

Sept. 3, 1957

L. O. CARLSEN ET AL
CUTTER SHARPENING MACHINE

2,804,722

Filed Aug. 24, 1953

9 Sheets-Sheet 1

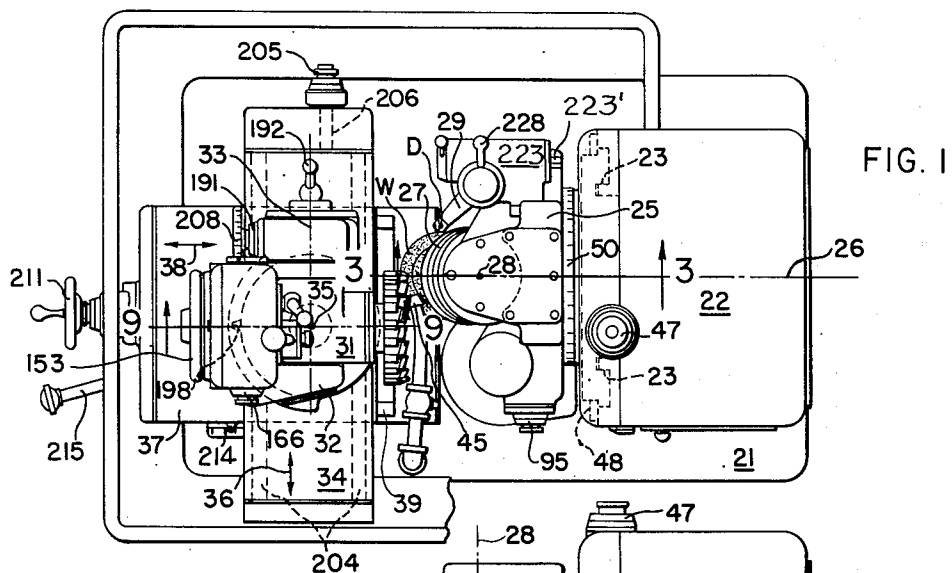


FIG. 1

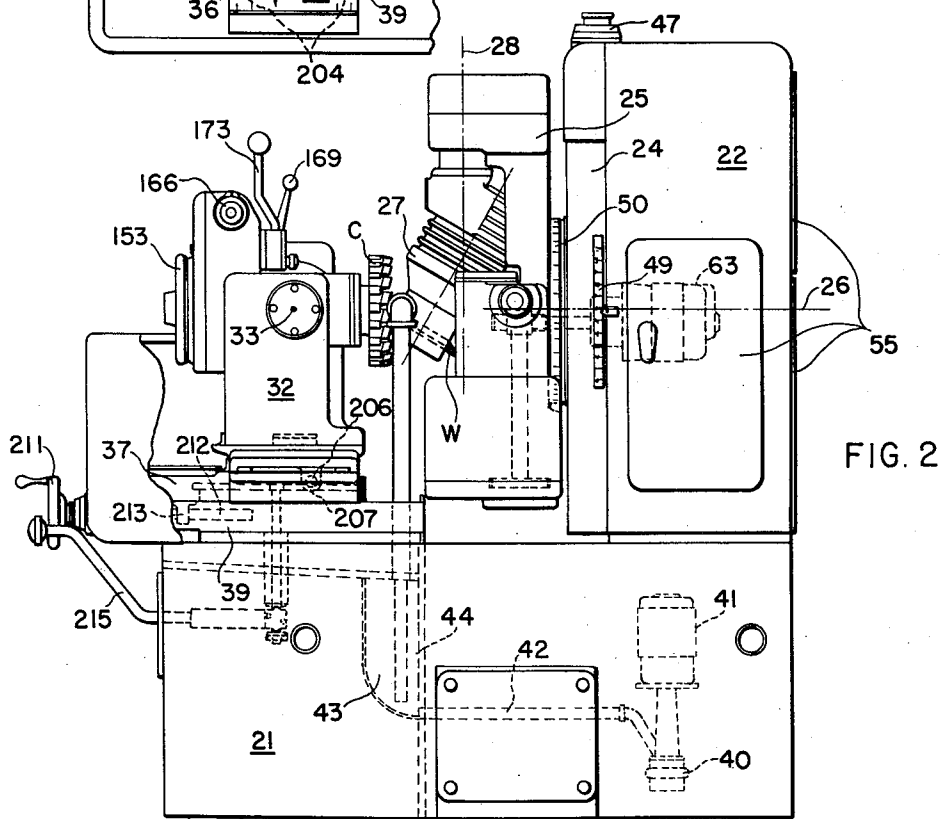


FIG. 2

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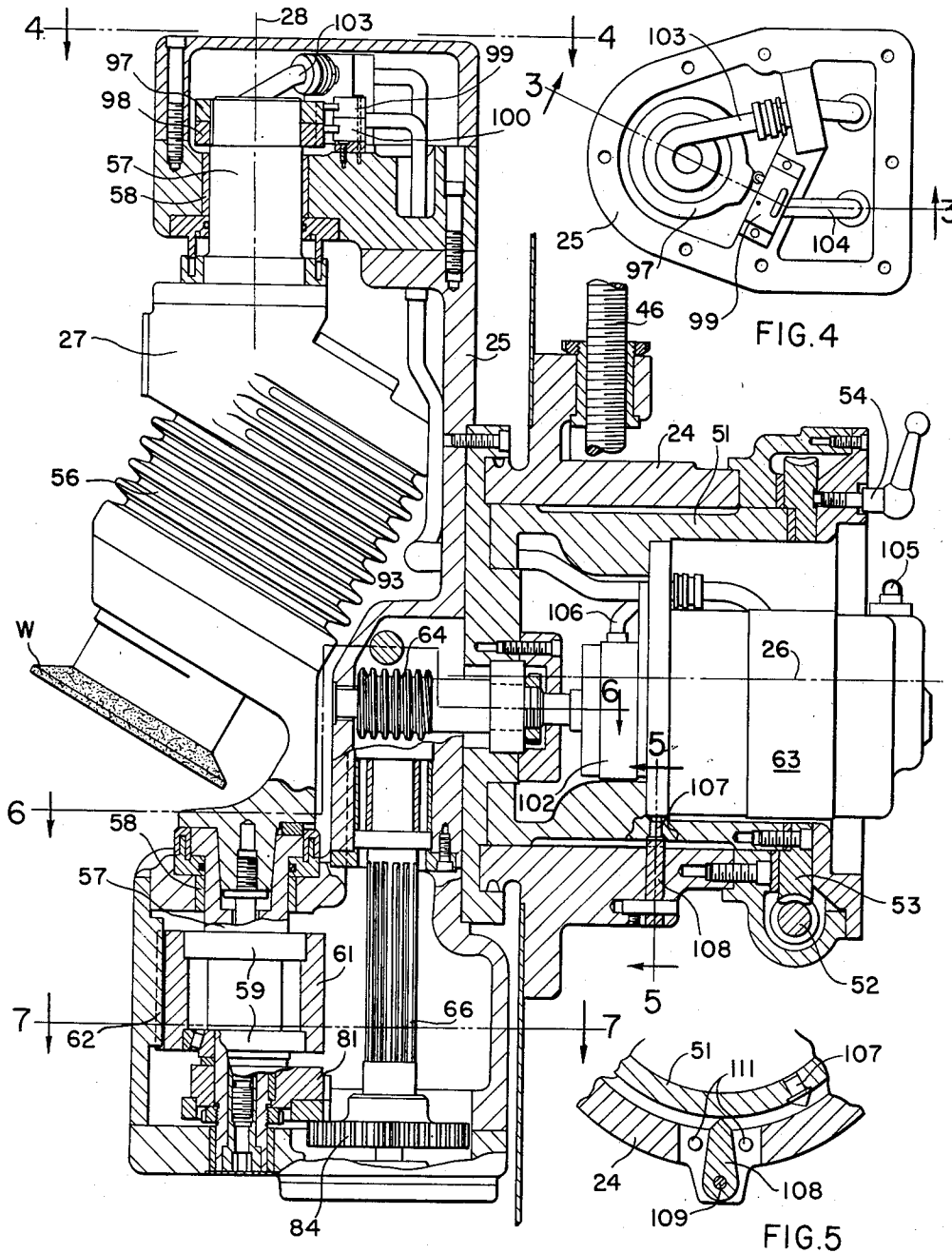


FIG. 3

FIG. 5

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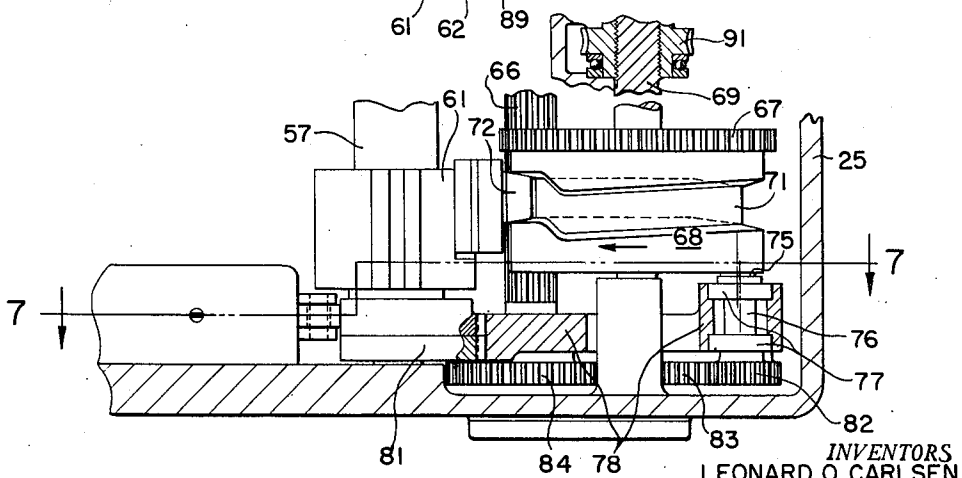
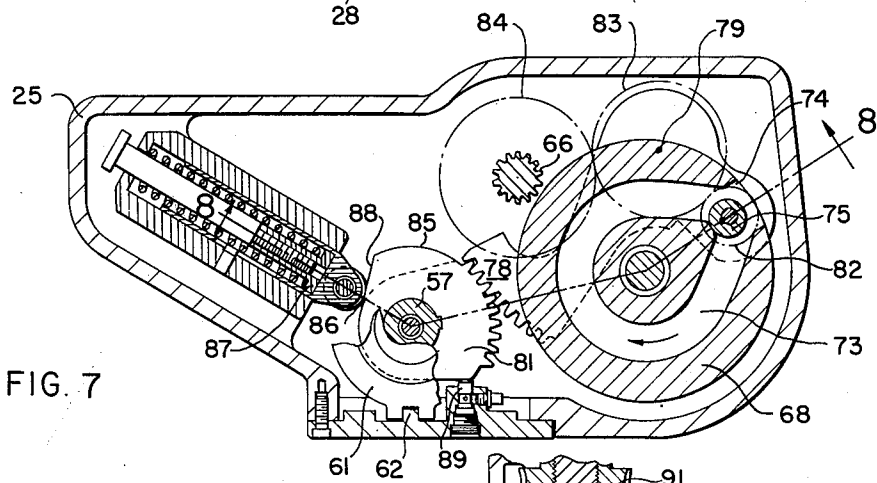
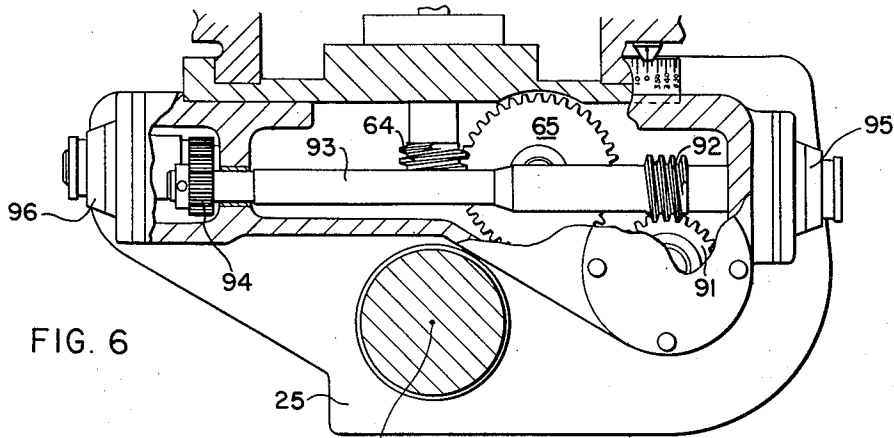
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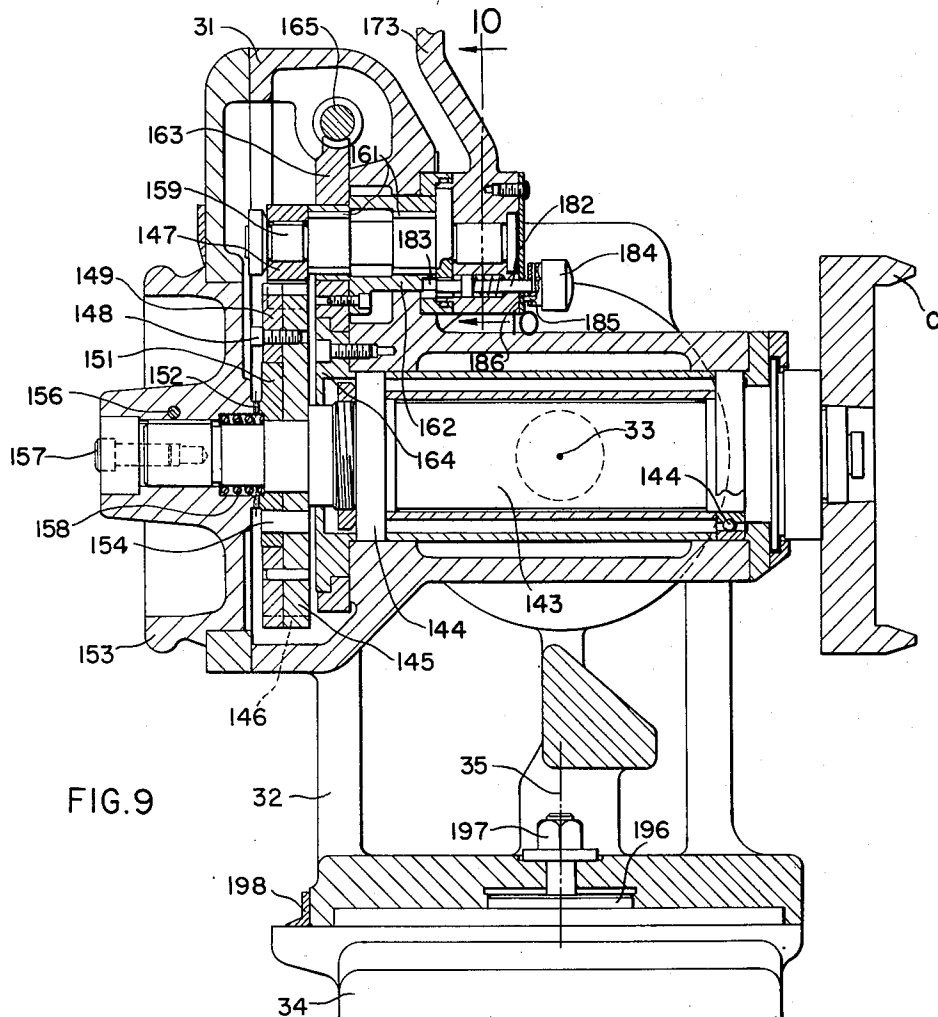


FIG. 9

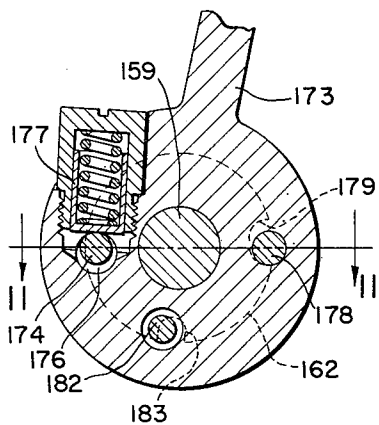


FIG. 10

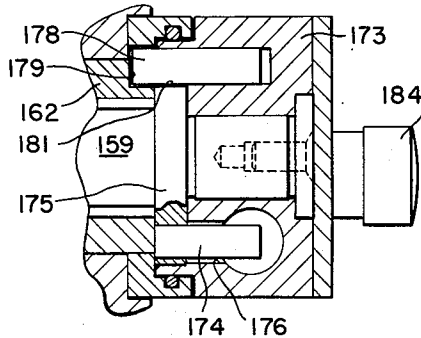


FIG. 11

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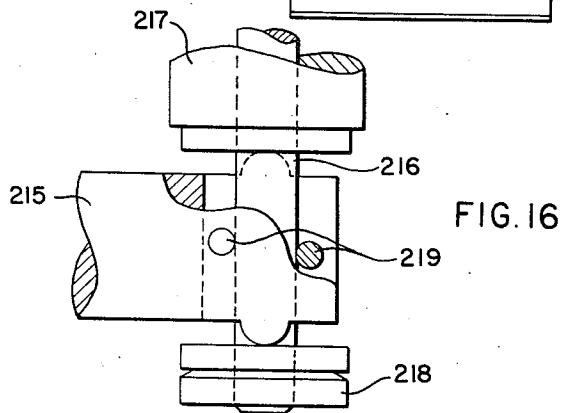
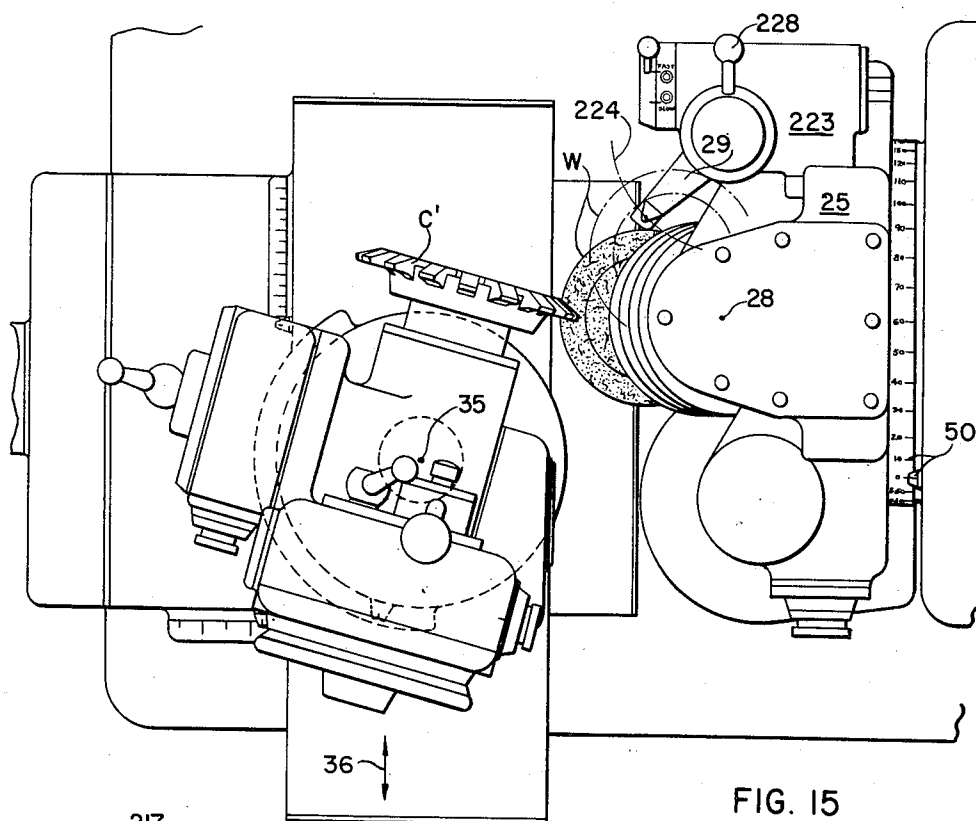
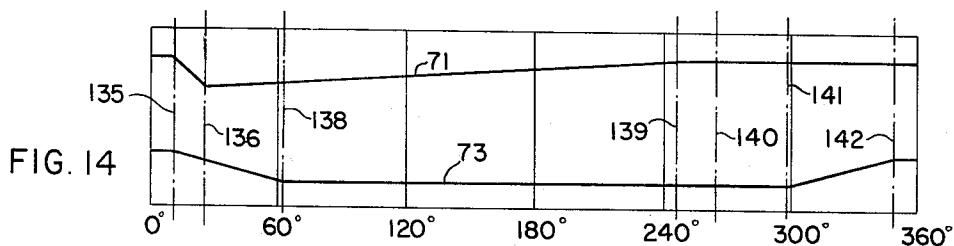
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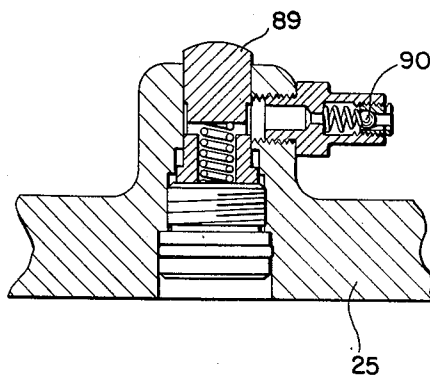
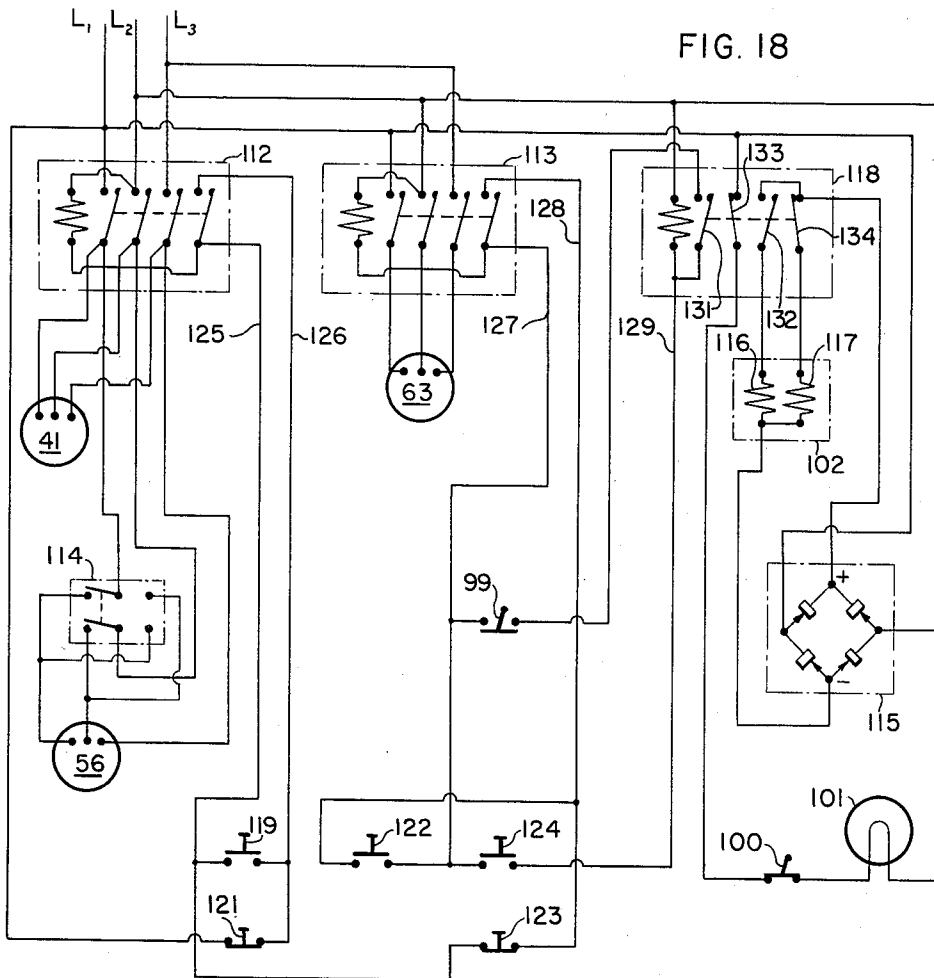
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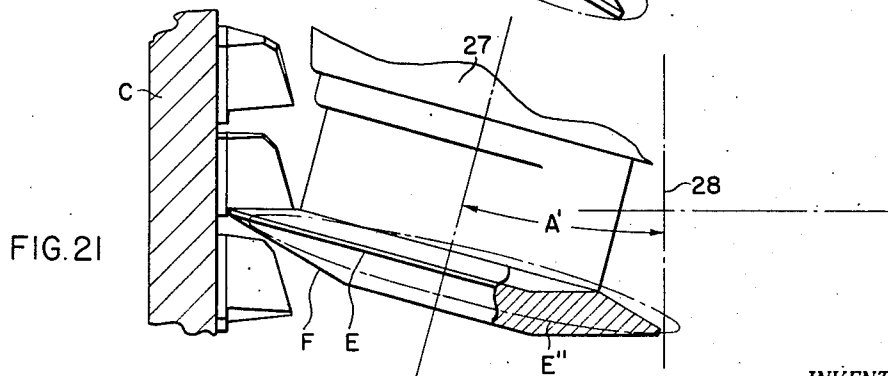
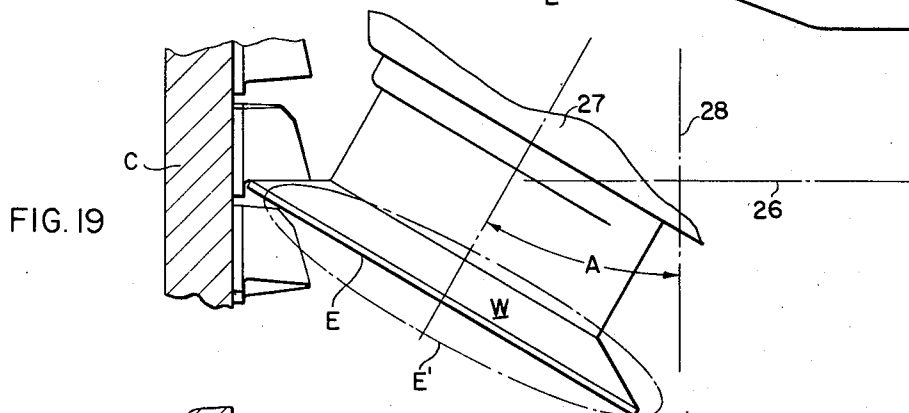
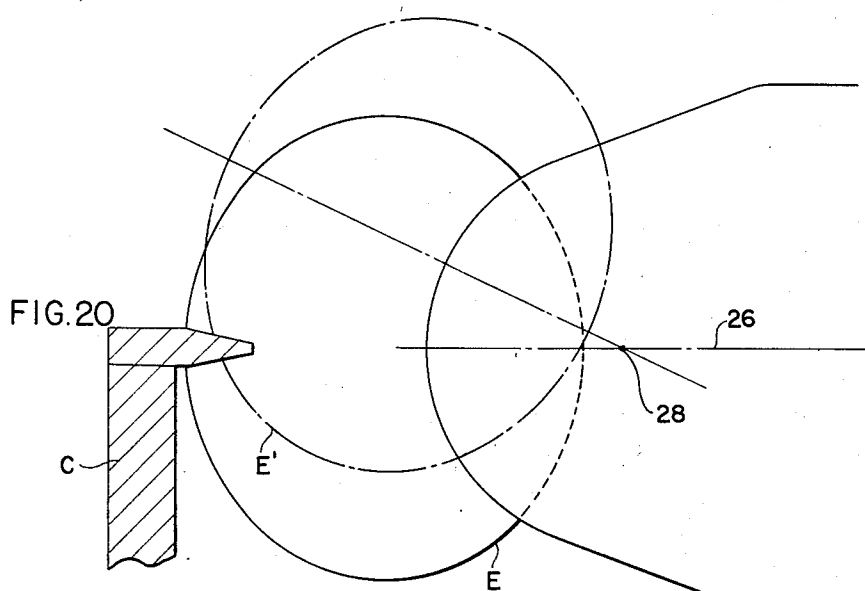
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FIG. 22

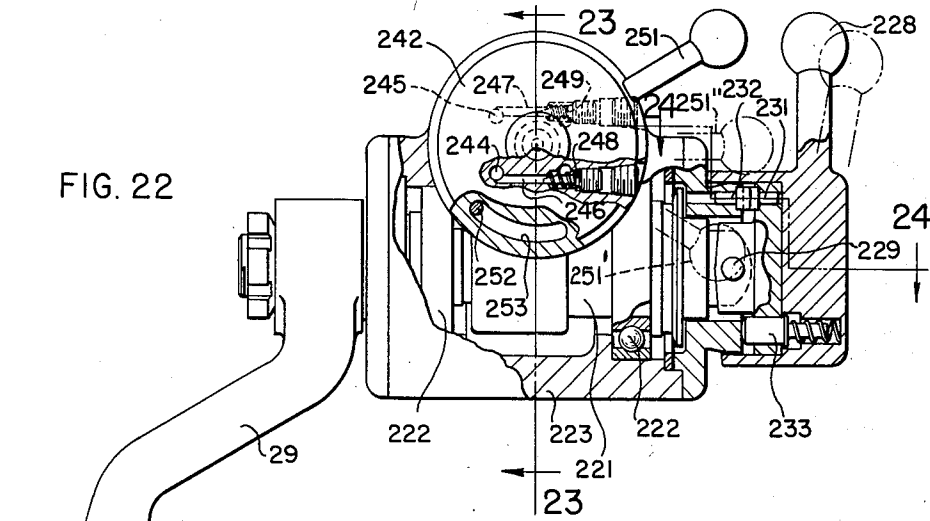


FIG. 23

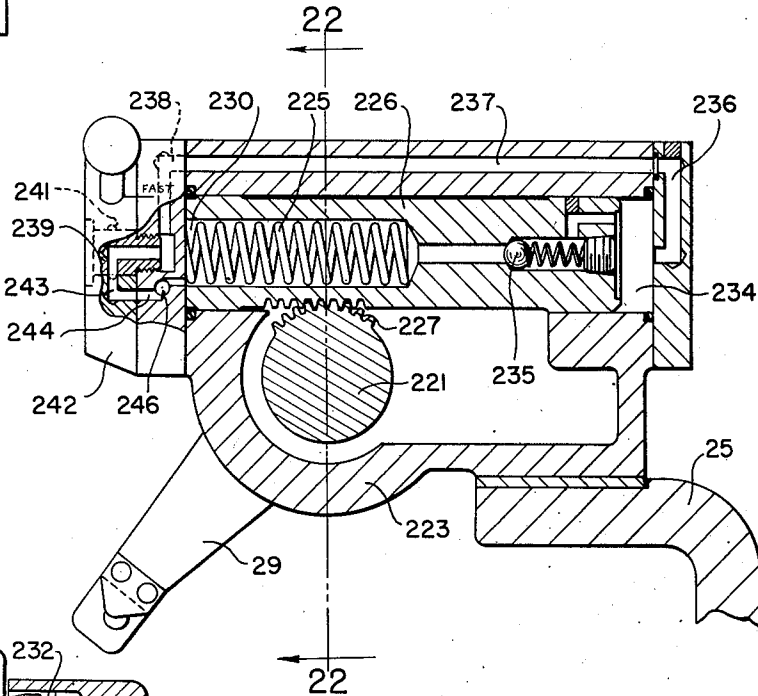
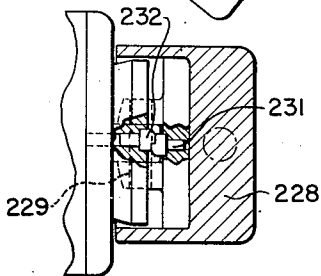


FIG. 24



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CUTTER SHARPENING MACHINE

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Application August 24, 1953, Serial No. 375,870

22 Claims. (Cl. 51—33)

The present invention relates to a machine for sharpening cutters, such for example as disc and face mill cutters used for cutting bevel gears.

Such a machine comprises a frame having a support for a cutter that is to be sharpened, and an oscillating wheel head for carrying a rotating abrasive wheel back and forth across the face of a blade of the cutter, the axis of rotation of the wheel being inclined at an acute angle to the axis of oscillation of the wheel head. The working face of the wheel is frusto-conical and of such cone angle that its locus of contact with the cutter blade lies in a plane perpendicular to the axis of oscillation. According to one aspect of the invention, the wheel head is mounted for oscillation on a turret that is adjustable on the frame about an axis perpendicular to the axis of oscillation, whereby the sharpening plane, i. e. the plane of contact of the wheel with the cutter blade, may be adjusted to any desired angle about the turret axis. Preferably the turret adjustment axis lies at least approximately in this sharpening plane; and, to further facilitate the desired adjustment of the locus of the sharpening action, the turret is secured to the frame by means of a vertically adjustable slide.

According to another aspect of the invention, the turret contains a mechanism for oscillating the wheel head and for periodically swinging it about its axis of oscillation to a position clear of the cutter to enable indexing to bring a succeeding blade of the cutter into position for sharpening. Turret-contained mechanism also feeds the wheel head along its axis of oscillation, so that on successive passes across a cutter blade the wheel removes successively more stock, and then, when the wheel head is swung to indexing position, returns it to its initial axial position. Preferably a dresser for the wheel is mounted on the turret and is adapted to be operated when the wheel head has been swung to indexing position. To provide wheel stock for dressing the wheel head is adjustable along its axis of oscillation relative to the turret.

The support for the cutter preferably comprises a spindle journaled in a work head that is adjustable universally on the frame to bring any of various types and sizes of cutters into the desired relation to the abrasive sharpening wheel. A notched index disc on the spindle is engaged by a spring-pressed pawl which may be lifted to free the spindle for indexing. For lifting the pawl there is a handle which has an angular play connection with the pawl and is urged to its rest position, to allow the pawl to engage the index disc, by spring means which act between the pawl and the handle. By this arrangement the pawl spring and the handle spring are, in effect, arranged in tandem so that in order to release the pawl the operator need apply to the handle only the force necessary to overcome the pressure of the pawl spring, yet the handle may be released by the operator and returned to its rest position before the pawl is again seated.

The foregoing and other objects and advantages of the

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invention will appear from the following description made with reference to the drawings, wherein:

Fig. 1 is a plan view of the machine adjusted for sharpening a face mill cutter which is shown mounted thereon;

Fig. 2 is a front elevation of the machine;

Fig. 3 is a sectional view taken approximately in the plane indicated by line 3—3 of Fig. 1, through the wheel head and the related parts of the machine, the upper part of the view being approximately in the planes indicated by line 3—3 of Fig. 4;

Fig. 4 is a view of the turret for the wheel head with one of its cover plates removed, the view being in the direction indicated by line 4—4 in Fig. 3;

Figs. 5, 6 and 7 are sectional views taken in the respective planes indicated by lines 5—5, 6—6 and 7—7 of Fig. 3, the plane of Fig. 7 also being indicated by line 7—7 in Fig. 8;

Fig. 8 is a section taken in the several planes indicated by line 8—8 of Fig. 7;

Fig. 9 is a vertical sectional view through the work head and related parts of the machine, taken in the plane indicated by lines 9—9 in Figs. 1 and 12;

Fig. 10 is a cross-sectional view through the handle for lifting the pawl, taken in the plane indicated by line 10—10 of Fig. 9;

Fig. 11 is an axial sectional view taken in the plane shown by line 11—11 of Fig. 10;

Fig. 12 is a side elevation, partly in vertical section, of the work head and related parts of the machine;

Fig. 13 is a detail sectional view taken along line 13—13 of Fig. 12;

Fig. 14 is a diagram showing the phase relation of the cam-effected motions of the wheel head;

Fig. 15 is a partial plan view of the machine with a disc cutter mounted thereon;

Fig. 16 is a detail sectional view of the clamp for the sliding base;

Fig. 17 is a detail sectional view illustrating a dash-pot stop means for determining the index-dress position of the wheel head;

Fig. 18 is a wiring diagram of the machine;

Fig. 19 is a fragmentary front elevational view showing on a larger scale the relationship between the abrasive wheel and cutter that appear in Fig. 2;

Fig. 20 is a fragmentary plan view further showing the relationship referred to in connection with Fig. 19;

Fig. 21 is a view similar to Fig. 19 but showing a modified machine design;

Fig. 22 is a view of the dresser mechanism, partly in elevation and partly in the plane indicated by line 22—22 of Fig. 23;

Fig. 23 is a cross-sectional view through the dresser mechanism, taken in the plane shown by line 23—23 of Fig. 22; and,

Fig. 24 is a detail sectional view taken approximately in the plane indicated by section line 24—24 of Fig. 22.

Referring to the general organization of the machine as shown in Figs. 1 and 2, there is a frame 21 having a column 22 with vertical ways 23 along which a slide 24 is adjustable. A turret 25 is adjustable on the slide about a horizontal axis 26 and carries a wheel head 27 for oscillation about an axis 28 that is perpendicular to axis 26. An abrasive wheel W having a conical working surface is mounted on a spindle that is rotatable in the wheel head on an axis that is inclined at an acute angle to the axis of oscillation 28. The wheel is oscillated back and forth across the front face of a blade of a cutter C to be sharpened, the conical surface of the wheel contacting the blade along a plane perpendicular to axis 28. As shown in Fig. 3 (and also in Figs. 19 and 21) the turret adjustment axis 26 lies substantially in this plane, which

is known as the sharpening plane. The head periodically swings far enough, in a clockwise direction in Fig. 1, to carry the wheel W clear of the cutter to permit indexing of the latter to bring successive blades into position to be sharpened, and to permit dressing of the wheel by means of a diamond D carried by a dressing arm 29 that is supported on turret 25.

The cutter C to be sharpened is mounted on a spindle that is journaled in a work head 31. This head is adjustable upon a turret 32 about a horizontal axis 33 which intersects the spindle axis at right angles, and the turret is adjustable on a cross-slide 34 about a vertical axis 35 that intersects axis 33. The cross-slide is adjustable in the direction of arrow 36 on a sliding base 37 which in turn is movable in the direction of arrow 38 along ways 39 on the frame 21. By the aforementioned adjustments that are provided for wheel head 27 and work head 31, either a face-mill cutter C, such as shown in Figs. 1 and 2, or a disc cutter C', Fig. 15, may be brought into position to have its blades sharpened to any desired hook angle and rake angle by the rotating and oscillating wheel W. During sharpening a suitable liquid coolant may be forced by a pump 40, driven by a motor 41, from a sump in the frame 21 through a conduit 42, chamber 43, conduit 44 and nozzle 45 onto the cutter blade that is being acted on by the wheel.

Referring now to the wheel head and the means for supporting and operating it, the slide 24 is adjusted vertically along ways 23 of column 22 by means of a screw 46, Fig. 3, that is screw-threaded to a nut carried by the slide and is journaled for rotation in the column. The adjusting screw is turned by means of a calibrated adjusting knob 47, and after such adjustment the slide is clamped to the column by tightening a gib 48 by means of a clamp screw (not shown). The position of adjustment of the slide is shown by a scale 49. The turret 25 includes a journal 51 that is rotatably adjustable in slide 24 about axis 26 by turning a worm 52, this worm being journaled for rotation in the slide and meshing with a worm wheel 53 secured to journal 51. After such angular adjustment of the turret, which determines the direction of the plane in which the wheel W oscillates, the turret may be clamped by means of a screw 54. Access to an adjusting knob on worm 52 and a handle on clamp screw 54, and also to other parts within column 22, is obtained by opening doors 55. The angular position of turret 25 is shown by a cooperating scale and pointer 50 on the turret and slide 24, Figs. 2 and 15.

The wheel W is mounted on the armature shaft of a motor 56 that is mounted within the wheel head 27, and to dissipate heat from the motor the surrounding surface of the head is provided with cooling fins. For supporting the head for oscillation about axis 28, it is provided with opposed trunnions 57 journaled in bearings 58 in turret 25. As the head is oscillated it is also fed along axis 28, so that on each pass across the work the wheel will remove slightly more stock. The bearings 58 accommodate this axial feed motion which is imparted to the head through anti-friction axial thrust bearings 59. The inner races of these bearings are secured to one trunnion 57 while the outer bearing races are secured to a feed slide 61, Figs. 3 and 8, that is slidable on ways 62 in turret 25.

The oscillating and feed motion are produced by means entirely within the turret 25 including drive motor 63. Aligned with and driven by the motor shaft is a worm 64 meshing with a worm wheel 65, Fig. 6, secured to a shaft which carries an elongated pinion 66. Figs. 3, 7 and 8. This pinion drives a gear 67 on a cam 68 that is rotatable, but axially immovable, upon a shaft 69 parallel to axis 28. The cam has a continuous peripheral feed track 71 engaging a follower roller 72 on the feed slide 61. The shape of this feed track is such that on each complete turn of the cam the slide is slowly moved (upwardly in

Figs. 2, 3 and 8) to feed the wheel W into the cutter C and then, at the end of the turn, is rapidly returned to its starting position.

The cam 68 also has in one end face a cam track 73 that is open at 74, at a point diametrically opposite to a circular arc portion thereof. Track 73 engages a follower roller 75 that is eccentrically mounted on a stub shaft 76 journaled on anti-friction bearings 77 in a gear segment 78. This segment is mounted for oscillation in the turret 25 about an axis 79, Fig. 7, and meshes with a pinion segment 81 secured to a trunnion 57 of the wheel head. A pinion 82 secured to stub shaft 76 is driven, through an idler gear 83 that is rotatable on axis 79, by a gear 84 that is on the same shaft with worm wheel 65 and elongated pinion 66. When the cam 68 is turned to such position that the circular arc portion of track 73 engages the eccentric follower 75, then, as the stub shaft 76 is rotated through the gear drive just described, the eccentricity of the follower will cause the shaft 76 and gear segment 78 to oscillate about axis 79, making one oscillation for each turn of stub shaft 76. This motion is transmitted through pinion segment 81 to the wheel head 27, thereby oscillating the wheel W back and forth across the front face of the cutter blade. As previously described, during such oscillation the wheel is gradually fed into the work along axis 28 so that on each stroke additional stock is ground from the cutter blade.

While the circular arc portion of cam track 73 engages eccentric 75 a circular arc portion 85 of pinion segment 81 is engaged by a roller 86 carried by a spring-backed plunger 87 slidable in the turret 25. However when the cam 68 turns far enough that the non-circular part of track 73 engages the eccentric, the mean position of the oscillating gear and pinion segments is shifted angularly. Finally, when the track 73 is in the position shown in Fig. 7, the segments are shifted far enough that the spring-pressed roller 86 engages an inclined cam surface 88 of the pinion segment, and urges the latter, clockwise in Fig. 7, against a stop 89. The wheel W has now been swung clear of the cutter C and may be dressed with diamond D, or the cutter may be indexed, or both. At this time the eccentric does not oscillate the segments because it is rotating idly in the cut-away or open portion 74 of the cam track.

The interior of the turret 25 is filled with lubricating oil and means are provided to also utilize this oil to snub the motion of the wheel head into the dress-index position determined by stop 89. For this purpose the stop is in the form of a spring-backed plunger, best seen in Fig. 17. The plunger has a limited motion, vertically in Fig. 17, in a bore in the turret and seats upon a plug that is screw-threaded into the turret. The oil can freely enter the chamber between the plunger and the plug by opening of a check valve 90 when the plunger is moved in the direction urged by its spring, but can escape only slowly through a metering orifice around the valve when the valve closes upon the plunger being moved in the opposite direction by the pinion segment 81 as the wheel head is swung into its dress-index position by spring-pressed roller 86.

To provide wheel stock for dressing, the cam 68 is fed axially, carrying with it the feed slide 61, wheel head 27 and wheel W. This axial motion is effected by rotating the shaft 69 on which the cam is rotatable. This shaft is movable axially, but not angularly, in the turret 25, and it is screw-threaded to a worm wheel 91, Figs. 6 and 8, that is held against axial motion in the turret. A worm 92 meshing with the worm wheel is mounted on a shaft 93 which at one end has a spur gear 94 and at the other a calibrated adjusting knob 95. A similar knob 96 carries a spur pinion meshing with gear 94. Thus, the operator can turn in the same direction either knob 95 or 96, whichever is most convenient, in order to feed the wheel to provide stock for dressing. It will be understood in this connection that in some positions of ad-

justment of the turret the operator may face knob 95 while in other turret positions he may face knob 96, and confusion is avoided if he can always turn them in the same direction.

Secured to one trunnion 57 (the upper one in Fig. 3) are cams 97 and 98 which are adapted to actuate limit switches 99 and 100 mounted on the turret 25. Switch 99 is normally closed and controls a clutch-brake unit 102 that is interposed between the armature shaft of motor 63 and worm 64, while switch 100 is normally open and controls lamp 101 which lights to signal that the wheel head has reached its indexing and dressing position. Cables 103 and 104, respectively for supplying current to motor 56 and for the leads to the limit switches 99 and 100, are joined with cables 105 and 106 respectively from the motor 63 and clutch brake unit 102, the joined cables having sufficient length between the turret and the frame to enable the turret to be adjusted through a full turn about axis 26. The cable 103 is wound into a helix within trunnion 57 that is of sufficient length to flex easily to accommodate the oscillation of the wheel head. To prevent adjustment of the turret through substantially more than one turn, cooperating stop parts 107 and 108 are provided respectively on the journal 51 and slide 24. Stop 108 is pivoted at 109 for limited motion between fixed abutments 111, its pivotal motion enabling the stop 107 to turn through very slightly more than 360° about axis 26.

The tracks 71 and 73 of cam 68 are preferably so shaped that the feed and wheel-throw motions respectively produced by them will be in the phase relationship shown in the diagram, Fig. 14.

The electrical system for the machine, shown in Fig. 18, includes, in addition to the elements previously referred to, a three-wire alternating current supply with main leads L₁, L₂ and L₃, a controller 112 for connecting coolant motor 41 and wheel motor 56 to the leads, a controller 113 for connecting drive motor 63 to the leads, a reversing switch 114 for motor 56, a rectifier 115 to provide direct current to clutch winding 116 and brake winding 117 of the clutch-brake device 102, a controller 118 for device 102, and several push-button switches. The latter comprise start and stop switches 119 and 121 for the coolant and wheel motors 41 and 56, start and stop switches 122 and 123 for the drive motor 63, and a feed start (clutch) switch 124.

The machine is stopped with the cam 68 in the 0 degree position shown at the left of Fig. 14, wherein both tracks 71 and 73 are at dwell. To start the machine the wheel motor start switch 119 is momentarily closed, thereby establishing a circuit from lead L₁ through stop switch 121, the start switch, lead 125, and the winding of controller 112 to lead L₂. This energizes the controller 112 and causes the wheel motor 56 to run in whichever direction is selected by reversing switch 114, the direction selected depending upon the relative position of the cutting edges of the cutter blade to the wheel. As soon as controller 112 is energized a shunt circuit is established around the start switch 119, from stop switch 121 through lead 126 and a now closed contact of the controller to the controller winding, so that opening of switch 119 now has no effect, and the wheel motor will continue to operate until stop switch 121 is opened.

Next the drive motor start switch 122 is closed, starting the motor 63 by energizing the controller 113 through a circuit from lead L₁ through stop switch 121, lead 126, contact of controller 112, lead 125, stop switch 123, start switch 122, lead 127 and the winding of controller 113 to lead L₂. As soon as controller 113 is energized a shunt is established around switch 122 so that opening of it has no effect, this shunt being from stop switch 123 through a lead 128 and a now closed contact of controller 113 to the controller winding. Hence motor 63 will continue to run until either stop switch 123 or stop switch 121 is opened.

Now the clutch coil 116 may be energized, to cause device 102 to couple the motor 63 to drive worm 64, by closing feed start switch 124 to establish a circuit from L₁ through stop switch 121, lead 126, contact of controller 112, lead 125, stop switch 123, lead 128, contact of controller 113, lead 127, feed start switch 124, a lead 129 and the winding of controller 118 to L₂. Accordingly controller 118 is energized so that its contacts 131 and 132 close and its contacts 13 and 14 open. The clutch coil 116 now is energized by a circuit from the positive terminal of rectifier 115, contact 132, and coil 116 to the negative terminal of the rectifier.

The cam 68 is now rotated by the drive from motor 63. The cam tracks 71 and 73 remain at dwell until position 135, Fig. 14, is reached. At this time track 71 begins to return the feed slide 61 from its most advanced position (i. e. from its uppermost position in the sense of Fig. 3) and the cam track 73 begins to regain control of eccentric 75. At position 136 the return motion of the feed slide is concluded and its advance or infeed by track 71 is begun. Track 73 has now engaged the rotating eccentric 75 so that the wheel head is being oscillated about axis 28, and the track has started to shift the eccentric clockwise in Fig. 7 about axis 79, so that the oscillating wheel W is being swung into engagement with the cutter C.

As soon as the wheel head is swung far enough to move the lobe of cam 97 away from the plunger of limit switch 99 the latter closes, thereby establishing a shunt circuit around feed start switch 124. This shunt is from lead 127 through switch 99, and contact 131 to the winding of relay 118. After the shunt is established the opening of switch 124 will have no effect and the clutch winding 116 will remain energized until limit switch 99 or stop switch 121 or 123 is subsequently opened.

When the rotating cam 68 reaches position 138, Fig. 14, the feed motion of slide 61 effected by track 71 has proceeded far enough to take up any play in the feed mechanism, and the rotating eccentric 75 is engaged with the circular arc portion of track 73 so that the wheel W is oscillated across the face of a cutter blade. The wheel infeed effected by track 71 continues at a constant rate until at position 139 it slows and at position 140 it stops, so that the last few strokes of the wheel across the cutter blades are made without infeed. Then at position 141 the track 73 again begins to swing eccentric 75 counter-clockwise (in Fig. 7) about axis 79 to move the path of the oscillating wheel W away from the cutter blade. At position 142 the track 73 has reached the dwell during which spring-pressed roller 86 takes over control of the wheel head and swings it to its indexing and dressing limit position determined by stop 89.

Just before the stop plunger 89 is seated the limit switch 99 is opened by cam 97, thereby deenergizing controller 118 and breaking the circuit for clutch winding 116 at contact 132. Simultaneously the brake winding 117 is energized through a circuit from the positive terminal of rectifier 115, contact 134, and winding 117 to the negative terminal of the rectifier. Accordingly the device 102 brakes the drive worm 64 and disengages it from the drive motor 63. By the time the worm is stopped the cam 68 has reached its 360 or 0 degree position, and one cycle of the machine has been completed.

At this time the cam 98 closes normally open limit switch 100 to establish a circuit which lights indicator lamp 101, the circuit being from lead L₁ through contact 133, the limit switch and lamp to lead L₂. The cutter C or C' may now be indexed to bring another of its blades into position to be sharpened, or the dresser diamond D may be actuated to redress the wheel W, or both the indexing and dressing operations may be performed. Then the sharpening cycle may be restarted by again closing the feed start switch 124. As soon as the wheel head moves away from dressing position the limit switch 101 of course opens, cutting off the lamp.

Reference will now be made to the details of the mech-

anism shown in Figs. 9 and 13 inclusive, for supporting the cutter C or C'. The cutter spindle, designated 143, is mounted in anti-friction bearings 144 in the work head 31. Rotatable on the spindle is a master index disc 145 having a very large number of notches 146 accurately spaced about its periphery and each adapted to receive an index pawl 147. Detachably secured to disc 146 by screws 148 is a masking disc 149 having a smaller number of notches corresponding to the number of blades on the particular cutter that is to be sharpened. The pawl can enter only those notches of the master disc that are aligned with notches of the masking disc, and for sharpening a cutter with a different number of blades a masking disc with a corresponding number of notches is substituted.

A clutch member 151, having face clutch teeth 152 meshing with mating teeth on the inner face of a hand wheel 153, is also rotatable on the spindle and is secured to the master index disc 145 for rotation therewith by a pin 154. The hand wheel is secured to the spindle by a screw 157 and by a spline means 155, from which backlash is removed by a screw 156. When the screw 157 is loosened a compression spring 158 urges disengagement of the hand wheel from clutch member 151. Such disengagement enables the cutter spindle to be turned relative to the index plate 145 to bring the face of a cutter blade into approximately the desired position about the cutter spindle axis.

The index pawl 147 is secured to a shaft 159 that is journaled on bearings 161 for rocking motion in a sleeve 162 that is carried by a worm wheel segment 163. This segment is mounted for rotation about the spindle axis on an annulus 164 secured to head 31. A worm 165 meshing with the segment is journaled in the head for rotation by means of a knob 166, and a coil spring 167 acts between the head 31 and the segment to constantly urge the latter in one direction, clockwise in Fig. 12, to take up backlash between the teeth of the worm and wheel. After adjustment of the segment by turning knob 166, to bring the cutter into the exact position desired about the cutter spindle axis, the segment may be clamped to the head by a disc 168, Fig. 13, and a clamp screw 169 therefor. The screw extends through an arcuate slot 171 in the head and is screw-threaded to the segment.

The index pawl 147 is urged into a notch of the index plate by a spring-backed plunger 172 carried by segment 163. To lift the pawl from the notch a handle 173 is rotatably mounted on shaft 159. A pin 174 carried by a flange 175 of the shaft extends through an enlarged opening 176 in the hub of the handle and is engaged by a spring-backed plunger 177 carried by the hub. The effect of the spring-backed plunger is to urge the handle, clockwise in Fig. 10, to a limit position determined by the engagement of a pin 178 carried by the handle with an end wall of a recess 179 in sleeve 162. As shown in Fig. 11 there is an opening 181 in the flange 175 to freely pass pin 178.

To index the cutter the operator with one hand first turns handle 173, counterclockwise in Fig. 10 and clockwise in Fig. 12, to the limit position determined by pin 178 and abutment 179. As the handle is turned the wall of opening 176 engages pin 174 causing the shaft 159 to turn to disengage pawl 147 from the notch in index plate 145. Then with his other hand on hand wheel 153 the operator turns the now free spindle 143. As soon as turning of the hand wheel is started the handle 173 is released, whereupon the spring-backed plunger 172 urges the pawl against the peripheral surface of the masking disc, along which it rides until it drops into the next unmasked notch in the index plate. As soon as the handle 173 is released the relatively light pressure of spring-backed plunger 177 returns it to its limit position determined by engagement of pin 178 with the wall of recess 179. In this way the handle is normally returned to its rest position before the pawl again seats in a notch of the index plate. To lift the pawl the operator need

exert only sufficient pressure on the handle to overcome the pressure of the spring back of the pawl seating plunger 172, because the latter is, in effect, arranged in tandem with the lighter spring which backs plunger 177 so that the forces exerted by the two springs are not added together.

In order to check the trueness of the several cutting edges of a cutter after sharpening, and for other purposes, it is at times desirable to latch the index pawl in its withdrawn position. For this purpose a spring-backed plunger 182 is provided in the hub of handle 173. When the handle is turned to its limit position, counterclockwise in Fig. 10, the plunger may enter a recess 183 in sleeve 162, and will remain therein under the pressure of its spring until it is manually withdrawn by pulling on its knob 184. A projection 185 on the knob normally engages the end face of handle 173 to hold the plunger out of recess 183, but when knob 184 is turned so that the projection is aligned with and can enter a recess 186 in the handle, the plunger will then enter recess 183 the next time the index pawl is lifted by turning handle 173. As shown in Fig. 9 the plunger 182 passes through an enlarged opening in shaft flange 175 and hence does not engage the latter.

For the purpose of adjustment about axis 33 the work head 31 has trunnions 187 journaled for rotation in turret 32, and to one trunnion there is secured a worm wheel 188 meshing with an adjusting worm 189. This worm is rotatable in the turret by means of a knob 191, Fig. 1, upon loosening a clamp lever 192. As shown in Fig. 12 this lever is screw-threaded to the end of one trunnion 187 and acts through a cup-shaped member 193 to clamp against the turret a disc 194 that is connected with the trunnion by a key 195. Cooperating calibrations on the disc and on the turret show the position of adjustment of the work head about axis 33.

The turret 32 may be adjusted, about vertical axis 35, around a center 196 on cross-slide 34 upon loosening a nut 197 of a clamp bolt, the head of this bolt being anchored in a T-slot (not shown) that extends along sliding base 37 in the direction of arrow 36. The turret has an indicator 198 cooperating with a scale on the cross-slide to show the position of adjustment about axis 35. For quickly bringing the turret to either of the two positions in which it is most frequently used (the respective positions shown in Figs. 1 and 15) a spring-backed plunger 199 carried by the turret and two cooperating recesses 201 in the cross-slide are provided. The plunger may be lifted out of one recess, to the position shown in Fig. 12, by turning a lever 202 whose shaft has an eccentric 203 engaging the plunger. After the turret is turned enough from one position to carry the plunger out of alignment with one recess the lever 202 may be released so that the plunger will drop into the other recess as soon as the turret reaches the other position.

When the clamp nut 197 is loosened the cross-slide may also be adjusted, this adjustment being along ways 204 on the sliding base 37 and in the direction of arrow 36, Fig. 1. The adjustment is effected by turning a knob 205 that is secured to a screw 206, the latter being journaled to rotate in the sliding base and screw-threaded to a lug 207 on the cross-slide. A scale 208 on the sliding base and a cooperating indicator on the cross-slide show the position of this adjustment.

The sliding base is adjusted along ways 39 in the direction of arrow 38, Fig. 1, by turning a handwheel 211 secured to a screw 212. This screw is mounted for rotation in the frame 21 and is screw-threaded to a lug 213 on the sliding base. A scale on the frame cooperating with a pointer 214 on the sliding base shows the position of this adjustment. After the adjustment is made the sliding base is clamped to the frame by raising a lever 215. As shown in Figs. 2 and 16 the bifurcated inner end of the lever straddles a bolt 216 that is slidable in a sleeve 217 carried by the frame. The bolt

has at its upper end a head anchored in a T-slot in the sliding base, this slot extending in the direction of arrow 38, Fig. 1. A nut 218 is secured to the lower end of the bolt and when the lever is raised this nut is forced away from the sleeve 217, to thereby draw the sliding base against the frame. Friction holds the lever raised until it is manually released. Pins 219 retain the lever on the bolt 216 when it is released.

It will be understood that by the adjustments described a cutter C or C' on the machine may be brought to any desired position relative to the wheel W in the direction of arrows 36 and 38 and about axes 33 and 35. Adjustment in the remaining direction, vertically, is accomplished by moving the slide 24 along ways 23 as before described. For providing room between the work head and the wheel head to remove or replace a cutter on the spindle 143, the sliding base is readily withdrawn by releasing lever 215 and turning handwheel 211, without affecting the other adjustments.

Between successive sharpenings a cutter is ordinarily turned on its axes through a small angle to advance the blades by an amount equal to the thickness of stock to be removed. Thus, a cutter C may first have all of its blades rough sharpened, then be rotated through a small angle by turning knob 166 so as to advance the front faces of the cutter blades by one or a few thousandths of an inch, and then have all of its blades finish sharpened. With the present machine another method of advancing the cutter blades between successive sharpenings may also be followed, this method comprising advancing the wheel W rectilinearly into the work by turning knob 47. By the first method the front face of each blade is successively sharpened back in radially related planes, whereas by the second method it is sharpened back in parallel planes.

In the event it is desired to sharpen cutters of only one kind of machine may be simplified by eliminating certain of the aforementioned adjustments. For example, if it is desired to sharpen only disc cutters of the kind shown at C' in Fig. 15, then the work head 31 may be rigidly mounted upon the sliding base 37 in the position shown in that figure, thereby eliminating the adjustments about axes 33 and 35, Figs. 1 and 2, and in the direction of arrow 36.

Referring to Fig. 19, the angle between the axis of rotation of the wheel W and the axis 28 is designated A, and the peripheral edge of the wheel, other than the edge of the working face of the wheel, is designated E. In both Figs. 19 and 20 the edge E is shown in full lines when the wheel is at the center of its swing, i. e. when its axis lies in the common plane of turret axis 26 and axis of oscillation 28. As the wheel swings about axis 28 toward its dress-index position the plane of edge E also is displaced about axis 26 with the result that the edge will interfere with a blade of the cutter adjacent to the blade being sharpened, if the blades are very closely spaced. In Fig. 20 the edge E is shown at E' in its position of swing about axis 28 in which maximum interference develops. The interference of the edge E' in this position with the cutter blade that is immediately beneath the one being sharpened appears in Fig. 19.

In order to avoid such interference, in cases where the machine may be called upon to sharpen cutters with closely spaced blades, the diameter of the wheel W may be decreased, or, preferably, the angle A decreased. The effect of such angle decrease is shown in Fig. 21 where the angle A' is half of the angle A in Fig. 19. With this change the wheel even when swung to the position of maximum interference, wherein the edge E assumes the position shown at E'', does not interfere with the adjacent cutter blade. In order to maintain the thickness and strength of the wheel and also to provide adequate wheel life, the wheel is preferably made to dish shape, so that in axial section it appears as shown at the right of Fig. 21.

The particular dresser illustrated as comprising arm 29 is the subject of our division patent application Serial No. 475,784, filed December 16, 1954, for Wheel Dressing Device. Referring to Figs. 15, 22, 23 and 24, the dresser arm 29 is mounted on a rock shaft 221 that is journaled on anti-friction bearings 222 in a dresser housing 223. This housing is mounted on the turret 25 for adjustment, along a way 223', Fig. 1, that is parallel to axis 26, to such position that when the wheel W is in its index-dress position shown in broken lines in Fig. 15, i. e. in the limit position determined by stop 89, Fig. 7, the arcuate path 224 of the diamond D about the axis of shaft 221 is substantially radial of the wheel at a means point on the wheel's active surface. With this arrangement the active surface of the wheel may be dressed to an almost exactly conical shape.

The dressing stroke of the arm 29, clockwise in Figs. 15 and 23, is effected by a coiled compression spring 225 moving a plunger 226 that is slidable in the housing, the plunger having rack teeth meshing with teeth 227 on the shaft. The assembly comprising the spring and plunger and arm is cocked for its dressing stroke by turning the shaft counterclockwise by means of a handle 228 which is pivoted to the shaft by a transverse pin 229; and the assembly is held cocked by abutment of a pin 231 on the handle with a pin 232 carried by the housing. The handle carries a spring-backed plunger 233 which constantly urges it about the axis of pin 229, in a counterclockwise direction in Fig. 22, to maintain the pins 231, 232 in abutting relation. To effect the dressing stroke after the assembly has been cocked, the operator need only push the handle 228 about the axis of pin 229, to the broken line position of the handle shown in Fig. 22. This releases the pin 231 from abutment with pin 232 and allows the spring 225 to move the assembly through its dressing stroke.

The velocity of this stroke, which determines the texture of the surface dressed on the rotating wheel W, is controlled by hydraulic dash-pot means. For this purpose the interior of the housing, including the cylinder chamber 234, and also the opposite cylinder chamber which opens into bore 230 in the end of the plunger 226, is filled with hydraulic fluid. The passage in the plunger connecting bore 230 with chamber 234 is closed by a spring-pressed ball check valve 235 arranged to open to freely pass fluid from the bore to the chamber and to close to prevent fluid flow in the opposite direction. However fluid displaced from chamber 234 by the spring-urged motion of plunger 226 passes to the opposite cylinder chamber through communicating passages 236, 237 and 238 in the housing.

From passage 238 the fluid flows through a passage in a screw 239 into an annular groove 241 of a rotary valve 242 which is supported by the screw. From this groove the fluid passes through a passage 243 in the valve into either port 244 or port 245 in the adjacent wall of the housing. These ports respectively open through passages 246 and 247 into the cylinder chamber that includes bore 230. Passage 246 is partially obstructed by a spring-locked adjustable plug valve 248 that is adjusted to permit a fairly fast flow of fluid, while passage 247 is obstructed partially by a similar valve 249 adjusted to permit a slower flow of fluid.

The rotary valve 242 has a handle 251 by which it may be turned on screw 239 between opposite limit positions that are determined by abutment of a pin 252 on the housing with the ends of an arcuate recess 253 on the inner face of the valve. When handle 251 is turned counterclockwise to its limit position shown in Fig. 22 valve passage 243 is aligned with port 244 and hence the dressing stroke of the diamond will be fairly fast, as is normally wanted to produce a coarse finish on the wheel for a rough grinding or sharpening operation. If the handle is turned to its opposite limit position, as at 251' in Fig. 22, passage 243 is aligned with port 245 and

hence the dressing stroke is slower and will produce a finer finish on the wheel, such as is normally wanted for finish sharpening a cutter. If the handle is turned to its central position, shown by broken lines 251" in Fig. 22, valve passage 243 does not register with either of ports 244 and 245. Hence no fluid can pass from chamber 234 and therefore the dressing stroke is prevented. In this connection it will be understood that at least in some cases, as for example where the cutter blade edges are badly chipped, it may be desirable to rough sharpen all of the blades around the cutter one or more times to remove the damaged stock, and then to finish sharpen all of the blades. After all the cutter blades have been rough sharpened, the cutter may be rotated slightly to provide stock for a subsequent sharpening, by turning adjusting knob 166 after first releasing clamp 169.

Having now described the machine which constitutes the preferred embodiment of the invention, and the method of operation and the use of the machine, what we claim as our invention is:

1. A cutter sharpening machine comprising a frame having a cutter support, a turret angularly adjustable on the frame, a wheel head mounted for oscillation on the turret about an axis perpendicular to the turret adjustment axis, means on the wheel head for supporting an abrasive wheel for rotation about an axis inclined at an acute angle to the axis of oscillation, an abrasive wheel so supported having the active surface thereof inclined to the plane of wheel rotation at the same acute angle, whereby during the oscillation said active surface traverses a cutter on the cutter support in a plane perpendicular to the axis of oscillation, and means for effecting such oscillation of the wheel head.

2. A machine according to claim 1 in which the turret adjustment axis lies at least approximately in said plane perpendicular to the axis of oscillation.

3. A machine according to claim 1 in which the cutter support comprises a work head and a work spindle carried thereby, the work head and said turret being relatively adjustable in the direction of the turret adjustment axis.

4. A machine according to claim 3 in which the work head and said turret are also adjustable relative to each other in a direction perpendicular to the turret adjustment axis.

5. A machine according to claim 3 in which the work head is adjustable rectilinearly on the frame in the direction of the turret adjustment axis and said turret is adjustable rectilinearly on the frame in a direction perpendicular to said adjustment axis.

6. A machine according to claim 5 in which the work head is also adjustable in a direction perpendicular to both of the aforementioned rectilinear adjustments, and is further adjustable about two axes that are perpendicular to each other and to the cutter spindle axis.

7. A machine according to claim 1 in which there is a mechanism within the turret for oscillating the wheel head to pass the wheel over a cutter support, said mechanism including means for periodically swinging the wheel head through a greater angle about the axis of oscillation to a position clear of the cutter to permit indexing the cutter about its axis.

8. A machine according to claim 7 in which there is a means for feeding the wheel head upon the turret along the axis of oscillation as said head is oscillated to pass the wheel over the cutter and for thereafter returning the wheel head to its initial position along the axis of oscillation.

9. A machine according to claim 7 in which there is a means mounted on the turret for dressing the abrasive wheel when the wheel is in said position for indexing.

10. A machine according to claim 9 in which there is a means to adjust the wheel head upon the turret in the direction of the axis of oscillation to enable advancing the wheel for dressing.

11. A cutter sharpening machine comprising a frame,

a work head on the frame, a work spindle rotatable in the work head, a wheel head movable on the frame to pass an abrasive wheel carried thereby across a cutter on said spindle, a multiple-notched index disc on the spindle, a pawl pivoted to the work head, spring means acting between the work head and the pawl for urging pivotal motion of the latter into seated relation in a notch in said disc, a handle for lifting the pawl from such notch to free the work spindle for rotation, the handle having limited angular motion relative to the pawl, a stop to limit angular motion of the handle relative to the work head in a direction to lift the pawl, and spring means acting between the pawl and the handle for urging the handle against said stop.

12. A mechanism comprising a support, a notched member movable relative to the support, a pawl pivoted to the support, spring means for urging pivotal motion of the pawl into seated relation in a notch in said member, a handle for the pawl connected thereto for limited relative angular motion, a stop to limit angular motion of the handle relative to the support in a direction to unseat the pawl, and spring means acting between the pawl and the handle for urging the handle against said stop.

13. A cutter sharpening machine comprising a support, a wheel head mounted on the support for oscillation and also for motion along the axis of oscillation, means on the wheel head supporting an abrasive wheel for rotation about an axis inclined to the axis of oscillation, means including a rotatable eccentric for oscillating the wheel head, and means including a cam rotatable in the support and geared to the eccentric for rotation in timed relationship therewith for feeding the wheel head along the axis of oscillation and then returning it to its initial position therealong.

14. A machine according to claim 13 in which the eccentric is rotatable on a member movable within the support for oscillating the wheel head, and the cam is arranged to move the eccentric to thereby swing the wheel head about its axis of oscillation into and away from cutter sharpening position.

15. A cutter sharpening machine comprising a support, a wheel head mounted on the support for angular oscillation, a member movable in the support for effecting such oscillation, an eccentric rotatable on said member, a cam rotatable on the support and geared to the eccentric for rotation in time therewith, said cam being arranged to control the position of the eccentric and having a dwell portion and an active portion, whereby during the portion of each revolution when said dwell portion is effective the wheel head is oscillated through a predetermined angle relative to the support and during the portion of each revolution when said active portion is effective the wheel head is swung beyond the limits of said predetermined angle.

16. A cutter sharpening machine according to claim 15 in which there is a discontinuity in said active portion of the cam, which, when effective, frees the eccentric for idle rotation, and means acting between the wheel head and the support for swinging the wheel head to a fixed limit position when the eccentric is so freed.

17. A cutter sharpening machine according to claim 16 in which the means acting between the wheel head and the support comprises a cam having a dwell surface and an active surface, said cam being movable with the wheel head, and a spring-pressed follower for said cam carried by the support.

18. A machine comprising a support, a cam rotatable in the support and having track with a dwell portion and an active portion with a discontinuity between parts of said active portion, a member movable in the support and an eccentric rotatable on the member and engaged in the track of the cam, and means for rotating the eccentric and the cam whereby when the dwell portion of the track positions the eccentric the member is oscillated by the eccentric, when the active portion of the track positions

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the eccentric the path of oscillation of the member is shifted, and when the discontinuity of the track is effective the eccentric is freed for idle rotation.

19. A machine according to claim 18 in which there is a spring means to position the member relative to the support when the eccentric is freed for idle rotation. 5

20. A cutter sharpening machine comprising a frame having a cutter support, a turret angularly adjustable on the frame, a wheel head mounted for oscillation on the turret about an axis perpendicular to the turret adjustment axis, means on the wheel head for supporting an abrasive wheel for rotation about an axis inclined to the axis of oscillation, means for oscillating the wheel head, and means for concomitantly feeding the wheel head along the axis of oscillation and for periodically returning it to its initial position therealong. 15

21. A cutter sharpening machine comprising a frame having a cutter support, a turret angularly adjustable on the frame, a wheel head mounted for oscillation on the turret about an axis perpendicular to the turret adjustment axis, means on the wheel head for supporting an abrasive wheel for rotation about an axis inclined to the axis of oscillation, and cooperating stops on the frame and on the turret to limit the turret angular adjustment, one of said stops being movable on the part which carries it to enable the adjustment to be made through at least 360 degrees. 20

22. A machine tool having two parts arranged for 25

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relative angular motion, a stop carried by each part, said stops being arranged for abutment with each other to limit such angular motion in one direction and also for abutment with each other to limit such angular motion in the opposite direction, and one of said stops being mounted for limited back and forth motion, on the part which carries it, in response to abutment of the stops, the direction of said limited motion being such as to extend the range of said relative angular motion, and the magnitude of said limited motion being such that the angular motion may be through at least 360 degrees.

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