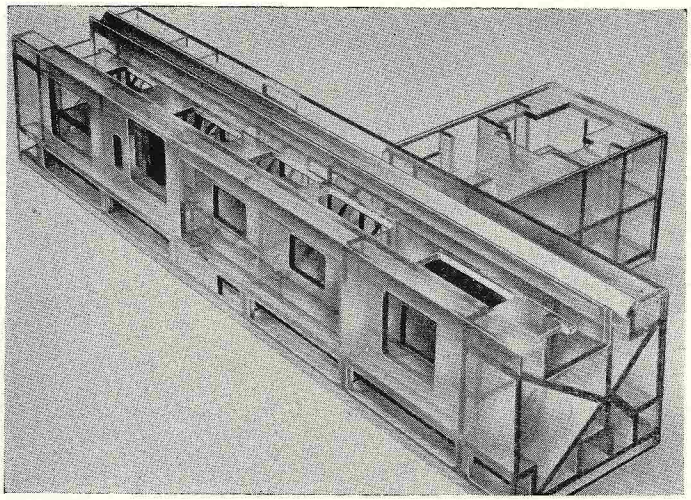
Reference may be made to the production of the rollers employed for measuring purposes on certain of the company's jig borers. These rollers are first turned in pairs, with a central neck of reduced diameter to facilitate subsequent separation, and after heat treatment, the turned blanks are hard chromium plated. Cylindrical grinding on Newall type QL or Newall-Keighley type L 12 machines follows, and the rollers are then separated with a rubber-bonded slitting wheel on a Jones & Shipman surface grinder. The individual rollers are then lapped in batches in a self-contained, temperature controlled department, on Newall type IOU machines. There are two rough-lapping and one finish-lapping stage, and the rollers are graded prior to initial rough lapping (each grade covering a variation of 0·0001 in.), also before finish lapping.

Grading is carried out in the lapping department, and an OMT optical projection comparator is installed for the purpose, this instrument enabling readings to be made to 0·00005 in. For the lapping operations, Centriforce BM304 abrasive compound is employed. Rollers are finally checked in the central metrology department of the No. 1 works, on a length measuring machine of Newall design. It is of interest to note that the roller measuring system was originated for this type of machine long before the company undertook the building of jig borers. Rollers are first measured individually and must be within ±0·00002 of the required size. They are then sorted into sets of ten, individual rollers being selected so that the maximum accumulative error in each set approaches zero, and each set is then checked on the Newall machine against a master set that has been calibrated by the N.P.L.

The central metrology department controls all inspection operations throughout the works, and



16 *Jig borer quill and spindle assemblies are run-in and tested on this rig in the hydraulic section of the No. 1 works. Sensing elements are secured to the quill at the front and rear bearing positions, and are connected to a Cambridge recording thermometer. Running-in is continued until the difference between the bearing temperatures and the ambient temperature does not exceed a specific tolerance*



17 *For investigating the structural properties of major machine components, The Newall Engineering Co., Ltd., makes use of reduced scale models made from steel or plastics, which are subjected to vibrations. The model here shown is of a new design of bed casting for a heavy duty type LA cylindrical grinding machine. For visual inspection, the model is viewed by the light of a stroboscopic lamp while it is being vibrated, and for quantitative investigations, signals from probes are fed to a cathode ray oscilloscope fitted with a recording camera*

a very wide range of equipment is provided. Reference may be made to a Leitz-Strasmann universal measuring machine which was the first to be installed in this country; a Talysurf surface finish measuring machine; and an OMT roundness measuring machine with a Foxboro recorder.

At one end of the main factory building there is a self-contained jig boring department, in which seven of the company's machines are installed. These machines comprise a type 1520 (20¾- by 15-in. worktable) with Airmec positioning control, a type 2443 (43- by 24-in. worktable) with optical positioning arrangements, three standard type 2443 machines, two of which are equipped for milling operations, a type 2451 (51- by 24-in. worktable) with the standard roller measuring system and with hydraulic power traverses for the table to provide for milling operations, and a type 2657 Spacematic machine (57- by 26-in. worktable), with A.E.I. control system, and equipped for contour and "staircase" milling. The machines in this department are used extensively for production machining operations, and an associated section undertakes production planning and the preparation of control tapes.

Assembly operations

Particular attention has been paid to assembly operations at the Peterborough factories. There is a special temperature-controlled shop, originally employed for the assembly of jig borer quills, which is supplied with electrostatically filtered air at a pressure that is slightly higher than atmospheric. The floor and benches in this department are made of "granolith" material to provide hard, dust-free surfaces, and the walls are tiled to shoulder height. A high standard of natural illumination is ensured by the incorporation of large glass-brick panels in the walls and roof.

For the main assembly of Spacematic jig boring machines, also any special machines of this type, there is another temperature controlled department. Other jig borers in the company's range are built in the assembly bay of the main shop, which is served by overhead cranes of 10 tons capacity. At one side of this bay there is a scraping section for finishing slideway surfaces, and it may be mentioned that the company does not employ grinding for this purpose. Extensive use is made of auto-collimators for checking alignments and the straightness of guideway surfaces.

At one end of the assembly bay there is a hydraulic test section, where all bought-out components are checked. Such components comprise principally cylinders and gauges, since the company makes all the hydraulic valves and other units needed for the jig boring and grinding machines. The hydraulic control assemblies are of unit construction, and test facilities have been provided to enable very complicated hydraulic assemblies to be checked. On the basis of investigations carried out for each type of Newall machine, certain values of pressure and flow have been established for particular settings of the various valves and other elements incorporated in the control units. These values are entered on test charts supplied to the hydraulic section, and the required conditions can be simulated on the test bed, so that the hydraulic assemblies are known to be correct before incorporation in machines.

The section is also provided with equipment for running-in and testing spindle assemblies. A

Cambridge recording thermometer provides for the direct comparison of spindle bearing and ambient temperature, and the spindle is run until the variation in temperature does not exceed a specified amount.

All electrical panels incorporated in Newall machines are built by the company in a department that adjoins the main factory building. During the building operations, the panels are supported on vertical racks, made from drilled lengths of angle section steel, and cable is drawn from reels mounted above the racks. A Meddings universal radial machine is employed for drilling the panels, and when they have been completed they are tested in a bay at one side of the department.

The company, which attaches great importance to machine tool research, collaborates with N.P.L., N.E.L. and P.E.R.A., and was a founder member of the Machine Tool Industry Research Association. Investigations are carried out at the Peterborough works, and reference may be made to the vibration test laboratory. A solid block of cast iron, of 4 by 3 ft. area and 2 ft. deep, is sunk into the floor to provide a suitable test bed. Small models in steel or plastics are used for initial investigations at the design stage, and a Goodmans vibrator and stroboscopic lamp provide for visual observation of behaviour. For quantitative investigations, a cathode ray oscilloscope, with a recording camera, are employed. Checks are finally carried out on a Perspex model of a complete machine element, and investigations of finished machines and machine foundations are also undertaken.

There is an apprentice school at the No. 1 works, with a full-time supervisor in charge and a good selection of basic machine tools. Ten apprentices are started each year, and the course is normally for five years, although if a pre-apprenticeship course is taken at the local technical school, training lasts until the age of 21. One year is spent in the Newall school, and then six months in each of the departments concerned with turning, milling (including jig boring), grinding, and fitting. The remainder of the training period is devoted to the work on which the apprentice decides to specialize, and one day each week is allocated to study at the Peterborough Technical College. Awards are made by the firm to the six best apprentices each year (in the opinion of the principal of the college), and those who excel at the college and in the works may transfer to a drawing office course which lasts for about three years. Each year, six visits are made to other engineering works, and the company provides overalls and lunches free to all apprentices up to the age of 17, and at half price up to the age of 19.

The company has recently installed a Stantec (Standard Telephones & Cables, Ltd.) computer and auxiliary facilities at the No. 1 works. This equipment will be used primarily to facilitate costing and stock control, also possibly for shop loading, wages calculations, and certain design problems.

Reference has already been made to the No. 2 factory where there are two large bays which are used exclusively for the erection of jig borers and grinding machines from sub-assemblies and major castings that are transferred from the No. 1 works. Both of these bays have a very high standard of natural illumination, and are served by 20-ton overhead cranes.

For the assembly of both types of machines, extensive use is made of auto-collimators for checking alignments, and special equipment has been developed by the chief inspector of the company to ensure the required fit between the

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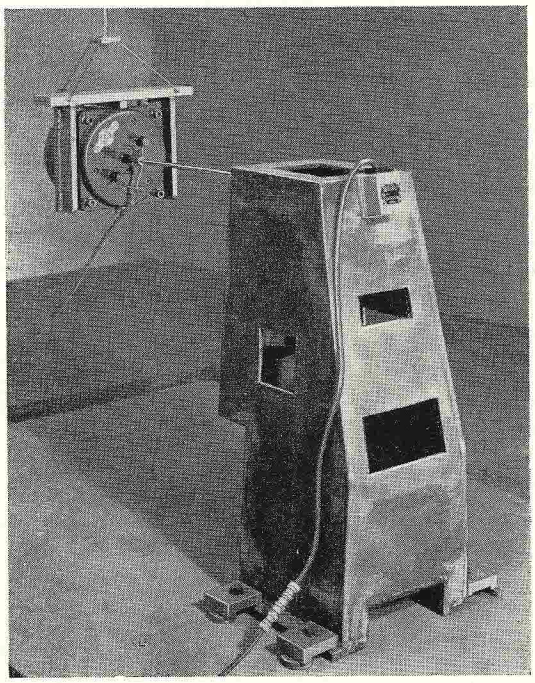
18 *A scale model of the column of a Newall type 2433 jig borer, made from steel plate, is here seen set up for investigation of structural rigidity in the company's vibration testing department. The model is mounted on a solid block of cast iron, measuring 4 by 3 by 2 ft., let into the floor, and vibrations are imparted to it by means of a Goodman's transducer*



19 *Part of the new bay at the company's No. 2 factory at Peterborough, showing the section for the assembly of jig borers. Attention may be drawn to the high standard of natural illumination provided by the roof lights and glazed panels in the walls, also the orderly arrangement of the section. The bay is served by an overhead travelling crane of 20 tons capacity*

quills of jig borers and the mating bores in the quill heads. This equipment consists essentially of an OMT-Etamic differential comparator and associated plug and ring air gauges, which provide for comparison in a manner similar to that employed for match grinding. The quill cylinder is first checked for size and geometry by air gauging and auto-collimation techniques, and the bore diameter of the head to provide the required sliding clearance is determined by direct comparison with the quill during the final honing stage.

Very accurately calibrated master plug and ring gauges are applied to the ring and plug air gauging elements respectively, and the dial of the comparator is then set to zero. Tolerance pointers on the dial are adjusted to indicate the desired limits of the clearance between the quill and the mating bore. The ring gauge remains in position on the quill, since the size and geometry of this component are known to be of the required standard and the plug gauge is applied to the bore at intervals during honing, which is performed on a 28-in. Rockford shaping machine adapted by the company. Normally, a clearance of 0·00015 in. is obtained between the quill and the bore in the quill head.

There is a separate shop at the No. 2 works for the production of hydraulic units, which are made in batches, also for making tooling—principally precision boring bars for use on Newall fine borers.

Manufacture of the company's range of lapping machines and fine borers is now undertaken at the recently commissioned No. 3 factory. The other sections of these premises are devoted to the production of mechanical handling equipment for grinding machines, and to the reconditioning of various types of machine tools built by the company and other makers.