Jan. 1, 1952 M. H. ARMS 2,580,989

GRINDING LOBED FORM

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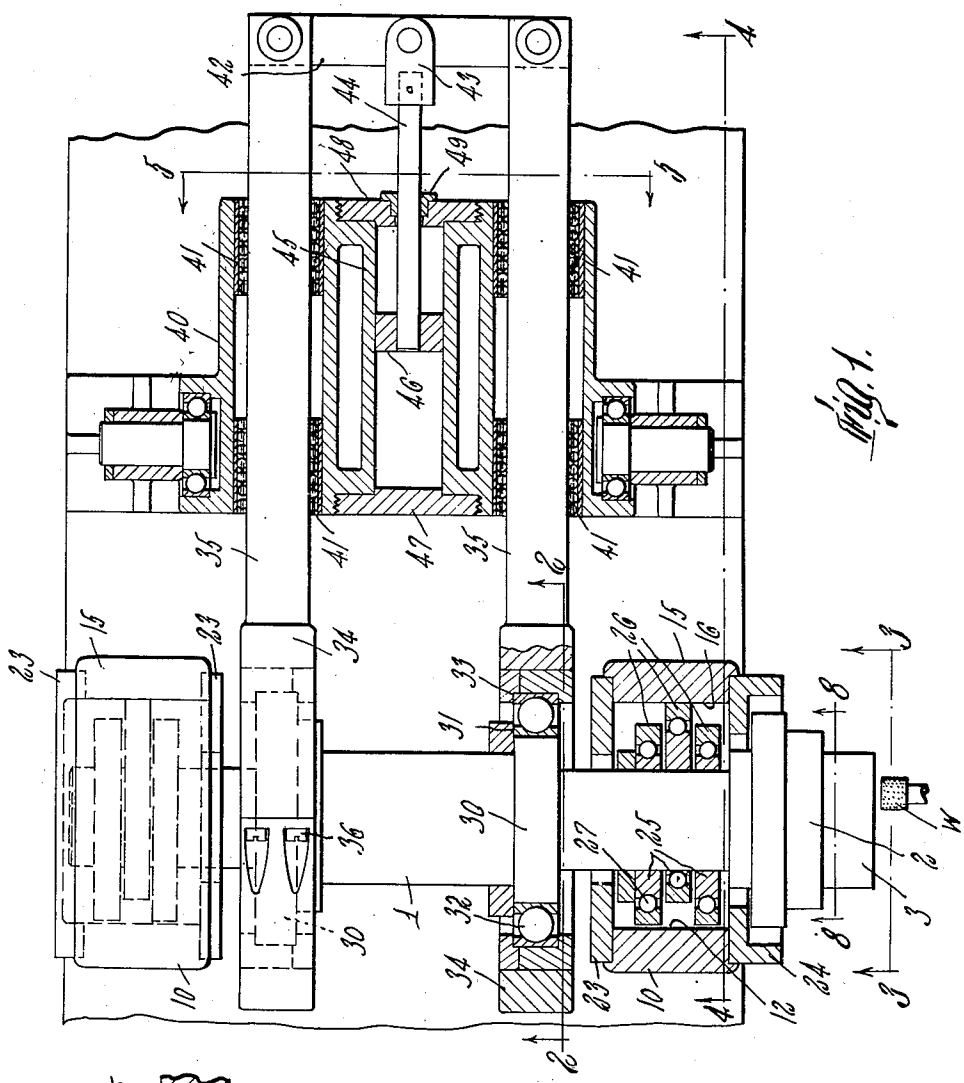


Fig. 1.

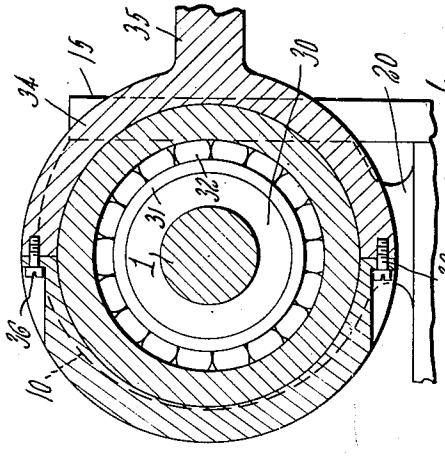


Fig. 2.

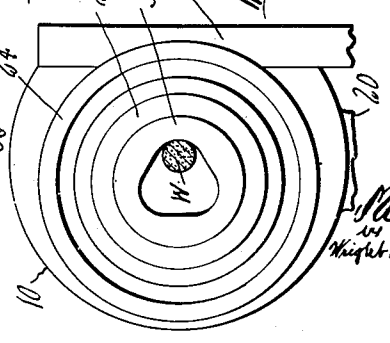


Fig. 3.

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GRINDING LOBED FORM

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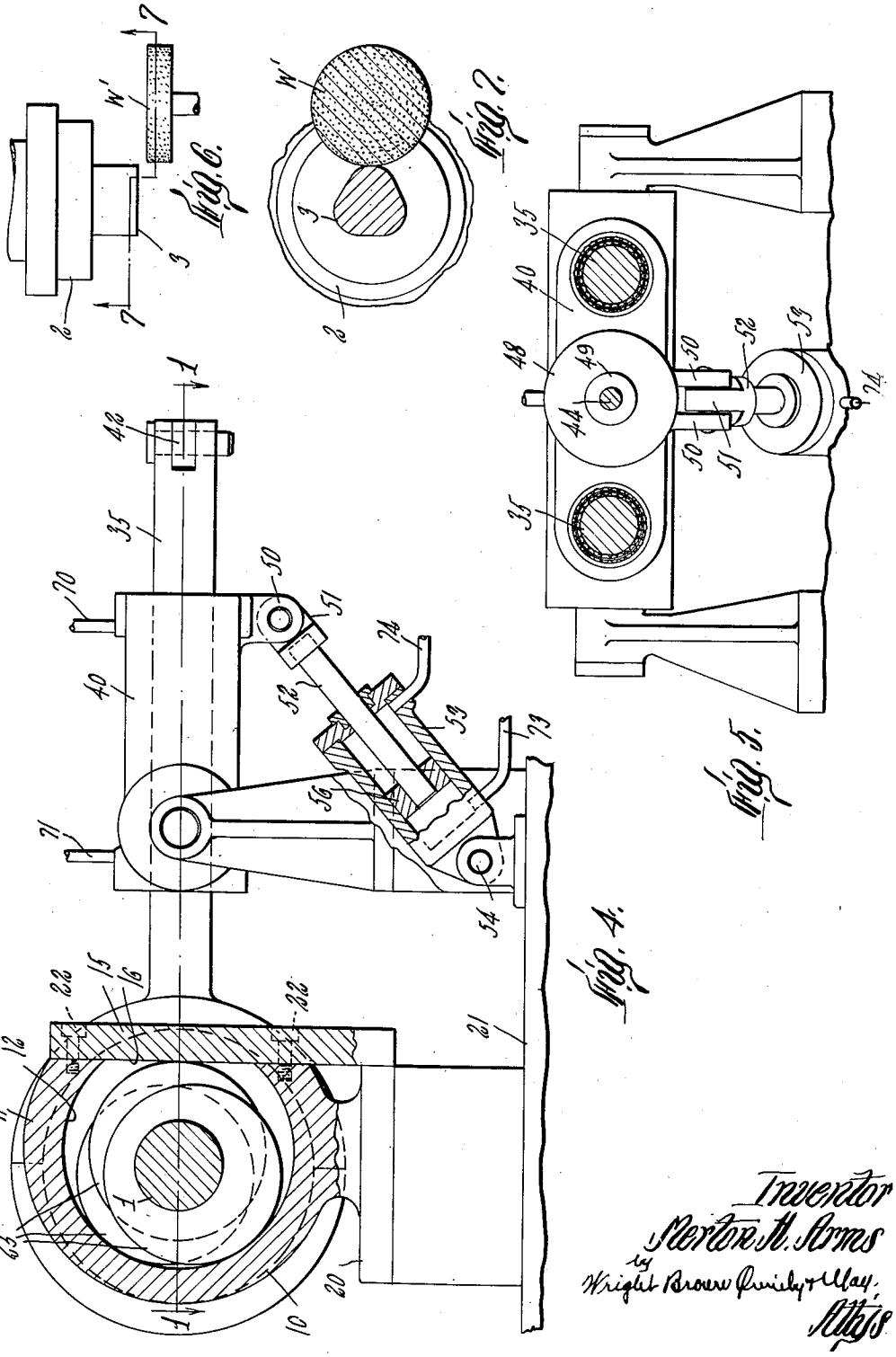


Fig. 6.

Fig. 2.

Fig. 5.

Fig. 4.

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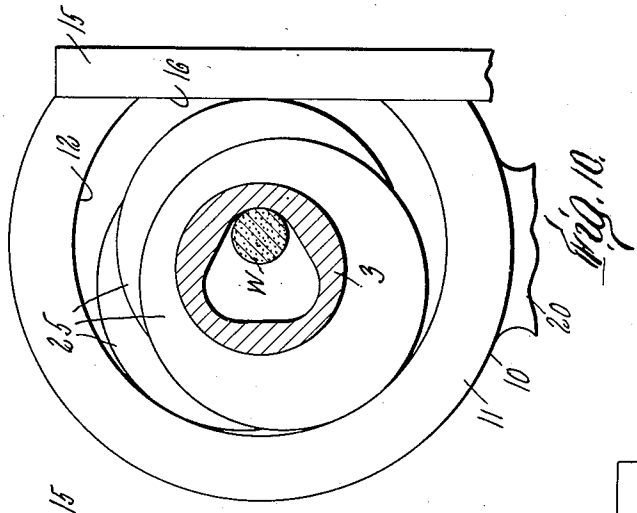


Fig. 10.

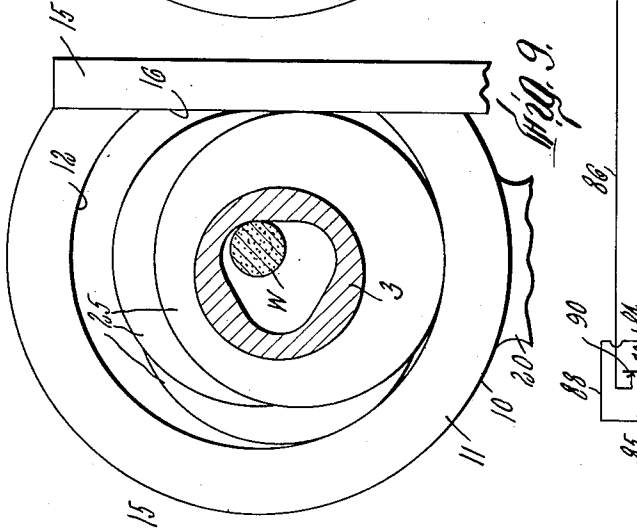


Fig. 9.

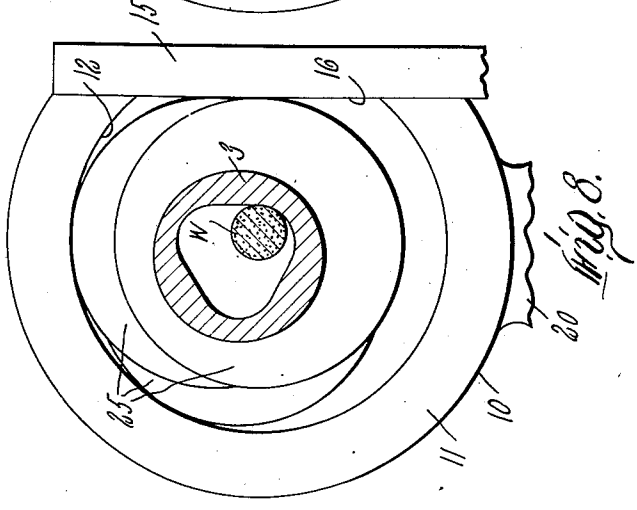


Fig. 8.

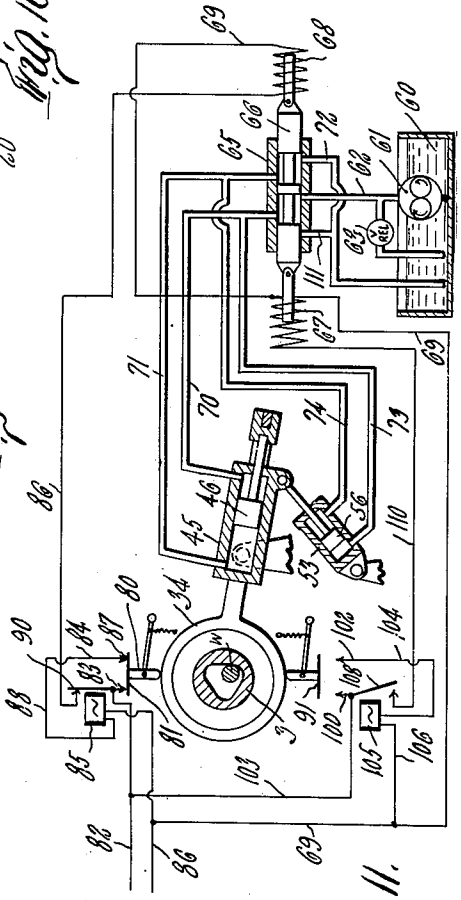


Fig. 11.

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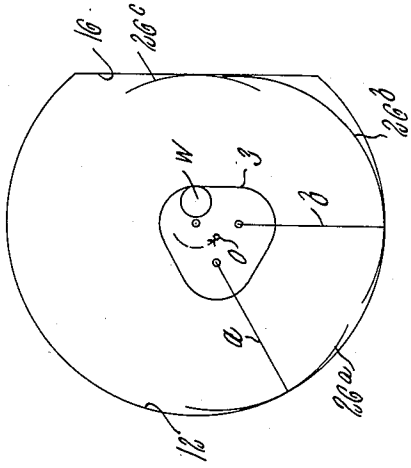


Fig. 14.

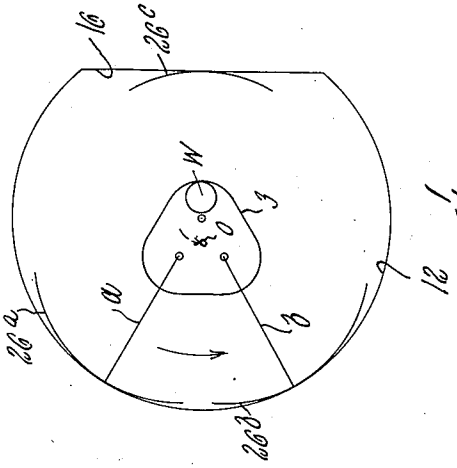


Fig. 13.

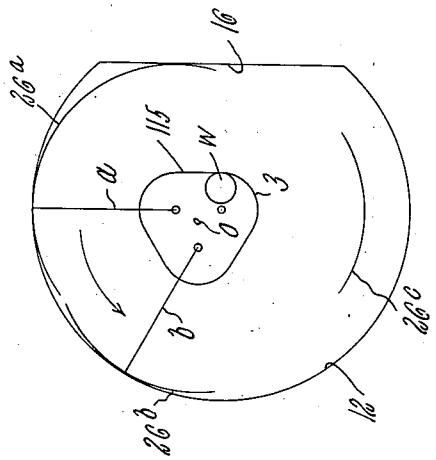


Fig. 12.

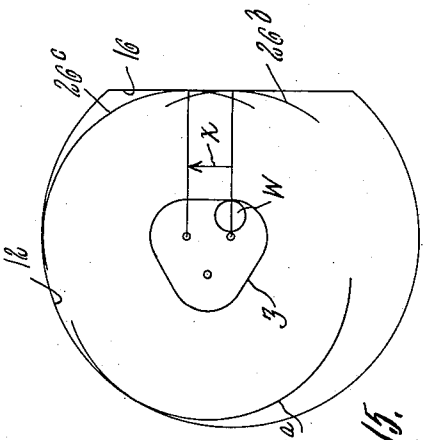


Fig. 15.

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GRINDING LOBED FORM

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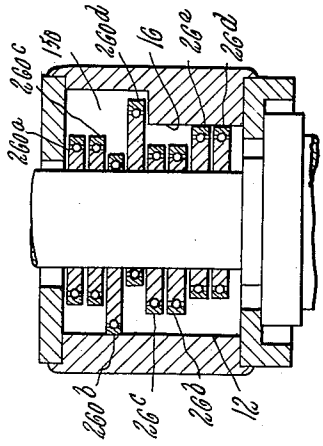


Fig. 18.

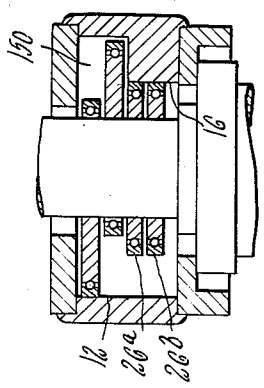


Fig. 20.

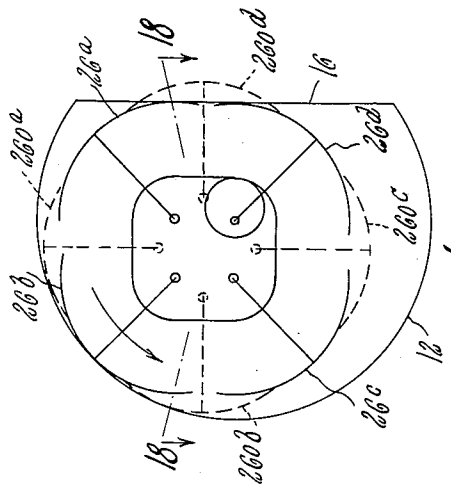


Fig. 17.

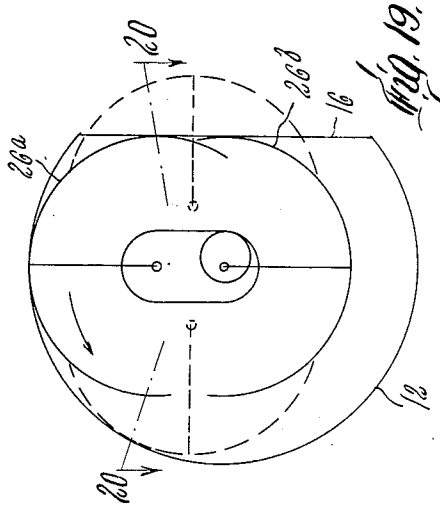


Fig. 19.

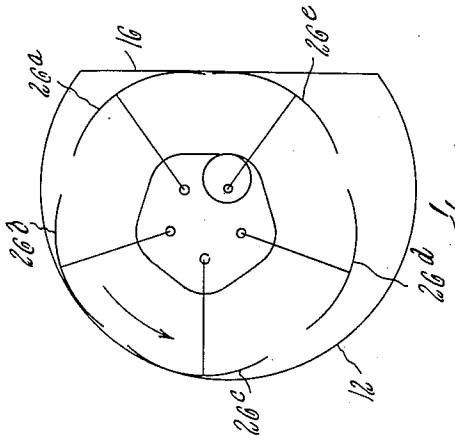


Fig. 16.

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UNITED STATES PATENT OFFICE

2,580,989

GRINDING LOBED FORMS

Merton H. Arms, Springfield, Vt., assignor to Bryant Chucking Grinder Company, Springfield, Vt., a corporation of Vermont

Application April 5, 1949, Serial No. 85,547

7 Claims. (Cl. 51—95)

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Where high torque transmission between shafts and parts carried thereby is required, it has been found desirable in some instances to dispense with the use of keys or splines for securing the parts to the shaft in view of the relative weakness of this type of securement, and instead to make use of shafts having lobed shaped cross sectional contours engaged in openings of mating contour through the carried parts.

An object of this invention is to facilitate accurate shaping of the shaft and mating parts to such lobed contour. Commonly a three-lobed contour has been employed, though in its broader aspects this invention is applicable to the production of shapes having any desired number of lobes as will later appear. This invention has particular utility where hard parts are employed when grinding to shape is indicated.

The work, whether internal or external, is arranged to be presented to a rotary tool, such as a grinding wheel, and moved in directions transverse to its axis so controlled that when presented to the tool the latter describes the desired lobed contour with relation to the work piece. Claims generic to this general method are contained in the application for United States Letters Patent filed February 18, 1949, Serial No. 77,183, by Philip C. Durland.

For a complete understanding of this invention, reference may be had to the accompanying drawings in which

Figure 1 is a sectional view of a machine for grinding internal three-lobed forms, the section being taken on line 1—1 of Figure 4.

Figures 2 to 5, inclusive, are sectional views on the correspondingly numbered section lines of Figure 1.

Figure 6 is a fragmentary top plan view showing the relation of an external grinding wheel to lobed work.

Figure 7 is a detail sectional view on line 7—7 of Figure 6.

Figure 8 is a fragmentary sectional view on line 8—8 of Figure 1, but showing the grinding wheel in grinding position.

Figures 9 and 10 are views similar to Figure 8, but showing different relative positions between the grinding wheel and the work piece, the end plate 24 being omitted.

Figure 11 is a diagrammatic view showing the work moving mechanism and its controls.

Figures 12 to 15, inclusive, are diagrammatic views showing the motion of the work while one lobe and an adjacent flat are being ground.

Figures 16, 17 and 19, inclusive, are diagrammatic views showing the tool and work motion controls for five, four, and two lobe-shaped grinding, respectively.

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Figures 18 and 20 are fragmentary views on lines 18—18 and 20—20 of Figures 15 and 16, respectively, and are somewhat similar to a portion of Figure 1.

Referring first to Figures 1, 4 and 5, the machine as shown includes a rotary work spindle 1 having at one end a suitable chuck 2 for the reception of a work piece 3. This work piece may be a piece to be internally shaped to lobe form, this being illustrated in Figures 1, 4 and 6 to 15, inclusive, or it may be an external work piece which is to be machined on its outer face to lobe form as shown in Figures 6 and 7. The shaft 1 extends through a pair of internal cams 10, and as these are identical a description of one will be sufficient. It has a portion 11 provided with an internal arc shaped opening 12 which throughout its full extent is circular. At one side the cam 10 is cut away and the cut away portion is bridged by a plate 15 which presents an internal flat vertical face 16. The arcuate and flat faces of the two cams are arranged identically angularly. Each of these cams may be supported as by a foot 20 from the base 21 of the machine. As shown, the flat for the interior of each cam 10 is formed by the separate plate 15 which is secured as by screws 22 to the arcuate portion. The shaft 1 is supported within each of these internal cams and to this end it has secured thereto a set of three eccentrics 25, the maximum eccentricities of which are arranged 120° apart angularly around the shaft, and the eccentrics of each set are arranged identically angularly spaced around the shaft. Means such as end plates 23 and 24 retain the eccentrics between the side faces of the cams. In order to reduce frictional drag, these eccentrics 25 are each provided with a circular rim 26 supported in ball bearings 27 and these circular rims may engage with the inner faces of the internal cams.

Means are provided by which the shaft 1 with the parts carried thereby may be caused to move in a plane transverse to the shaft axis and with at least two of the eccentrics 25 in engagement with the inner faces of each of the two cams, and since the cams and eccentrics are similarly arranged, the motion of the spindle 1 is limited to motion transverse to its length and with the motion of the work holder or chuck 2 in a plane.

Means are provided by which the spindle 1 and the parts carried thereby are moved in a closed path guided by the operative engagements

between the eccentrics 25 and the interior walls of the cams. To this end the spindle 1 between the cams 10 is shown in Figure 1 as provided with spaced disk portions 30 on which are mounted the inner raceways 31 of ball bearings 32. As shown there are two of these disks 30 spaced apart along the length of the spindle and arranged between and adjacent to the inner faces of the cams 10. The outer ball raceways 33 of these ball bearings, as shown best in Figure 2, are carried by annular straps 34 to which are secured in the same planes the bars 35. As shown in Figure 2, the straps 34 are made in two semicircular portions which are secured together as by screws 36. The bars 36 are slidably guided through sleeves 40. As shown each of the sleeves 40 has a pair of spaced ball bearings 41 which slidably support the bars 35. At their rear ends they are joined by a cross bar 42 which is attached through a pivoted link 43 to the rear end of a piston rod 44. This piston rod extends into a hydraulic pressure cylinder 45 positioned between and integral with the sleeves 40 and within this cylinder it carries a piston 46. Cylinder heads 47 and 48 close off the ends of the cylinder, the head 48 having a suitable gland 49 through which the piston rod 44 extends. The outer end of the cylinder 45 is provided with a pair of spaced depending ears 50 between which is hinged a flattened portion 51 of a head secured to the upper end of a piston rod 52 which extends into a hydraulic cylinder 53, the lower end of which is pivoted as at 54 to the bed 21. It will be evident that by admitting hydraulic fluid under pressure to one or the other side of the piston 46 carried by the rod 52, this piston may be moved lengthwise of the cylinder 45 and that likewise by admitting fluid under pressure to opposite ends of the cylinder 53, the piston 56 therein may be driven lengthwise, thus to rock the sleeves 40. By a combination of these motions the work spindle may be moved in a closed path determined by the contour of the internal cam 10. Means may be provided for so controlling these motions as to cause a bodily movement of the spindle and the work carried thereby controlled by the contours of the cams 10. Such means is shown diagrammatically in Figure 11.

Hydraulic fluid under pressure is derived from a suitable supply tank 60, being pumped therefrom through a pump 61 into a pressure line 62 from which a relief valve 63 controls discharge back to the tank, thus to limit the pressure in the pipe 62. This pipe 62 leads to a valve casing 65 within which is an axially movable valve 66. This valve may be moved in opposite directions by energization of a pair of solenoids 67 and 68. In the position shown fluid under pressure from the pipe 62 passes through the valve casing 65 through a pipe 70 into the right hand end of the cylinder 45, thus to drive the piston 46 inwardly. Fluid under pressure discharges from the left hand end of the cylinder 45 through the pipe 71 to the valve casing 65 and back through the discharge line 72. At the same time pressure from the pressure pipe 70 leads through the pipe 73 to the lower left hand end of the cylinder 53 in position to drive its piston 56 upwardly, fluid discharging from the upper end of the cylinder 53 through the pipe 74 into the pipe 71 and past the valve 65 into the discharge pipe 72. This causes the outer end of the cylinder 45, together with the guide sleeves 40, to be lifted while the piston 46 is driven inwardly, thus pressing the spindle downwardly and to the left so that its eccentrics 25 are pressed against the curved faces 16 of the internal cams.

Assume that the cams are to be traversed counterclockwise as viewed from the work holder end of the spindle. At the start of this motion the eccentric straps 34 are at their upper limits of motion impinging upon a switch member 80 which closes a contact at 81. This closes a circuit from the line 82 through one pole 83 of the switch 81, leads 84, solenoid 85, back to the line 86. Energizing the coil 85 closes the switch 90. The closing of the switch 90 closes a circuit from the line 82 through switch 90 and lead 86 through a solenoid 68, lead 69, back to the line 86. This energizes the solenoid 68 and moves the valve 66 to the position shown.

The effect of the fluid pressure to move the piston 46 to the left and to move the piston 56 upwardly and outwardly is to rock the sleeves 40 in such a direction as to lower each strap 34 while the rings 26 surrounding the eccentrics are pressed against the internal curved faces of the internal cams and to allow switch 81 to open, deenergizing solenoid 68. This motion of the work takes place until each eccentric strap 34 approaches its lowest position at which time one engages the switch element 91 and closes the switch contacts 100 and 102. The closing of the switch contact 102 establishes a circuit from the line 82 through leads 103, switch contact 100, switch element 91, contact 102, lead 104, solenoid 105 and leads 106 and 69, back to the line 86. Energization of the solenoid 105 closes the switch 108 which completes a circuit from the lead 103 through the switch 109, the lead 110, solenoid 67 and lead 69 back to the line 86. This acts to move the reversing valve 66 to its left hand position wherein the pressure line 68 is connected through the pipe 71 to the left hand end of the cylinder 45 while the right hand end of this cylinder is opened to the discharge pipe 111 which connects to the discharge pipe 72. This presses the rings 26 around the eccentrics 25 against the flat faces 16 of the internal cams while at the same time the pressure connections to the cylinder 53 have also been reversed so that the cylinder 45 is rocked downwardly. Thus the effects of the fluid pressure are to cause the work piece to be brought downwardly while the eccentrics 25 are pressed into operative engagement with the curved portions of the internal cams, while during the upward stroke these eccentrics are pressed against the straight faces of these cams.

The resultant effects may be understood by referring to Figures 12 to 15 in connection with Figures 8, 9, and 10. In Figures 12 and 8 the work is shown at its upward limit of position and about to move downwardly. In this position two of the eccentrics 25 have their rings 26 bearing against the upper curved portion of the corresponding internal cam 10. These rings 26 are designated as 26*a* and 26*b* on Figure 12. The third ring 26*c* is out of contact with the interior of its internal cam. The grinding wheel which is shown in these diagrams as an internal wheel at W is then in engagement with the lower portion of the flat 115. The axial center of the work spindle is shown at O. As the strap 34 descends while the rings 26*a* and 26*b* are pressed against the curved face of the cam, the center O of the work piece moves through the path shown by the curved arrow in Figure 13, while the work piece itself is turned through an angle represented by the angular motion of the space between the lines *a*—*b*. The wheel is then in the

position shown in Figures 10 and 13. This downward motion continues, the rings 26*a* and 26*b* continuing their downward motion in contact with the arcuate face of the corresponding cam until the strap 34 reaches its lowest position shown in Figures 14 and 9, the lines *a*—*b* then assuming the angular position shown in Figure 14 and the center of the work having described a path shown by the curved arrow. The grinding wheel W has now traversed a lobe of the work from the position shown in Figure 12 to that shown in Figure 14 through the intermediate positions shown in Figures 13 and 10. The work now being in its lowest position and starting upwardly, the ring 26*c* and the ring 26*b* are now pressed into engagement with the flat face 16 of the cam as shown in Figure 14, and as the work is moved upwardly these follow up in a straight path a distance shown by the arrow X of Figure 15 and from the positions shown in Figures 14 and 9 to the position shown in Figures 15 and 8. It will thus be seen that no turning of the work piece takes place during this upward motion which causes the grinding wheel to generate a flat on the work. In one circuit of the cams, one lobe and one flat have been ground. As the work then is lowered again and its controlling rings 26 are again pressed against the curved faces of the internal cams, the rings 26*b* and 26*c* are now in engagement with this curved face, as shown in Figure 15, the ring 26*a* being then out of control. This cycle continues, each time the curved faces of the cams being engaged by one of the rings previously in engagement therewith and the other ring which was out of engagement with this face during the preceding motion. Thus at the first rotation the rings 26*a* and 26*b* are controlling, in the second rotation the rings 26*c* and 26*b* are controlling, and in the third rotation the rings 26*b* and 26*a* are controlling. It will be seen, therefore, that at each rotary movement, the work has been turned throughout 120° about one of the lobed portions of the contour and that between these turning motions the grinding wheel is effective to grind the flats between the lobes. In three circuits around the cams, one complete contour of the work has been ground, the work describing a circular curved path while being turned, and a straight path joining the ends of the circular path without turning.

The same action takes place when external work is being ground, as is shown in Figures 6 and 7, except that the wheel W′ is fed in the opposite direction against the outside of the work rather than being fed against the inside face of the work as is necessary for the internal grinding. Suitable means, not shown herein but well known in the art, may be employed to support the grinding wheels for feeding with reference to the work and for truing them as occasion demands.

The general arrangement hereinbefore described is applicable with certain modifications to the cutting or grinding of any lobed form having an odd number of lobes, it being necessary only that there be provided equally angularly spaced eccentrics in number equal to the number of lobes, and that the curved portion of the cam path is of the proper angular extent to cause turning of the work spindle through the proper angular extent for the number of lobes. Thus in Figure 16 there is shown diagrammatically mechanism for grinding five-lobed forms. The number of eccentrics with their externally journaled rings is five, the rings being shown partially and diagrammatically at 26*a*, 26*b*, 26*c*, 26*d* and 26*e*. During the traverse of the flat 16 of the internal cam, two of these rings, such as 26*a* and 26*e*, contact therewith at one time, thus preventing rotation of the spindle, while when certain of the rings are pressed against the arcuate portion of the internal cam, two of these rings engage it as at 26*b* and 26*c* and cause turning of the work spindle through one-fifth of a revolution, or 72°, the particular rings engaging being stepped around by one after each cycle of grinding of one lobe and one flat corresponding to one complete traverse around the inner face of the internal cam.

If it be attempted to cut a form with an even number of lobes, the same number of eccentrics as lobes cannot be used, however, as if this be attempted an unstable condition arises so that positive control of the angular position of the work spindle at all times is not afforded. However, by employing twice the number of eccentrics as lobes, positive control can be had but certain changes have to be made to prevent interference of parts as will now be pointed out.

Figures 17 and 19 show diagrammatically by views similar to Figure 16, an arrangement for grinding four and two lobed forms, respectively, and Figures 18 and 20 show in section the corresponding parts. The eccentrics and rings are arranged in two sets, one set comprising the rings 26*a*, 26*b*, 26*c* and 26*d*, and the other the rings 260*a*, 260*b*, 260*c* and 260*d*.

In the position shown in Figure 17, the two rings 26*a* and 26*d* contact with the flat cam face 16 and as the work piece is moved vertically, this contact prevents rotation of the work spindle. From an inspection of Figure 17, it will be evident, however, that when the work spindle reaches its limiting position for grinding a flat, only one of the first set of rings, as 26*b*, is in engagement with the curved portion of the internal cam. Thus the angular position of the spindle cannot be controlled by this engagement, and the necessary positive turning of the spindle for grinding the lobe curvature cannot be produced.

In order to provide for positive turning control of the spindle, the second set of four eccentrics with journaled rings 260*a*, 260*b*, 260*c* and 260*d* is provided, these eccentrics being positioned intermediate in angular positions to the eccentrics and rings 26*a*, 26*b*, 26*c* and 26*d*. At the end of the stroke of the work spindle along the flat 16, two of these rings 260*a* and 260*b* are in contact with the arcuate face 12 and these act together to positively control and turn the spindle through 90° before the next traverse of the flat 16. It will be noted, however, that when the two rings 26*d* and 26*a* engage the flat, the ring 260*d*, as shown in dotted lines in Figure 17, will project beyond the flat. It is thus necessary to position the eccentrics and rings 260*a* to 260*d* where they are out of line with the flat 16, if the arcuate portion traversed by these rings is to be of the same diameter as that traversed by the rings of the first set. The second set of rings, therefore, are shown axially off-set from the first set of rings in a chamber 150 which may, however, have its arcuate face formed as a continuation of the arcuate face 12, and in any event it is concentric therewith, whether or not it is of the same diameter, and this chamber 150 is extended on the side corresponding to the flat face 16 so as to provide room for the passage of the rings of the

second set while rings of the first set are guiding the work spindle for non-rotating but bodily traversing motion.

Similarly where two-lobed forms are to be prepared, there will be two sets of eccentrics and rings, the rings 26*a* and 26*b* of one set engaging the flat 16 at certain times. When grinding the lobes while the arcuate face 16 is controlling the turning of the spindle, one of the rings of the second set and one of the rings of the first set together engage the arcuate face. Here, again, the second set of rings is arranged offset axially from the first and out of the general plane of the flat face 16 beyond which they would have to extend provided that all the rings are the same size, and the curved face portion of the internal cam with which they engage is an axial continuation of the arcuate face engaged by the rings of the first set.

In all cases it will be noted that the arcuate portion of the internal cam is of such an extent that the angular turning of the spindle is the reciprocal of the number of lobes, that is, for two-lobed forms each turning is half a revolution, and for three-lobed forms each turning is one-third of a revolution, etc. It will be noted that the cutting action takes place throughout a closed path and either on the inside or outside peripheries thereof.

In all cases, also, the end face of the rotary tool may be employed in facing the work or in forming shoulders on external work against which the parts carried by the lobed shafts may be seated.

From the foregoing description of an embodiment of this invention it should be evident to those skilled in the art that various changes and modifications might be made without departing from its spirit or scope.

I claim:

1. A machine of the class described, comprising a work holder, means supporting said work holder for motion in a plane, means limiting the motion of said work holder comprising an internal cam having an arcuate portion and a straight portion joining the ends of said arcuate portion, means including a multiple-point support movable with said work holder for engagement with the cam face of said cam, means moving said support in one direction around said cam contour with at least two of said supporting points in engagement with said cam at all times, and a tool positioned to engage a work piece carried by said holder while said holder is being so moved.

2. A machine of the class described, comprising a rotary work spindle, a work holder carried at one end of said spindle, a pair of similar internal cams spaced along said spindle, three eccentrics fixed to said spindle and operatively engaging the inner faces of each of said cams, said eccentrics having their maximum eccentricities spaced from each other by 120°, each of said cams having a circular curved portion and a flat joining the ends of said curved portion, the curved portions and flats being similarly angularly arranged on both cams, means engaging said spindle between said cams and moving said spindle in a closed path with said eccentrics moving around the inner faces of said cams, and a tool positioned to operate on work carried by said work holder during the motions of said spindle in said closed path.

3. A machine of the class described, comprising a rotary work spindle, means rotatably supporting said spindle comprising a pair of closed internal cams spaced along said spindle and a set of three eccentrics fixed to said spindle within each cam, the eccentricities of the eccentrics of each set being spaced angularly by 120°, each of said cams having an arcuate portion and a flat joining the ends of said arcuate portion, means for moving said spindle in a closed path with two of the eccentrics of each set operatively engaging its internal cam at all times, and a tool in operative relation to work carried by said spindle as said spindle is so moved.

4. In a machine of the class described, a rotary work spindle, means rotatably supporting said spindle comprising a pair of closed internal cams spaced along said spindle and a set of three eccentrics fixed to said spindle within each cam, the eccentricities of the eccentrics of each set being spaced angularly by 120°, each of said cams having an arcuate portion and a flat joining the ends of said arcuate portion, a ring within which said spindle is journaled, a bar fixed to said ring, a sleeve through which said bar is slidably mounted, means pivotally supporting said sleeve, and means actuable to move said bar through said sleeve and to rock said sleeve in time therewith to cause said eccentrics to be moved around in operative contact with said cams in a closed path.

5. A machine of the class described for tooling a work piece to a contour having an odd number of lobes symmetrically disposed about its axis, comprising a rotary work spindle, a work holder carried by said spindle for supporting said work piece with said axis parallel to the axis of said spindle, an internal cam arranged transverse to the axis of said spindle and having an arcuate portion and a flat joining the ends of said arcuate portion, a plurality of eccentrics fixed to said spindle one for each lobe and arranged equally angularly spaced about the axis of said spindle and in position to operatively engage the inner face of said internal cam, means engaging said spindle and moving said spindle in a closed path with at least two of said eccentrics in operative contact with said internal cam, the arcuate portion of said cam being of such an extent as to cause said shaft to rotate through that fraction of a revolution denoted by the reciprocal of the number of said lobes during each complete circuit of said spindle within said closed path, and a tool positioned to operate on work carried by said work holder during the motions of said spindle in said closed path.

6. A machine for tooling a work piece to a contour having an even number of lobes symmetrically disposed about an axis, comprising a rotary work spindle, a work holder carried by said spindle supporting said work piece axis parallel to the axis of said spindle, an internal cam having an arcuate portion and a flat joining the ends of said arcuate portion, a plurality of eccentrics fixed to said spindle and spaced equally angularly therearound, there being twice as many eccentrics as lobes of said work piece and said eccentrics being arranged in two sets alternately around the axis of said spindle, all of the eccentrics of one set being in position to operatively engage the inner wall of said cam, an arcuate wall concentric with said arcuate cam portion and against which the cams of the other of said sets may operatively engage, means engaging said spindle and moving said spindle in a closed path with at least two of said eccentrics operatively engaging at all times with either said internal cam or said arcuate wall, the arcuate

portion of said cam and wall being of such extent as to cause said shaft to rotate that fraction of a revolution denoted by the reciprocal of the number of said lobes during each motion of said spindle in a complete circuit of said closed path, and a tool positioned to operate on work carried by said work holder during the motions of said spindle in said closed path.

7. A machine of the class described, comprising a rotary work spindle, means rotatably supporting said spindle comprising a pair of closed internal cams spaced along said spindle and a set of three eccentrics fixed to said spindle within each cam, the eccentricities of the eccentrics of each set being spaced angularly by 120°, each of said cams having an arcuate portion and a flat joining the ends of said arcuate portion, a ring within which said spindle is journaled, a bar fixed to said ring, a sleeve through which said bar is slidably mounted, means pivotally supporting said sleeve, means actuable to move said bar through said sleeve and to rock said sleeve in time therewith to cause said eccentrics to be moved around in operative contact with said cams in a closed path, and a tool positioned to act upon work carried by said holder during the motions thereof.

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