A. E. JERRAM.

PRECISION MACHINE TOOL.

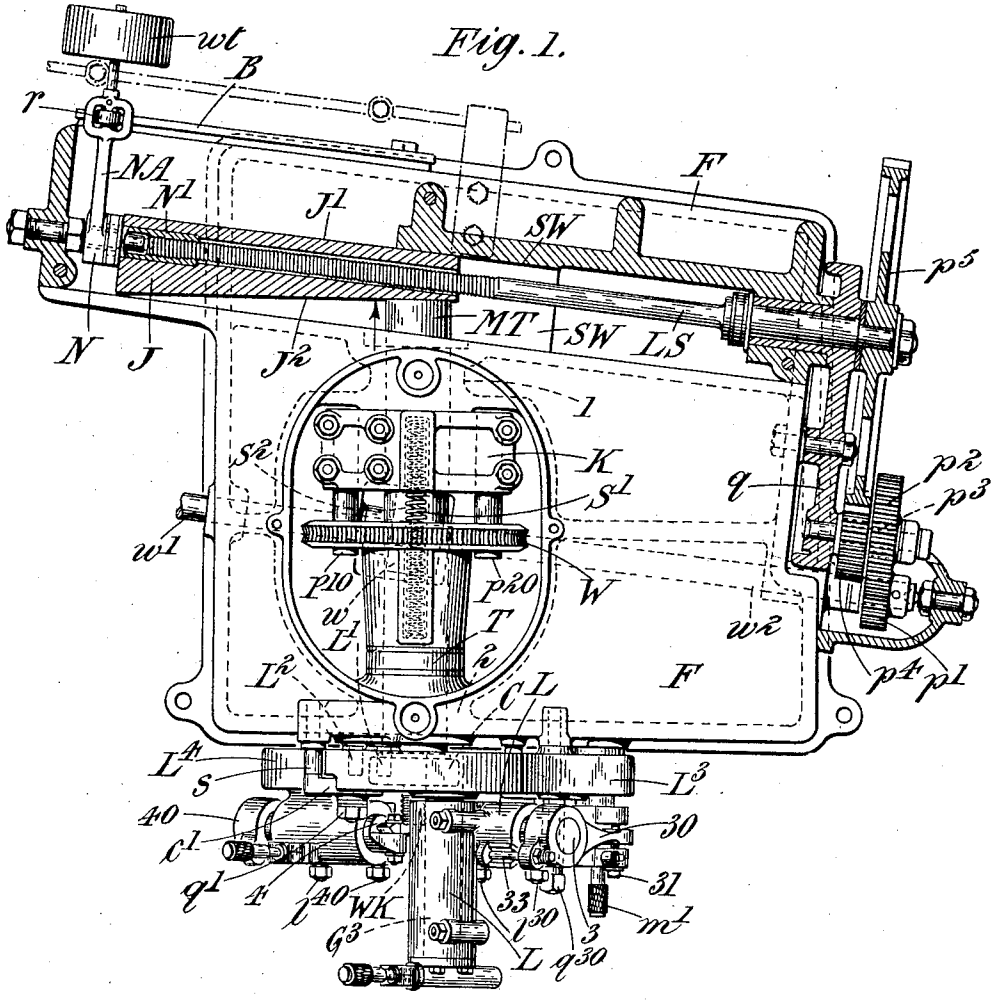
APPLICATION FILED APR. 22, 1918.

1,344,536.

Patented June 22, 1920.

4 SHEETS—SHEET 1.

Fig. 1.



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4 SHEETS—SHEET 2.

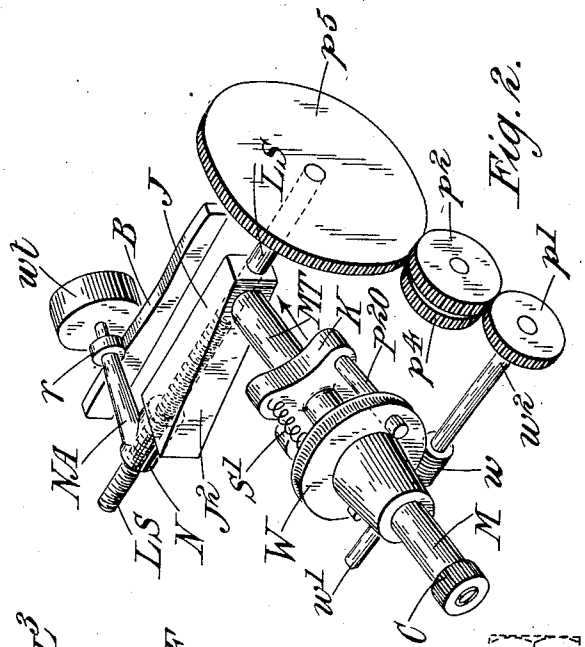


Fig. 2.

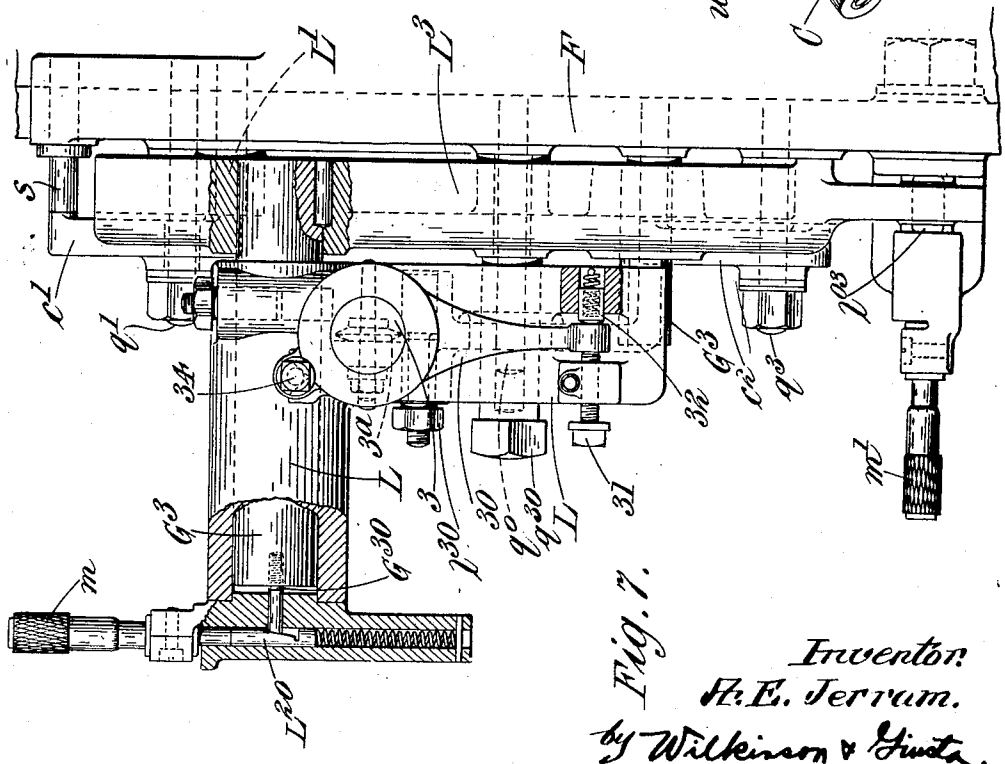


Fig. 1.

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4 SHEETS—SHEET 3.

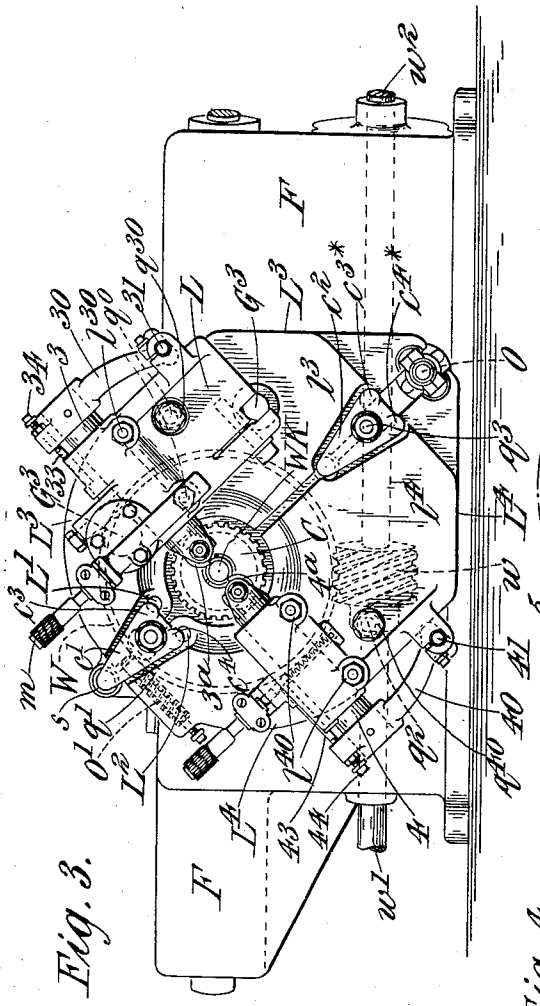


Fig. 3.

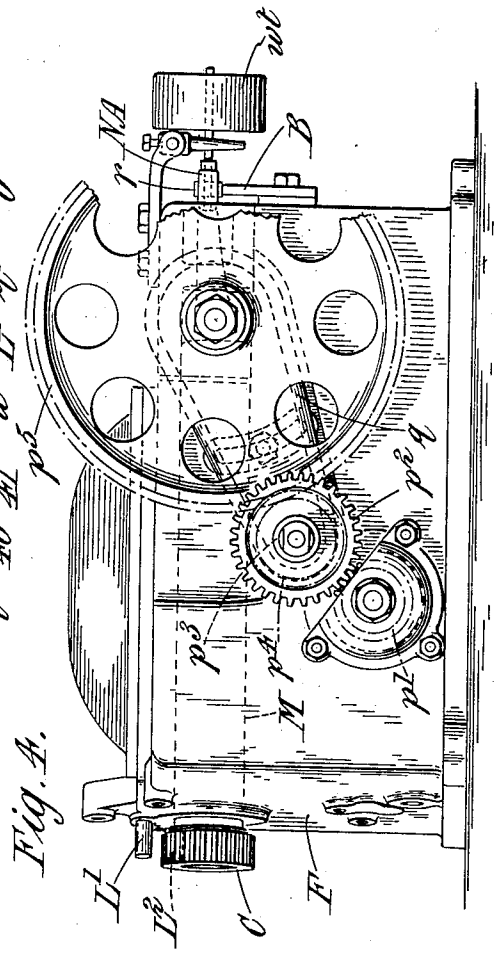


Fig. 4.

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4 SHEETS—SHEET 4.

Fig. 6.

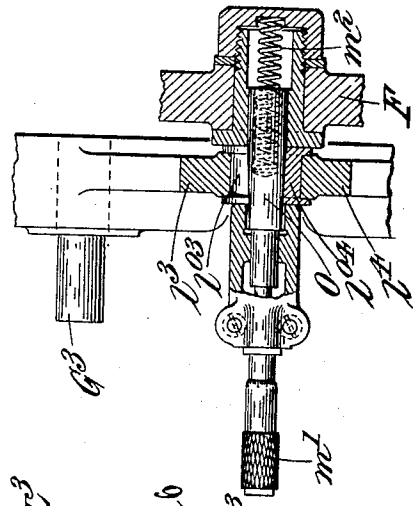
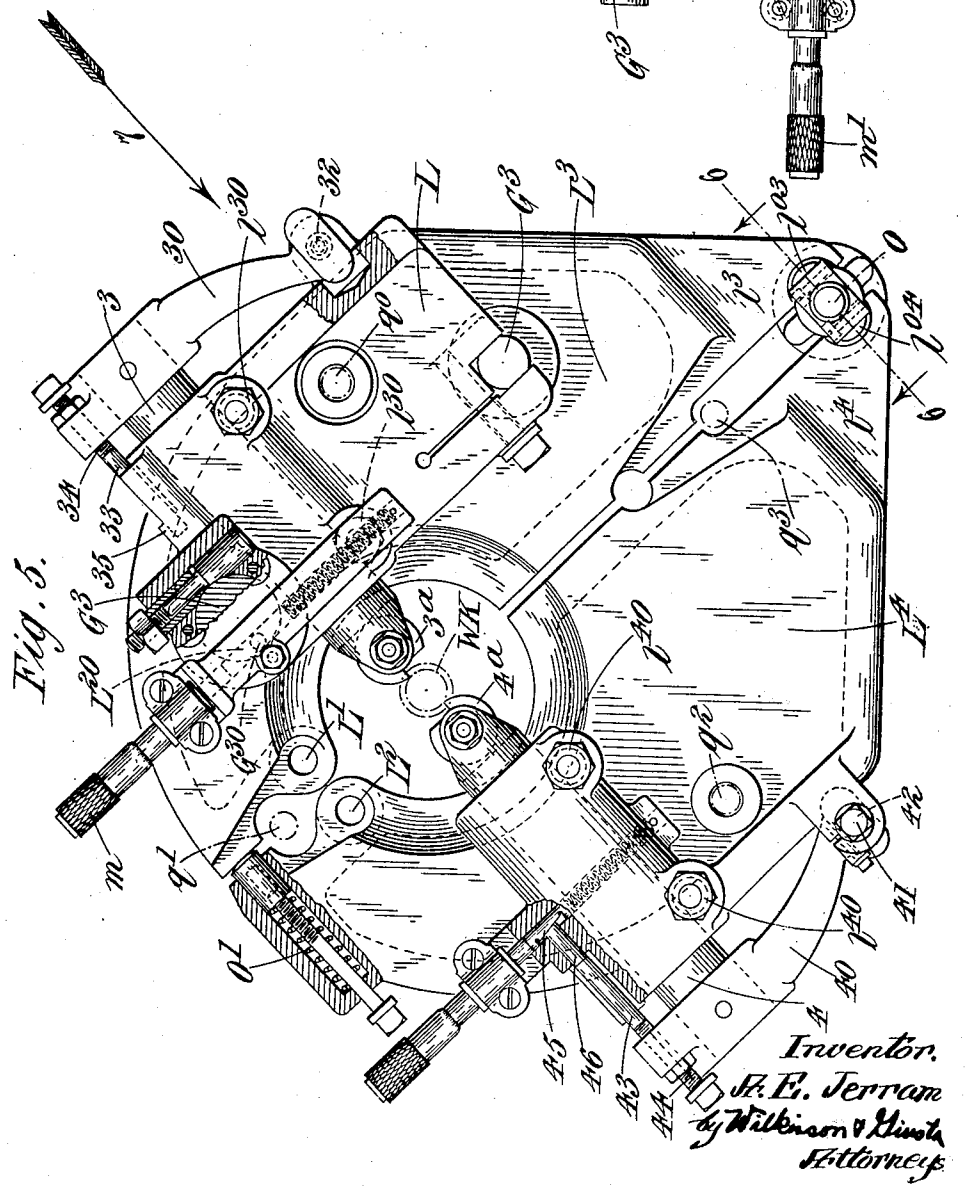


Fig. 5.



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UNITED STATES PATENT OFFICE.

ARTHUR ERNEST JERRAM, OF LEICESTERSHIRE, ENGLAND.

PRECISION MACHINE-TOOL.

1,344,536. Specification of Letters Patent. Patented June 22, 1920.

Application filed April 22, 1918. Serial No. 230,088.

To all whom it may concern:

Be it known that I, ARTHUR ERNEST JERRAM, a subject of the King of England, residing at Leicestershire, England, have invented certain new and useful Improvements in Precision Machine-Tools, of which the following is a specification.

This invention relates to a process and apparatus for making accurate precision screws, such for example as are required for use as screw gages or as components of measuring devices.

Broadly speaking the improved process is one wherein two cutting tools for forming the screw threads are arranged to act on opposite ends of a diameter of the work and each against a different part of the thread contour to the other, for example against opposite flanks of a screwthread in order that the pressure each thus exerts against the work shall be almost entirely counterbalanced by the equal pressure of its companion situated nearly in the same plane and acting in the opposite direction and therefore shall neither put any considerable bending stress on the work nor set up any material side thrust against the work-holder or against the bearings in the machine in which the latter is supported.

By dividing between the two cutters the work of taking a finishing cut over the flanks and root of the thread the individual thrusts of each tool are approximately halved as compared with the single tool ordinarily used and are thus reduced to the minimum compatible with finishing the entire contour of the screw thread at one traverse. Furthermore, by allocating the finishing cut on each flank of a thread to a different cutter the cutting edges can have the top rake that is required to enable the tool to cut the material efficiently and with a minimum of thrust.

Furthermore this distribution and minimizing of the thrusts of cutting enable work that is held in a chuck to be screw-threaded with greater precision than has been heretofore practicable. Prior to this invention precision screws such as screw gages have always been machined between centers supporting both ends of the work and the necessary slack to insure a running fit on the centers is a source of trouble affecting both the diametral and pitch measurements and rendering uniformity of temperature of work and machine more essential than is necessary according to the preferred method of carrying out my process.

Heretofore screw-gages and the like have been made in machines in which the traversing motion of the cutter or of the mandrel was obtained directly from a lead-screw which is well-known to be a device extremely difficult to make accurately. The machine of the present invention is primarily designed to secure extraordinary accuracy in the working of the complete machine, while the separate elements concerned do not require to be of anything more than the accuracy that is readily obtainable commercially. A second object of the present invention is the finishing of a maximum number of thread-gages with one sharpening and setting of the cutters so that the minimum amount of skilled labor shall be required. This result is secured by employing cutters of the correct form for cutting tools for steel to perform only the fine finishing cuts along the contours of the screw-thread which when submitted to their action, is slightly above the finished size and has been made accurate within what are known as "commercial limits" only. The principal features of a machine constructed according to the present invention are:—A rotary traversing mandrel combined with a shaft for actuating it, and with two trains of reducing-gearing which two trains are operative connections of a positive kind which connect the mandrel and said shaft and are proportioned the one train to turn the mandrel at an angular velocity low in relation to that of the said shaft and the other train to impart a "traverse" to the mandrel of a linear velocity low in relation to the peripheral velocity of that shaft; also as elements in the traversing train, a wedge and a screw to propel the wedge; also a nut journaled in the wedge to effect the traverse of the wedge while under the control of a compensating-cam operating in the manner hereinafter explained; and also certain arrangements and adjustments, hereinafter described in detail, of the cutters which operate on the work.

In the accompanying drawings:—

Figure 1 is a plan view, partly in section of a machine-tool constructed and operating according to the present invention;

Fig. 2 is a perspective view illustrating diagrammatically certain essential features

of Fig. 1, hereinafter more particularly referred to;

Fig. 3 is an elevation of that portion of the machine which in the plan, Fig. 1, is the lower portion;

Fig. 4 is an elevation of part of what is the right-hand end of the machine in Fig. 1;

Fig. 5 is an enlarged view of part of what is shown on a smaller scale in Fig. 3 and with certain of the details in section;

Fig. 6 is a section of wedge devices employed in Fig. 5, the section being taken on the line 6—6 of Fig. 5; and

Fig. 7 is a side elevation of Fig. 5 taken in the direction of the arrow, Fig. 5.

Like letters and reference numerals indicate like parts throughout the drawings.

The machine (see primarily Figs. 1 and 2) comprises a main frame F with bearings 1 and 2 in which is a parallel rotary traversing mandrel M. At the forward end of the mandrel is a collet chuck C or other means to fix the work securely to it.

A worm-wheel W is provided on the mandrel M by which the mandrel can be turned and through which the mandrel can move endwise, they being prevented from having a rotatory motion one in relation to the other, by pins P^{10} P^{20} parallel with the mandrel and carried spaced well apart on a cross-head K attached rigidly thereto, and sliding through holes in the worm-wheel toward opposite ends of a diameter of the latter. A worm *w* is provided to drive the worm-wheel W.

Two springs S^1 S^2 are interposed between the worm-wheel and the cross-head K and act to press the mandrel in an endwise direction, *i. e.* the direction indicated by the arrow in Figs. 1 and 2 toward the rear of the machine and the worm-wheel forwardly up against a thrust bearing T abutting against the part 2 of the main frame. The thrust bearing T is preferably a ball thrust. The springs are sufficiently strong to insure that the tail end MT of the mandrel shall always bear against the face of the wedge J hereinafter described.

To move the mandrel endwise against the resistance of the springs S^1 S^2 a wedge J is provided which slides across the rear end of the mandrel upon a slide-way SW on the main frame, the slideway being slightly angled, as shown in Fig. 1, in relation to the mandrel axis. The wedge J bears against the flat-ended tail MT of the mandrel M to move it endwise in the mandrel bearings 1, 2. This wedge is driven by a lead-screw LS arranged parallel to the slideway SW. A nut N on the wedge is engaged by the lead-screw; it is held against endwise movement in relation to the wedge (by any convenient means which will permit it to rotate in relation to the wedge though in Fig. 2, to avoid complicating the diagram it is indicated as being merely contiguous to the end of said wedge) in which wedge an extension N^1 of the nut is journaled as shown in Fig. 1. This nut is provided with an arm NA. A stationary cam-bar B is fixed to the rear of the machine-frame F and along this cam-bar the said arm NA travels in the movement of the wedge J so as to keep the arm and its nut from turning or to impart to them a small angular adjustment, as required. This small angular adjustment is employed to correct minutely the relationship between the travel of the wedge J and the rotation of the lead-screw LS so that by suitably shaping the top edge of the cam-bar B the small periodic or other errors existent in all machine parts such as the lead-screw or the wedge can be accurately and readily compensated for.

There is an anti-friction roller *r* on the arm to bear on the cam-bar B, and on the outer end of the arm a weight *wt* which keeps the arm NA pressed toward the roller and keeps the roller down on the bar.

The cam-bar is preferably secured to a facing on the machine-frame by screws at either end and in such manner that either end of the bar may be raised or lowered to compensate for total error of traverse or it may be to enable metric threads to be cut in a machine initially arranged for English threads, or vice versa. In certain cases the cam-bar might even be a simple bar with a straight upper face inclined slightly out of the horizontal.

The wedge J is a solid and long one, with an easy taper upon it and two directly-opposite acting faces J^1 J^2, one J^1 acting against an abutting face of the slideway SW aforesaid and the other J^2 against the tail MT of the mandrel M; the taper is about one in ten, consequently inaccuracies in the pitch of the lead-screw LS are minimized to about one-tenth, and small errors that can be discovered in resultant work can be practically eliminated by suitably shaping in a comparatively rough and ready manner the cam-bar B acting on the arm NA of the nut N above referred to, so as to correct not only inaccuracies in the lead-screw but also inaccuracies in the wedge J.

The shaft w^1 w^2 on which is the before-mentioned worm *w* for rotating the mandrel, is driven at its end w^1 (preferably by a self-adjusting coupling of any suitable construction) from a countershaft not shown in the drawings, provided with a reversing device, and the other w^2 end of the worm-shaft carries a gear-pinion p^1 adapted to engage a change-gear wheel p^2 carried on a rotating sleeve p^3 that is provided with a gear-pinion p^4 meshing with a gear-wheel p^5 which latter is fixed to the lead-screw LS that propels the wedge J. The change-gear wheel sleeve p^3 is mounted

on an arm q that can be adjusted about the axis of the lead-screw as in a lathe, so as to support change wheels p^2 and bring different sizes of these wheels into accurate mesh with the gear-pinion p^1 on the worm shaft. The rotation of the worm-wheel W that turns the mandrel M being effected slowly by the relatively fast-turning worm w fixed on the shaft w^1 w^2, and the traversing of the mandrel (that combined with the turning, generates the spiral of the screw-thread) being effected slowly by reducing-gear p^1 p^2 p^4 p^5, lead-screw LS and wedge J, it will be seen that just as the rotary movement of W and the traversing movement of M are reduced in relation to the angular velocity of the shaft w^1 w^2, so also will be reduced the effect on the rotation of W and the traverse of M of any error in the transmission of the angular velocity of w^1 w^2 aforesaid to the parts ultimately driven by it. Furthermore, the change-gear (such as p^1 p^2 p^4 p^5) for the different pitches of screwthread being high speed and acting as a reducing-gear in synchronizing both the turning and traversing of the mandrel, it follows that ordinary commercially-cut gears can be used without materially affecting the accuracy of the work, for errors in the gears will be reduced down before they get as far as the lead-screw spindle, to dimensions so small as even upon the finest work to be negligible.

Inasmuch as the springs S^1 S^2 as aforesaid are sufficiently strong to prevent the tail end MT of the mandrel M from ever leaving the face J^2 of the wedge J, the traversing movement of the mandrel, no less than its movements of rotation may be considered as under positive control, for while the devices for rotating the mandrel are in the strictest sense positive, the gear for traversing the mandrel is strictly positive when the mandrel is being thrust toward the front of the machine and the screw is being formed.

Referring now to Figs. 3, 5, 6 and 7, cutter-carrier-bars or "carriers" 3 and 4 are set on opposite sides of the chuck C (Fig. 3) so as to be 180 degrees apart and radial and perpendicular to the mandrel-axis. The cutters 3^a 4^a for cutting the thread are circular "form" turning-tools preferably each cutting on one flank of the screw-thread only, and each is mounted with the center line of its cutting edge in line with the axis of the cutter-carrier, which carrier is cylindric. A saddle for each cutter-carrier is provided and may be constituted by a substantial lever L^3 or L^4 appropriated to it and pivoted at L^1 or L^2 respectively to the main frame F at a point much nearer the left-hand end of each lever than to the other. The longer ends l^3 l^4 of these levers are capable of a slight movement toward and away from one another, like a pair of jaws. Each cylindric cutter-carrier 3 or 4 is adjustable to slide endwise along and also to turn in a bearing or bore in its saddle arranged radially to the mandrel-axis, and it can be clamped by clamp-screws l^{30} (see Fig. 5) or l^{40} in the position to which it is thus adjusted. One cutter-carrier 4 (see also Fig. 5) is directly mounted in the lever L^4, the other 3 is in a carriage L forming part of the lower arm of the lever L^3 but capable of being moved in relation to the latter along guide bars G^3 on the lever that are parallel to the mandrel-axis. This latter adjustment is to enable the cutter-carrier with its cutter to be set to suit the pitch of the thread being cut, and is controlled by a suitable micrometer m which actuates an adjusting wedge L^{20} bearing against a projection G^{30} on the upper guide bar G^3. Clamping bolts are provided at q^1 q^2 q^3 to lock the levers in adjusted position while a cut is being taken.

Of these bolts, q^1 passes through a plain hole in a triangular clamp-plate c^1 into a threaded hole in the frame F of the machine (see Figs. 5 and 7). The bolt-head bears on the clamp-plate near one end thereof, and the outer end of the clamp-plate c^1 rests on a fixed extension or stud s in the frame F. The corners c^3 and c^4 of c^1 rest respectively on the levers L^3 and L^4; so, by screwing in the bolt q^1 the levers L^3 and L^4 are pressed by the clamp-plate c^1 toward the frame, at points near to the lever pivots L^1 L^2.

The bolt q^3 controls a similar clamp c^2 which by its corners $c^{3\times}$ and $c^{4\times}$ bears on the levers L^3 L^4 at points remote from their pivots L^1 and L^2.

The bolt q^2 has upon it a box nut $q^{4\circ}$ the inner end of which bears on the side of the lever L^4; a similar bolt q° has a similar box nut $q^{3\circ}$ which bears on the side of the lever L^3.

A wedge O and a micrometer adjustment m^1 therefore are provided to move the cutters toward and away from one another by altering the distance between the adjacent longer ends l^3 l^4 of the saddles or levers L^3 L^4 aforesaid. The wedge is kept by a spring in compression, m^2, against the end of the micrometer device m^1 and the sides of the wedge bear against half-bushes l^{03} l^{04} which are seated in the ends of the longer arms l^3 l^4. A spring O^1 in compression acts, see Figs. 3 and 5, between the adjacent heels or arms of the said levers L^3 L^4 to keep the outer arms thereof pressed toward the aforesaid wedge O.

The cutter-carriers 3 and 4 are adjustably rotatable in their bearings to set the cutters to suit the angle of thread to be cut, and they are arranged to slide in the same bearings to suit different diameters of screw-gages or other work indicated at WK in

Figs. 3 and 5. The rotation of the cutter-carriers 3 and 4 in their bearings is controlled by an arm 30 or 40 fixed to each and actuated by an adjusting screw 31 or 41 and spring-plunger 32 or 42. After the cutters have been thus angled correctly, the endwise adjustment of the cutter-carriers can be effected by means of standard distance-pieces 33 43. Against the outer end of each distance-piece rests a screw 44 in the carrier 40 and 34 in the carrier 30. The inner end of the distance-piece 33 rests in a seat 35 formed in the carriage L as shown. By a choice of distance-pieces of suitable length the situation of the carriers 3 and 4 can be adjusted to definite positions to suit particular diameters of screws as regards their endwise movement in relation to the levers in which they are borne.

An independent fine axially-endwise adjusting device for the carrier 4 consists of a micrometer-screw-actuated wedge 45 for adjusting a sliding abutment 46 against which the inner end of the distance-piece 43 bears; this is provided in the lever L^4 only, so that the carrier 4 and its cutter 4^a may be adjusted to and from the work to precisely the same distance as that of the cutter 3^a from the exact center of the work.

The clamping bolts l^{30} l^{40} clamp the cutter-carriers in their bores in the positions into which they have been radially and rotatably adjusted.

The saddles or levers L^3 L^4 themselves are finally clamped down to the frame F by the clamping devices q^0 q^1 q^2 q^3 aforesaid which engage each saddle at three points (see Fig. 3) so that no distortion or displacement of the saddle can take place from the action of the clamps.

As the cutter-carriers and the saddles or levers on which they are mounted are all rigidly locked after adjustment, there are no slacks or oil films anywhere in the cutter-supporting devices that vary and may alter the cut during the actual cutting of the screwthread.

The work in the collet chuck C is preferably gripped on two parts of the shank of the screw or gage so as in effect to secure it rigidly to the mandrel M before mentioned.

In the case of cutters with widely-spaced teeth, these driving-shafts should preferably be so geared together as to insure that the respective teeth of each cutter act on the work simultaneously with the respective teeth on the other cutter.

What I claim as my invention and desire to secure by Letters Patent is:—

1. A machine provided with a rotary traversing mandrel combined with a shaft and two separate trains of reducing gearing, which two trains are connected separately from one another to the said shaft, and are operative connections of a positive kind connecting the mandrel and said shaft and are proportioned the one train to turn the mandrel at an angular velocity low in relation to that of the said shaft and the other train to impart "traverse" to the mandrel of a linear velocity low in relation to the peripheral velocity of that shaft.

2. The subject-matter of preceding claiming-clause No. 1, plus two cutting-tools adjustably mounted in supports on the machine-frame and situated at opposite sides of the mandrel-end to minimize unbalanced cross-thrust on it.

3. The subject-matter of preceding claiming-clause No. 1, plus two cutting-tools adjustably mounted in supports on the machine-frame and situated at opposite sides of the mandrel-end to minimize unbalanced cross-thrust on it and locking means for locking the adjusted tools and their supports in relation to the machine-frame after their adjustment in relation thereto.

4. The subject-matter of preceding claiming-clause No. 1, plus two cutting-tools adjustably mounted in supports on the machine-frame and situated at opposite sides of the mandrel-end to minimize unbalanced cross-thrust on it and so as to be adjustable along radii of the work toward and away from it and adjustable rotarily about their own axes which are normal to the axis of the work.

5. The subject-matter of preceding claiming-clause No. 1, plus two cutting-tools adjustably mounted in supports on the machine-frame and situated at opposite sides of the mandrel-end to minimize unbalanced cross-thrust on it, and so to be adjustable along radii of the work toward and away from it and adjustable rotarily about their own axes which are normal to the axis of the work, and locking means for locking the adjusted tools and their supports in relation to the machine-frame after their adjustment in relation thereto.

6. The subject-matter of preceding claiming-clause No. 1, plus two cutting-tools adjustably mounted in supports on the machine-frame and situated at opposite sides of the mandrel-end to minimize unbalanced cross-thrust on it and so as to be adjustable along radii of the work toward and away from it and adjustable rotarily about their own axes which are normal to the axis of the work, and means to adjust one of the cutters in a direction parallel to that of the work-axis.

7. The subject-matter of preceding claiming-clause No. 1, plus two cutting-tools adjustably mounted in supports on the machine-frame and situated at opposite sides of the mandrel-end to minimize unbalanced cross-thrust on it and so as to be adjustable along radii of the work toward and away

from it and adjustable rotarily about their own axes which are normal to the axis of the work, means to adjust one of the cutters in a direction parallel to that of the work-axis and locking means for locking the adjusted tools and their supports in relation to the machine-frame after their adjustment in relation thereto.

8. In a machine tool the combination of a plurality of cutters supported on opposite sides of the work, each cutter to act against a face of the thread contour different from the face against which the companion cutter acts, one cutter adjustable in its support in a direction parallel to that of the axis of the work and independently of the other, and means for adjusting them simultaneously toward and away from the work.

9. In a machine tool the combination of two cutters supported on opposite sides of the work one adjustable in its support in a direction parallel to that of the axis of the work and independently of the other, means for adjusting them simultaneously toward and away from the work and means whereby one of the cutters is adjustable along a radius of the work toward and away from the work independently of its companion.

10. In a machine tool the combination of a rotary traversing mandrel, bearings in which it is movable endwise as well as rotatably, a driving-shaft, a train of reducing gearing which forms an operative connection between said mandrel and driving-shaft and turns the former at an angular velocity lower than that of the latter, a wedge with two long faces against one of which faces the tail of the traversing mandrel abuts, yielding means to press the said tail against the wedge, a slideway constituting an abutment along which the wedge slides and which is at an angle to that one of the long wedge-faces against which the mandrel tail abuts and a train of reducing-gearing forming an operative driving-connection to propel the wedge and so proportioned that the linear movement thereby imparted to the wedge shall be low in relation to the peripheral velocity of the shaft from which said reducing gear is actuated.

11. In a machine tool the combination of a rotary traversing mandrel, bearings in which it is movable endwise as well as rotatably, a driving-shaft, a train of reducing gearing which forms an operative connection between said mandrel and driving-shaft and turns the former at an angular velocity lower than that of the latter, a wedge with two long faces against one of which faces the tail of the traversing mandrel abuts, yielding means to press the said tail against the wedge, a slideway constituting an abutment along which the wedge slides and which is at an angle to that one of the long wedge-faces against which the mandrel tail abuts, a lead-screw in fixed bearings, a driving-shaft for the lead-screw, and a train of reducing-gearing which forms an operative connection between said lead-screw and the said driving-shaft of the lead-screw and turns the lead-screw at an angular velocity lower than that of its driving-shaft.

12. In a machine tool the combination of a rotary traversing mandrel, bearings in which it is movable endwise as well as rotatably, a driving shaft, a train of reducing-gearing which forms an operative connection between said mandrel and driving-shaft and turns the former at an angular velocity lower than that of the latter, a wedge with two long faces against one of which faces the tail of the traversing mandrel abuts at a right angle, yielding means to press the said tail against the wedge, a slideway constituting an abutment along which the wedge slides and which is at an angle to that one of the long wedge-faces against which the mandrel tail abuts, a lead-screw in fixed bearings, a driving-shaft for the lead-screw, a train of reducing-gearing which forms an operative connection between said lead-screw and the said driving-shaft of the lead-screw and turns the lead-screw at an angular velocity lower than that of its driving shaft, a worm-wheel co-axial with the traversing mandrel and in sliding but relatively non-rotary connection therewith, and a worm-shaft geared with the worm-wheel and set in bearings in the machine-frame with its axis parallel to the axis of the lead-screw.

13. In a machine tool the combination of a rotary traversing mandrel, bearings in which it is movable endwise as well as rotatably, a driving-shaft, a train of reducing-gearing which forms an operative connection between said mandrel and driving-shaft and turns the former at an angular velocity lower than that of the latter, a wedge with two long faces against one of which faces the tail of the traversing mandrel abuts, yielding means to press the said tail against the wedge, a slideway constituting an abutment along which the wedge slides and which is at an angle to that one of the long wedge-faces against which the mandrel tail abuts, a lead-screw in fixed bearings, a driving-shaft for the lead-screw, a train of reducing-gearing which forms an operative connection between said lead-screw and the said driving-shaft of the lead-screw and turns the lead-screw at an angular velocity lower than that of its driving-shaft, a nut mounted on the wedge and rotatable on it but held against endwise movement in relation to the wedge and threaded to the lead-screw, a cam stationary alongside the line in which the nut moves with the wedge, and a lever extending from the nut and means to keep said

lever pressed against the cam while it is drawn along the cam in the movement of the nut.

14. In a machine tool the combination of a rotary traversing mandrel, bearings in which it is movable endwise as well as rotatably, a driving-shaft, a train of reducing-gearing which forms an operative connection between said mandrel and driving-shaft and turns the former at an angular velocity lower than that of the latter, a wedge with two long faces against one of which faces the tail of the traversing mandrel abuts at a right angle, yielding means to press the said tail against the wedge, a slideway constituting an abutment along which the wedge slides and which is at an angle to that one of the long wedge-faces against which the mandrel tail abuts, a lead-screw in fixed bearings, a driving-shaft for the lead-screw, a train of reducing-gearing which forms an operative connection between said lead-screw and the said driving-shaft of the lead-screw and turns the lead-screw at an angular velocity lower than that of its driving-shaft, a nut mounted on the wedge and rotatable on it but held against endwise movement in relation to the wedge and threaded to the lead-screw, a cam stationary alongside the line in which the nut moves with the wedge, and a lever extending from the nut and means to keep said lever pressed against the cam while it is drawn along the cam in the movement of the nut.

15. In a machine tool the combination of a rotary traversing mandrel, bearings in which it is movable endwise as well as rotatably, a driving-shaft, a train of reducing-gearing which forms an operative connection between said mandrel and driving-shaft and turns the former at an angular velocity lower than that of the latter, a wedge with two long faces against one of which faces the tail of the traversing mandrel abuts, yielding means to press the said tail against the wedge, a slideway constituting an abutment along which the wedge slides and which is at an angle to that one of the long wedge-faces against which the mandrel tail abuts, a lead-screw in fixed bearings, a driving-shaft for the lead-screw, a train of reducing-gearing which forms an operative connection between said lead-screw and the said driving-shaft of the lead-screw and turns the lead-screw at an angular velocity lower than that of its driving-shaft, a nut mounted on the wedge and rotatable on it but held against endwise movement in relation to the wedge and threaded to the lead-screw, a cam stationary alongside the line in which the nut moves with the wedge, a lever extending from the nut and means to keep said lever pressed against the cam while it is drawn along the cam in the movement of the nut and two cutting-tools adjustably mounted in supports on the machine-frame and situated at opposite sides of the mandrel-end to minimize unbalanced cross-thrust on it.

16. In a machine tool the combination of a rotary traversing mandrel, bearings in which it is movable endwise as well as rotatably, a driving-shaft, a train of reducing-gearing which forms an operative connection between said mandrel and driving-shaft and turns the former at an angular velocity lower than that of the latter, a wedge with two long faces against one of which faces the tail of the traversing mandrel abuts, yielding means to press the said tail against the wedge, a slideway constituting an abutment along which the wedge slides and which is at an angle to that one of the long wedge-faces against which the mandrel tail abuts, a lead-screw in fixed bearings, a driving-shaft for the lead-screw, a train of reducing-gearing which forms an operative conection between said lead-screw and the said driving-shaft of the lead-screw and turns the lead-screw at an angular velocity lower than that of its driving-shaft, a nut mounted on the wedge and rotatable on it but held against endwise movement in relation to the wedge and threaded to the lead-screw, a cam stationary alongside the line in which the nut moves with the wedge, a lever extending from the nut and means to keep said lever pressed against the cam while it is drawn along the cam in the movement of the nut, and cutter-carrier bars borne by the machine frame 180° apart and radial and perpendicular to the mandrel-axis and rotatable and endwise movable in relation to their supports on the machine-frame.

17. In a machine tool the combination of a rotary traversing mandrel, bearings in which it is movable endwise as well as rotably, a driving-shaft, a train of reducing gearing which forms an operative connection between said mandrel and driving-shaft and turns the former at an angular velocity lower than that of the latter, a wedge with two long faces against one of which faces the tail of the traversing mandrel abuts, yielding means to press the said tail against the wedge, a slideway constituting an abutment along which the wedge slides and which is at an angle to that one of the long wedge-faces against which the mandrel tail abuts, a lead-screw in fixed bearings, a driving-shaft for the lead-screw, a train of reducing gearing which forms an operative connection between said lead-screw and the said driving-shaft of the lead-screw and turns the lead-screw at an angular velocity lower than that of its driving-shaft, a nut mounted on the wedge and rotatable on it but held against endwise movement in relation to the wedge and threaded to the lead-screw, a cam stationary along-

side the line in which the nut moves with the wedge, a lever extending from the nut and means to keep said lever pressed against the cam while it is drawn along the cam in the movement of the nut, two cutting-tools adjustably mounted in supports on the machine-frame and situated at opposite sides of the mandrel-end to minimize unbalanced cross-thrust on it, a saddle carrying each cutting-tool and pivoted by one end of the saddle to the machine-frame, both saddles pivoted at one side of the mandrel and extended from their pivots past the mandrel to its opposite side, and clamps for the saddles.

18. In a machine tool the combination of a rotary traversing mandrel, bearings in which it is movable endwise as well as rotatably, a driving-shaft, a train of reducing gearing which forms an operative connection between said mandrel and driving-shaft and turns the former at an angular velocity lower than that of the latter, a wedge with two long faces against one of which faces the tail of the traversing mandrel abuts, yielding means to press the said tail against the wedge, a slideway constituting an abutment along which the wedge slides and which is at an angle to that one of the long wedge-faces against which the mandrel tail abuts, a lead-screw in fixed bearings, a driving-shaft for the lead-screw, a train of reducing gearing which forms an operative connection between said lead-screw and the said driving-shaft of the lead-screw and turns the lead-screw at an angular velocity lower than that of its driving-shaft, a nut mounted on the wedge and rotatable on it but held against endwise movement in relation to the wedge and threaded to the lead-screw, a cam stationary alongside the line in which the nut moves with the wedge, a lever extending from the nut and means to keep said lever pressed against the cam while it is drawn along the cam in the movement of the nut, two cutting-tools adjustably mounted in supports on the machine-frame and situated at opposite sides of the mandrel-end to minimize unbalanced cross-thrust on it, a saddle carrying each cutting-tool and pivoted by one end of the saddle to the machine-frame, both saddles pivoted at one side of the mandrel and extended from their pivots past the mandrel to its opposite side, clamps for the saddles, a carriage interposed between one saddle and one cutter, to support the cutter adjustably along the length of the mandrel in relation to that saddle, and guides on said saddle for the carriage that are parallel to the mandrel-axis.

19. In a machine tool the combination of a rotary traversing mandrel, bearings in which it is movable endwise as well as rotatably, a driving-shaft, a train of reducing gearing which forms an operative connection between said mandrel and driving-shaft and turns the former at an angular velocity lower than that of the latter, a wedge with two long faces against one of which faces the tail of the traversing mandrel abuts, yielding means to press the said tail against the wedge, a slideway constituting an abutment along which the wedge slides and which is at an angle to that one of the long wedge-faces against which the mandrel tail abuts, a lead-screw in fixed bearings, a driving-shaft for the lead-screw, a train of reducing gearing which forms an operative connection between said lead-screw and the said driving-shaft of the lead-screw and turns the lead-screw at an angular velocity lower than that of its driving-shaft, a nut mounted on the wedge and rotatable on it but held against endwise movement in relation to the wedge and threaded to the lead-screw, a cam stationary alongside the line in which the nut moves with the wedge, a lever extending from the nut and means to keep said lever pressed against the cam while it is drawn along the cam in the movement of the nut, two cutting-tools adjustably mounted in supports on the machine-frame and situated at opposite sides of the mandrel-end to minimize unbalanced cross-thrust on it, a saddle carrying each cutting-tool and pivoted by one end of the saddle to the machine-frame, both saddles pivoted at one side of the mandrel and extended from their pivots past the mandrel to its opposite side, yielding means which thrust the saddles toward one another at that side of the mandrel which faces away from the saddle pivots, and a wedge between the approaching portions of the saddles which is adjustable in a direction perpendicular to the plane of their approach, and clamps for the saddles.

20. In a machine tool the combination of a rotary traversing mandrel, bearings in which it is movable endwise as well as rotatably, a driving-shaft, a train of reducing gearing which forms an operative connection between said mandrel and driving-shaft and turns the former at an angular velocity lower than that of the latter, a wedge with two long faces against one of which faces the tail of the traversing mandrel abuts, yielding means to press the said tail against the wedge, a slideway constituting an abutment along which the wedge slides and which is at an angle to that one of the long wedge-faces against which the mandrel tail abuts, a lead-screw in fixed bearings, a driving-shaft for the lead-screw, a train of reducing gearing which forms an operative connection between said lead-screw and the said driving-shaft of the lead-screw and turns the lead-screw at an angu-

lar velocity lower than that of its driving-shaft, a nut mounted on the wedge and rotatable on it but held against endwise movement in relation to the wedge and threaded to the lead-screw, a cam stationary alongside the line in which the nut moves with the wedge, a lever extending from the nut and means to keep said lever pressed against the cam while it is drawn along the cam in the movement of the nut, two cutting-tools adjustably mounted in supports on the machine-frame and situated at opposite sides of the mandrel-end to minimize unbalanced cross-thrust on it, a saddle carrying each cutting-tool and pivoted by one end of the saddle to the machine-frame, both saddles pivoted at one side of the mandrel and extended from their pivots past the mandrel to its opposite side, yielding means which thrust the saddles toward one another at that side of the mandrel which faces away from the saddle pivots, a wedge between the approaching portions of the saddles which is adjustable in a direction perpendicular to the plane of their approach, clamps for the saddles, a carriage interposed between one saddle and one cutter, to support the cutter adjustably along the length of the mandrel in relation to that saddle, and guides on said saddle for the carriage that are parallel to the mandrel-axis.

21. In a machine tool the combination of a rotary traversing mandrel, bearings in which it is movable endwise as well as rotatably, a driving-shaft, a train of reducing gearing which forms an operative connection between said mandrel and driving-shaft and turns the former at an angular velocity lower than that of the latter, a wedge with two long faces against one of which faces the tail of the traversing mandrel abuts, yielding means to press the said tail against the wedge, a slide-way constituting an abutment along which the wedge slides and which is at an angle to that one of the long wedge-faces against which the mandrel tail abuts, a lead-screw in fixed bearings, a driving-shaft for the lead-screw, a train of reducing gearing which forms an operative connection between said lead-screw and the said driving-shaft of the lead-screw and turns the lead-screw at an angular velocity lower than that of its driving-shaft, a nut mounted on the wedge and rotatable on it but held against endwise movement in relation to the wedge and threaded to the lead-screw, a cam stationary alongside the line in which the nut moves with the wedge, a lever extending from the nut and means to keep said lever pressed against the cam while it is drawn along the cam in the movement of the nut, two cutting-tools adjustably mounted in supports on the machine-frame and situated at opposite sides of the mandrel-end to minimize unbalanced cross-thrust on it, and locking means for locking the adjusted tools and their supports in relation to the machine-frame after their adjustment in relation thereto.

22. In a machine tool the combination of a rotary traversing mandrel, bearings in which it is movable endwise as well as rotatably, a driving-shaft, a train of reducing gearing which forms an operative connection between said mandrel and driving-shaft and turns the former at an angular velocity lower than that of the latter, a wedge with two long faces against one of which faces the tail of the traversing mandrel abuts, yielding means to press the said tail against the wedge, a slide-way constituting an abutment along which the wedge slides and which is at an angle to that one of the long wedge-faces against which the mandrel tail abuts, a lead-screw in fixed bearings, a driving-shaft for the lead-screw, a train of reducing gearing which forms an operative connection between said lead-screw and the said driving-shaft of the lead-screw and turns the lead-screw at an angular velocity lower than that of its driving-shaft, a nut mounted on the wedge and rotatable on it but held against endwise movement in relation to the wedge and threaded to the lead-screw, a cam stationary alongside the line in which the nut moves with the wedge, a lever extending from the nut and means to keep said lever pressed against the cam while it is drawn along the cam in the movement of the nut, cutter-carrier bars borne by the machine-frame 180° apart and radial and perpendicular to the mandrel-axis and rotatable and endwise movable in relation to their supports on the machine-frame, and locking means for locking the adjusted tools and their supports in relation to the machine-frame after their adjustment in relation thereto.

23. In a machine tool the combination of a rotary traversing mandrel, bearings in which it is movable endwise as well as rotatably, a driving-shaft, a train of reducing gearing which forms an operative connection between said mandrel and driving-shaft and turns the former at an angular velocity lower than that of the latter, a wedge with two long faces against one of which faces the tail of the traversing mandrel abuts, yielding means to press the said tail against the wedge, a slideway constituting an abutment along which the wedge slides and which is at an angle to that one of the long wedge-faces against which the mandrel tail abuts, a lead-screw in fixed bearings, a driving-shaft for the lead-screw, a train of reducing gearing which forms an operative connection between said lead-screw and the said driving-shaft of the lead-screw and turns the lead-screw at an angular velocity lower than of its driving-shaft,

a nut mounted on the wedge and rotatable on it but held against endwise movement in relation to the wedge and threaded to the lead-screw, a cam stationary alongside the line in which the nut moves with the wedge, a lever extending from the nut and means to keep said lever pressed against the cam while it is drawn along the cam in the movement of the nut, two cutting-tools adjustably mounted in supports on the machine-frame and situated at opposite sides of the mandrel-end to minimize unbalanced cross-thrust on it, a saddle carrying each cutting-tool and pivoted by one end of the saddle to the machine-frame, both saddles pivoted at one side of the mandrel and extended from their pivots past the mandrel to its opposite side, clamps for the saddles and locking means for locking the adjusted tools and their supports in relation to the machine-frame after their adjustment in relation thereto.

24. In a machine tool the combination of a rotary traversing mandrel, bearings in which it is movable endwise as well as rotatably, a driving-shaft, a train of reducing gearing which forms an operative connection between said mandrel and driving-shaft and turns the former at an angular velocity lower than that of the latter, a wedge with two long faces against one of which faces the tail of the traversing mandrel abuts, yielding means to press the said tail against the wedge, a slideway constituting an abutment along which the wedge slides and which is at an angle to that one of the long wedge-faces against which the mandrel tail abuts, a lead-screw in fixed bearings, a driving-shaft for the lead-screw, a train of reducing gearing which forms an operative connection between said lead-screw and the said driving-shaft of the lead-screw and turns the lead-screw at an angular velocity lower than that of its driving-shaft, a nut mounted on the wedge and rotatable on it but held against endwise movement in relation to the wedge and threaded to the leadscrew, a cam stationary alongside the line in which the nut moves with the wedge, a lever extending from the nut and means to keep said lever pressed against the cam while it is drawn along the cam in the movement of the nut, two cutting-tools adjustably mounted in supports on the machine-frame and situated at opposite sides of the mandrel-end to minimize unbalanced cross-thrust on it, a saddle carrying each cutting-tool and pivoted by one end of the saddle to the machine-frame, both saddles pivoted at one side of the mandrel and extended from their pivots past the mandrel to its opposite side, clamps for the saddles, a carriage interposed between one saddle and one cutter, to support the cutter adjustably along the length of the mandrel in relation to that saddle, guides on said saddle for the carriage that are parallel to the mandrel-axis, and locking means for locking the adjusted tools and their supports in relation to the machine-frame after their adjustment in relation thereto.

In testimony whereof I affix my signature.

ARTHUR ERNEST JERRAM.