March 12, 1946. LE ISLE D. NOBLE ET AL 2,396,281

MACHINE TOOL

Filed Nov. 6, 1943 4 Sheets-Sheet 1

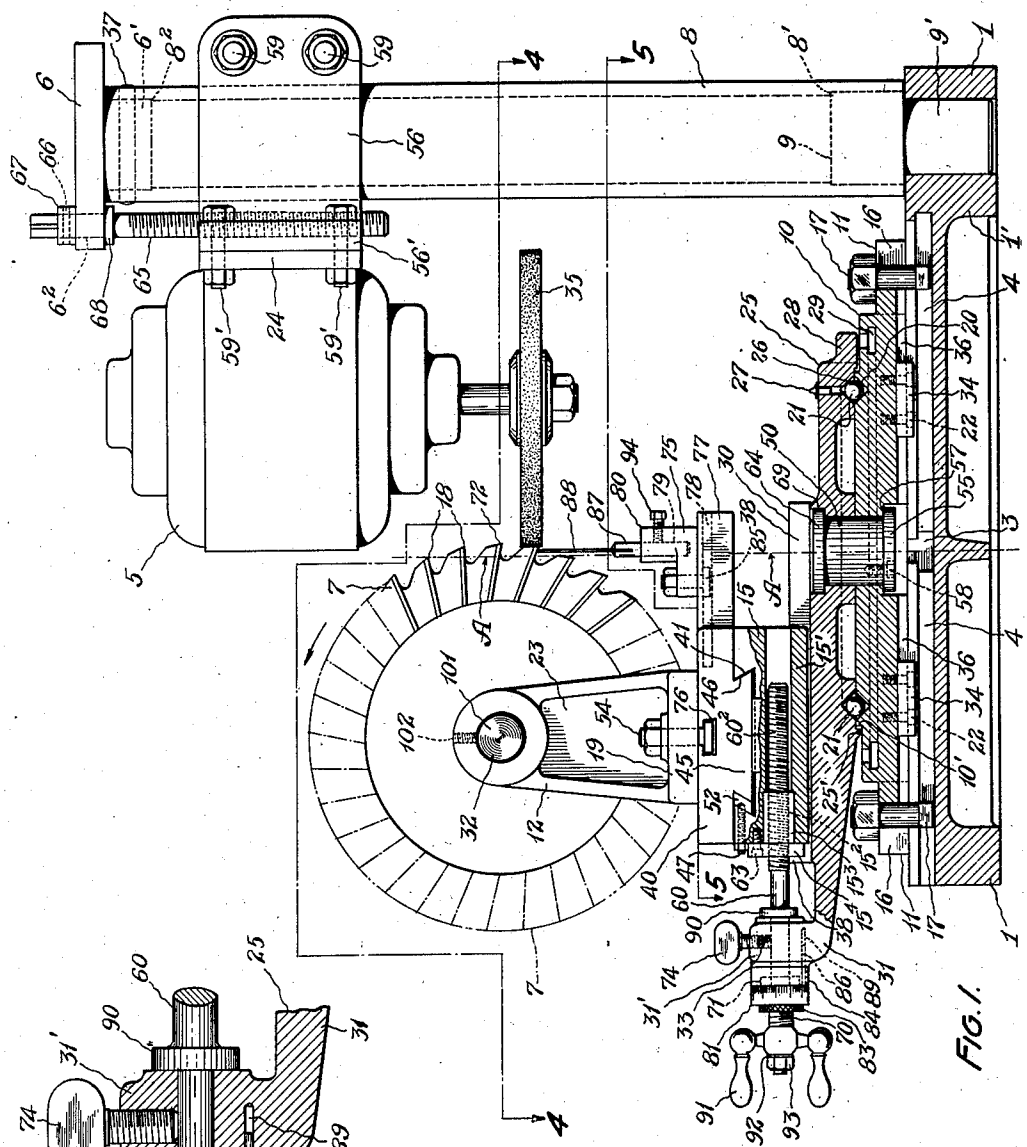


FIG. 1.

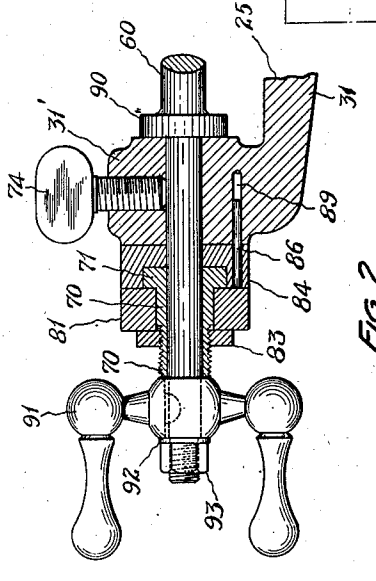


FIG. 2

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MACHINE TOOL

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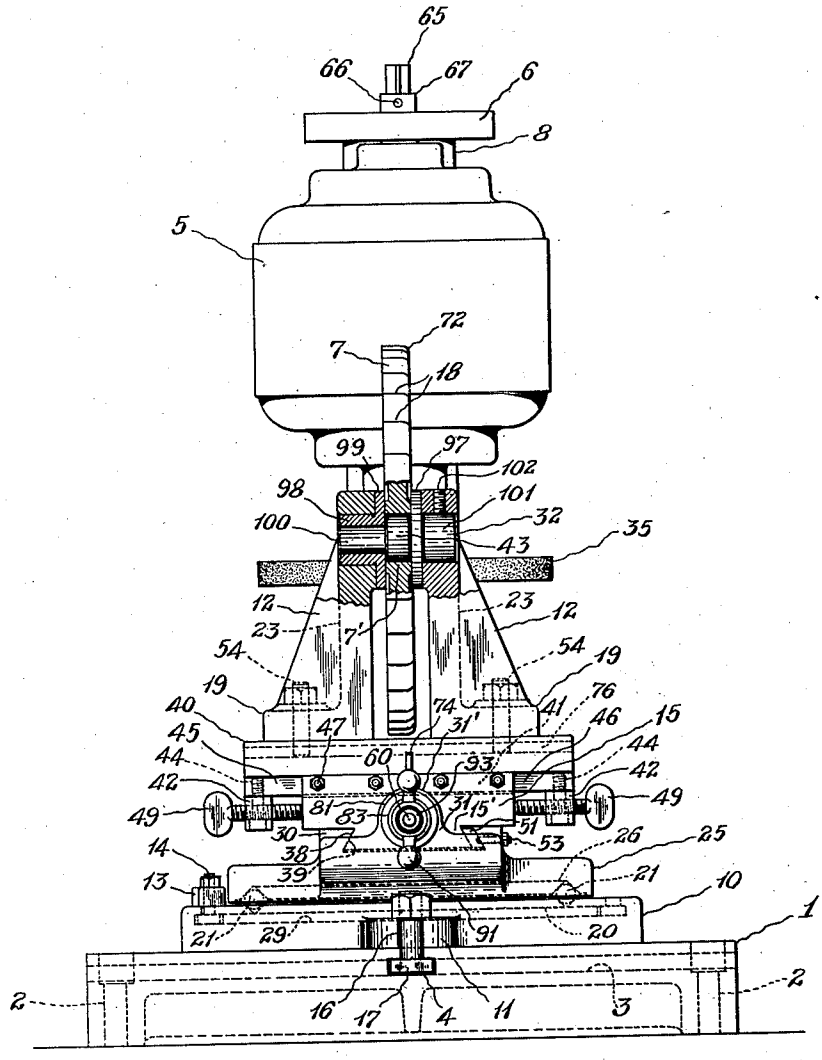


FIG. 3.

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MACHINE TOOL

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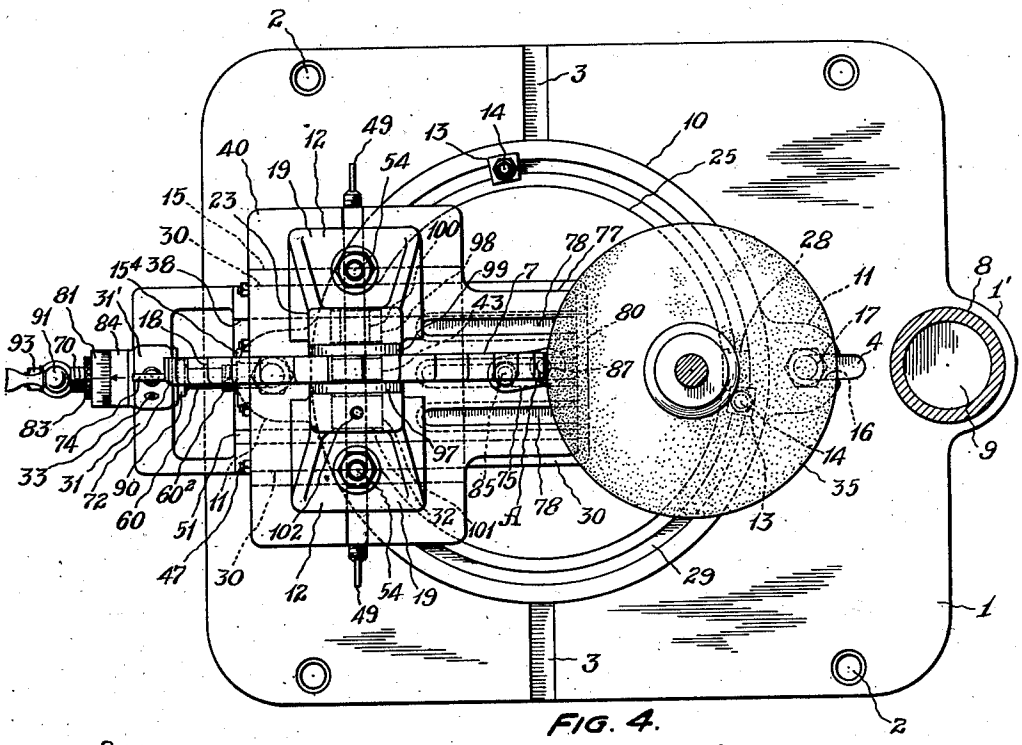


FIG. 4.

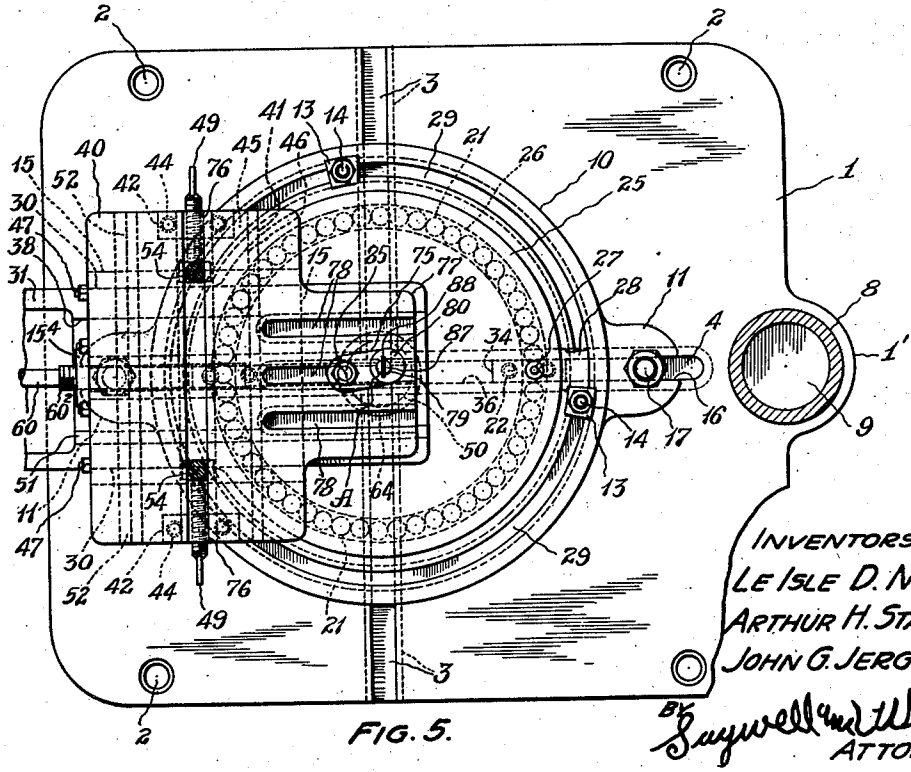


FIG. 5.

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MACHINE TOOL

Filed Nov. 6, 1943 4 Sheets-Sheet 4

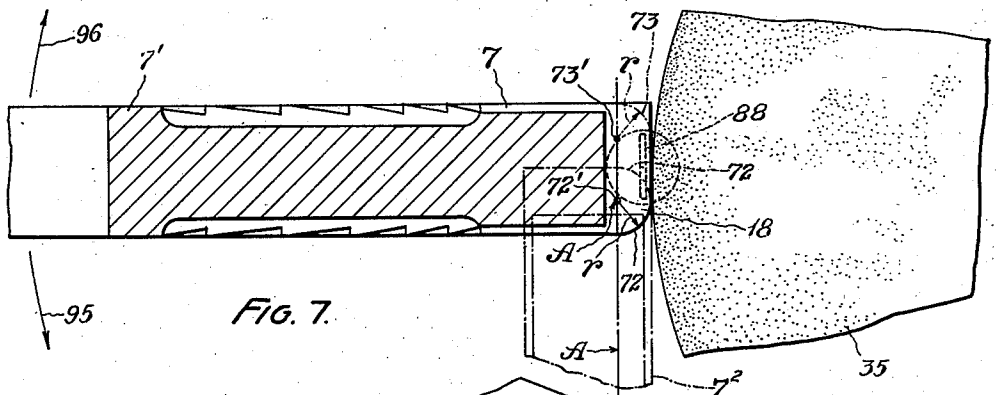


FIG. 7.

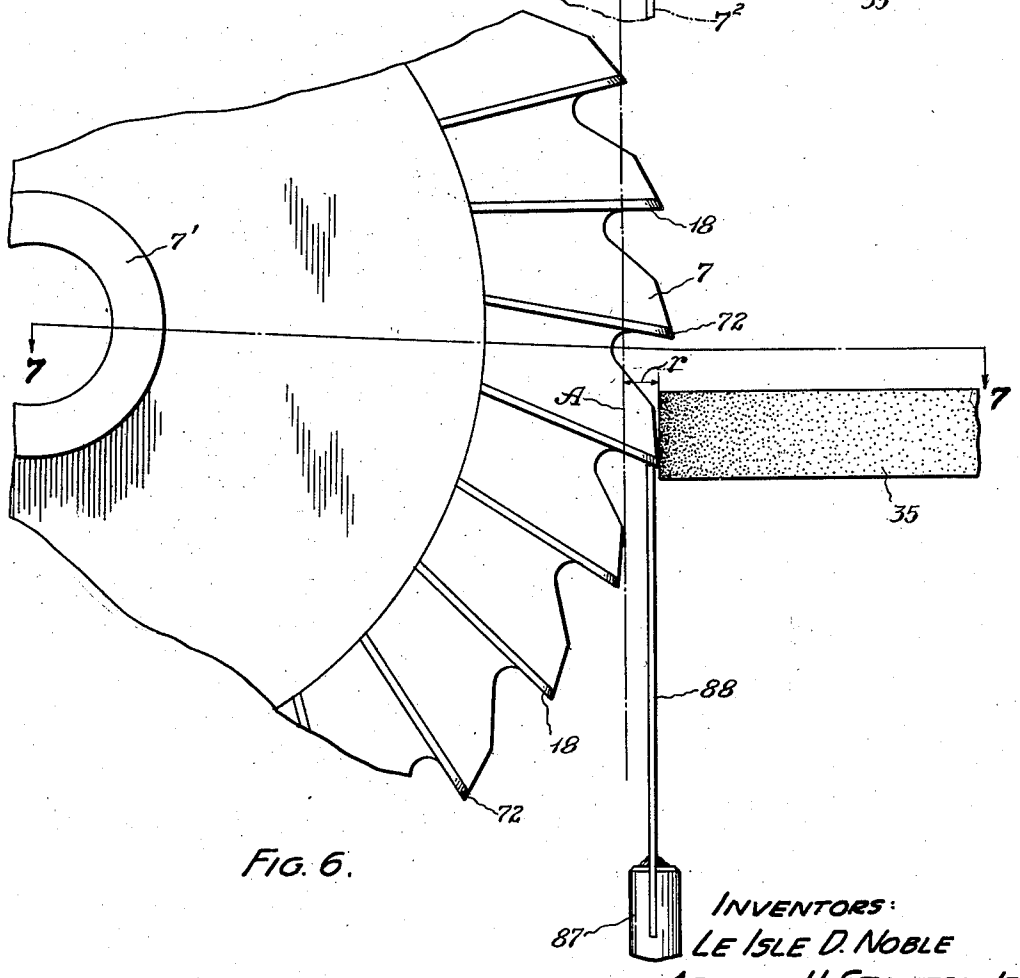


FIG. 6.

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UNITED STATES PATENT OFFICE

2,396,281

MACHINE TOOL

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Application November 6, 1943, Serial No. 509,172

6 Claims. (Cl. 51—225)

The invention relates to improvements in machine tools, and is particularly illustrated in the accompanying drawings and described in the following description as embodied in a radius grinding machine.

The objects of the invention are to provide a machine of the character described which may be readily and easily assembled from its component parts, which shall have a wide range of adjustments, and which may be easily and effectively manipulated to produce a closely accurate operation on the work.

In the application of the principle of the invention to a radius grinding machine, the entire table supporting the work is oscillated upon a central vertical pivot to pass the work mounted on a horizontal axis in a horizontal arc against the effective surface of the grinding tool which is mounted upon a vertical axis, the grinding surface of the grinding tool being spaced from the oscillatory axis of the work table, during the grinding operation, a distance equal to the radius of the arc being formed on the work.

The annexed drawings and the following description set forth in detail certain means illustrating the improved machine tool, such means constituting, however, only one of the various forms in which the principle of the invention may be embodied.

In said annexed drawings:

Figure 1 is a side elevation of a radius grinding machine in which the improvements of the invention are embodied, the view being partially in central longitudinal vertical section;

Figure 2 is a side elevation, partially in vertical axial section, and upon an enlarged scale, of certain elements constituting a feed control mechanism shown at the left-hand end of Figure 1;

Figure 3 is a front elevation, partially in transverse section, taken from the left-hand end of Figure 1;

Figure 4 is a plan section, taken from the planes indicated by the line 4—4, Figure 1;

Figure 5 is a fragmentary plan section, taken from the planes indicated by the line 5—5, Figure 1;

Figure 6 is a partial side elevation, upon an enlarged scale, particularly showing the relative positions of the work and the grinding wheel detached from the machine, the relative position of a certain work-tooth supporting blade being also indicated; and

Figure 7 is a partial plan section, taken from the planes indicated by the line 7—7, Figure 6.

Referring to the annexed drawings in which the same parts are indicated by the same several numbers in the respective views, the main parts of the improved radius grinding machine consist of a base 1, a work table support casting 10 longitudinally and transversely adjustable of the base 1, and bolted in adjusted position thereon, a table 25 mounted to oscillate in a horizontal plane around the axis A of a main pivot pin 50 upwardly extended into the table 25 from the casting 10, the table 25 having an upper sliding surface, a slide 15 having a lower slide surface whereby it can be longitudinally adjusted relatively to the table 25 and an upper slide surface upon which may be transversely adjusted an upper slide 40 forming a base for work standards 12, the latter and the slide 40 also being formed with sliding surfaces whereby the standards 12 can be transversely adjusted on the upper slide 40, the work 7 shown as a milling cutter being centrally mounted on a horizontal axis in the work standards 12. Other important parts of the improved radius grinding machine include a motor 5 for driving the grinding wheel 35, a tubular motor post 8 mounted in the base 1, a cutter tooth blade support 88 longitudinally adjustably mounted on the upper slide 40 and also adjustable in an arc about a vertical axis, and a screw 60 engaging the slide 15 and serving for longitudinal feeding of the latter and all parts thereabove relatively to the grinding wheel 35.

As stated, the table 25 and the parts supported thereby oscillate in a horizontal plane around the vertical axis A of the main pivot pin 50 and the abrading surface of the grinding wheel 35 and the cutting edge of the tooth of the milling cutter 7 being ground thereby, are substantially parallel to and spaced from the axis A of this main pivot pin 50 during the grinding operation, the spacing distance being equal to the radius r of the curve 72 being formed on the cutter 7, as clearly indicated in Figures 6 and 7, this position being perfect, within working conditions, at the termination of the grinding operation.

Referring now to the detail of the main parts hereinbefore mentioned and the method of their assembly, and their relative adjustments, the base 1 is formed with corner bolt holes 2 whereby it may be securely fastened to any permanent foundation. The casting 10 is formed with end ears 11 having open-ended slots 16 which accommodate T-head bolts 17, whereby the casting 10 can be releasably secured to the base 1. The base

1 is formed in its upper surface with a central transverse T-groove 3 and a central longitudinal T-head groove 4. Seated in the casting 10 intermediate the respective ends of the latter and the transverse groove 3 are two pairs of depending bolts 22 whose lower enlarged head portions are embedded in a pair of blocks 34 adapted to slide in the narrow portion of the T-groove 3 or the T-groove 4, depending upon the angular position in which the casting 10 is mounted upon the base 1, the ears 11 being so located that the lower enlarged heads of the bolts 17 slide in the wide portion of the grooves 3 and 4. The upper ends of the blocks 34 are laterally fixed by radial grooves 36 formed in the bottom surface of the casting 10 in which the blocks 34 are seated. Therefore, the casting 10 can be both longitudinally and transversely adjusted on the base 1 by a sliding of the blocks 34 in the grooves 3 and 4, the casting 10 being turned 90°, if necessary, for the engagement of the blocks 34 with the particular groove 3 or 4 desired.

The base 1 is also formed on the longitudinal center line with a lower tubular boss 1^1 at the rear, which receives a reduced bottom end portion 9^1 of a pin 9 extended upwardly into the bottom end of the vertical tubular motor post 8 which is mounted on the boss 1^1 and has a shoulder 8^1 against which the upper end of the pin 9 abuts, the upper end of the tubular post 8 accommodating a depending pin portion 6^1 of a cap 6 mounted on the top of the motor post 8, the depending pin portion 6^1 abutting a shoulder 8^2 of the motor post 8 and being rotatably fixed in the motor post 8 by a pin 37.

One side of the cap 6 is formed with a vertical hole 6^2 therethrough through which is passed a vertical screw 65 formed with a shoulder or flange 68 which engages the lower face of the cap 6 in the desired adjusted position of the screw 65, the screw 65 above the cap 6 passing through a collar 67 secured thereto by a pin 66. The upper end of the screw 65 extending above the top face of the collar 67 is formed with a squared portion to facilitate turning of the screw 65. The threaded portion of the screw 65 is passed through a threaded hole formed in one side of a motor support 56 split at its opposite side whereby by bolts 59 it may be clamped to and released from the tubular motor post 8 which it surrounds, the opposite side 56^1 of the clamp 56 which is adjacent the screw 65 having a plane surface which is fastened by bolts 59^1 to the base 24 of the motor 5. Inasmuch as the grinding wheel 35 is secured to the shaft of the motor 5, it is evident that the grinding wheel 35 can be adjusted as to height, by an adjustment of the motor 5 and split motor support 56 relative to the motor post 8.

The table 25 which is rotatably guided on the main pivot pin 50 is locked to the underlying casting 10 by a plate 55 which is secured to the bottom face of the pivot pin 50 by screws 58 and abuts the top wall of a recess 57 formed in the bottom face of the casting 10, an upper flange 64 of the pivot pin 50 being disposed in a recess 63 formed in the top surface of the table 25. The table 25 is formed in its bottom face with an annular ball race 26 and the top face of the casting 10 is formed with a complementary ball race 20, which races 20 and 26 accommodate balls 21 whereby the table 25 is oscillatory in a horizontal plane on the casting 10 around the pin 50 as a pivot. The upper part of the casting 10 is formed with a peripheral shoulder 10^1 exteriorly of the ball race 20 which fits within a shoulder 25^1 formed on the bottom face of the work table 25.

The top of the table 25 is formed to serve as a slide for the longitudinal adjustment of the slide 15 and all parts thereabove. This is effected by providing longitudinal upwardly-extended side portions 30 of the table 25 with opposed inner beveled slide surfaces 38 cooperating with lower outer beveled slide surfaces 39 formed on a depending portion 15^1 of the slide 15, a gib 51 being provided adjacent one of the slide surfaces 38 and adjusted thereagainst by screws 53 mounted in a side portion 30 of the table 25. Secured by depending screws 44 to the sides of the upper slide 40 are blocks 42 which are tapped to accommodate thumb screws 49 whose inner ends engage the side surfaces of the slide 15 whereby the latter can be transversely adjusted and locked in its adjusted position.

The longitudinal adjustment of the slide 15 is effected by the feed screw 60 actuated by a ball handle 91 keyed to the outer end thereof, the inner end threaded portion 60^2 of the screw 60 engaging a longitudinal elongated tapped hole 15^2 formed in a bushing 15^3 seated in an opening in the slide 15 and formed with an enlarged from end portion 15^4 secured flush against the front face of the slide 15 by a screw 63.

An intermediate portion of the screw 60 passes through a boss 31^1 formed in an upwardly-extended front arm 31 of the table 25 and is adapted to be rotatably secured therein by a thumb screw 74. The screw 60 is formed with a flange 90 which engages the rear surface of the boss 31^1 and between the ball handle 91 and the forward face of the boss 31^1 is mounted a graduated dial 81 rotatable upon a plug 70 having a rear flange 71 mounted in a collar 84 disposed between the front face of the boss 31^1 and the rear face of the dial 81. Secured to and rearwardly-extended from the collar 84 is an alignment pin 86 which is passed through the collar 84 and into an elongated longitudinal hole 89 formed in the arm 31, thus rotatably fixing the collar 84 with reference to the table 25. An arrow is impressed in the collar 84 which serves as a reference mark for the graduations on the dial 81. The dial 81 is secured at the front by a knurled nut 83 engaging a front end threaded portion of the plug 70. The ball handle 91 is keyed to the screw 60 and is mounted between the threaded portion of the plug 70 and a washer 92 surrounding the screw 60 by a nut 93 also engaging a threaded portion of the screw 60. It is evident that a loosening of the thumb screw 74 will permit longitudinal feeding by means of the screw 60 of the slide 15 and all parts thereabove relative to the table 25.

The upper slide 40 and the parts thereabove are transversely adjustable relatively to the underlying slide 15 and the parts therebelow. This adjustment is effected by beveled outer surface front and rear slideways 46 formed upon a downwardly-extended portion 45 of the upper slide 40 which cooperate with inner surface opposed slideways 41 formed upon the slide 15, a gib 52 being interposed between one pair of slideways 46 and 41 and adapted to be adjusted against the slideway 46 by screws 47 threaded in the slide 15.

The laterally-opposed work-supporting standards 12 are secured to the upper slide 40 by T-bolts 54 which have depending enlarged heads engaging the lower enlarged portion of a transverse T-slot 76 formed adjacent the top of the

upper slide 40. Thus the work standards 12 can be adjusted transversely of the upper slide 40 and all parts therebelow. These standards 12 are of angular formation and it is through bottom horizontal portions 19 thereof that the bolts 54 are passed, the upper vertical portions 23 of the standards 12 being spaced and opposed and providing an area within which the work 7 may be rotatably mounted. This mounting is effected on an intermediate journal portion 43 of a pin 32 one end 101 of which is released seated in one of the members 23 by a set screw 102, a flanged portion 97 of the pin 32 being interposed between said member 23 and the journal portion 43 upon which the work 7 freely turns, an opposite reduced end portion 100 of the pin 32 being seated in a plug 98 mounted in the opposite member 23, said plug 98 having an inner end flange 99 mounted between said last-mentioned member 23 and the adjacent face of the intermediate journal portion 43. It is evident that both standards 12 as a whole may be adjusted transversely of the machine and that the two standards 12 may be relatively laterally spaced to accommodate the thickness of the hub 7^1 of the work 7 mounted on the journal portion 43 of the pin 32.

The work 7 herein shown is a milling cutter, and the teeth 18 thereof are supported by the blade support 88 mounted on the upper slide 40. This mounting is effected on a rearwardly-extended upper portion 77 of the upper slide 40 by means of an angular post 75 longitudinally adjustably mounted in any desired one of several parallel transversely spaced T-slots 78 formed in the top face of the upper slide 40 and adapted to receive in bottom enlarged portions thereof the lower enlarged heads of a bolt 85 passed through the post 75, an upwardly-extended portion 80 of the post 75 having a vertical cylindrical recess 79 within which is adjustably mounted by screw 94 an upwardly-extended post 87 in the upper end of which in turn is mounted the blade support 88. The bottom base portion of the angular post 75 which receives the bolt 85 can be disposed at an angle to the axes of the slots 78 so that by swinging the same on the axis of the bolt 85 considerable latitude is given to the position of the blade support 88 even in one position of the bolt 85. Therefore, this swinging adjustment and the multiplicity of slots 78, together with the longitudinal adjustment therein of the angular post 75, permits adjustment of the blade support 88 to a great number of positions.

A lubricating fitting 27 is mounted in the table 25 to service the ball races 20 and 26, and a lubricating fitting 33 is mounted in the boss 31^1 to lubricate the bearing for the screw 60 in the boss 31^1.

Referring particularly to Figures 6 and 7, attention is directed to the fact that the oscillatory axis A of the table 25 is vertical and is spaced a distance equal to the radius *r* from that portion of the periphery of the grinding wheel 35 which is in grinding engagement with a tooth 18 on the work 7. This oscillatory axis A is also substantially parallel with the outermost surface portion of the tooth after it is ground and while it is in the grinding position shown in Figure 6. The radius grind is effected by the oscillating of the table 25 about the pivot pin 50 which swings the work 7, 90° in the direction indicated by the arrow 95, to the position shown in dot and dash lines at 7^2 in Figure 7, to produce the arc 72 ground on one side of the tooth. The center 72^1 of the desired curve 72 is longitudinally aligned with and forwardly spaced from the axis A at the beginning of the operation.

The extent and amplitude of the oscillation of the table 25 which, as mentioned, is 90° for the operation described herein, is determined by certain adjustable stops which are provided for this purpose. These stops are shown in Figures 3, 4, and 5 as set for effecting the radius grind 72 shown in Figure 6 and are comprised of the following elements: The rear end of the table 25 is formed with a nose portion 28 which to determine the oscillatory swing of the table 25 engages blocks 13 secured to the casting 10 by spaced bolts 14 mounted in an arcuate T-slot 29 formed in the casting 10.

Successive grinding operations 72 are effected upon one side of each of the teeth 18 successively, by manually indexing the work, one tooth at a time, against the support 88 while the plane of the work 7 is parallel to the adjacent periphery of the grinding wheel, and oscillating the work 7 through its angle of 90°.

Thereupon the work 7 is progressively fed toward the grinding wheel and each tooth 18 is successively ground until the center 72^1 is coincident with the axis A in which position the grind 72, having the desired radius *r*, will be produced on the tooth.

Then, if desired, radius grinds 73 may be effected successively upon the opposite sides of the teeth 18, as suggested in dot and dash lines in Figure 7. In order to produce such grinds 73 on the opposite side of the work teeth 18 it is necessary to retract the work from the periphery of the grinding wheel 35 by turning the screw 60 in a suitable direction and it is further necessary to shift the work laterally by a suitable manipulation of the screws 49 until the center 73^1 of the desired curve 73 is longitudinally aligned with and forwardly spaced from the axis A. The work 7 is then oscillated in a 90° arc in the direction indicated by the arrow 96, Figure 7. The work 7 is then manually indexed, one tooth 18 at a time, against the support 88, while the plane of the work is parallel to the adjacent periphery of the grinding wheel and, after each indexing, the work is oscillated through its angle of 90°. This indexing and oscillating operation is repeated until each tooth 18 has been ground at least once by the wheel 35. Thereupon the work 7 is progressively fed toward the grinding wheel and each tooth 18 is successively ground until the center 73^1 is coincident with the axis A in which position the grind 73 having the desired radius *r* will be produced on the tooth.

The production of the grind 73 necessitates the re-setting of the respective blocks 13 in the T-slot 29 to positions on the opposite sides of the machine from the positions occupied by these blocks 13 when the grind 72 was produced, as will be understood.

What we claim is:

1. A radius grinding machine comprising a base, a work-table mounted thereon for turning movement in a horizontal plane, a slide adjustable on the table in one direction and a second slide adjustable on the first-mentioned slide in a relatively right angular direction, feed-control mechanism for adjusting the first-mentioned slide in said one direction, a work-standard erected on the second slide and adjustable thereon, means for mounting work on a horizontal axis in the work-standard, a motor vertically adjustably mounted on the base, and a grinding wheel supported by and rotatable by the motor and

mounted to turn on a vertical axis with its peripheral grinding surface spaced a horizontal distance from vertical alignment with the turning axis of the work-table equal to the radius of the designed operation upon the work.

2. A radius grinding machine comprising a base, a work-table adjustably mounted thereon and also mounted for turning movement on an axis angularly related to the plane of adjustment, a slide adjustable on the table in one direction and a cross slide adjustable on the first-mentioned slide, feed-control mechanism for the first-mentioned slide, a work-standard mounted on the second slide and comprising two spaced laterally-opposed relatively adjustable members, the second slide being formed with T-slots, and T-bolts depending from said members and engaging the slots, means for mounting work in the work-standard comprising a pin having an intermediate journal portion, a plug mounted in one member and adjustably receiving one end of the pin, and means mounted in the other member and releasably retaining the opposite end of the pin, a motor, and an adjustable grinding wheel rotatable by the motor.

3. A radius grinding machine comprising a base, a work-table mounted thereon for oscillatory movements in a horizontal plane, adjustable means limiting the extent of such oscillatory movements, a slide adjustable on the table in one direction and a second slide adjustable on the first-mentioned slide in a relatively right angular direction, feed-control mechanism for adjusting the first-mentioned slide in said one direction, a work-standard erected on the second slide and adjustable thereon, means for mounting work on a horizontal axis in the work-standard, a motor vertically adjustably mounted on the base, and a grinding wheel supported by and rotatable by the motor and mounted to turn on a vertically axis with its peripheral grinding surface spaced a horizontal distance from vertical alignment with the oscillatory axis of the work-table equal to the radius of the designed operation upon the work.

4. A radius grinding machine comprising a base, a work-table mounted thereon for oscillatory movements in a horizontal plane, adjustable means limiting the extent of such oscillatory movements, a slide adjustable on the table in one direction and a second slide adjustable on the first-mentioned slide in a relatively right angular direction, feed-control mechanism for adjusting the first-mentioned slide in said one direction, a work-standard erected on the second slide and adjustable thereon, means for mounting work on a horizontal axis in the work-standard, a tooth support blade adjustably mounted on the second slide, a motor post erected on the base, a motor vertically adjustably supported by the post, and a grinding wheel supported by and rotatable by the motor and mounted to turn on a vertical axis with its peripheral grinding surface spaced a horizontal distance from vertical alignment with the oscillatory axis of the work-table equal to the radius of the designed operation upon the work.

5. A radius grinding machine characterized as in claim 4 in which the work-table is mounted on a sub-table casting for oscillatory movements thereon, and the casting is releasably fastened to the base and the casting and base are formed for adjustments of the former upon the latter.

6. A machine tool comprising a base, a work-table pivotally mounted on the base and also adjustable thereon in a plane at right angles to the plane of the pivotal axis, a work-holder mounted on the table and adjustable thereon in relatively right angular directions, means providing for the adjustment of the work-holder for the accommodation of work of varying characters, a grinding wheel and means for rotating it, means for adjusting the grinding wheel in a direction parallel to the pivotal axis of the work-table, and a support blade mounted on the table and angularly and rectilinearly adjustable relative to the work-standard.

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