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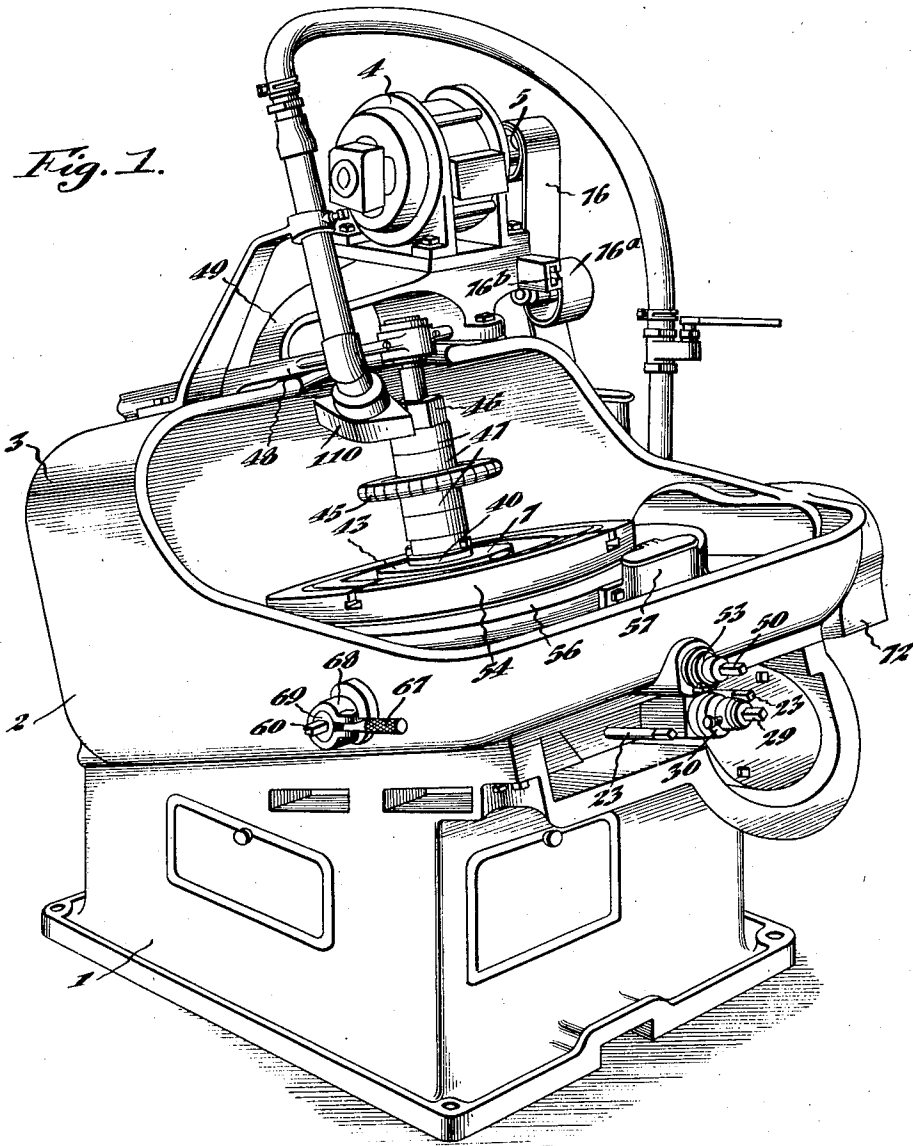
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1,925,599

MILLING MACHINE

Filed April 1, 1929

9 Sheets-Sheet 1



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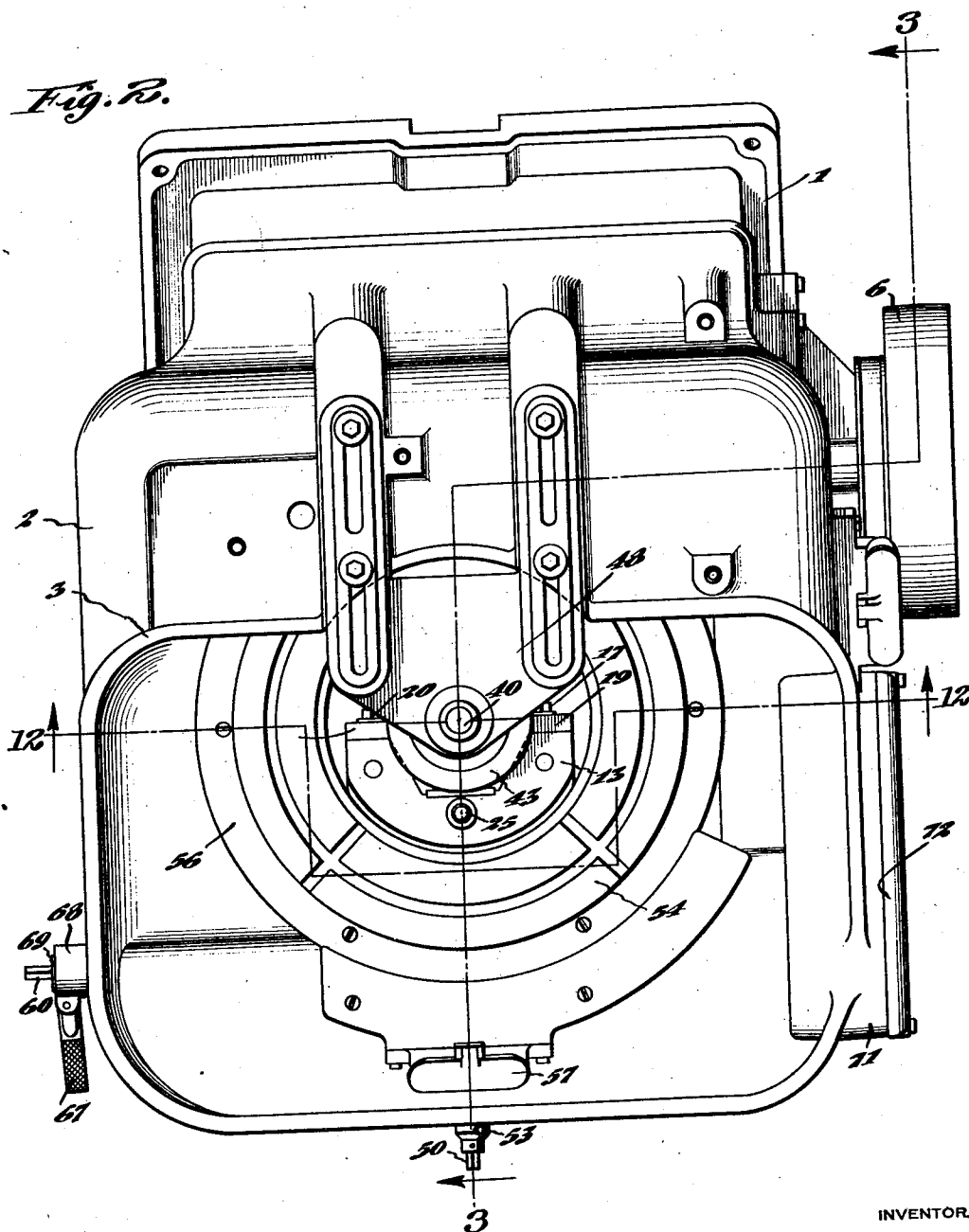
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9 Sheets-Sheet 2

Fig. 2.



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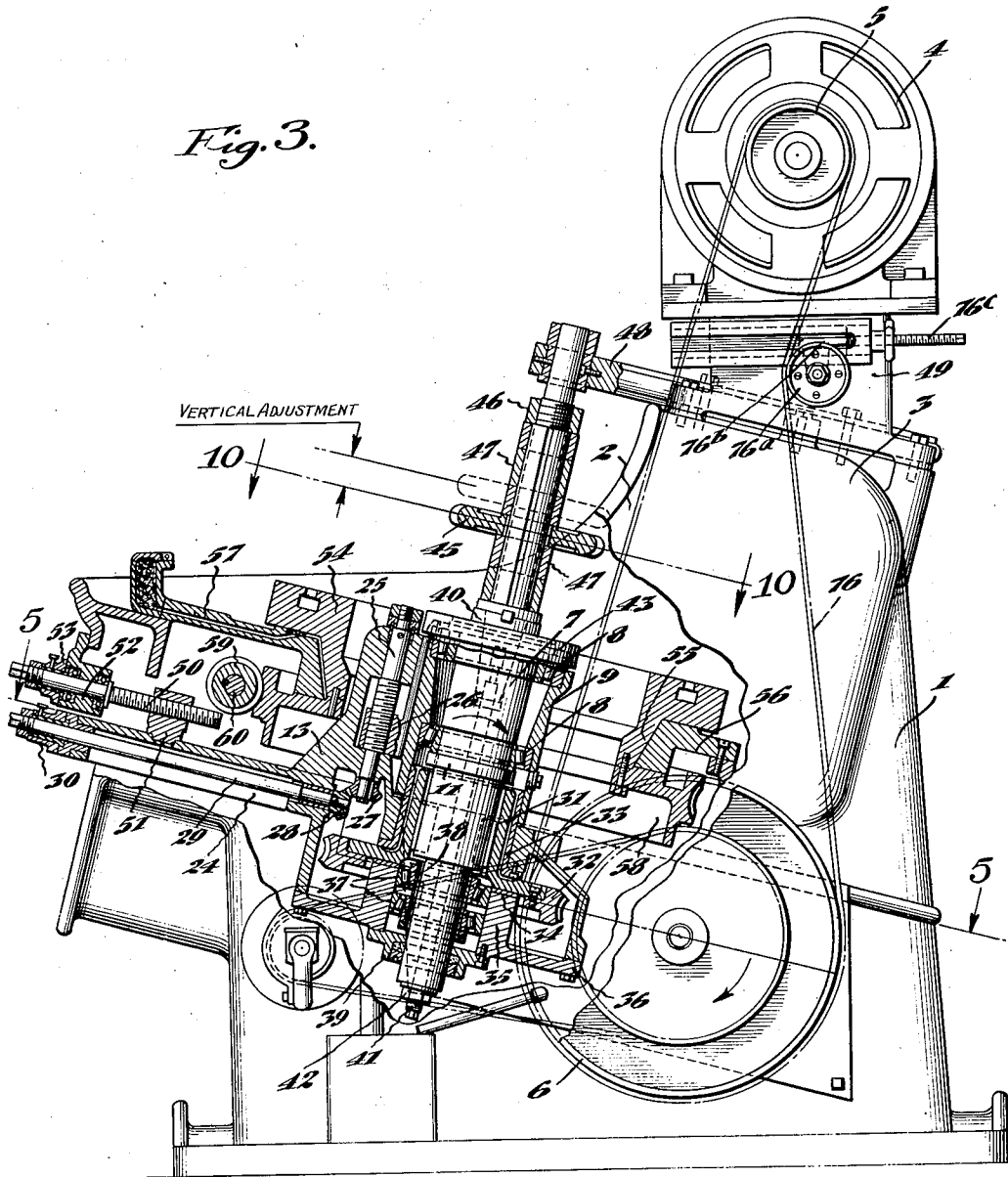
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9 Sheets-Sheet 3

Fig. 3.



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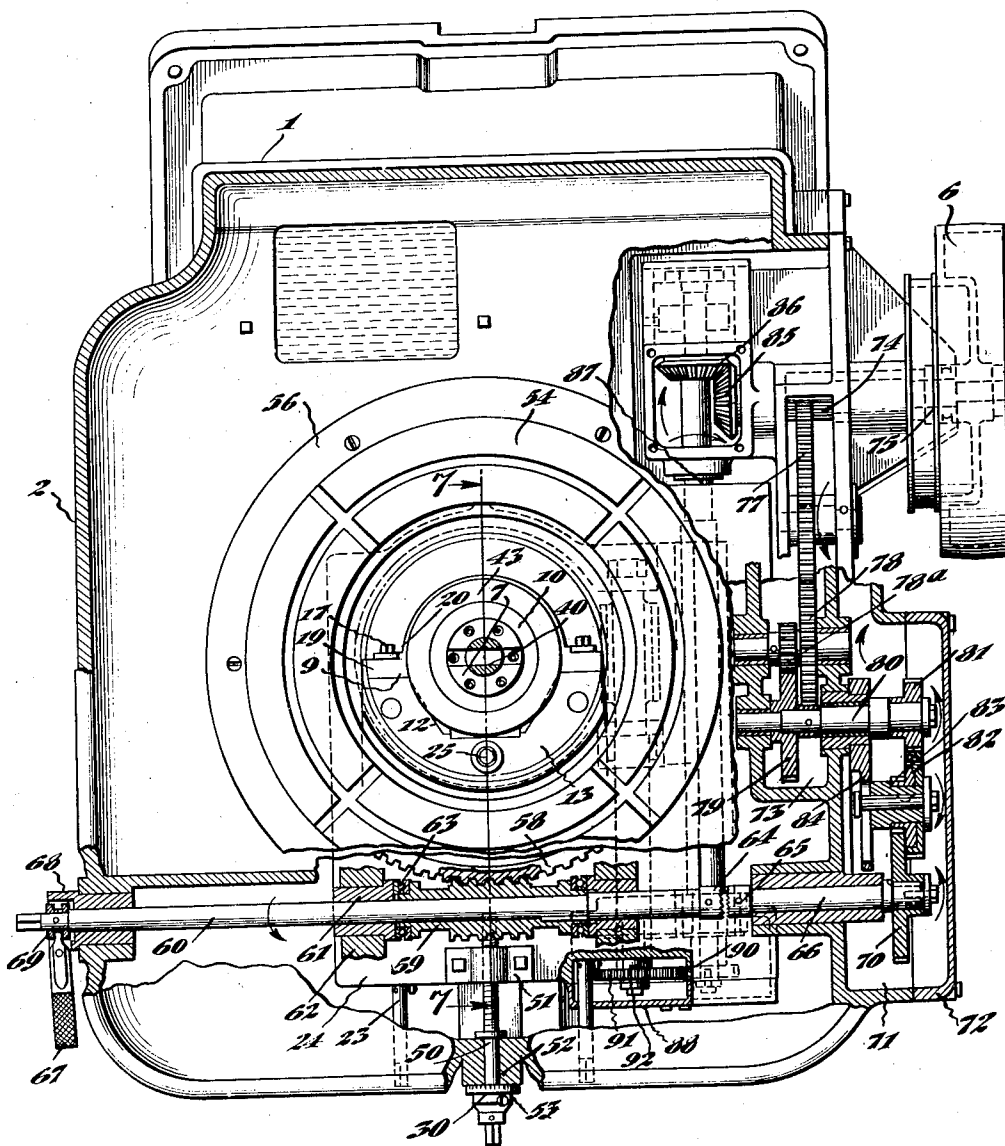
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9 Sheets-Sheet 4

Fig. 4.



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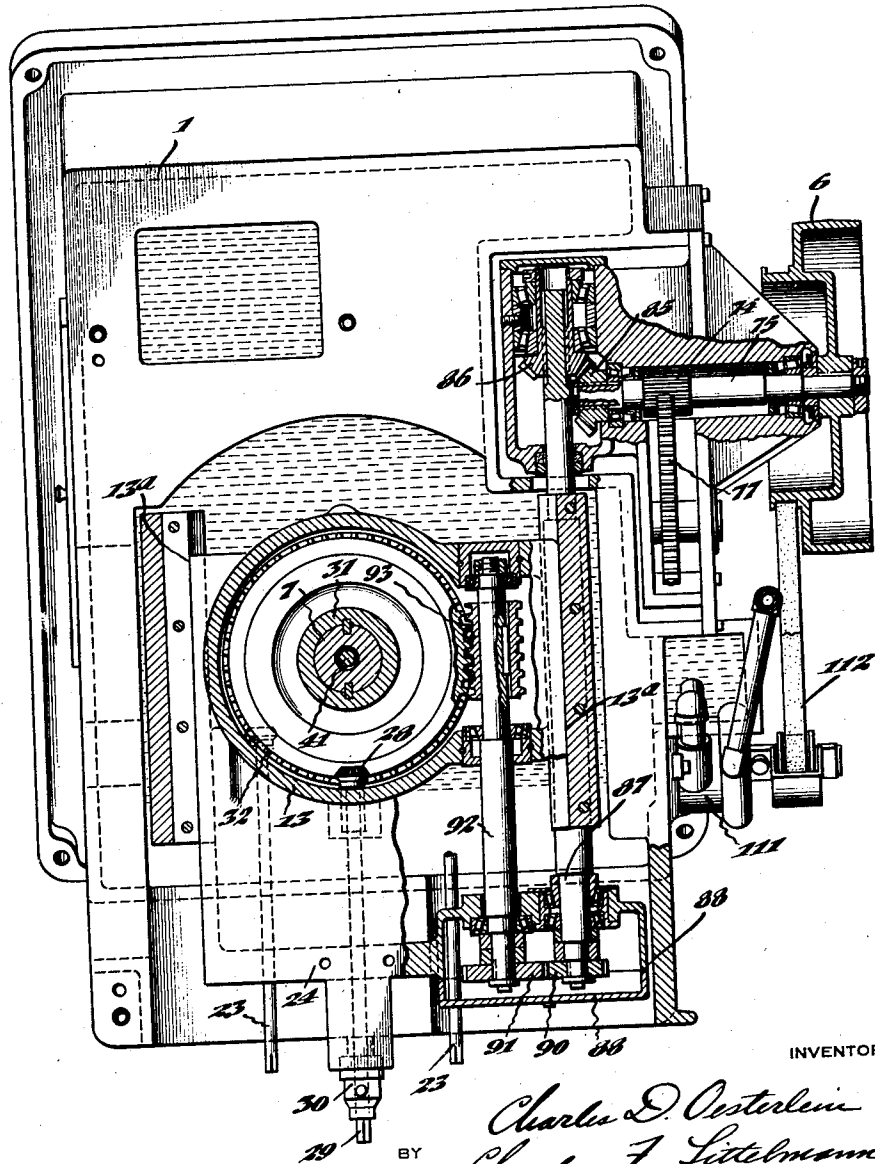
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MILLING MACHINE

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9 Sheets-Sheet 5

Fig. 5.



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9 Sheets-Sheet 6

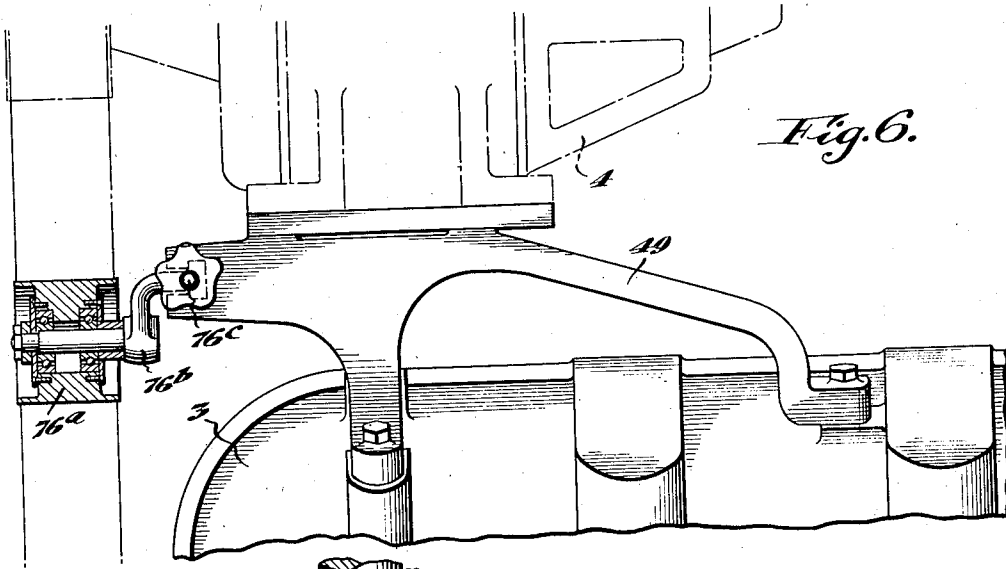


Fig. 6.

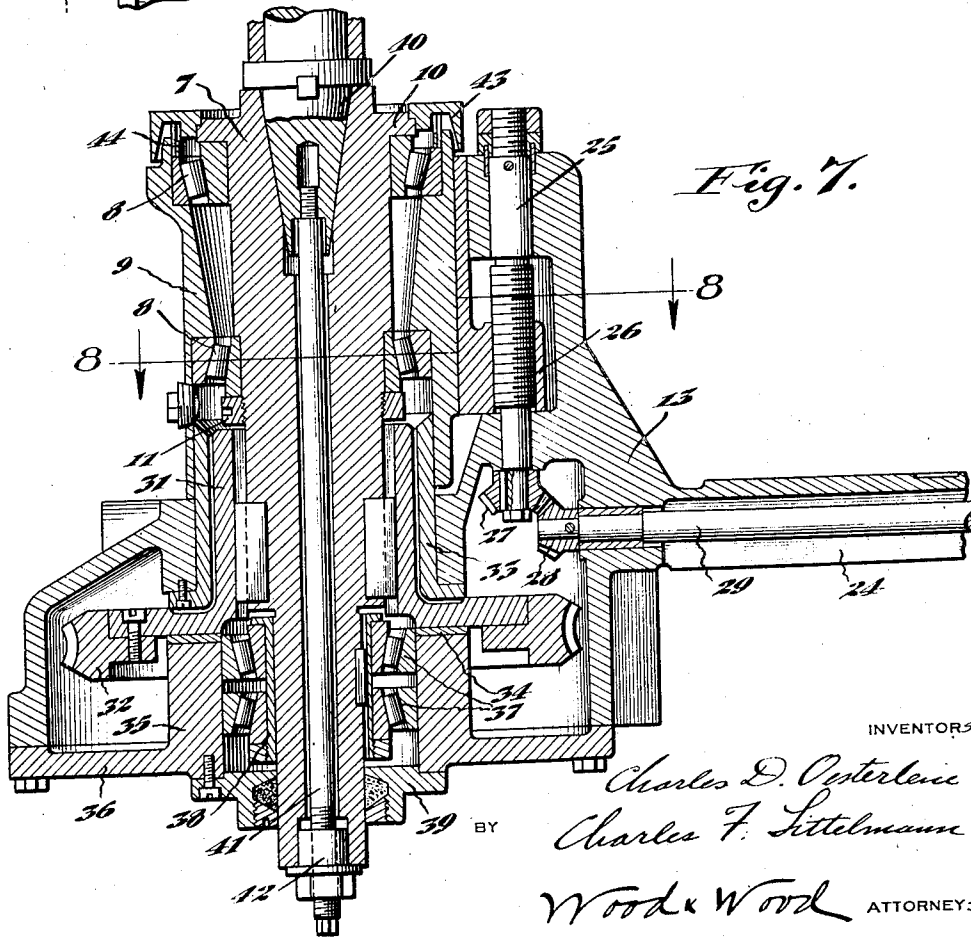


Fig. 7.

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MILLING MACHINE

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9 Sheets-Sheet 7

Fig. 9.

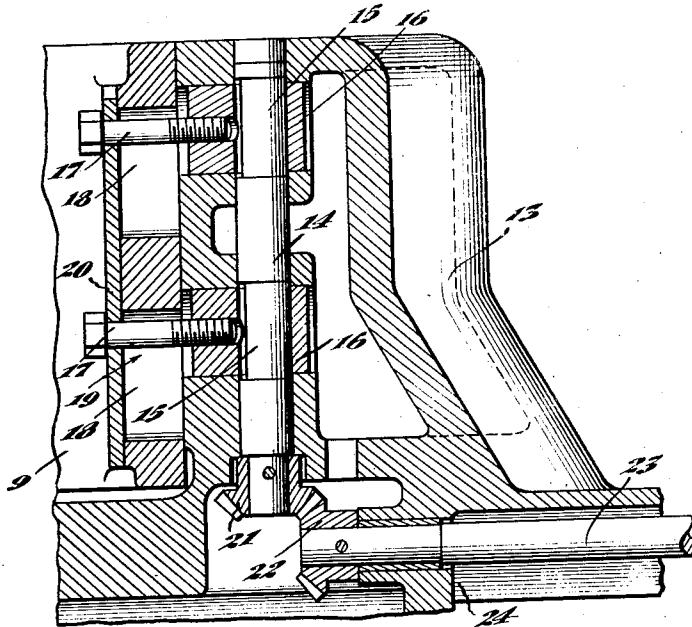
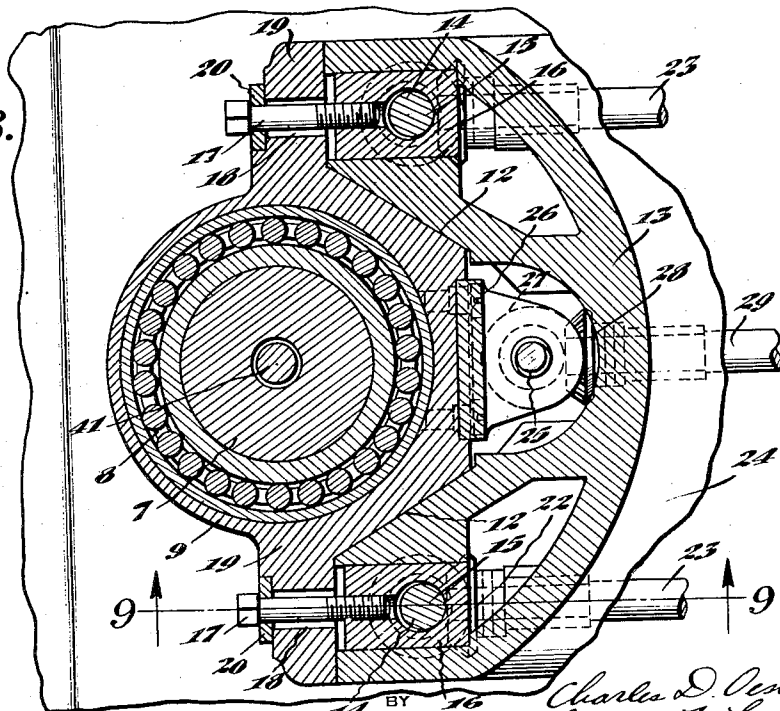


Fig. 8.



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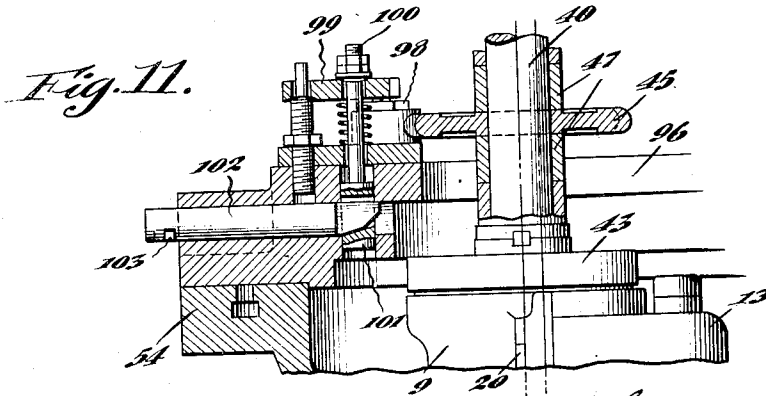
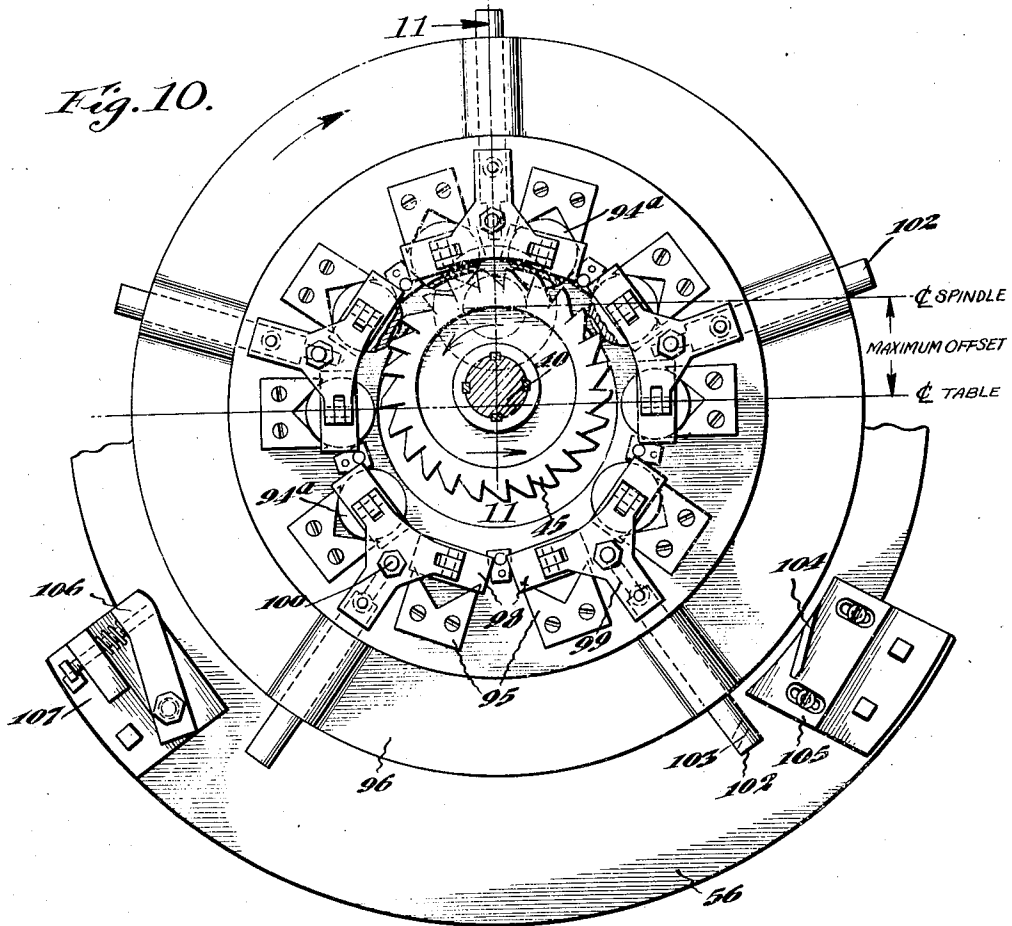
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MILLING MACHINE

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9 Sheets-Sheet 8



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MILLING MACHINE

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9 Sheets-Sheet 9

Fig. 12.

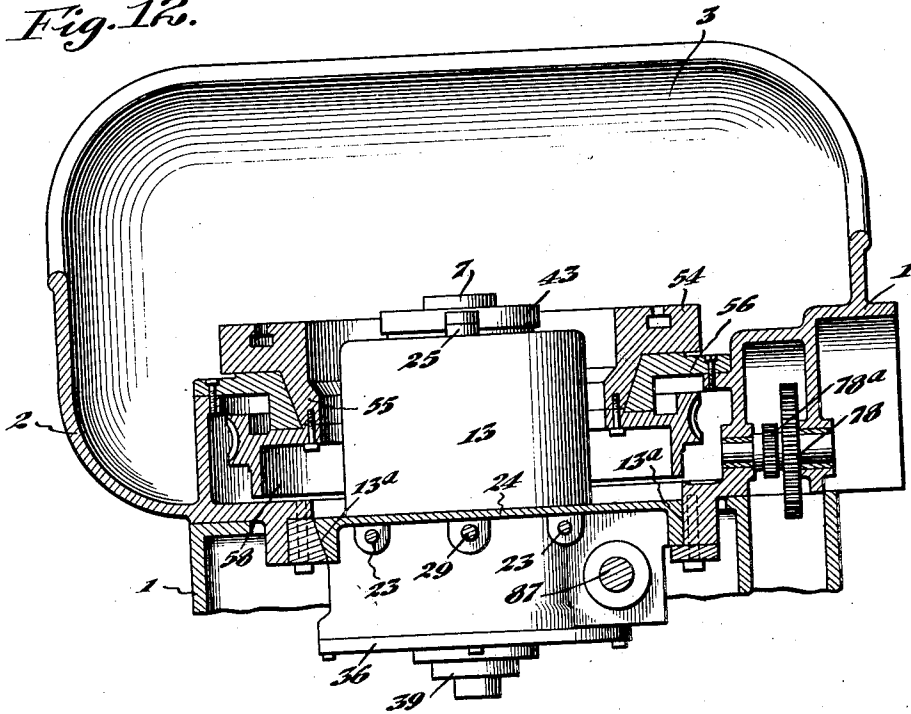
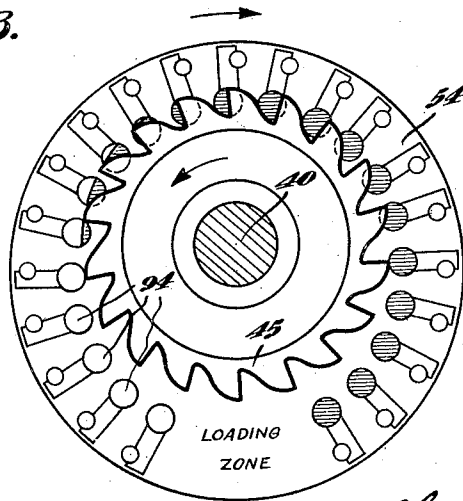


Fig. 13.



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MILLING MACHINE

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Application April 1, 1929. Serial No. 351,498

8 Claims. (Cl. 90—20)

This invention relates to a process or method of simultaneously and continuously machining or milling a plurality of parts or pieces of work for high production capacities, and to the apparatus therefor.

The method consists in mounting a plurality of parts or pieces of work in a consecutive order upon a continuously revolving support and about a large central revolving cutter mounted eccentrically or offset to the circular or elliptical path or traverse of the work, the parts or work moving gradually into the path of the cutter teeth and for a portion of their orbital or elliptical path to the full depth of cut, the relative cutter rotation and rotative traverse of the work being at different rates, and the depth of cut regulated by the distance the cutter is offset.

The finished parts in their traverse move clear of the cutter, whence they may be unloaded by hand or mechanical ejector devices and replaced. The cutting or milling zone assumes a crescent form, starting into the work at zero to full depth, and leaving at zero to the relief of the cutter teeth, the action being substantially free from chatter.

An ample portion of the work traverse about the cutter is left outside the milling zone in which unclamping, unloading, reloading, and re-clamping can be executed, and in which the rotation or travelling motion of the work can be utilized for unclamping and reclamping.

The apparatus employed for practicing the method embodies a circular revolving work table with a revolving milling cutter centrally thereof and adjustable to present the cutter either eccentric or concentric with or to the axis of the revolving work table and in its eccentric capacity applicable for continuous multiple milling. The work table and cutter occupy an inclined position, with the milling zone at a rear side fully housed or enclosed, enabling the use of a high volume and pressure of coolant flow directed against the cutter and work for washing the cuttings and chips from the inclined table and at its lowest elevation, allowing the work to drain as it moves in an upward grade, permitting the same to efficiently drain as it moves into the loading zone.

The transmission mechanism for both the spindle and table is carried within bearings below the plane of the table and provides for a simple massive drive from below, and of ample strength and rigidity, adequate to any torsional stress of the heaviest cuts to be encountered. It also permits of a centralized system of lubrication, a

compact arrangement of parts, easily accessible, and the controlling and adjusting hand levers at the front side of the machine, conveniently accessible to the operator.

The cutter being positioned centrally of the table enables the use of an increased diameter of table for holding a large number of parts or work holding fixtures and the use of an unusually large diameter of spindle, short and heavy, journalled in substantial bearings, and is journalled within a vertically adjustable slide journal mounted upon a transversely adjustable headstock, adapting the spindle to be vertically and laterally adjusted.

An object of the invention is to provide a method for simultaneously and continuously milling a plurality of parts or pieces of work for high production capacity.

Another object is to provide a method of constant milling characterized by useful employment of the maximum portion or number of teeth of a milling cutter within the milling field of the cutter revolution, and by this increase in milling field or zone providing that a great number of parts may be constantly and simultaneously milled within the increased zone, resulting in high production capacity.

Another object of this invention is to provide a method for milling wherein the work continuously moves in an endless path about a rotating circular cutter, the work gradually moving into the path of the cutter and correspondingly receding therefrom during a portion of its path of movement and after the full depth of cut or finished milling is reached to completely clear the cutter for replacement, and wherein the rotative work traverse is utilized for actuating work holding fixtures to unclamp and clamp the work without milling interruption.

Another object of the invention is to provide a large central circular revolving cutter set eccentric or offset to a work carrying table, adapting the parts mounted upon the table to travel with rotation of the table in an endless path engaging the cutter during a portion of its traverse, gradually intercepting the cutter to the full depth of cutter or degree of milling, and thence receding correspondingly therefrom, to completely free the parts for removal and replacement during the continuous rotation of the table.

Another object of the invention is to provide a milling machine which by the offset arrangement of the cutter relative to the work circle af-

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fords a coarser cut in the early stages of the milling, the depth of cut diminishing as the work moves through the milling zone and easing off to an infinitely fine cut at the conclusion of the operation, whereby a burr is prevented.

6 Another object of the invention is to provide a machine for milling a plurality of parts simultaneously and at relatively different degrees from the time of starting the cut until the finished depth is reached and in proportion to the degree or regulated distance that the cutter is offset or eccentric to the path of travel of the work, for presenting an increased number of cutter teeth in action or engaged with the work at a time, maintaining a relatively constant working load upon the spindle, eliminating chatter.

10 Another object of the invention is to provide a revolving milling cutter centrally of a revolving table with the journals and driving gears below the plane of the table providing a compact and sturdy structure occupying a minimum floor space, the table and cutter horizontally disposed and at an elevation from the floor conveniently accessible to the operator for removing and applying the work to the fixtures carrying the work, and also for applying and removing the cutter.

25 Another object of the invention is to provide a milling machine with the journals and gearing for supporting and rotating the table and spindle housed within oil-tight compartments below the elevation of the table for centralized lubrication.

30 Other features and advantages of the invention relate to structural details and arrangement of parts, all of which will be more fully set forth in the description of the accompanying drawings, in which:

35 Figure 1 is a perspective view of the milling machine, with the work holding clamps removed from the revolving table.

40 Figure 2 is a top plan view.

Figure 3 is a section on line 3—3, Figure 2.

Figure 4 is a fragmentary section through the bed and transmission mechanism journaled and housed within the bed.

45 Figure 5 is a sectional view taken on line 5—5, Figure 3.

Figure 6 is a rear elevation of the overhead bracket supporting the motor with an idler pulley for the driving belt shown in section.

50 Figure 7 is a section taken on line 7—7, Figure 4.

Figure 8 is a section on line 8—8, Figure 7.

Figure 9 is a section on line 9—9, Figure 8.

55 Figure 10 is a section on line 10—10, Figure 3, illustrating the revolving table in top plan, with a plurality of work holding fixtures and pieces of work clamped to the table.

Figure 11 is a section on line 11—11, Figure 10.

60 Figure 12 is a sectional view taken on line 12—12, Figure 2.

Figure 13 is a diagrammatic plan view of the table, work, and cutter.

65 Referring to the drawings, 1 indicates the bed of the machine organized as a hollow casing for journaling and supporting a revolving spindle carrying the milling cutter and a work table revolving about the cutter, the cutter and work table revolving in relatively reverse rotation and the spindle and work table relatively adjustable for positioning the same either eccentric or concentric. The work is clamped upon the table about the spindle for continuous milling.

70 The spindle and revolving work table are indicated as rotated in counter or reverse directions and at relatively different rates by transmission

gearing journaled and housed within the bed, producing a compact organization easily accessible to the operator. It will be understood, however, that the cutter and table may revolve in the same direction at relatively different rates, if desired. The spindle and work table are preferably set askew, presenting the table in an inclined position inclining downwardly rearwardly so that the coolant and chips can be drained and carried rearwardly into the base of the bed or a pan-shaped portion of the casing above the bed, avoiding the necessity of the operator brushing the parts to keep the same clean during milling operations. The spindle and work table, however, may be set in horizontal instead of tilted.

80 The upper portion 2 of the casing is of pan shape fixed upon the bed and surrounds the table, for confining the chips and coolant within the machine. The rear portion 3 of the casing is arched, providing a support for an electric motor 4 having a pulley 5 in belt transmission with a driven pulley 6 of the gearing journaled within the bed of the machine.

85 The casing presents a design of unique appearance, open for the upper forward portion for convenient access to the table for clamping the work thereon either manually or automatically, and closed for the rear portion, completely covering the work and cutter in the milling zone. The bearings for the spindle, table, and transmission gearing, therefore, are housed below the work holding surface of the table on lubricant tight casings or compartments for efficient or constant lubrication.

90 It has been experienced that a circular revolving table is highly adaptable for continuous milling, the table moving continuously in a forward direction, and with the tilting form of table there is no opportunity for the piling up of the chips upon the table. The milling is primarily performed within a rear section so that the chips and coolant are easily delegated or drained from the lowermost elevation of the table.

95 In utilizing a single milling cutter centrally of a plurality of pieces of work clamped in a circular order upon the work table, the work moves in an orbital path about the cutter, so that each piece is consecutively presented to the cutter and gradually to the action of the cutter from a starting cut to the fullest depth of cut, from whence the work moves gradually away and out of reach of the cutter, to be removed or replaced by another piece.

100 The work, therefore, for each revolution of the table moves within what may be termed a loading zone and thence within a milling zone, and in passing from one zone to the other is automatically unclamped or clamped when free of the cutter.

105 A large milling cutter in an offset capacity relative to the work has its teeth out of engagement for a sufficient length of time to prevent the cutter from being unduly heated. Large diameter cutters make it possible to use large spindles and arbors, adding rigidity to the spindle structure, allowing more substantial bearings or journalings for the spindle.

110 The spindle 7 (see Figures 3 and 7) is of hollow form having its upper or head end journaled within roller bearings 8—8 mounted and seated within a vertically adjustable bearing or journal 9. The spindle is held within the journal 9 against axial displacement by an annular flange 10 at its head end, abutting an inner collar of the upper roller bearing 8 and a collar or nut 11 screw-

threaded upon the spindle, bearing and abutting an inner collar of the lower roller bearings 8 seated within the journal 9. Arrangement is made for supplying lubricant between the spindle and journal to keep the parts constantly lubricated.

The journal 9, as shown in Figure 8, is provided with opposingly inclined surfaces 12—12 at relatively opposite sides thereof, giving the forward side a dovetail formation for slidably seating into the V-way or channel of a column or headstock 13 slidably supported in the underhung dovetailed gib or slideways 13^a on the lower side of the pan casing 2. The slide journal 9 is rigidly clamped to the headstock by hand operated clamping devices carried by the headstock at relatively opposite sides of the journal slide-way (see Figures 8 and 9).

The clamping devices are the duplicate of one another, each comprising an eccentric shaft 14 vertically journaled in the headstock having a pair of eccentrics 15—15, each eccentric engaged through a clamp block 16 slidably supported in a bore in the headstock transverse to the eccentric shaft. The block 16 has a bolt 17 secured thereto and extended through an elongated slot 18 in a lateral flange 19 integral with and extending approximately radially from the slide journal 9, the head of the bolt 17 bearing against a cap plate 20 upon the outer side of the flange 19 covering the elongated slots 18. Turning the eccentric shaft in appropriate directions moves the slide blocks 16 in either of alternate directions, clamping the journal 9 rigidly to the headstock or releasing the same.

Each eccentric shaft at its lower end has a bevel gear 21 fixed thereon in mesh with a bevel gear 22 fixed upon the end of a shaft 23 journaled in the forwardly projecting wing 24 of the headstock, the shaft extending through the forward upper end of the bed for access at the forward side of the machine. The forward end of the shaft 23 is squared for the reception of the crank handle for manually rotating the shaft to operate the clamps.

The spindle is vertically adjusted to change the elevation of the cutter relative to the plane of the table by a screw 25 journaled in the headstock, at the forward side of the journal 9 and in threaded engagement through a nut element or ear 26 projecting from and integral with the journal 9. The lower end of the adjusting screw 25 has a bevel gear 27 fixed thereon in mesh with a bevel gear 28 fixed on the rear end of a shaft 29 journaled in the forwardly extended wing 24 of the headstock and extends for access at the front side of the machine. The forward end of the shaft is squared for applying a hand crank for manual shaft rotation. Gauge devices 30 are provided at the forward end of the shaft 29 for indicating the degrees of the spindle adjustment.

The spindle 7 extends beyond the slide journal 9 and through an elongated hub 31 of the worm wheel 32, to which the spindle is splined. The hub 31 extends concentrically through a bushing 33 having an annularly flanged lower end fixed to the headstock, with its opposite end telescopically engaged into the lower end of the slide journal 9. The hub 31 rests upon a bearing washer 34 interposed between the face side of the hub and upper end of a hub extension 35 of the closure cap 36 secured through the lower end of the headstock. The hub 35 of the cap provides a housing and bearing for a pair of roller bearings 37—37 engaged upon a bushing 38 splined

on a counterturned lower end of the spindle. The cap plate 36 is provided with a stuffing box cover 39 concentrically about the lower end of the spindle closing and sealing the bearing chamber formed by the hub 35.

The bore of the spindle at its head end is tapered to receive a corresponding tapered shank of a cutter carrying arbor 40, the arbor being locked to the spindle by a tie rod 41 threaded into the tapered end of the arbor and projecting through the bore of the spindle and in threaded engagement through a bushing nut 42 socketed into the lower or tail end of the spindle. The spindle head is provided with a collar 43 annularly engaged with a flanged end of the spindle capping over the upper end of the slide journal 9 to provide a cover for the bearing chamber intermediate the spindle and journal, the collar 43 being engaged by the packing 44 interposed between the collar and upper end of the journal 9 to provide a lubricant sealing joint.

A circular cutter 45 is keyed upon the arbor 40 at an appropriate elevation above the surface of the table and secured against lateral axial displacement by a lock nut 46 screw-threaded upon the arbor and spacing collars 47 disposed at opposite sides of the cutter. The upper or free end of the arbor 40 is journaled and slidable in a steady rest or bracket 48 adjustably mounted upon the arch portion 3 of the casing and preferably centrally thereof and at one side of the motor supporting bracket 49 bolted upon the casing.

The headstock, as shown in Figures 5 and 12, is slidably mounted in ways 13^a—13^a at relatively opposite sides of the headstock and underhung from the lower side of the pan-shaped casing 2, and is adjusted or moved in the ways for positioning the spindle either concentric with the revolving work table or at varying degrees eccentric thereof. The headstock (see Figure 3) is adjusted by a screw 50 engaged through a nut 51 fixed upon the forwardly projecting wing portion of the headstock, with the forward end of the screw journaled in a bearing 52 at the forward end of the casing 2 centrally of the machine. The forward end of the screw is squared for the reception of a hand crank, and is also provided with indicator devices 53.

The revolving table 54 is in the form of an annulus, with its upper surface provided with circular and radial T-slots for securing the work holders upon the table about the cutter. The lower side of the table is provided with a conical hub 55 journaled within a correspondingly tapered bearing 56 fixed upon the base of the casing portion 2. Lubricant distributing means 57 for supplying lubricant to the bearing surface of the table are shown as leading forwardly of the frame or casing 2 (see Figure 3) and terminating in a fill cup within convenient access to the operator.

A worm wheel 58 is fixed to the end of the hub 55 of the table in mesh with a worm sleeve 59 splined upon a cross shaft 60, the shaft 60 journaled in bearing bushings 61—61 at opposite ends of the worm sleeve 59, the bushings being suitably mounted in bearings or supports 62 as a part of the base of the pan-shaped casing 2 and at the lower side thereof. End thrust roller bearings 63 are interposed between the ends of the worm sleeve 59 and bearing bushings 61.

The shaft 60 is slidable longitudinally for engaging and disengaging its clutch end 64 with a corresponding clutch end 65 of shaft 66. A hand lever 67 pivoted to a bearing bushing 68 is en-

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gaged into an annular shifter spool 69 fixed on the shaft 60 for actuating the shaft. The bearing bushing 68 is engaged and socketed into the side of the casing 2 and provides a bearing for the end of the shaft 60, and the end of the shaft 60 is squared for the reception of a crank handle.

The shaft 66 is journaled within a bearing bushing mounted in a side wall of the casing 2, the shaft carrying on its outer end a gear 70 as a member of change gear transmission housed within the transmission compartment 71 of the casing 2, the transmission compartment having a closure cap 72 covering an opening through the casing outer wall.

The change gear transmission connects with a train of gearing housed within a second compartment 73 of the casing 2 and in connection with the gear 74 on a shaft 75 journaled in bearings in the bed portion of the machine. The shaft 75 is driven by the pulley 6 fixed upon the end of the shaft, the pulley being in connection with the driving pulley of the motor through a belt 76.

The driving belt 76 is tightened by means of an idler pulley 76^a journaled on a bracket 76^b slidably mounted in a slideway in the side face of the support 49. An adjustment screw 76^c is screw-threaded into the support 49, longitudinally entering the slideway and engaging with the slidable bearing support 76^b for adjusting the same, the adjustment screw having a nut thereon for permanently setting the idler pulley in position.

Various forms of transmission may be instituted between the driven shaft 75 and the driven shaft 60 or worm sleeve 59 for rotating the table, the particular system of gearing herein employed constituting a gear 77 suitably journaled in bearings in the bed and in mesh with the gear 74 fixed on the drive shaft 75. The gear 77 in turn is in mesh with a gear 78 within the transmission compartment 73 as a member of a compound gear. The second gear 78^a of the compound is in mesh with a gear 79 on a shaft 80 extending from the transmission compartment 71 into the adjacent transmission compartment 71 and carries a second gear 81 in mesh with a gear 82 as a member of a compound change gear, the second member 83 of the compound meshing with the gear 70 on shaft 66. The compound gear is supported upon a swinging lever or quadrant 84 suitably supported.

A bevel gear 85 is fixed upon the inner end of the main drive shaft 75 in mesh with a bevel gear 86 splined upon the end of a shaft 87 (see Figure 5). The shaft 87 extends forwardly and into a transmission compartment 88 in the front end of the headstock and moves longitudinally with the headstock in the lateral adjustment of the spindle.

A gear 90 is fixed upon the end of the shaft 87 within the transmission compartment 88 in mesh with a gear 91 likewise housed within the transmission compartment 88 fixed upon the forward end of a shaft 92 extending longitudinally with the shaft 87. The shaft 92 carries a worm sleeve 93 splined thereon and in mesh with the worm wheel 32 of the spindle. The various shafts are suitably journaled in roll or ball bearings to which detail description need not be made.

Likewise, arrangement is made for complete lubrication of the bearings and gearing by housing the same as in oil-tight casings and compartments.

The spindle can be adjusted relative to the axis of the work table without disturbing the

transmission connection and while the transmission is in motion due to the splined connection of shaft 87 with the bevel gear 86, and for vertical adjustment of the spindle due to the splined connection of the spindle with the worm wheel.

For increased production capacities and continuous milling, the table is provided with a plurality of automatically actuated work holders or work clamps adapting the pieces of work to be quickly clamped or unclamped with the continued rotation of the table, the continued rotative function of the table utilized for actuating clamp controlling devices located within a suitable loading zone of table rotation at which the work is clear of the cutter.

The milling job is accomplished within a single revolution of the table, and the work is engaged or in action with the revolving cutter during only a portion of each revolution of the cutter. The work in each revolution from a loading zone is gradually presented to the action of the cutter teeth and correspondingly retreats therefrom, allowing ample opportunity for removing a finished piece and replacing it with another while the table continues its rotation.

The pieces of work are arranged upon the table in a consecutive circular order, the path being eccentric to the axis of the cutter, and the table being of comparatively large diameter allows for a large number of duplicate pieces to be mounted thereon. The method is more easily comprehended upon reference to the diagrammatic view, Figure 13, which illustrates the table equipped with twenty-one pieces of work 94, equally spaced apart and in a circular row, eccentric to the axis of the cutter, the degree of eccentricity governing the depth of cut or degree of milling. In the diagrammatic view, a spacing is shown between the opposite ends of the row of work, designated as a loading zone, and merely as indicative of an area within the convenient access of the operator, at which the work is unclamped and free to be removed by the operator and replaced with another. In actual operation this spacing does not appear, the parts being equally spaced from each other around the entire circumference of the table.

The work or portion milled or to be milled is indicated as a cylindrical or circular part or portion which is shaded to show the degree of milling when presented to the action of the cutter and when finished. Thus, the first three pieces to the left of the loading zone space in the figure are free from the cutter and can be said to be in the clamping zone. The next nine pieces are within the milling zone. The next five pieces are retreating from the cutter, the milling having been finished, and the following four out of reach of the cutter and within what may be termed "the unclamping zone".

Thus, nine pieces are continuously and simultaneously operated upon for each revolution of the table, giving an idea of the milling or production capacity under this method. The number of pieces of work has been merely arbitrarily selected, the parts passing to the path of the cutter in a planetary manner and have to travel through a third of a turn of the table in advancing far enough toward the center of the spindle, so that the cutter reaches the bottom of the cut. This is equivalent to feeding the parts directly toward the spindle, the exact depth of the cut.

Facilities are provided for automatically clamping and unclamping the work as they ap-

proach the loading zone and depart therefrom, so that the operator needs only to remove the unclamped piece and replace the same with another. Various types of work holding fixtures can be employed, and in the instance herein illustrated each fixture is arranged to hold two pieces, and constitutes a pair of V-notched stocks 95—95 fixed upon a ring bed plate 96 which in turn is fixed to the work table. The ring plate permits the fixtures to be mounted as a unit, facilitating assembly of fixtures taking a particular piece of work and in substituting one type of fixture for another upon the table.

A piece of work 94^a represented as a cylindrical block is set within the V-notch of the stock, the stocks arranged in pairs for holding two pieces of work simultaneously clamped by a single clamping device consisting of a pair of clamp plates 98—98 pivotally suspended from a connecting plate 99, the clamping plates respectively engaging upon a piece of work set in one of the stocks. The connecting plate 99 is engaged by a clamp rod or bolt 100 having a slide block 101 fixed to its lower end slidably engaged within a bore in the base plate and engaged by a laterally moving wedge rod 102 slidably sustained within the base plate 96 for depressing the clamp rod and releasing the same for clamping and unclamping the work.

The inner end of the wedge rod is inclined and extends through a slot in the slide block 101 which is correspondingly inclined, as shown in Figure 11, and when the rod is forced inwardly the clamp rod is drawn downwardly, bringing the clamp plates upon the work, rigidly holding the same within the stocks. The forward end of the wedge rod is provided with a transverse groove 103 for engagement with a stationary cam 104 extending from a bracket plate 105 rigidly bolted to the machine casing or other suitable stationary support, the cam causing the withdrawal of the wedge rod as the rod in its traverse with the rotating table moves into cooperation with the cam.

The wedge rod as it leaves the loading zone is moved inwardly by a push lever or dog 106 pivotally mounted upon a bracket or support 107 as a stationary support. The dog or lever is spring-pressed so as to yield under undue resisting pressure against the inward movement of the rod when its full wedging force is exerted for the required clamping pressure upon the work. This provides a safety feature and allows for variations in clamping pressures of the several fixtures.

The operator is stationed at the front side of the machine for removing the unclamped finished pieces of work within the loading zone and replacing the same by a second to be machined. The speed of operation is only limited by the ability of the operator to remove and insert the work without stopping or starting the machine or table rotation.

A round revolving table lends itself admirably for the automatic operation of work clamped at definite points in each revolution of the table and operative through the rotative motion of the table.

In the particular arrangement and tilting form of table, the milling is accomplished at the rear side of the machine completely housed by the casing of the machine, away from the operator, and permits the supply of a coolant of a high pressure and volume discharged from a nozzle 110 directed against the cutter and work rear-

wardly, the coolant washing the chips from the work and table into the reservoir portion of the pan-shaped casing, and the inclination of the table allows ample drainage of coolant from the work and table as it passes out of the milling zone and into the unclamping zone. The lubricant is fed to the nozzle 110 from the base of the machine by means of a pump 111 mounted on the side of the machine and driven from the main driving pulley 6 by means of a belt 112.

The larger the cutter the larger will be the milling range or zone, consequently allowing for more parts to be mounted within the range for simultaneous operation thereon. With many teeth of a large cutter engaged with the work at one time, the more constant is the braking load on the machine. This results in a very smooth movement of the cutter blades at all stages of a revolution. In the use of small diameter cutters with only one or a few teeth engaged at a time the effect is a succession of hammer blows, and to speed up production the cutter must be run at high rates of speed.

Under the present method, new parts are constantly presented to the cutter, requiring no change in feeding rate from starting cut to finishing, and high production rate is obtained without cramming the feed to the detriment of the cutters. There is no shifting or cutting off of the coolant for there is no idling or travel to position for successive milling. There is constant variation in cut from the time of starting on one piece to the time of finishing it, the cut being extremely coarse in the early stage of the milling and steadily reduced in an approximate geometric progression to zero or a very fine cut at the end of the operation.

It frequently occurs that the length of cut is heaviest at the base of a groove being milled as where there is a groove being formed partly through a circular part (see Figure 10), and the advantage of having the cut extremely fine at the end of the operation will be apparent.

From the diagram it will be seen that as a part approaches the bottom or end of cut, the feed gradually tapers off to zero, where the two circles become tangent, from which point the work begins to recede from the cutter. In milling steering spindles and similar parts, this arrangement is of particular advantage.

The machine is adapted for small face milling jobs, slotting, straddle milling, and to some extent form milling.

Having described our invention, we claim:

1. A milling machine, comprising a bed, a ring-form rotary work holding table journaled in said bed, transmission gearing for rotating the table, a headstock, constituting a column portion and a base portion, the base portion slidably supported in the column, said headstock adjustable radially of the axis of the table, a slide journal in said column portion of the headstock, and a spindle journaled in said slide journal for axial adjustment with said slide journal, and transmission gearing for rotating said spindle.

2. A milling machine, comprising, a frame, a table mounted on said frame, said table having a conical hub seating in a conical opening in said frame, a ring form worm wheel hung from said table, a transmission for driving said gear and table, a headstock slidably mounted in the frame below the table, a spindle extending upwardly from said headstock through the table, a tool carrier in said spindle, a journal slidably mounted in the upper end of said carrier, a driv-

ing transmission for said spindle, and means for adjusting said headstock radially of the center of said table for offsetting the tool carrier relative to said center.

5 3. In a milling machine, a frame, a table jour-
nalled in said frame, a transmission for rotating
said table, a headstock mounted below said ta-
ble, a spindle extending upwardly from said
10 headstock and disposed centrally through said
table, said headstock being adjustable on the
frame for offsetting the center of the spindle
relative to the center of the table, a transmis-
sion carried by said headstock, said transmis-
15 sion in driving connection with the transmis-
sion driving the table, and means for elevating
and setting the tool carried by the spindle rela-
tive to the table.

4. In a milling machine, a frame, a table jour-
nalled in said frame, a transmission for rotating
20 said table, a headstock mounted below said ta-
ble, a spindle extending upwardly from said
headstock and disposed centrally through said
table, said headstock being adjustable on the
frame for offsetting the center of the spindle
25 relative to the center of the table, and a trans-
mission carried by said headstock, said transmis-
sion in driving connection with the transmission
driving the table.

5. In a milling machine, a frame, a work-hold-
30 ing table journaled in said frame, transmission
means for rotating said table, a headstock slid-
ably mounted in the frame below the table for
adjusting the headstock radially of the table
and having a spindle support extending through
35 a central opening through the table, a spindle
journal slidably mounted upon the headstock for
adjustment transversely to the radial adjustment
of the headstock, a spindle journaled in said
slide journal and adjustable therewith as a unit,
40 and transmission means journaled in said head-
stock for rotating the spindle.

6. In a milling machine, a frame, a work-
holding annulus journaled in said frame, trans-
mission means for rotating said annulus, a head-
45 stock slidably mounted in the frame below the
table for adjusting the headstock radially of the
table and having a portion extending through the
work-holding annulus, a spindle journaled in
said headstock, the radial adjustments of the
50 headstock adapting the spindle to the position
concentric with and eccentric to the axis of said
work-holder annulus, and transmission means
journaled in said headstock for rotating the
spindle.

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7. In a machine for continuously milling a
plurality of pieces of work, a rotatable work sup-
port, a plurality of work holders mounted upon
said support for holding the pieces of work in a
consecutive order and the portion thereof to be
80 milled in a common work circle, a rotative spindle
and circular milling cutter mounted thereon, op-
erative within the work circle, the cutter of a
diameter to simultaneously mill a number of
85 pieces of work with its cutter teeth relatively
concentric and rotating at a higher rate than
the traversing rate of the work support making
a multiple number of revolutions in the period
a piece of work traverses through a milling zone
90 or for a partial revolution of the work support,
and means for relatively offsetting the cutter
and work circle for governing the maximum de-
gree of milling depth of the cutter, the work in
moving in an orbit about the cutter, eccentric
95 to the circumference of the cutter traversing in
milling and non-milling zones for each revolu-
tion of the work support, the non-milling zone
utilized for removal and replacement of the
pieces of work.

8. In a machine for continuously milling, a
100 plurality of pieces of work, a rotating work sup-
port, one or more work holders mounted upon
said support for holding the pieces of work in a
consecutive order and the portions thereof to be
milled in a common work circle, a rotative spin-
105 dle and circular milling cutter therefor, the spin-
dle and cutter rotating at a higher rate than the
traversing rate of the work support making a
multiple number of revolutions in the period a
piece of work traverses through a milling zone
110 or for a partial revolution of the work support,
the cutter having its cutter teeth relatively con-
centric and as a unit of a diameter to simul-
taneously operate upon a number of pieces of
work as they are continuously traversed within
115 a milling zone for each revolution of the work
support, the axis of the work support and mill-
ing cutter relatively eccentric, the degree of ec-
centricity governing the milling depth of the
cutter, the work moving in an orbit about the
120 cutter and traversing the milling and non-mill-
ing zones for each revolution of the work sup-
port, the non-milling zone utilized for removal
and replacement of the pieces of work.

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