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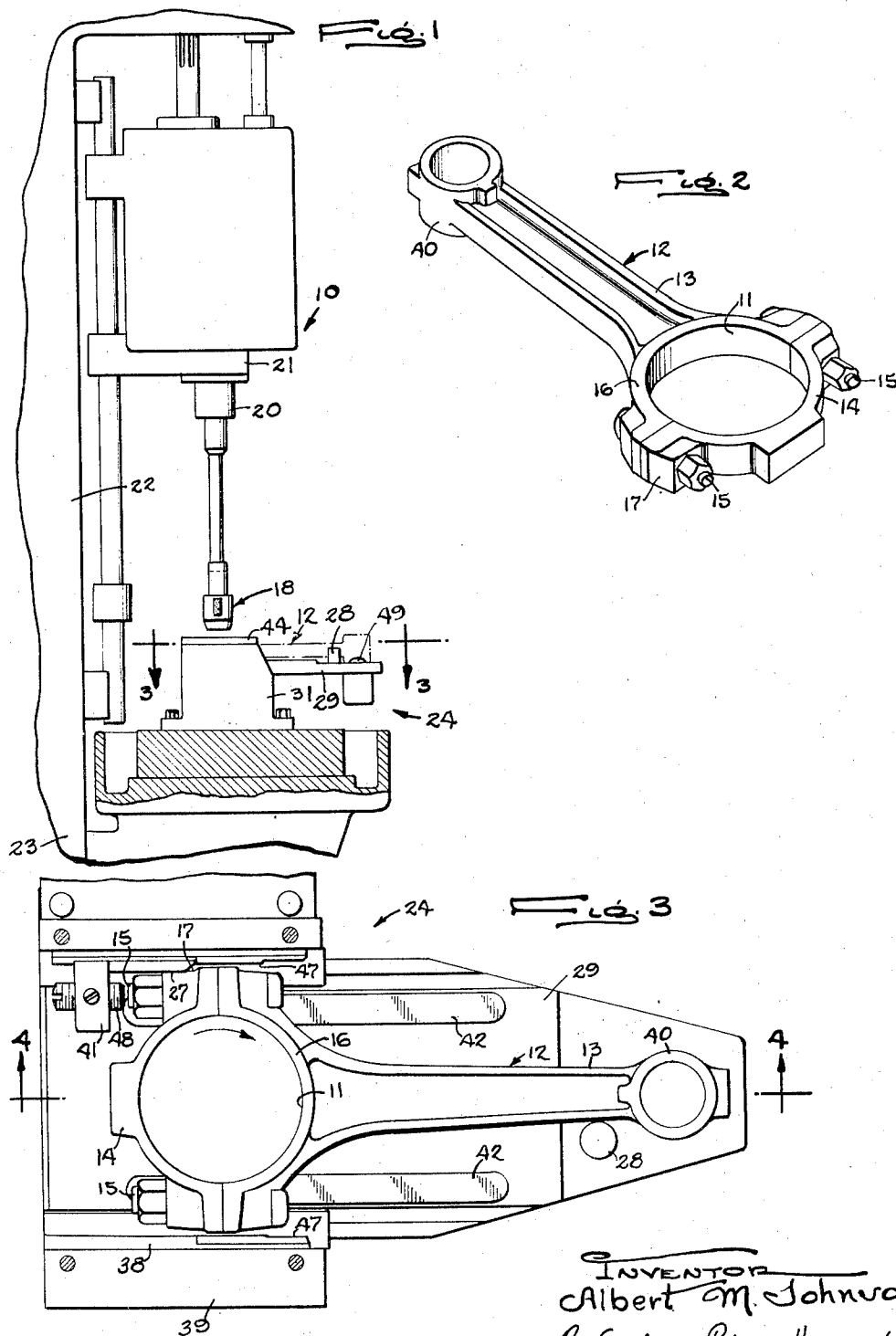
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MACHINE FOR FINISHING HOLES IN IRREGULAR WORKPIECES

Filed July 22, 1955

2 Sheets-Sheet 1



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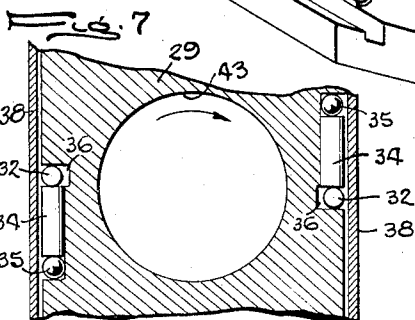
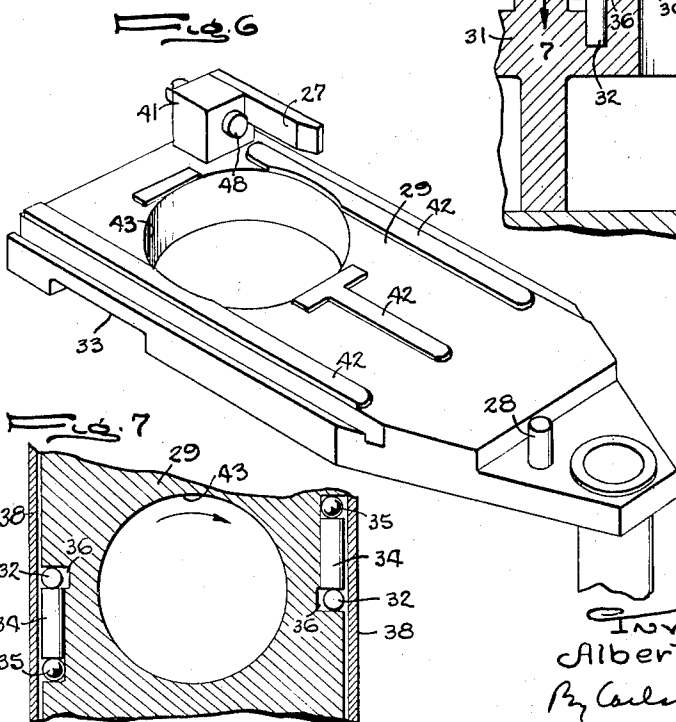
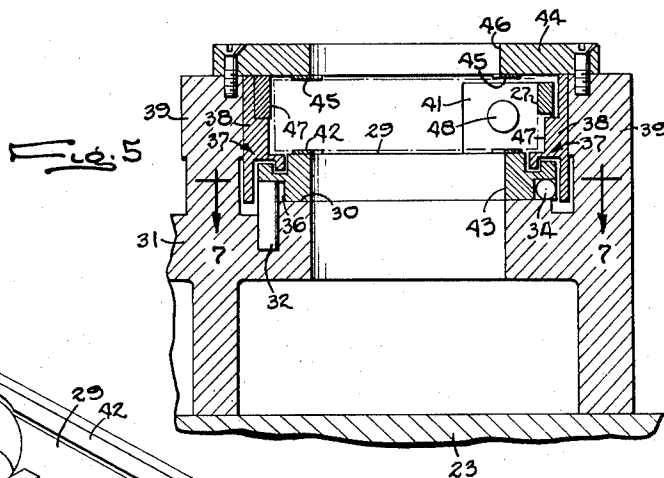
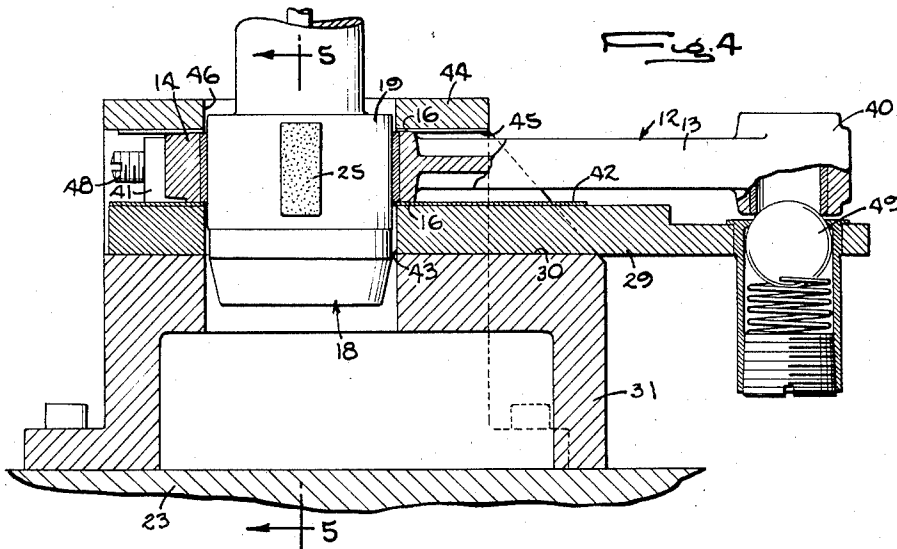
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MACHINE FOR FINISHING HOLES IN IRREGULAR WORKPIECES

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2 Sheets-Sheet 2



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MACHINE FOR FINISHING HOLES IN IRREGULAR WORKPIECES

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6 Claims. (Cl. 51—34)

This invention relates to a machine for performing honing, reaming and similar finishing operations on a cylindrical bore of a workpiece, for example, an engine connecting rod, which is of irregular external contour. More particularly, the invention relates to a machine in which the rotary finishing tool is supported in cantilever fashion on a rigid spindle and the workpiece is guided in its fixture to float transversely of the tool axis for centering of the workbore with the tool. To permit of such floating heretofore, the workpiece was held against turning with the tool by a fixed stop abutting the exterior of the workpiece at a point offset from the center of the workbore. In workpieces finished in accordance with this practice, the axis of the finished bore has been found to be inclined from a true perpendicular to the plane of the workpiece even though the latter is guided accurately in its transaxial movement. While this inclination is small, it nevertheless is highly objectionable in modern precision built engines.

The primary object of the invention is to overcome the alignment defect referred to above and to provide for finishing of a workbore with its axis precisely perpendicular to the face of the workpiece.

I have discovered that the inclination defect noted above is due to the fact that the workpiece, when held as described, exerts torque on the tool tending to bend the spindle laterally so that the axis of the tool becomes inclined slightly away from a perpendicular to the plane of the workpiece. Based on this discovery, a more detailed object of the invention is to provide a novel work support which holds the workpiece against turning with the tool while avoiding any lateral bending torque on the spindle and still providing free transaxial floating of the workpiece.

The invention also resides in the novel and simple construction of the work supporting fixture for eliminating lateral bending forces on the tool while providing proper floating of the workpiece and facilitating insertion and withdrawal of the workpiece.

Other objects and advantages of the invention will become apparent from the following detailed description taken in connection with the accompanying drawings, in which:

Figure 1 is a fragmentary side elevational view of a finishing machine embodying the novel features of the present invention, some of the parts being broken away and shown in section.

Fig. 2 is a perspective view of an engine connecting rod having a workbore to be finished in the improved machine.

Fig. 3 is a fragmentary sectional view taken along the line 3—3 of Fig. 1.

Fig. 4 is a fragmentary sectional view taken along the line 4—4 of Fig. 3.

Fig. 5 is a fragmentary sectional view taken along the line 5—5 of Fig. 4.

Fig. 6 is a perspective view of a part of the work fixture.

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Fig. 7 is a fragmentary sectional view taken along the line 7—7 of Fig. 5.

The invention is shown in the drawings for purposes of illustration embodied in a honing machine 10 which is especially adapted for finishing the crank shaft bore 11 of a connecting rod 12 for an internal combustion engine. In the rod shown (see Fig. 2), the bore is defined by one end of the elongated rod body 13 and a cap 14 secured to the latter by bolts 15. Prior to finishing of the bore 11, flat external surfaces 16 surrounding the bore and normal to the axis thereof are finish ground within close tolerances and other external surfaces 17 on opposite sides of the cap also are machined but within larger tolerances.

Generally, the machine comprises the honing tool 18 with its body 19 fast on the lower end of a rigid vertical spindle 20 which, at its upper end, is rotatably mounted in cantilever fashion on a tool support 21. The latter is supported on a column 22 upstanding rigidly from a bed 23 and is reciprocable on the column along the spindle axis and toward and away from a work fixture 24 on the bed for projecting the hone into and withdrawing the same from the bore 11 of a connecting rod in the fixture. During the honing operation, the hone is rotated and honing stones 25 (Fig. 4) on the hone body 19 are expanded under pressure radially and outwardly against the bore wall by mechanism (not shown) well known in the art. Entry of the hone into the bore is facilitated by tapering of the lower end portion of its body 19 as shown in Fig. 4.

To permit mounting of the hone 18 on a rigid spindle 20 as described above while still enabling of the bores 11 of successive connecting rods 12 to be centered on the spindle axis even though the bores vary in their spacing from the exterior surfaces 17 of the rods, it has been the practice heretofore to guide each rod for floating movement transversely of the spindle axis and to hold the rod against turning with the hone by a fixed stop abutting the exterior of the rod at a point spaced from the bore axis. In spite of accurate guiding of the rods in their transaxial floating, the axes of the finished bores of rods supported in this manner have been inclined slightly away from a normal to the plane machined surfaces 16 on the exteriors of the rods. In modern high precision engines, this inclination, although small, is larger than can be tolerated.

I have discovered that such inclination of the axis of the finished bore 11 from a normal to the plane faces 16 of the connecting rod 12 is due to bending of the free end of the spindle 20 laterally with respect to its axis during the honing operation and that such bending is a direct result of the manner of supporting the rod. When the rod is mounted as described above, it exerts on the hone a transaxial bending force which is reactionary to the torque exerted on the rod by the hone during engagement of the latter in the bore. While it is stiff enough to resist bending during transaxial shifting of the connecting rod 12 to center the bore 11 on the hone axis, the spindle, having no lateral support adjacent the hone, is subject to lateral flexing under the reactionary force exerted on hone by the rod.

Based on the foregoing discovery, the present invention contemplates a novel construction of the fixture 24 for eliminating the reactionary bending forces on the hone 18 while still holding the rod 12 against turning with the hone and permitting free transaxial floating of the rod for centering of the bore 11 on the hone. To these ends, the rod is mounted in the fixture 24 for transaxial floating in perpendicular directions normal to the spindle axis and is held not only against turning with the hone about the axis thereof, but also, against swinging of its bore end transaxially of the spindle 20 about

a fulcrum or reaction point spaced from the spindle axis after centering of the bore 11 on the hone and when the latter is expanded to engage the bore wall and exert torque on the rod. Such holding is effected by two stops 27 and 28 paralleling and disposed on opposite sides of the spindle axis in this instance for abutting engagement with opposite sides of the rod. The stops guide the rod for sliding movement in one of the perpendicular directions and are secured rigidly together by a connection 29 mounted in the fixture in the manner described below for rectilinear floating in the other one of the perpendicular directions. By virtue of such rigid connection and the floating mounting of the stops, the torque exerted on the rod by the hone is transmitted to the machine bed 23 so as to eliminate the reactionary forces tending to bend the spindle 20 laterally.

While the connecting rod 12 may be clamped against the stops 27 and 28 with the rigid connection 29 mounted in the fixture 24 to float transversely of the spindle axis in both of the perpendicular directions referred to above, it is preferred to simplify the construction of the fixture by mounting of the connection for floating in only one of such directions and arrangement of the stops to permit shifting of the rod relative to the stops in the other direction as described above. In this instance, the connection 29 comprises a flat plate which is elongated to accommodate the elongated workpiece and bears against an upwardly facing flat guide surface 30 (Figs. 4 and 5) normal to the spindle axis and formed on a base 31 of the fixture which is bolted to the machine bed 23.

Guiding of the connecting plate 29 for transverse rectilinear movement on the base 31 is effected by pins 32 projecting rigidly from the base on opposite sides of the spindle axis and into elongated recesses 33 in the underside of the plate (Figs. 6 and 7). Each pin fits between one end of its recess 33 and one end of a dowel pin 34 whose other end bears against a ball thrust bearing 35 contacting the other end of the recess. Adjacent the thrust pins 32, each recess is cut away laterally as indicated at 36 (Fig. 7) to permit limited sidewise movement of the plate relative to the base 31, the fit of the two pins and the ball longitudinally of each recess being tight to avoid turning of the plate on the base. Movement of the plate upwardly away from the guide surface 30 is limited by hold down bars 38 suitably secured to laterally spaced upright side members 39 of the fixture base and fitting loosely over the side edges of the plate as indicated at 37 (Fig. 5) to permit lateral sliding of the plate relative to the pins 32. To transmit torque from the plate to the base through the ball bearings, the thrust pins 32 are located in the farther ends of the recesses in the direction in which the plate tends to rotate, herein, clockwise as indicated by the arrows in Figs. 3 and 7.

To hold the rod 12 against turning with the hone 18 relative to the connecting plate 29, the stops 27 and 28 are disposed on opposite sides of the spindle axis to abut leading surfaces on the rod in the direction in which the rod tends to rotate. Relative shifting of the rod and the stops normally of the direction of transverse shifting of the plate 29 is permitted by spacing of the stops apart both longitudinally and transversely of the plate to abut such leading surfaces of the rod when the latter is aligned longitudinally with the plate. Herein, where the direction of rotation of the hone 18 is clockwise as viewed in Figs. 3 and 7, one stop 28 in the form of a pin projecting rigidly from the plate is disposed adjacent one end of the plate and is spaced transversely from the center thereof a short distance in a clockwise direction to abut one side of the rod body 13 adjacent the wrist pin end 40 thereof. The other stop 27 is formed as an arm projecting rigidly from a block 41 fastened to the plate adjacent its other end and is spaced transversely from the center of the plate in a clockwise direction a

farther distance to abut the external surface 17 on the cap 14 of the rod.

In order to simplify the fixture construction further, the connecting plate 29 for the stops 27 and 28 is utilized to perform the additional function of guiding the rod accurately in its transaxial floating movement. Thus, the upper surface of the plate lies in a plane normal to the spindle axis and is adapted for sliding engagement with one of the plane faces 16 of the rod. Herein, this flat sliding surface is formed on hardened wear resistant metal strips 42 secured to the plate around a hole 43 in approximate axial alignment with the spindle and large enough to receive the hone 18 with clearance as shown in Fig. 4. The other plane face 16 of the rod is engaged by a member 44 which is spaced axially from the wear strips to hold the rod against the latter tightly enough to prevent cocking of the rod while permitting the same to slide between the member and the strips. Herein, the member 44 comprises a flat plate having wear strips 45 similar to the strips 42 of the sliding plate 29 and spanning and secured as by screws to the side members 39 of the fixture base 31 with a central hole 46 in approximate axial alignment with the spindle to receive the hone.

It will be seen that the two plates 29 and 44 cooperate to define a guideway opening transversely of the spindle axis for insertion and withdrawal of the connecting rod 12 by edgewise sliding of the rod between the plates. To facilitate insertion of the rod between the plates, the bars 38 on the base side members 39 carry guides 47 engaging the exterior surfaces 17 on the crankshaft end of the rod. Inward movement of the latter to a position of approximate alignment of the bore 11 with the hone 18 is limited by a screw 48 threaded into the block 41 on the sliding plate 29 to abut one of the bolts 15 securing the cap 14 on the rod body 13. The rod is held yieldably in such position of approximate alignment by a ball 49 mounted on the sliding plate 29 and yieldably urged outwardly and into the bore at the wrist pin end 40 of the rod. When the ball 49 is seated in this bore, the limiting screw 48 is spaced slightly from the cap bolt 15 as shown in Fig. 3 to permit longitudinal shifting of the rod relative to the plate 29 and the stops 27 and 28.

To insert a connecting rod 12 into the fixture 24 preparatory to finishing of the crankshaft bore 11 thereof, one plane face 16 at the crankshaft end of the rod is laid onto the wear strips 42 of the sliding bottom plate 29 and the rod is simply slid edgewise into the guideway between the plates 29 and 44 first at an angle to the sliding plate until the crankshaft end clears the outer stop 28 and then longitudinally of the plate and into abutment with the limiting screw 48. With the rod body abutting the outer stop 28, the ball 49 is partially seated in the wrist pin bore to hold the rod yieldably against removal from the guideway.

The honing operation then is begun by lowering of the hone 18 into the bore 11 and, while the hone is rotating, expanding of the stones 25 radially into engagement with the bore wall. During entry of the hone into the bore, the tapered end of the hone engages the bore wall and cams the rod 12 either longitudinally relative to the stops 27 and 28 or transversely with the sliding plate 29 for centering of the bore on the tool axis. Upon engagement of the stones with the bore wall, the hone exerts a torque on the rod to rotate the rod about the hone axis and into abutment with the stops and to hold the rod in such abutment. The torque exerted on the stops by the rod then is transmitted to the base through the plate 29, the ball bearings 35, the dowel pins 34, and the thrust pins 42.

With the plate 29 held against rotation relative to the fixture base and therefore the spindle support 21 and with the stops 27 and 28 spaced apart on the plate in the direction of movement of the plate 29 so that, when the rod 12 abuts both stops, the latter guide the rod accurately for sliding movement in the direction normal to that of the

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plate movement, the rod will be brought against the stops simultaneously as the hone 18 is expanded against the bore wall and exerts a torque thereon tending to rotate the rod about the hone axis. With such simultaneous abutment, any force exerted on the rod by the hone and tending to swing the bore end of the rod transaxially of the spindle 20 in one direction about one of the stops is balanced by a similar force tending to swing the bore end in the opposite direction about the other stop. As a result, there is no reactionary torque on the hone tending to bend the spindle 20 laterally. At the same time, however, the rod is free to float in one direction with the stops and the plate normal to the spindle axis and in a perpendicular direction longitudinally of the plate and relative to the stops while being guided accurately in such movement and held against cocking between the plates 29 and 44. Inclination of the spindle axis relative to the plane faces 16 of the rod thus is avoided so as to insure that the axis of the finished bore 11 is precisely perpendicular to such faces.

The honing operation is completed by contraction of the stones 29 radially out of engagement with the wall of the bore 11 and withdrawal of the hone axially from the bore and to its retracted position shown in Fig. 1. The rod then is removed from the fixture 24 simply by first sliding of the rod endwise and longitudinally of the lower plate 29 past the outer stop 23 until the crankshaft end clears the upper plate 44 and then lifting of the rod off of the lower plate. Since the latter is utilized both as the rigid floating connection between the stops 27 and 28 and as a guide for transaxial floating of the connecting rod, the fixture may be of simple construction with few parts while supporting the rod in the desired manner.

I claim as my invention:

1. In a machine for finishing a bore of an elongated workpiece having an irregular external contour including a flat finished surface normal to the bore axis, the combination of, a tool support, a rigid spindle projecting from and rotatably mounted on said support, a finishing tool fixed to the end of said spindle, a fixture axially spaced from said tool for supporting said workpiece, and means mounting said fixture and said support for relative movement along the axis of said spindle and toward and away from each other to project the tool into and withdraw the same from the bore, said fixture comprising a base, a first member guided on said base for rectilinear movement in a first direction normal to said axis and presenting a flat surface normal to the axis and engageable with said flat workpiece surface, two stops projecting rigidly and laterally from said member and spaced apart on opposite sides of said axis and in a second direction normal to said axis and to said first direction for abutting engagement with opposite sides of the workpiece to hold the same against turning with said tool relative to said member and to guide the workpiece accurately for shifting thereof relative to the member in said second direction, and a second member spaced along said axis from said first member and secured in such spaced relation to hold the workpiece surface flat against said surface of the first member while permitting edgewise sliding of the workpiece into and out of the space between the members.

2. In a machine for finishing a bore of a workpiece, the combination of, a tool support, a rigid spindle projecting from and rotatably mounted in cantilever fashion on said support, a finishing tool fixed to the end of said spindle, a fixture axially spaced from said tool for supporting said workpiece with the bore thereof centered on the axis of said spindle, and means mounting said support and said fixture for relative movement along said axis toward and away from each other to project the tool into and withdraw the same from said bore, said fixture comprising a base, a first member guided on said base for rectilinear movement in a first direction normal to said axis, a second member spaced along said axis from said first member and cooperating therewith to receive

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said workpiece and guide the same for movement in a plane normal to said spindle axis, and stops rigid with said first member and spaced apart in said plane in a second direction normal to said first direction and to said axis to abut opposite sides of said workpiece to hold the latter against turning with said tool relative to said first member and said base and to guide the workpiece accurately for shifting thereof in said second direction between the members for centering of said bore on said spindle axis.

3. In a machine tool, the combination of, a tool support, a rigid spindle projecting from and rotatably mounted in cantilever fashion on said support, a finishing tool fixed to the end of said spindle, a fixture axially spaced from said tool for supporting a workpiece having a bore therein to be finished, and means mounting said support and said fixture for relative movement toward and away from each other to project the tool into and withdraw the same from said bore, said fixture comprising a base, two members mounted on said base and spaced apart along the axis of said spindle to define a guideway for receiving said workpiece and guiding the same for movement in a plane normal to the axis, two stops paralleling said spindle axis and spaced apart in said plane in a first direction normal to the axis for abutting engagement with spaced parts of a workpiece in said guideway whereby to hold the workpiece against turning with said tool during engagement of the latter in said bore while guiding the workpiece accurately for shifting movement of the workpiece in said direction and relative to the stops, and means securing said stops together and supporting the same on said base for rectilinear movement in a direction normal to said first direction and said spindle axis, such movement of the workpiece relative to and with said stops in said two directions permitting centering of the bore on said spindle axis.

4. In a machine tool, the combination of, a tool support, a rotary spindle projecting from and mounted in cantilever fashion on said tool support, a finishing tool fixed to the end of said spindle, a fixture axially spaced from said tool for mounting an elongated workpiece having a bore therein to be finished, means in said fixture adapted to support said workpiece and guide the same for free floating in two perpendicular directions normal to the axis of said spindle, said fixture means comprising stops rigid with each other and spaced apart in a first one of said directions for abutting engagement with spaced parts of the workpiece whereby to hold the latter against turning under the torque exerted on the workpiece by said tool during its engagement in said bore and to guide the workpiece for shifting movement in said one direction and means supporting said stops and guiding the same for reciprocating movement in the other of said directions, and means mounting said tool support and fixture for relative movement toward and away from each other to project the tool into and withdraw the same from said bore.

5. In a machine tool for finishing a bore of a workpiece, the combination of, a tool support, a rotary spindle projecting from and mounted in cantilever fashion on said tool support, a tool fixed to the projecting end of said spindle, a fixture having a base spaced along the axis of said spindle from said tool, a reciprocable member, torque sustaining means on said base supporting and guiding said member for rectilinear movement in a first direction normal to said spindle axis, means on said member providing spaced guide surfaces facing longitudinally of said first direction for abutting spaced surfaces rigid with the workpiece to hold the latter against turning relative to the member and said base about said axis while guiding the workpiece accurately for bodily reciprocating movement relative to the member in a second direction normal to the axis and said first direction, and means mounting said tool and said fixture for relative movement along said axis to project the tool into the workpiece bore.

6. In a machine tool, the combination of, a tool support, a rotary spindle projecting from and mounted in cantilever fashion on said tool support, a tool fixed to the projecting end of said spindle, a fixture spaced along the axis of said spindle from said tool and adapted to support a workpiece and guide the same for free floating in two perpendicular directions normal to the spindle axis while holding the workpiece against rotation with the tool, and means mounting said tool and said fixture for relative movement along said axis to project the tool into the workpiece bore, said fixture comprising a base secured against rotary and transverse movements with respect to said spindle axis, a reciprocable member, torque sustaining means supporting said member on said base and guiding the member for rectilinear movement in a first one

of said directions, and means on said member engageable with the workpiece for holding the same against rotation relative to the member while guiding the workpiece accurately for bodily shifting relative to the member in said second direction, said means on said member including spaced guide surfaces facing longitudinally of said first direction.

References Cited in the file of this patent

UNITED STATES PATENTS

1,962,567	Lovejoy	June 12, 1934
2,266,928	Walker	Dec. 23, 1941
2,422,114	Matter	June 10, 1947
2,670,635	Evans	Mar. 2, 1954