

Dec. 17, 1940.

C. T. GALLOWAY

2,224,959

CUTTER SHARPENER

Filed June 29, 1938

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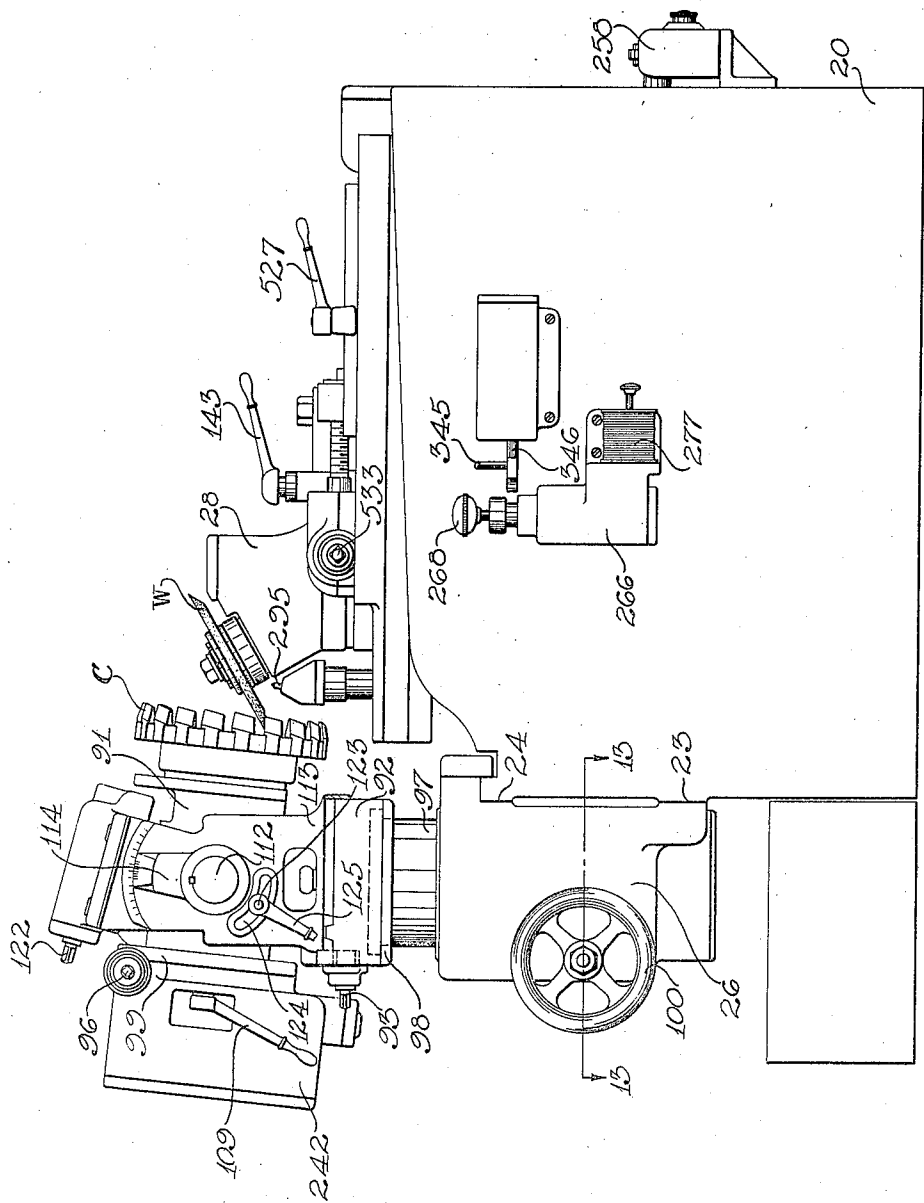


Fig. 1

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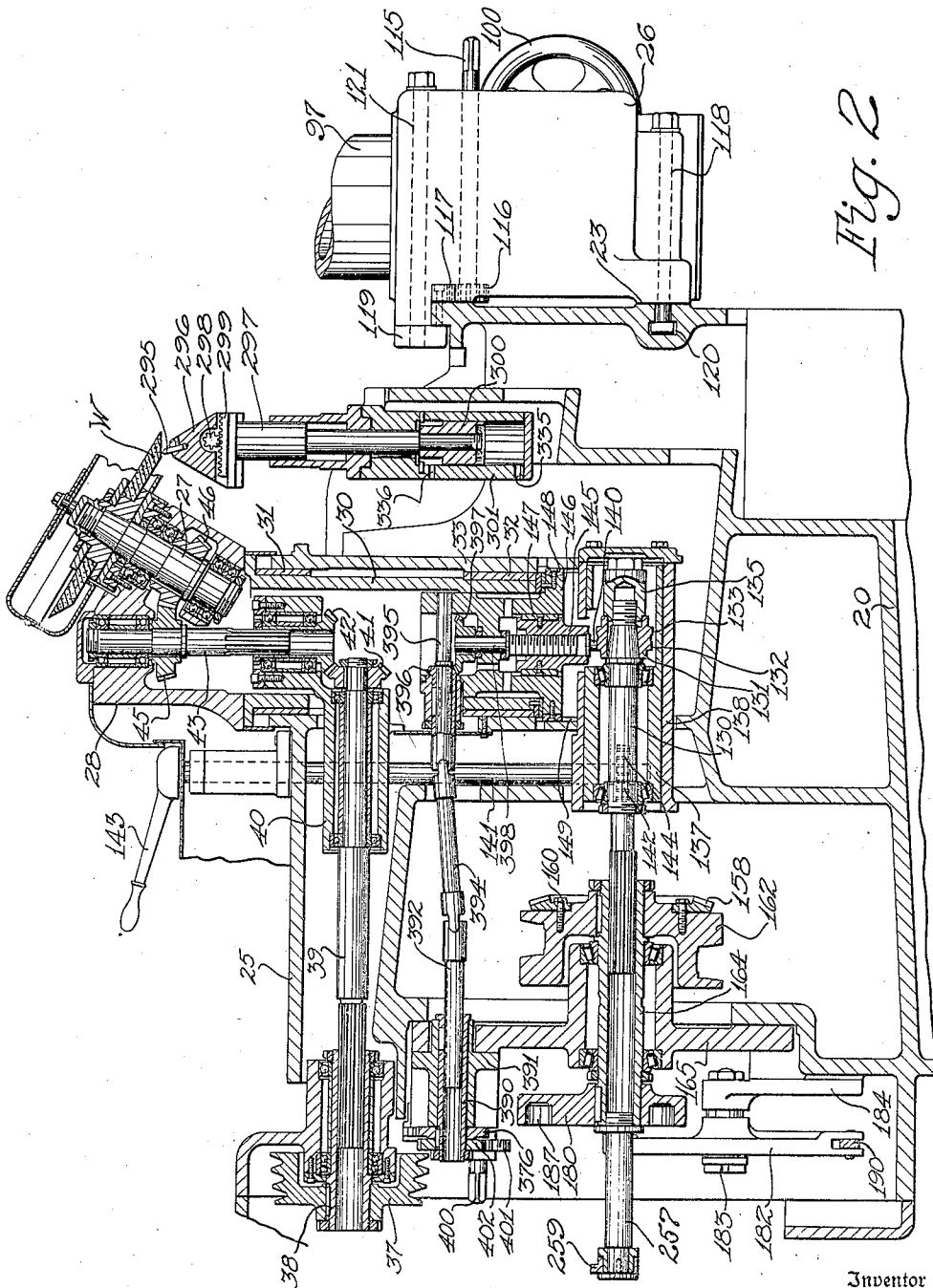


Fig. 2

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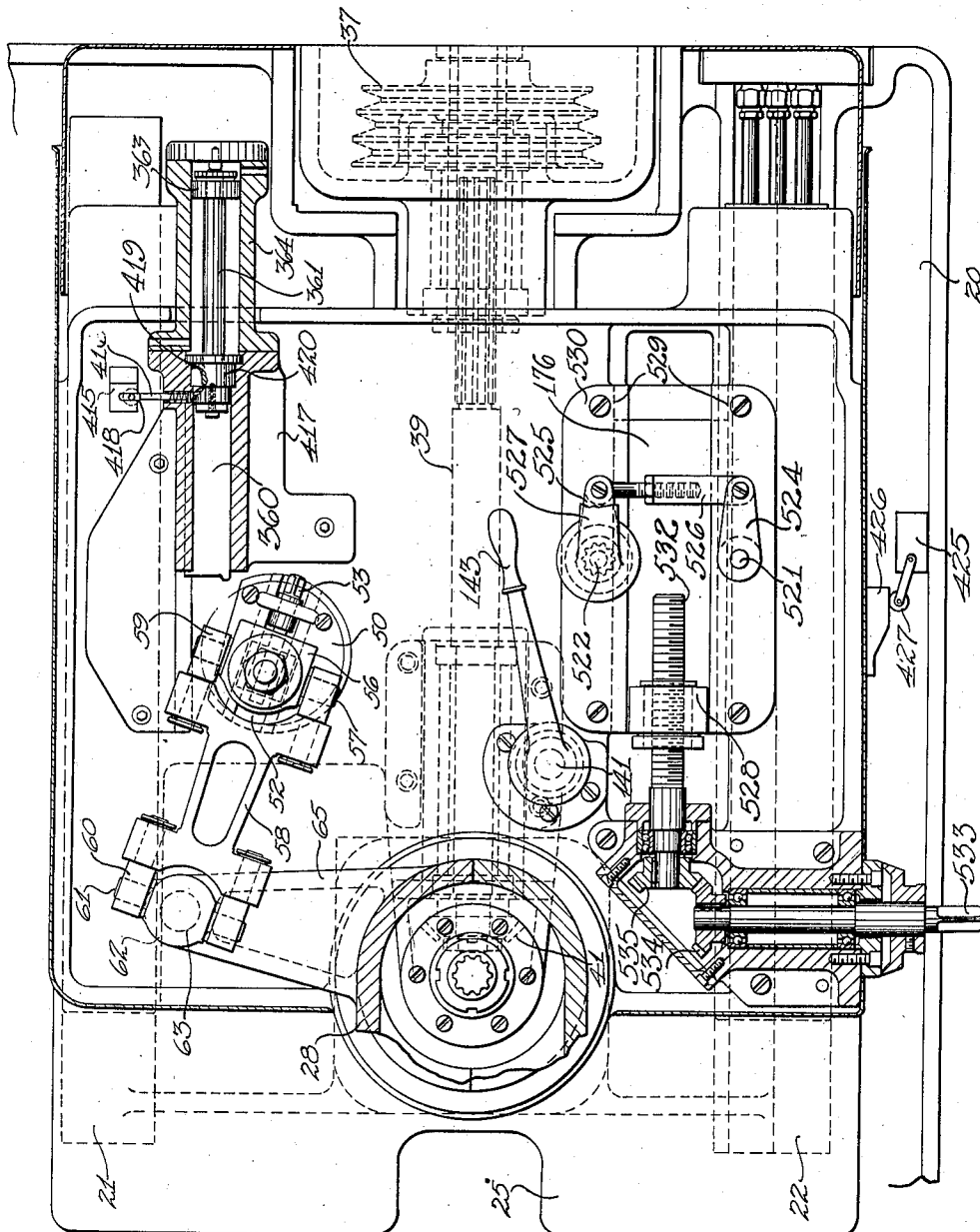
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10 Sheets-Sheet 3



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10 Sheets-Sheet 4

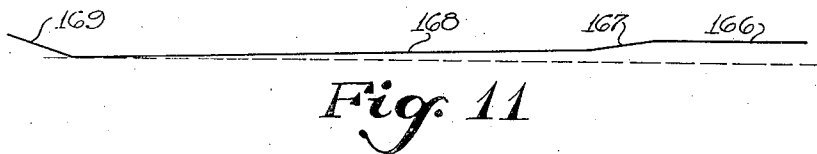
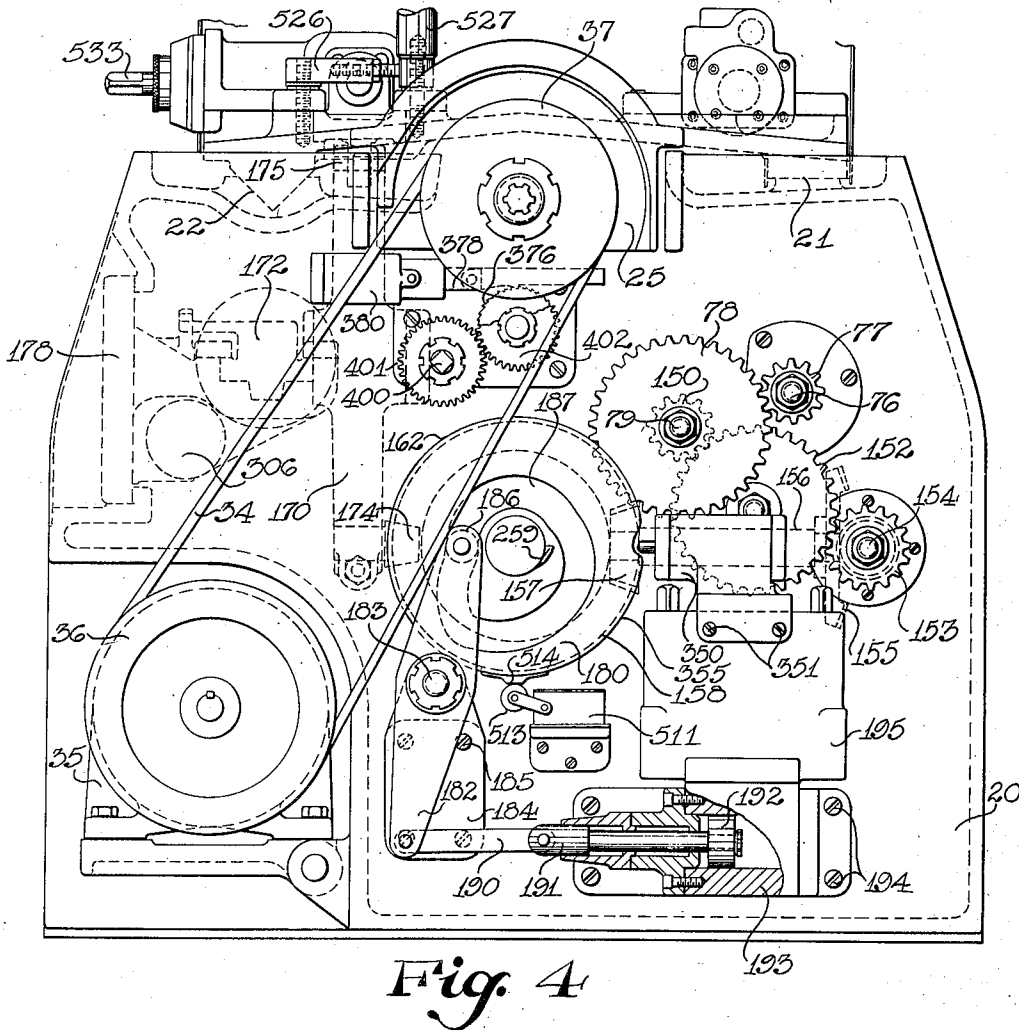


Fig 12

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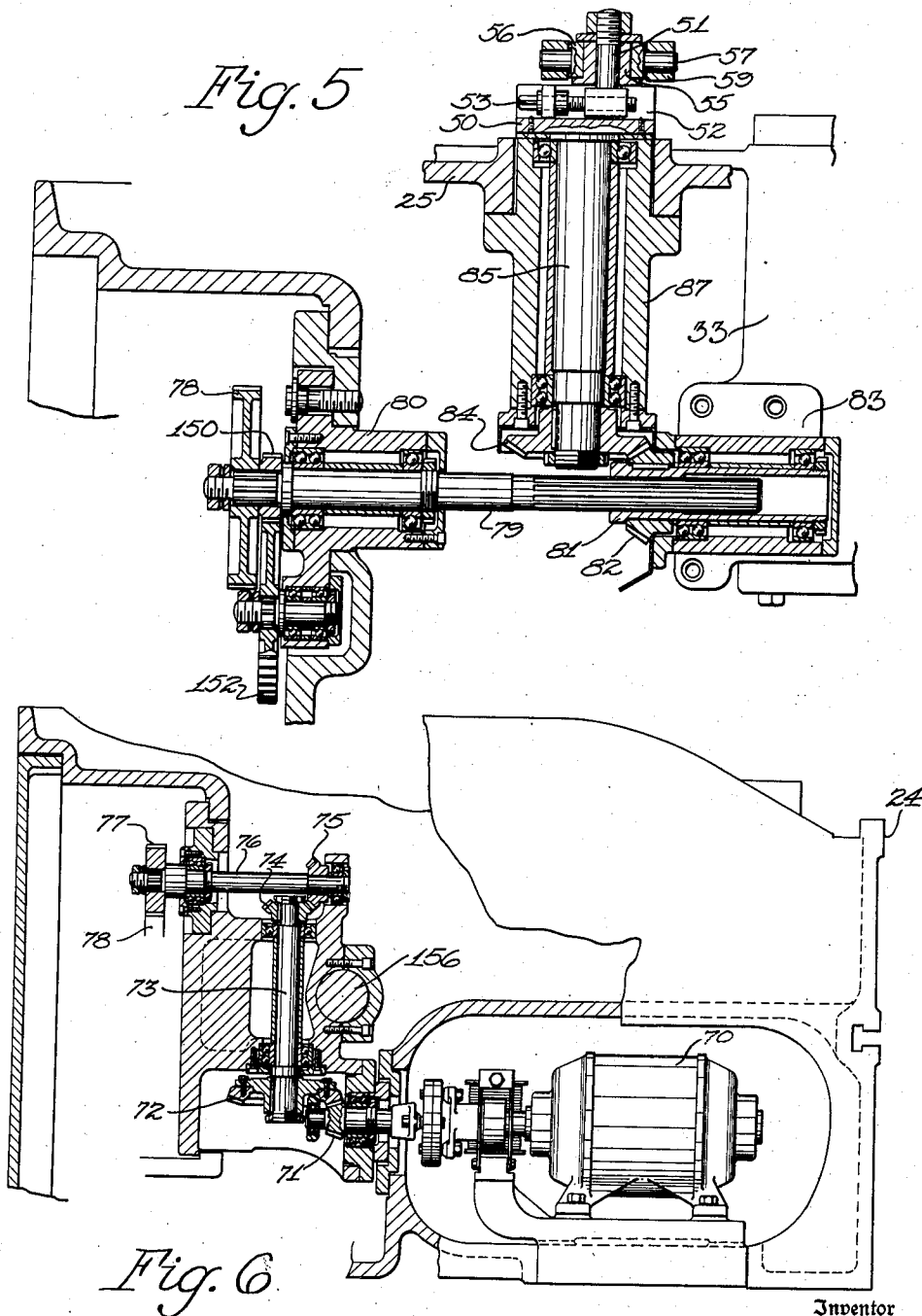
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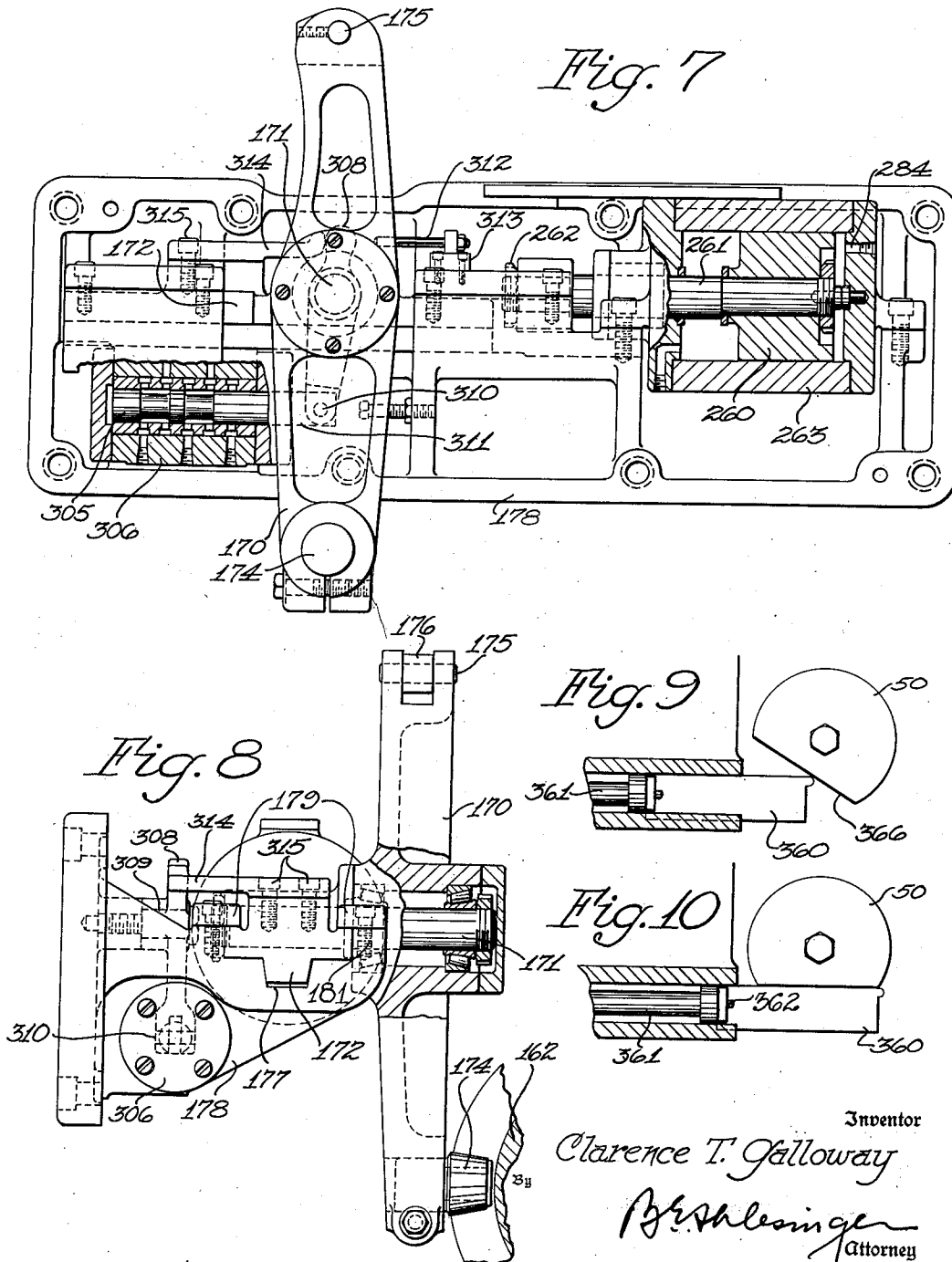
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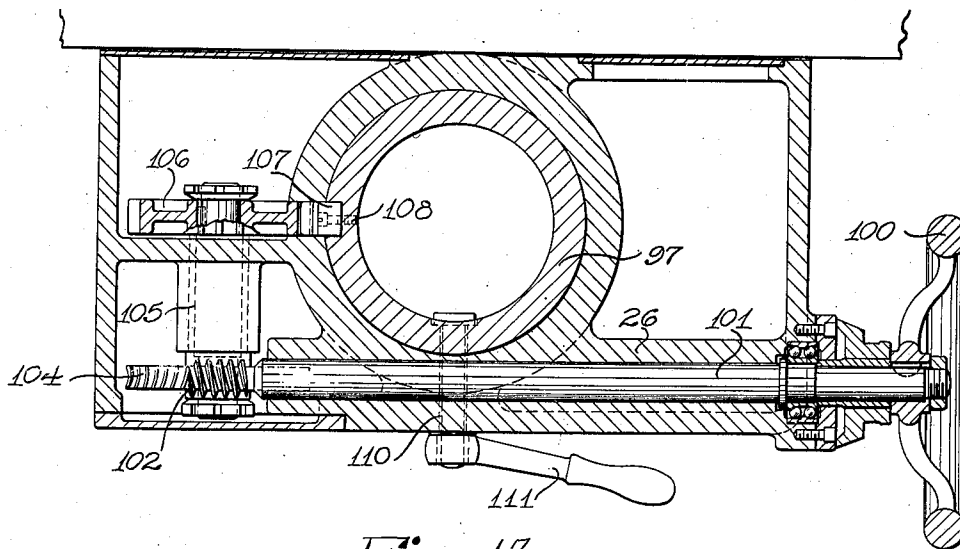


Fig. 13

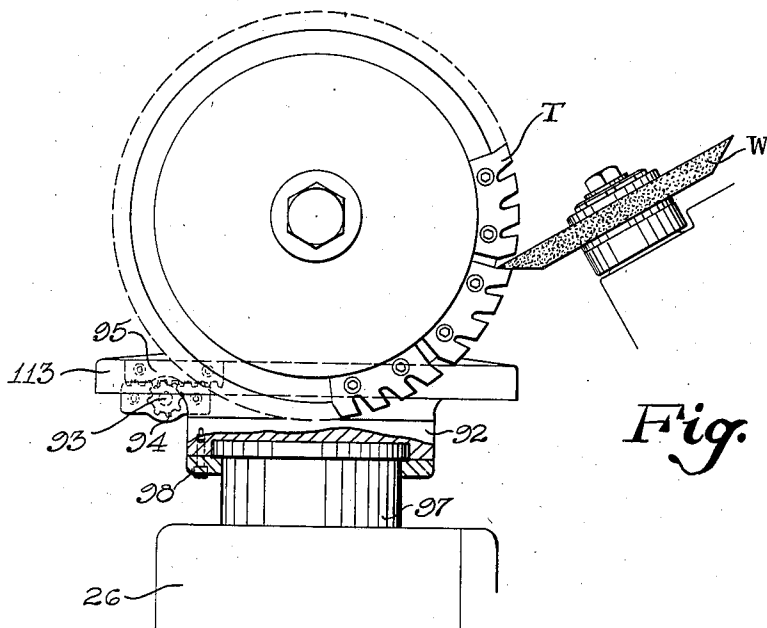


Fig. 16

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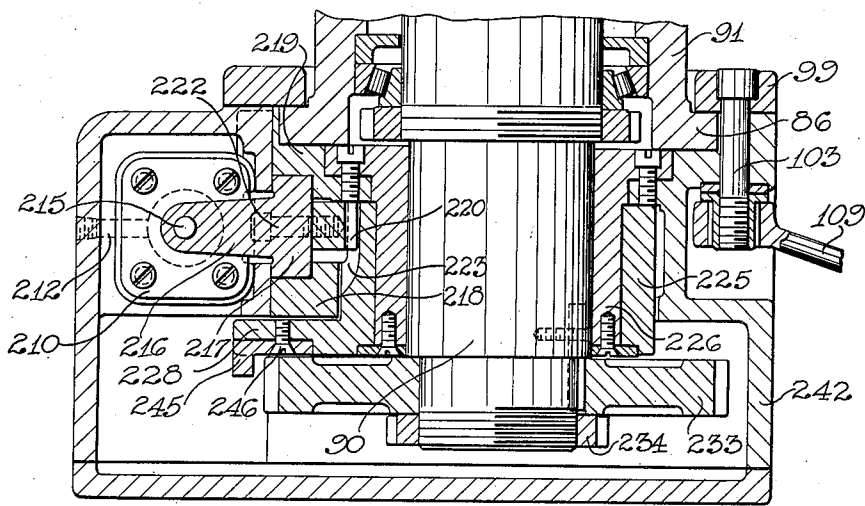


Fig. 14

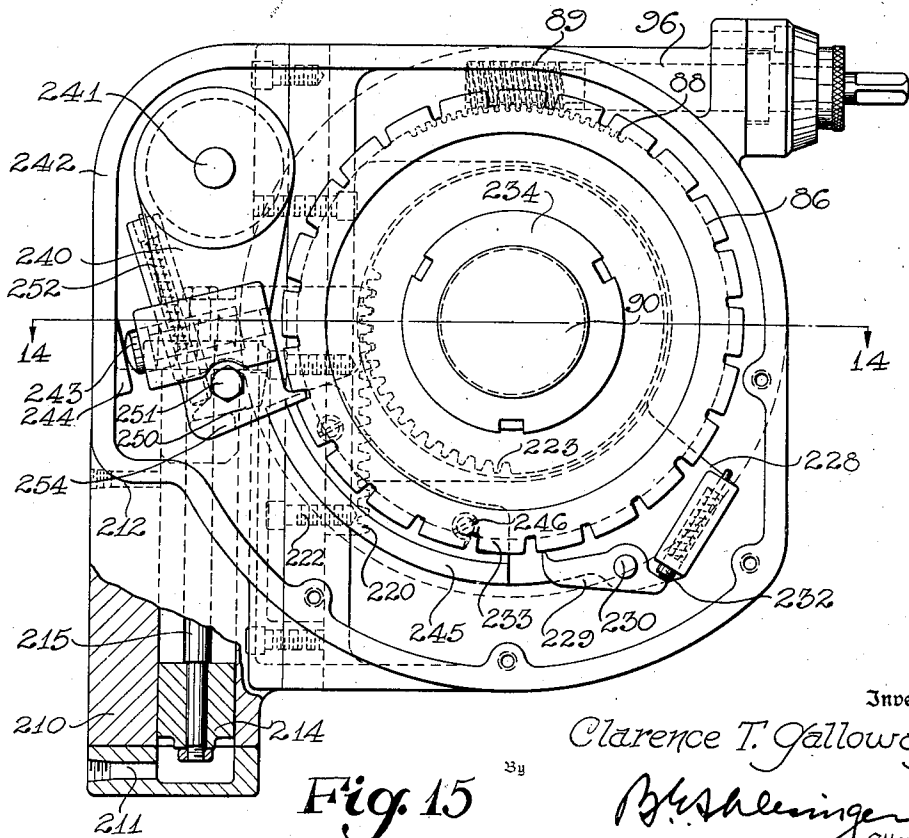


Fig. 15

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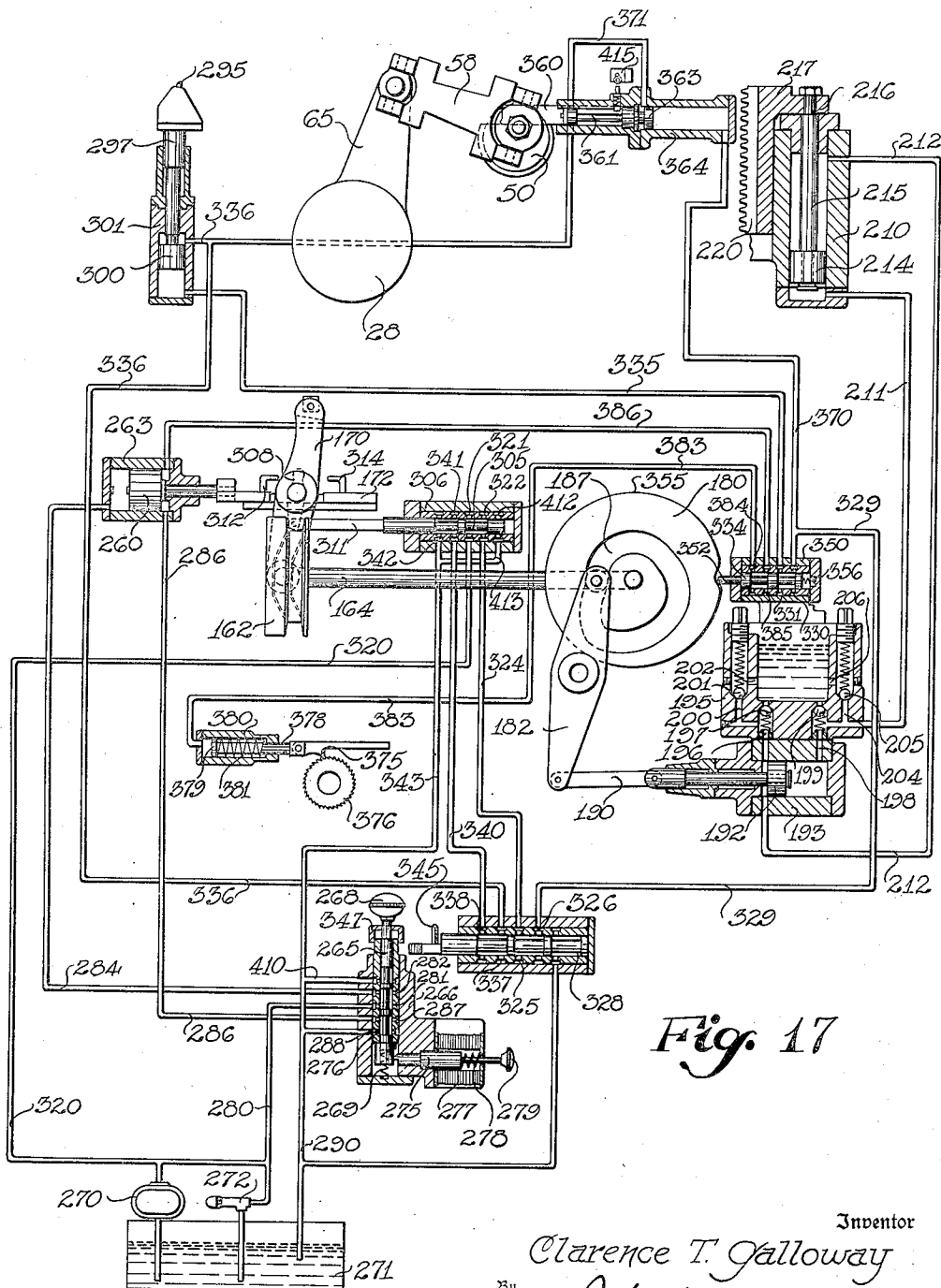


Fig. 17

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10 Sheets-Sheet 10

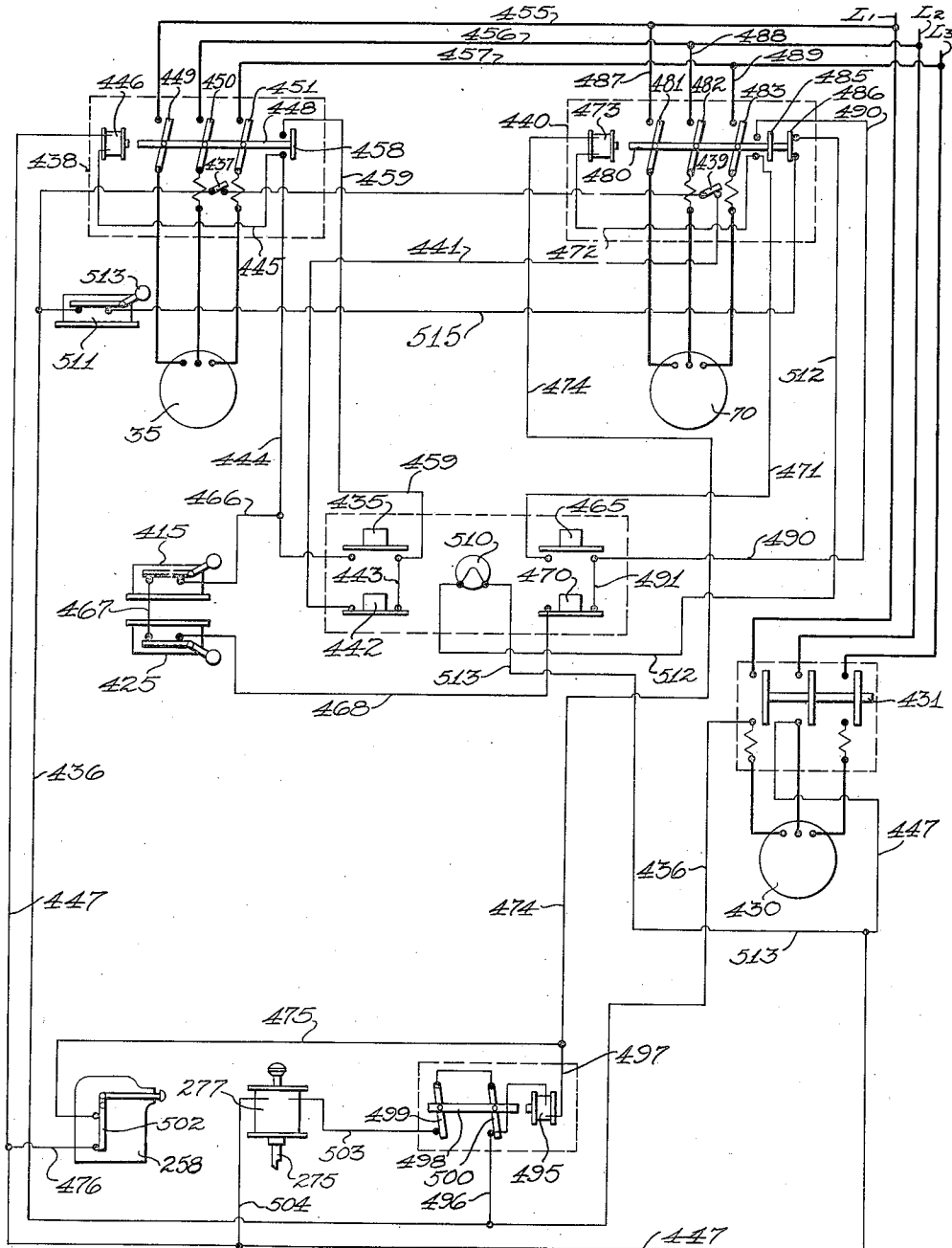


Fig. 18

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UNITED STATES PATENT OFFICE

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CUTTER SHARPENER

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tion of New York

Application June 29, 1938, Serial No. 216,553

18 Claims. (Cl. 51—33)

The present invention relates to machines for sharpening cutter blades and particularly to machines for sharpening the blades of face-mill and disc-type gear cutters.

One object of this invention is to provide a machine which will be faster in operation than machines of previous design for sharpening gear cutters.

A further object of the invention is to provide a cutter sharpening machine which will produce a smoother, finer finish on the sharpened surface and in which danger of "burning" the blades during sharpening is obviated.

Another object of the invention is to provide a cutter sharpening machine on which the blades of a cutter may be both rough and finish ground.

Still another object of the invention is to provide a cutter sharpening machine in which the grinding wheel makes a plurality of passes across the face of the cutter blade during the sharpening of the blade and in which the wheel is fed automatically toward the blade on successive passes so as to take off more stock on each pass.

A further object of the invention is to provide a machine in which the grinding wheel is withdrawn automatically an extended distance from its normal working path, after all of the blades of a cutter have been sharpened, to permit removal of the cutter from the machine, and in which the grinding wheel is dressed automatically when the wheel is in withdrawn position.

Still another object of the invention is to provide a dressing mechanism that will so function that the movement of the wheel in its extended path will itself operate to pass the dressing tool across the wheel and effect the dressing operation.

A further object of the invention is to provide means which will prevent dressing of the wheel unless the wheel is at a predetermined position in its swinging movement.

Another object of the invention is to provide on a cutter sharpening machine means for automatically advancing the grinding wheel relative to the work and to the dressing tool, before each dressing operation, in order to compensate for wheel wear.

The invention also includes various other improvements and refinements having to do with the perfection of machines for automatically sharpening cutters, all of which will appear clearly from the following description and from the recital of the appended claims.

In the drawings:

Fig. 1 is a side elevation of a cutter sharpen-

ing machine built according to one embodiment of this invention and arranged for sharpening the blades of a face-mill gear cutter;

Fig. 2 is a vertical sectional view of the machine on a somewhat enlarged scale, parts being broken away;

Fig. 3 is a fragmentary plan view of the machine on an enlarged scale with parts broken away;

Fig. 4 is an end elevation looking at one end of the machine, parts being broken away;

Fig. 5 is a fragmentary view showing, in section, details of the drive to the crank which oscillates the grinding wheel to pass it back and forth across the blade to be sharpened;

Fig. 6 is a fragmentary sectional view showing further details of the drive to the mechanically operated parts of the machine;

Fig. 7 is a view on an enlarged scale and partly in section, showing details of the mechanism for producing the alternate movement of the grinding wheel into and out of operative position for the sharpening of each blade of a cutter, and of the mechanism for effecting full withdrawal of the grinding wheel from operative position when all of the blades of a cutter have been sharpened;

Fig. 8 is a view taken at right angles to the view of Fig. 7;

Figs. 9 and 10 are fragmentary views illustrating the operation of the means for insuring that the grinding wheel is at a predetermined position in its arc of swing when it is dressed;

Figs. 11 and 12 are, respectively, layouts of the cams which control the rough-sharpening and finish-sharpening operations;

Fig. 13 is a section on an enlarged scale taken along the line 13—13 of Fig. 1;

Fig. 14 is a sectional view on the line 14—14 of Fig. 15, showing details of the indexing mechanism of the machine;

Fig. 15 is a rear elevational view of the work head of the machine, showing further details of the indexing mechanism;

Fig. 16 is a fragmentary view illustrating the positions of the work and of the grinding wheel in the sharpening of the blades of a disc type milling cutter;

Fig. 17 is a diagrammatic view showing the hydraulically operated control mechanism of the machine; and

Fig. 18 is an electrical wiring diagram of the machine.

In machines built to operate according to the present invention, the sharpening operation is

5 effected by grinding back the front face of each blade of a cutter. The grinding wheel used is of the conical type and the sharpening operation is effected by rotating the wheel on its axis and simultaneously swinging it about an axis which intersects the axis of the wheel and is inclined thereto. In the grinding of any one blade, the rotating wheel is passed back and forth a number of times across the face of the blade. To take off the amount of stock necessary to provide a new, keen cutting edge, the wheel is fed into the blade between passes.

10 In the machine illustrated in the drawings, the feed is effected by movement of a slide upon which the grinding wheel is mounted and which is movable in the direction of the axis of swing of the wheel. Preferably the feed movement is controlled by a rotary cam which is constructed so as to impart a continuous feed movement to the wheel during the sharpening of a blade and which operates to return the wheel to original position, after a blade has been sharpened, so that the wheel will be in correct position to start the sharpening of a new blade of the cutter, when the new blade has been indexed into operative position.

15 In the preferred form of machine, two different feed control cams are provided, one of which controls the feed of the grinding wheel during a rough-sharpening operation and the other of which controls the feed of the grinding wheel during a finish-sharpening operation. Ordinarily, all the blades of the cutter are first rough-sharpened. Then the grinding wheel is dressed and a second light grinding operation is taken on each of the blades to finish-sharpen it. Manual control means is provided to move the rough and finish feed cams selectively into operative position.

20 The cutter is held against rotation during the sharpening of each blade. After a blade has been sharpened, the grinding wheel is withdrawn from operative position and the cutter is indexed to bring a new blade into position to be sharpened. Then the grinding wheel is returned into operative relation with the cutter and the new blade is sharpened. The cutter indexing mechanism may be of any known or suitable type.

25 When all of the blades of a cutter have been operated upon, the oscillating movement of the grinding wheel is stopped and the rotating wheel is withdrawn an extended distance to permit shifting of the feed cams and/or removal of the cutter and chucking of a new cutter. In the preferred form of machine, the movements of the grinding wheel to and from operative position are controlled by a cam which is mounted upon the same shaft with the cam that controls the operation of the indexing mechanism. The movements of the grinding wheel into and out of operative position are produced by movement of a lever which is fulcrumed intermediate its ends and which is connected at one end to a carriage upon which the grinding wheel is mounted and which carries at its other end a roller that engages in the track of the cam that controls these movements. The fulcrum of this lever is mounted in a slide which can be moved back and forth by a hydraulically actuated piston. When all of the blades of the cutter have been ground, this slide is moved causing the lever to withdraw the grinding wheel the extended distance away from the work, required to permit taking the cutter off the machine and chucking of a new cutter thereon.

For dressing the wheel, a diamond or other suitable dressing tool is provided. The dressing tool is held in inoperative position during the sharpening of the cutter, but during the movement of the wheel to its extended withdrawn position, the dressing tool is moved into operative position.

When the wheel is fully withdrawn, the feed cam may be shifted manually and, if the cutter has been completely ground, it may be removed from the machine and a new cutter chucked thereon. The operator can then return the grinding wheel to operative position. As a wheel returns into operative position, the grinding wheel is advanced toward the work to compensate for wheel wear and is then passed over the dressing tool, to be dressed. At the end of the return movement, the dressing tool is withdrawn from operative position.

The movements of the wheel to and from fully-withdrawn position, the movements of the diamond into and out of operative position and the advance of the wheel to compensate for wear are all hydraulically operated and controlled.

To insure correct sharpening, it is necessary to dress the grinding wheel when the wheel is in the central position of its swing. Otherwise, the diamond will not dress the wheel along a straight line and the wheel will not have a true conical surface. Various safety devices are provided. Among them is means which will move the wheel to its central position, if it does not stop in that position.

Additional safety devices are provided also which insure that the wheel will be out of operative position when it is dressed and which insure that the wheel cannot be moved into operative position while it is being dressed.

Reference will now be had to the drawings for a more detailed description of the invention.

20 denotes the bed or frame of the machine. This bed is formed on its upper face with a plane way or guide 21 and a parallel V-shaped way or guide 22 (Fig. 4). The bed or frame is also formed at one end with parallel plane ways 23 and 24 (Figs. 1 and 2).

Mounted to slide on the ways 21 and 22 is a carriage 25. The grinding wheel W employed for sharpening the cutter is mounted on this carriage 25. Mounted to slide on the ways 23 and 24 is a slide or carriage 26 on which the cutter is mounted as will hereinafter be more fully described.

The wheel has a conical grinding surface. It is secured in any suitable manner to a spindle 27 that is journaled on anti-friction bearings in a head 28.

The head 28 is fixedly secured in any suitable manner to a sleeve member 30 that is journaled on spaced bearings 31 and 32 (Fig. 2) in a depending circular support or housing 33 which is formed integral with the carriage 25.

Wheel drive

During the operation of the machine, the grinding wheel rotates continuously. It is driven from a motor 35 (Fig. 4). There is a pulley 36 keyed to the armature shaft of the motor 35. This pulley 36 drives a second pulley 37 through a belt 34. The pulley 37 is keyed to a sleeve 38 (Fig. 2) which is journaled on anti-friction bearings in the bed or frame of the machine. This sleeve 38 has a splined telescoping connection with a shaft 39. The shaft 39 is journaled on

anti-friction bearings in a bracket member 40 and there is a bevel gear 41 keyed to its front end. This bevel gear meshes with a bevel gear 42 which is journaled on anti-friction bearings in the bracket member 40. The gear 42 has a telescoping splined connection with the shaft 43 which is journaled at its upper end on anti-friction bearings in the head 28. There is a bevel gear 45 keyed or otherwise secured to the shaft 43 and this bevel gear 45 meshes with a bevel gear 46 that is keyed to the grinding wheel spindle 27.

To sharpen a blade of a cutter, the grinding wheel head 28 is oscillated back and forth about the axis of the shaft 43 to pass the rotating wheel back and forth across the front face of the blade which is being ground. The oscillatory movement of the head 28 is produced by rotation of the crank 50 (Figs. 3 and 5). The crank 50 carries a pin 51 which is adjustable radially by a screw 53 in a slot 52 which is formed in the crank plate. The pin 51 is journaled in a bushing 55 on which is mounted a ring-member 56 that carries two laterally projecting pins 57. There is an arm or link member 58 connected with the ring member 56 by two connecting members 59. Each of the connecting members 59 is secured in the link member 58 and has an opening to receive a pin 57. The link member 58 is connected by connecting members 60 and pins 61 with a ring-member 62. This ring-member 62 is integral with a pin 63 which is secured in an arm 65. The arm 65 is integral with the wheel head 28 and projects from one side of the same.

The pins 57 and 61 and connecting members 59 and 60 allow of vertical displacement of the head 28 relative to the crank. Thus the oscillating drive to the head is maintained during feed of the wheel which will hereinafter be described.

The grinding wheel oscillates back and forth continuously while it is in operative position. The drive to the crank member 50 is therefore continuous while the grinding wheel is in operative relation with the work. This drive is from the main drive motor 70 (Fig. 6) which is mounted on the bed or frame of the machine. The armature shaft of the motor 70 is connected by any usual or suitable coupling with a bevel pinion 71. This pinion meshes with a gear 72 which is keyed to a vertical shaft 73. The shaft 73 is journaled on anti-friction bearings in the base of the machine and has keyed to its upper end a bevel pinion 74. The pinion 74 meshes with a bevel gear 75 that is keyed to a horizontal shaft 76. The shaft 76 is journaled on suitable anti-friction bearings in the base of the machine and has secured to its rear end a spur pinion 77 (Figs. 6 and 4). The pinion 77 meshes with a spur gear 78 (Figs. 4 and 5). The spur gear 78 is fastened to a shaft 79 which is journaled on anti-friction bearings in a quadrant 80 that is adjustably secured on the bed or frame of the machine. The shaft 79 has a telescoping splined connection at its inner end with a sleeve 81 which is journaled on suitable anti-friction bearings in a bracket 83 that is secured to the depending portion 33 of the carriage 25. There is a bevel pinion 82 keyed to the sleeve 81. This pinion meshes with a bevel gear 84 which is keyed to the shaft 85. The shaft 85 is journaled on anti-friction bearings in a sleeve or housing 87 which is secured in any suitable manner to

the carriage 25. The crank-plate 50 is mounted upon the upper end of the shaft 85.

As already stated, the machine illustrated may be employed for grinding either face-mill type or disc type gear cutters.

Work adjustments

The cutter which is to be sharpened is secured in any usual or suitable manner to the work spindle 90 of the machine (Figs. 14 and 15). In Fig. 1, the machine is shown set up to grind the front faces of the blades of a face-mill gear cutter, while in Fig. 16, the set up for sharpening the blades of a disc-type cutter is illustrated.

The work spindle 90 is journaled on suitable bearings in a sleeve or housing 91. An index housing 242 is mounted on the rear end of this sleeve or housing 91.

To permit of precisely positioning the cutter with reference to the grinding wheel to control the amount of stock to be removed from the blades of the cutter in the sharpening operation, the work spindle 90 is rotatably adjusted on its axis. For this purpose, the rear end of the sleeve or housing 91 is formed with a circular flange 86 (Figs. 14 and 15). This flange has worm wheel teeth 88 cut part-way around its periphery. A worm 89, which is integral with the shaft 96, meshes with the worm wheel segment 88. The shaft 96, which is manually rotatable, to effect the desired angular adjustment of the cutter, is suitably journaled in the index housing 242 and the index housing 242, as will appear hereinafter, is in driving connection with the work spindle through the index mechanism of the machine. Therefore, when the shaft 96 is rotated, the work spindle is revolved on its axis to effect the desired adjustment.

After the described angular adjustment of the work spindle 90 has been effected, the sleeve 91 and index housing 242 are clamped together by the circular gib 99 and clamping bolt 103. The latter is manipulated by the handle or lever 109.

There is a trunnion 112 (Fig. 1) projecting laterally from each side of the sleeve or housing 91. These trunnions are journaled in a head 113. One trunnion has an arm 114 fastened to it. This arm carries a vernier which reads against a scale scribed on one side of the head 113 in juxtaposition to the vernier.

The sleeve or housing 91 is adjustable angularly in the head 113 and the scale and vernier are provided in order to make this adjustment precisely. The adjustment is effected by manual rotation of a shaft 122. The shaft 122 is journaled on the head 113 and carries a worm (not shown) that meshes with a worm wheel segment (not shown) which is integral with the sleeve or housing 91. After adjustment, the sleeve 91 is secured in its adjusted position by clamping bolt 123 which is secured to the sleeve 91 and passes through an arcuate slot 124 in the head 113. The bolt is manipulated by a handle or lever 125.

The angular adjustment of the sleeve 91 in the head 113 permits of inclining the front face of a blade of the cutter with reference to the grinding wheel to determine the front rake angle to be ground on the cutting blades.

The head 113 is mounted for lateral adjustment on a base 92. This adjustment is effected by rotation of a shaft 93 (Figs. 1 and 16) to which is secured a pinion 94 that meshes with a rack 95. The rack 95 is secured to the head 113 and the shaft 93 is journaled in the base 92.

The base 92 is rotatably adjustable on a post 75

97, being held on the post by a circular gib 98 which engages under the enlarged head of the post. The post 97 is mounted in the slide 26 for vertical adjustment therein. The adjustment of the post is effected by rotation of a hand wheel 100 (Fig. 13) which is keyed to a shaft 101 that is journaled in the slide 26. The shaft 101 carries a worm 102 which meshes with a worm wheel 104 that is secured to the shaft 105 which is also journaled in the slide 26. There is a spur pinion 106 keyed to the shaft 105 at the inner end thereof. This spur pinion meshes with the rack 107 that is secured by screws 108 to one side of the post 97. The post 97 is secured in any position of its vertical adjustment by a clamping bolt 110 which is mounted in the slide 26 and which passes through a vertical slot formed in one side of the post 97. This clamping bolt is manipulated by a handle or lever 111.

The slide 26 (Figs. 1 and 2) is mounted, as already described, on the ways 23 and 24 of the bed of the machine for lateral adjustment thereon. This adjustment is effected by rotation of a shaft 115. This shaft is journaled in the slide 26 and carries at its inner end a spur pinion 116 that meshes with a rack 117 which is secured to the bed of the machine. The slide 26 is secured in any position of its lateral adjustment by T-bolts 118 and a gib 119. The T-bolts 118 are mounted in the slide 26 and their heads engage in a T-slot 120 cut into the end face of the bed. The gib 119 is manipulated by bolts 121.

The rotary adjustment of the base 92 on the post 97 permits of adjusting the work spindle through an angle of 90° or more. This allows of using the same machine to sharpen both face-mill and disc-type gear cutters. In Fig. 1, a face-mill gear cutter is shown mounted in position to permit the wheel W to sharpen the front faces of its cutting blades. In Fig. 16, the base 92 has been turned on the post 97 through an angle of 90° from the position shown in Fig. 1 and a disc-type cutter T is shown mounted in position for sharpening the front faces of its blades. The lateral adjustment of the head 113 on the base 92, the lateral adjustment of the slide 26 on the bed 20 and the vertical adjustment of the post 97 on the slide 26 are for the purpose of positioning the cutter, which is to be sharpened, in correct operative relation with the grinding wheel, in accordance with the diameter and hand of the cutter. When the various adjustments have been made, a plane tangent to the grinding wheel along the line of contact of the grinding wheel with a blade of the cutter will contain the front face of the blade. Then, as the rotating grinding wheel is swung back and forth about the axis of the shaft 43, its line of contact with the blade will move in this plane and grind a plane front face on the blade. The blade is ground back the desired distance by feeding the grinding wheel into the blade as the wheel passes back and forth across the front face of the blade. The feeding mechanism will now be described.

Wheel feed mechanism

Keyed to a shaft 130 (Fig. 2) is a double cam member 131. This cam member is formed with a finishing cam track 132 and a roughing cam track 133. The cam member 131 is adapted to be held on to the shaft 130 by a cap-member 135 which threads onto the inner end of the shaft 130.

The shaft 130 is journaled on suitable anti-friction bearings in a sleeve 137 which is mount-

ed for axial reciprocating movement in a housing 138 that is secured in any suitable manner to the depending portion 33 of the carriage 25. The sleeve 137 is adjusted axially in the housing 138 to bring the tracks 132 or 133 selectively into engagement with a follower 140. This adjustment is effected by rotation of a shaft 141 which is journaled in the carriage 25 and which carries at its lower end a spur pinion 142. The pinion 142 meshes with a rack 144 which is secured to one side of the sleeve 137. The shaft 141 is manipulated by the lever or handle 143.

The follower 140 is secured in the lower end of a nut 145 that is mounted in a head 146 and held against rotation in the head by means of keys 147 which slide in elongated slots that are formed in the head. The head 146 is adapted to slide in the depending portion 33 of the carriage 25 but is held against rotation therein by keys 148 which slide in slots 149 formed in the depending portion 33 of the carriage. The head 146 forms a support for the sleeve member 30 and the sleeve member 30 rests thereon, although thrust washers, such as shown in Fig. 2 may be interposed between the bottom end face of the sleeve and the opposed upper face of the head 146 if desired.

The shaft 130, which carries the cam member 131, is driven continuously during a sharpening operation in time with the drive to the crank 50 which oscillates the grinding wheel. The drive to the shaft 130 is from the shaft 76 (Fig. 6) through the gears 77 and 78 (Figs. 6 and 5), a spur pinion 150 which has a splined connection with the shaft 79 on which the gear 78 is mounted, a spur gear 152 which meshes with the pinion 150 (Figs. 4 and 5), a spur gear 153 which meshes with the gear 152 (Fig. 4) and which is secured to a shaft 154, a bevel pinion (not shown) which is also secured to the shaft 154, a bevel gear 155 which meshes therewith and which is secured to a shaft 156, a bevel pinion 157 which is also secured to the shaft 156 and a bevel gear 158 (Figs. 2 and 4) which meshes with the bevel pinion 157. The bevel gear 158 is secured by screws 160 to a cam 162 which, as will hereinafter appear, controls the periodic withdrawals of the grinding wheel from operative position to permit indexing of the cutter. The cam 162 is keyed to a sleeve 164 which is journaled on suitable anti-friction bearings in a bracket 165 that is secured to the frame of the machine. The sleeve 164 has a telescopic splined connection with the shaft 130.

Through the means described, it will be seen that the cam member 131 is rotated continuously to impart an alternate rise and fall movement to the sleeve 30 and grinding wheel head 28. The character of this movement will depend, of course, upon the contours of the cam tracks 132 and 133 and which one of these tracks is engaged at any given time with the follower 140. The gearing driving the shaft 130 is so selected that the shaft makes one revolution in the cycle of grinding a blade of the cutter.

Thus, as the rotating wheel swings back and forth in grinding a blade, it is fed toward the blade in order to remove the stock necessary to produce a new, keen cutting edge, and then, when the wheel has been withdrawn from operative engagement with the cutter for indexing the cutter as will hereinafter be more fully described, the wheel is moved back the distance it has previously been fed, so that it will be in initial position ready to commence the grinding of the next blade of the cutter when that blade is indexed into operating position.

In Figs. 11 and 12, layouts are shown of typical roughing and finishing feed cam tracks. The roughing cam track is shown in Fig. 11. 166 denotes a dwell portion during the time the wheel is withdrawn from the cutter for indexing the cutter. 167 is a rapid feed portion, to feed the wheel rapidly toward a blade at the beginning of the sharpening operation on a blade. 168 denotes the slow continuous feed portion which controls the slow, continuous feed of the wheel into the blade to grind the stock off the blade and 169 denotes the rapid return movement at the end of sharpening of a blade to withdraw the wheel to initial position, ready to commence the sharpening of a new blade.

In Fig. 12, 166' denotes the dwell portion of the finishing cam track which controls the position of the wheel when the cutter is being indexed. 167' is the rapid feed when the wheel has been returned to operative position after the indexing has been completed. 168' is the portion of the finishing cam path which produces the feed for removal of the stock for finish-sharpening of a blade of the cutter. 173 is a dwell during which the wheel remains in operative engagement with the blade, simply cleaning up the blade and 169' is the portion of the track producing the rapid withdrawal at the end of the sharpening operation for returning the wheel to initial position.

Mechanism for periodically withdrawing wheel from operative position and returning same thereto

As already indicated, after a blade of the cutter has been ground, the grinding wheel is withdrawn from operative position and the cutter is indexed to bring another blade into position to be sharpened. Then the wheel is returned into engagement with the cutter. The periodic withdrawal and return movements of the wheel are effected by operation of the cam 162 through the medium of the lever 170 (Figs. 4, 7 and 8). This lever is fulcrumed intermediate its ends on a pin 171 that is carried by a slide 172. At one end, the lever carries a roller 174 which engages in the track way of the cam 162. At its opposite end the lever is connected by means of a pin 175 with a block 176. The block 176 is adjustable relative to the carriage 25, as will be described more fully hereinafter, but is clamped rigidly to the carriage when the machine is in operation.

The slide 172 is movable in a guide or track 177 formed in a bracket 178 that is secured by bolts or screws to the bed or frame 20 of the machine. The slide 172 is held on the guide or track 177 by gibs 179 and screws 181.

Index mechanism

When the grinding wheel is withdrawn from operating position, the cutter is indexed. The indexing mechanism may be of any suitable character. That shown in the drawings is of the type described in the United States patent to Hill, No. 2,005,142 of June 18, 1935. This index mechanism is operated from a cam 180 which is keyed to the sleeve 164 (Fig. 2) to which the cam 162 is fastened. The cam 180 operates the index mechanism through the medium of a lever 182. This lever is pivotally mounted intermediate its ends upon a stud 183 which is secured in a bracket 184 (Figs. 2 and 4) that is fastened by means of screws 185 to the bed or frame of the machine. The lever 182 carries a roller 186

at one end which engages in the track way 187 of the cam 180. At its opposite end, the lever 182 is pivotally connected to a link 190 which is in turn pivotally connected to the piston rod 191 of a piston 192. This piston reciprocates in a cylinder 193 which is secured by screws 194 to the bed or frame 20 of the machine (Figs. 4 and 17).

There is a reservoir 195 mounted above the cylinder 193 and in communication therewith. This reservoir is connected to the cylinder 193 on one side of the piston 192 through a duct 196 which is normally closed by a spring pressed ball-check valve 197. The reservoir is connected with the cylinder 193 on the opposite side of the piston 192 through a duct 198 which is normally closed by a ball-check valve 199. There are also by-passes between the reservoir and the cylinder 193 around each of the ball-check valves 197 and 199. The by-pass around the ball-check valve 197 is through a duct 200, a spring pressed ball-check valve 201 and a duct 202. The by-pass around the ball-check valve 199 is through a duct 204, a spring-pressed ball-check valve 205 and a duct 206.

The cylinder 193 is connected hydraulically with the cylinder 210 (Figs. 14, 15 and 17). At one side of the piston 192, the connection is through the duct 198 and a duct 211. At the opposite side of the piston 192, the connection is through a duct 212. There is a piston 214 which reciprocates in the cylinder 210.

The piston rod 215 of this piston is secured at its upper end to an arm 216 which projects from one side of a slide 217 that slides on guide-ways formed at one side of the cylinder 210. This slide 217 is held on these guide-ways by gibs 218 and 219. There is a rack 220 secured by screws 222 to the slide 217. This rack meshes with a spur gear segment 223 which is formed integral with a hub member 225. The hub member 225 is rotatably mounted upon a bushing 226 in which the work spindle 90 is journaled.

The hub member 225 is formed at one side with an arm 228. There is a pawl 229 pivotally mounted at 230 on this arm. A spring-pressed plunger 232 which is housed in the arm 228 and which engages the tail of the pawl 229 serves to urge the pawl 229 into engagement with a notched index plate 233. The index plate 233 is keyed to the work spindle 90 of the machine and is held on the work spindle by a nut 234.

The index plate 233 is locked during grinding to hold the work spindle against rotation. For this purpose, a locking dog 240 is provided. This locking dog is pivotally mounted at 241 in the guard or housing 242 which encloses the index mechanism. The locking dog is constantly urged into locking position by a spring-pressed plunger 243 which is housed in the locking dog and which engages with a lug 244 that is integral with the index housing 242.

To trip the locking dog out of locking position to permit of indexing of the work spindle, a trip rail 245 is provided. This is secured by screws 246 to the arm 228. This trip-rail is adapted to engage a trip-dog 250 that is pivotally mounted at 251 on the locking dog 240. A spring pressed plunger 252, which is housed in the locking dog, engages the tail of the trip-dog 250 and serves to urge the trip-dog constantly in one direction about its pivot 251. A lug 254 which is formed integral with the lock-dog 240 serves to limit the movement of the trip-dog 250 in this direction.

The cylinders 210 and 193 and the ducts connecting them constitute a normally closed hydraulic system so that when the piston 192 is moved in either direction, the piston 214 is moved also. The check valves 197 and 199, 201 and 205 are simply provided to allow excess oil from the system to flow out of the system into the reservoir 195 and to allow the reservoir to keep the system full. Figs. 15 and 17 show the positions of the parts when the indexing mechanism is in locked up position.

As the cam 180 rotates, it will rock the lever 182 about its pivot to shift the piston 192 to the right from the position shown in Figs. 4 and 17. This will force the hydraulic motive fluid from the right hand end of the cylinder 193 through the ducts 198 and 211 into the bottom of the cylinder 210, causing the piston 214 to be moved upwardly in this cylinder. The motive fluid will at the same time exhaust from upper end of the cylinder 210 through the duct 212. As the piston 214 travels upwardly, the rack 220 will be moved upwardly with it to rock the hub 225 and arm 228 in a clockwise direction as viewed in Fig. 15. This will cause the trip-rail 245 to come into engagement with the trip-dog 250 and lift the locking lever 240 out of engagement with the index plate 233. Immediately thereafter, the pawl 229, which has been riding on the periphery of the index plate 233, will drop into engagement with a notch of the index plate. In the further movement of the rack 220, then, the index plate and the work spindle 90 to which the plate is secured, will be rotated to index the work spindle. The indexing movement will continue until the trip dog 250 rides clear of the trip rail 245. Then the locking dog 240 will drop back into engagement with a notch of the index plate. The indexing of the cutter will have been completed. The indexing mechanism will now be reset. The cam 180 through the medium of the lever 182 will reverse the piston 192 to cause it to move back to the position shown in Figs. 4 and 17. This will cause the piston 214 to be moved downwardly in the cylinder 210, causing the hub 225 and arm 228 to be rotated in a counter-clockwise direction as viewed in Fig. 15. In this movement of the arm 228, the trip dog 250 will be rocked by the trip rail 245 about its pivot 251 against the resistance of the spring-pressed plunger 252 and the locking dog 240 will not be lifted out of locking engagement with the index plate. In this movement of the arm 228, also, the pawl 229 will ratchet idly over the index plate.

Mechanism for withdrawing wheel wholly out of operative position

After all of the blades of the cutter have been ground, the grinding wheel carriage 25 is withdrawn completely out of operative position to permit shifting of the shaft 130 (Fig. 2) for shifting the roughing and finishing feed cams 132 and 133 and/or removal of the cutter from the machine and chucking of a new cutter in position.

The complete-withdrawal movement is effected automatically and is controlled from the automatic stop device provided on the machine. This automatic stop device may be of any usual or suitable construction. Suitable devices are described in the Ford U. S. Patent No. 1,908,626 of May 9, 1933 and the Hill U. S. Patent No. 1,577,121 of March 16, 1926. The stop device which is denoted at 258 in Figs. 1 and 18 is adjusted initially for the number of blades of the cutter that are to be ground in a particular sharpening op-

eration. A cam 259 (Figs. 2 and 4) which is keyed to a rod 257 serves to actuate this stop device. The rod 257 is fastened to the sleeve 164 to rotate therewith. On each revolution of the sleeve 164, that is, each time a blade of the cutter has been ground, the cam 259 advances the stop device. When the sharpening operation (rough or finish-sharpening as the case may be) has been effected on the last blade of the cutter, the stop device is tripped and the carriage 25 is withdrawn fully out of operative position. The manner in which this full withdrawal of the carriage 25 is effected and the means for accomplishing the same will now be described.

To effect the complete withdrawal of the carriage 25 out of its normal working path, the slide 172 (Figs. 4, 7, 8 and 17) is moved rearwardly. The movement of the slide 172 shifts the fulcrum 171 of the lever 170, causing the lever to rock about the roller 174 as a fulcrum. Thus an extended movement is imparted to the carriage 25.

The movement of the slide 172 is produced by reciprocation of the piston 260 (Figs. 7 and 17) which reciprocates in a cylinder 263. The piston rod 261 of this piston is secured by a nut 262 to the slide 172.

The movements of the piston 260 are controlled by a valve 265 (Fig. 17). This valve slides in a casing 266 (Figs. 1 and 17) which is fastened to one side of the bed 20 of the machine. The valve is moved manually in one direction by pressing upon the knob 268. It is spring-pressed in the opposite direction by a coil spring 269 which is interposed between the valve and the bottom wall of the casing 266.

There is, of course, a main hydraulic reservoir or sump 271 (Fig. 17) provided in the bed of the machine. An oil pump which may be of any suitable construction and which is shown diagrammatically at 270 in Fig. 17 is provided to pump the oil from this sump 271 and effect the hydraulic operations now to be described. The oil pump is driven by a suitable motor denoted diagrammatically at 430 in Fig. 18. A relief valve 272 of standard construction may be provided to control the hydraulic pressure in the supply line from the sump.

The valve 265 is manually depressed to return the carriage to operative position from fully-withdrawn position. A spring-pressed detent 275 is provided to hold the valve 265 in its depressed position during the ensuing sharpening operations on a cutter. This detent has a beveled inner end and is adapted to engage over the shoulder 276 of the valve stem. The detent is resiliently held in operative position by a coil spring 278 but is adapted to be withdrawn from engagement with the shoulder 276 automatically on completion of the sharpening operations on a cutter by operation of the solenoid 277. This solenoid is energized when the automatic stop 258 of the machine is tripped at the end of the grinding operation as will be described more fully hereinafter. The detent 275 can be manually operated by grasping a knob 279.

The valve 265 is shown in Fig. 17 in the position which it occupies when the carriage 25 is in its fully-withdrawn position. The pressure fluid then flows from the pump 270 through the duct 280, the ports 281 and 282 of the valve 265, and the duct 284 to the cylinder 263. The motive fluid is at this time exhausted from the opposite end of this cylinder through the duct 286, the ports 287 and 288 of the valve 265 and the ex-

haust duct 290 which leads back to the sump of the machine.

Dressing mechanism

At the time of return of the carriage 25 to operative position, the grinding wheel is dressed. The dressing of the wheel is effected by passage of the wheel over a dressing tool which has been moved up into operative position at the end of the movement of the carriage 25 into inoperative position.

The dressing tool, which is in the form of a diamond 295 (Figs. 1, 2 and 17), is secured in a head 296 that is adjustably mounted upon the upper end of a piston rod 297. Journaled in the head 296 is a shaft (not shown) that carries the pinion 298 which meshes with a rack 299 that is secured to the upper end of the piston rod 297. The adjustment of the head 296 on the piston rod is in the direction of movement of the carriage 25.

The piston rod 297 is secured to a piston 300 which reciprocates in a cylinder 301 that is fastened in any suitable manner to the bed or frame 20 of the machine.

The movements of the piston 300 are controlled by a valve 305 (Figs. 7 and 17) which is housed in a valve casing 306 (Figs. 7, 8 and 17) that is secured in any suitable manner to the bracket 178.

The valve 305 is operated by movement of the slide 172. There is a lever 308 pivotally mounted intermediate its ends upon a stud 309 that is threaded into the bracket 178. This lever is pivotally connected at its lower end by means of a pin 310 with the stem 311 of the valve 305. A pin 312, which is secured in a lug 313 that in turn is secured to the slide 172, is adapted to engage the free end of the lever 308 to rock this lever in one direction on movement of the slide 172 in one direction. A dog or finger 314, which is secured to the slide 172 by screws 315, is adapted to engage the free end of the lever 308 to rock the lever in the opposite direction on movement of the slide 172 in the opposite direction.

When the valve 305 is in the position shown in Fig. 17, the pressure fluid flows from the pump 270 through the duct 320, the ports 321 and 322 of the valve 305, the duct 324, the ports 325 and 326 of a shut-off valve 328, the duct 329, the ports 330 and 331 of a safety valve 334 and the duct 335 to the lower end of the cylinder 301, moving and holding the diamond 295 in dressing position. At the same time, the motive fluid exhausts from the upper end of the cylinder 301 through the duct 336, the ports 337 and 338 of the valve 328, the duct 340, the ports 341 and 342 of the valve 305 and the duct 343 which connects with the main exhaust duct 290.

Safety valves

The shut-off valve 328 is provided to permit withdrawal of the dressing tool from operative position as, for instance, when swinging the work supporting base 92 around from the position shown in Fig. 1 to that shown in Fig. 16 to permit changing over from sharpening face-mill cutters to disc-type cutters. The shut-off valve also acts as a safety valve to maintain the correct relation of the diamond and carriage movements. It prevents return of the carriage 25 to its working position if the diamond is in its lowered, inoperative position. Moreover, when the carriage 25 is in operative position, the valve 328 cannot be moved.

There is a pin or handle 345 secured to the stem 346 of the valve 328 to permit manual movement thereof. The stem 346 of the valve projects beyond the pin or handle 345. If the valve 265 is in the position shown in Fig. 17, the dressing diamond can be moved from operative position by shifting the valve 328 to the left from the position shown in Fig. 17. When the valve 328 is so shifted, the projecting portion of the stem 346 engages under a cap 347 that is secured to the stem of the valve 265. This prevents downward movement of the valve 265 for returning the carriage 25 to its working position while the diamond is in inoperative position. Further than this, when the valve 265 is down and locked by the detent 275, that is, when the carriage 25 is in operative position, the valve 328 cannot be moved to the left to lower the diamond to inoperative position, because the collar 347 is then in line with the end of the valve stem 346 and prevents movement of the valve 328. Thus, when the grinding wheel is in operative position, the valve 328 cannot be shifted.

The valve 334 is a safety valve which insures that the grinding wheel is in its full withdrawn position when dressing occurs. This valve is housed in a valve casing 350 (Figs. 4 and 17) which is secured by screws 351 to the reservoir 195. The stem 352 of the valve 334 projects through one end wall of the valve casing and engages with a cam track 355 that is formed on the periphery of the cam 180. The valve 334 is pressed by the coil spring 356 against this cam track. In each revolution of the cams 162 and 180, the carriage 25 is moved into and out of operative position, the extent of this movement being determined by the swing of the lever 170 (Figs. 7 and 8) about its fulcrum 171. To insure that the grinding wheel will always be dressed in the same way, it is desirable to dress the wheel when it is at one end of this in and out movement of the carriage 25 in its working path. This the valve 334 does. If the machine does not stop with the grinding wheel carriage at the indexing end of its working stroke, then the valve 334 will be to the right of the position shown in Fig. 17 and the duct 335 that leads to the lower end of the piston 300 cannot be put on supply. Hence, the dressing diamond 295 will not be moved to dressing position.

When the automatic stop device 258 trips at one end of sharpening operations on a cutter, the main-drive motor 70 is stopped. Hence the swinging movement of the grinding wheel and the to and fro movement of the carriage 25 in its limited working path are stopped.

To insure proper dressing of the grinding wheel, the grinding wheel must be at the center of its swing when it is dressed so that as the wheel is moved across the dressing diamond, the wheel will move along a generatrix of its conical active surface and a straight profile will be dressed thereon.

To insure that the wheel will be in central position, a combined pusher and lock bar 360 (Figs. 9, 10, 3 and 17) is provided. This is a flat bar that is secured to the head of a piston rod 361 by a screw or bolt 362. The piston rod 361 is secured to a piston 363 which reciprocates in a cylinder 364 that is mounted on the carriage 25.

When the main drive motor 70 is stopped at the end of the grinding operations on the cutter, it has been found that the crank plate 50 will stop somewhere within 90° of the position at which the grinding wheel is in the central point

of its swing. The pusher 360 is provided to move the crank 50 on to the desired position, if it does not stop at this position. For this purpose, the crank plate is slabbed off at one side as indicated at 366. If the crank plate does not stop in the desired position, the pusher 360 engages the slabbed off portion of the crank plate and moves it on from the position in which it stops such as the position shown in Fig. 9 to the position shown in Fig. 10, which is the correct position of the crank plate for dressing. If the crank plate stops in the correct position, the pusher 360 simply moves outwardly to the position shown in Fig. 10 without moving the crank plate. In this position it serves to lock the crank plate against further rotation and the grinding wheel against swinging movement while the wheel is being dressed.

The pusher is actuated at the same time that the dressing diamond 295 is being moved up into dressing position. The duct 329 which supplies the motive fluid to the lower end of the piston 300 connects with a duct 370 (Fig. 17) which leads to the right hand end of the cylinder 364. The left hand end of the cylinder 364 is connected by a duct 371 with the duct 336 which leads from the upper end of the piston 300.

Wheel-feed actuating mechanism

Before dressing the grinding wheel, it is necessary to advance the grinding wheel toward the plane of grinding in order to compensate for wear of the wheel. For this purpose, a pawl 375 and ratchet wheel 376 (Figs. 17, 4 and 2) are provided. The pawl is pivotally connected to a piston rod 378 which is integral with the piston 379 that reciprocates in a cylinder 380 which is secured to one end of the bed 20 of the machine. The piston 379 is constantly urged in one direction by the coil spring 381. It is moved in the opposite direction by fluid pressure. For this purpose, the cylinder 380 is connected by the duct 383, ports 384 and 385 of valve 334 and duct 386 with the duct 286 that leads to the control valve 265.

The ratchet wheel 376 is keyed to a sleeve 380 (Fig. 2) that is journaled in a bearing member 391 that is secured in any suitable manner to the bracket 165. The sleeve 380 has a telescoping connection with the shaft 392. The shaft 392 is held against rotation relative to the sleeve 380 by a key that fits into an elongated groove or slot cut in the shaft 392. The shaft 392 is connected by means of a universal joint with a shaft 394 which in turn is connected by means of a universal joint with a shaft 395. A bevel pinion 396 is keyed to this last named shaft. This pinion meshes with a bevel gear 397 which is keyed to a screw shaft 398 that threads into the nut 145.

The nut 145 is held, as already described, against rotation in the head 146 by the keys 147. The nut 145 cannot move downwardly because it is held against downward movement by the contact of the follower 149 on the track 132 or the track 133 of the cam member 131. As a result, when the shafts 392, 394, 395 and 398 are rotated, the head 146 is moved relative to the nut 145, thereby raising or lowering the sleeve 30 and with it the head 28 on which the grinding wheel W is mounted.

Manual adjustment of the position of the grinding wheel for depth of feed may be effected by rotation of the stub-shaft 400 (Figs. 4 and 2) to which is secured the spur gear 401 that meshes

with a spur gear 402 which is keyed to the sleeve 390.

The various parts shown in Fig. 17 are illustrated in the positions which they occupy when the carriage 25 is in the fully withdrawn position. To return the carriage 25 to operative position, the operator depresses the valve 265 by pushing down on the knob 263. This causes the duct 286 to be put on supply and the duct 284 to be put on exhaust. The duct 284 exhausts through the ports 282 of the valve 265 and the duct 410. The duct 410 communicates with the main exhaust duct 290. At the same time, the duct 363 that leads to the cylinder 380 is put on supply from the duct 386 through the valve 334. This causes the pawl 375 to be moved to the right from the position shown in Figs. 4 and 17 to advance the ratchet wheel 376 and rotate the shaft 398 to advance the grinding wheel to compensate for the wear of the wheel.

As the piston 260 moves to the left from the position shown in Fig. 17, the lug 314 strikes the lever 308, causing the valve 305 to be shifted from the position shown in Fig. 17 to the position shown in Fig. 7. This causes the upper end of the cylinder 301 to be put on supply from the duct 320 through the ports 321 and 341 of the valve 305, the duct 340, and the duct 336. The lower end of the cylinder 301 then exhausts through the duct 335, ports 331 and 330 of safety valve 334, duct 329, ports 326 and 325 of shut-off valve 328, duct 324, ports 322 and 412 of valve 305 and ducts 413, 343 and 290. This withdraws the dressing tool from dressing position. At the same time also that the duct 336 is put on supply and the duct 335 put on exhaust, the duct 371 of the cylinder 364 is put on supply and the duct 370 of the cylinder 364 is put on exhaust. This causes the piston 363 to be moved to the right in its cylinder 364 to the position shown in Fig. 3.

Electrical safety devices

The grinding wheel carriage 25 is now in operative position again, the dressing tool is withdrawn from operative position and the crank 50 is unlocked. The normal grinding operations of the machine can now be started by restarting the main drive motor 70. A safety device is provided, however, to insure against starting of this motor until the pusher 360 has been fully withdrawn from operative position. For this purpose, a normally open limit switch 415 (Figs. 3 and 17) is incorporated in the starting circuit of the motor 70. A spring-pressed plunger 416 is mounted in a hole in one side of the casting 417 to which the cylinder 364 is secured. This plunger contacts at one end with the roller 418 of the limit switch 415. The opposite end of the plunger 416 is adapted to ride on the bottom of a cam slot 419 which is cut into the head 420 of the piston rod 361. In the position shown in Fig. 3, the plunger is riding on the highest point of this cam slot 419 and the limit switch 415 is closed so that the motor 70 can be started. When the piston rod 361 moves to the left of the position shown in Fig. 3, however, the plunger 416 rides down to the bottom of the cam slot 419, releasing the roller 418 and allowing the switch 450 to open, thus opening the circuit of the motor 70.

An additional safety device is provided to insure against starting of the main drive motor 70 until the carriage 25 has been returned to operative position. This is in the form of a second limit switch 425 (Fig. 3). This limit switch is also a normally open limit switch. It is

mounted upon the bed or frame 20 of the machine. There is a cam plate 426 secured to one side of the carriage 25. The roller 427 of the limit switch 425 is intended to ride on this cam plate. When the carriage 25 is in operative position, the roller 427 is on the high part of the cam surface and the switch 425 is closed, closing the starting circuit to the motor 70. When the carriage 25 is in fully withdrawn position, however, the roller 427 rolls down on to the low part of the cam plate 426, allowing the switch 425 to open and to break the starting circuit.

Electrical circuit

One way in which the machine may be wired electrically in order that it may function properly is illustrated diagrammatically in Fig. 18. The motor which drives the fluid pressure pump is denoted at 430. To start the machine, this motor must be started first. This is done by pressing in the start button 431 which closes the circuit to the motor 430 from the main lines L₁, L₂, L₃.

After the motor 430 has been started, the motor 35, which drives the grinding wheel, may be started by pressing in the start button 435. This closes the circuit from the main line L₁ through the start button 431, the line 436, overload switch 437 of a standard controller 438, the overload switch 439 of a standard controller 440, the line 441, the stop button 442, the line 443, the start button 435, the line 444, the line 445, the solenoid 446, the line 447 and the start button 431 to the main line L₂.

The circuit just described energizes the solenoid 446 causing the bar 448 to be pulled to the left from the position shown in Fig. 18 to close the switch arms 449, 450 and 451. This closes the circuit from the main lines L₁, L₂ and L₃ to the motor 35 through the main lines 455, 456 and 457 and switches 449, 450 and 451. The start button 435 is a normally open button and will fly open when it is released. The circuit to the solenoid 446 is maintained, however, through the switch arm 458 which connects the line 445 with the line 443 through the line 459.

When the pump motor 430 and wheel motor 35 are running and the carriage 25 is in operative position, the main drive motor 70 may be started by pressing in the starting button 465. This closes the circuit from the main line L₁ through the line 436, overload switches 437 and 439, line 441, stop button 442, lines 443 and 459, the switch arm 459, line 444, line 466, limit switch 415 which is at this time closed by cam 419 (Fig. 3), line 457, limit switch 425 which is at this time closed by cam 426 (Fig. 3), line 468, stop button 470, start button 465, line 471, line 472, solenoid 473, line 474, line 475, automatic stop device 258, line 476, line 447, and start button 431 to main line L₂. This energizes the solenoid 473, causing the bar 480 to be pulled to the left from the position shown in Fig. 18 to close the switches 481, 482, 483, and 485 and open the switch 486. The switch arms 481, 482 and 483 close the circuits to the main drive motor 70 through the lines 487, 488 and 489. The start button 465 is a normally open switch, but the circuit to the solenoid 473 is maintained after this button is open, through the switch arm 485 and lines 490 and 491.

At the same time that the circuit to the solenoid 473 is closed by pressing in the start button 465, a circuit to a solenoid 495 is closed from the line 436 through the lines 496 and 497 to the line 474. Thus the solenoid 495 is energized to pull the switch bar 498 to the right from the position

shown in Fig. 18 and open the switch arms 499 and 500.

To move the carriage 25 to operative position, the operator depresses the valve 265 (Fig. 17) as already described. This permits the detent 275 to engage over the shoulder 276 of the valve to hold the valve in its lower position as already described. The detent remains in this position while the cutter is being ground. The detent is automatically disengaged when the solenoid 277 (Figs. 17 and 18) is energized. This occurs when the automatic stop 258 is tripped, after sharpening operations on a cutter have been completed. The switch arm 502 forming part of the stop is then swung open to break the circuit to the solenoid 473, thus stopping the main drive motor 70. When the automatic stop is tripped, it also breaks the circuit to the solenoid 495, allowing the switch arms 499 and 500 to return to the position shown in Fig. 18. This closes the circuit to the solenoid 277 from the line 436, through the line 496, the switches 500 and 499, the line 503, the line 504 and the line 447.

As soon as the detent 275 is disengaged, the valve 265 moves upwardly under actuation of the spring 269. This causes the slide 172 to be shifted to cause the carriage 25 to be moved to fully disengaged position as above described.

For the convenience of the operator, a light is provided on the machine to indicate to him when the carriage 25 is in position to permit dressing of the grinding wheel. This light serves, in effect, to indicate that the safety valve 334 (Fig. 17) is in open position and that the main drive motor 70 is stopped. The circuit to this light, which is denoted at 510 in Fig. 18, is made through a limit switch 511 and the switch arm 486. The circuit is from the main line L₁ through the line 436, the limit switch 511, the line 515, the switch arm 486, the line 512, the light 510, and the lines 513 and 447 back to the main line L₂. The limit switch 511 is operated by a lug 514 which is secured to the periphery of the cam 180 (Fig. 4). This cam lug is so positioned that the limit switch is only closed when the carriage 25 is in its withdrawn position. The switch arm 486 is only closed when the motor 70 is stopped. Hence, the light 510 is only lighted when the carriage 25 is in withdrawn position and the main drive motor 70 is stopped. By glancing at the light, then, the operator can determine the state of the machine.

Adjustments for height of cutter blades to be ground

To enable cutter blades of different heights to be ground, the carriage 25 is mounted for adjustment with reference to the lever 170 (Figs. 7 and 8). This lever, as already described is connected to the block 176 (Fig. 3). This block is normally secured against movement relative to the carriage 25 by a pair of bolts 521 and 522. The bolts are connected by the links 524, 525 and toggle member 526 so that they can be manipulated simultaneously by a lever 527 (Figs. 1 and 3). The block 176 is mounted for sliding adjustment in opposed guide-ways 529 that are formed in the carriage 25 and the block is held on these guide-ways by gibs 530.

The block carries a nut 528. There is a screw shaft 532 which threads into this nut. This shaft can be rotated by rotating the shaft 533. There is a bevel gear 534 keyed to the latter shaft that meshes with a bevel gear 535 which is keyed to the screw-shaft. When the bolts 521 and 522 are released, then, the carriage 25 may be ad-

justed relative to lever 170 to position the grinding wheel in accordance with the height of the blades of the cutter which is to be sharpened.

At the same time that the wheel is adjusted, the operator may also adjust the dressing diamond by rotation of the pinion 298 (Fig. 2). Thus the diamond can be maintained in correct operative relation with the wheel.

General operation of the machine

The operation of the machine may now be described. The operator first chucks the cutter which is to be ground upon a work spindle 90 and makes the necessary linear and angular adjustments of the work and of the grinding wheel for grinding this cutter. He also shifts the shaft 130 (Fig. 2) by manipulation of the lever 143 to bring the roughing track 133 of the feed cam into operative engagement with the follower 140. The automatic stop 258 is also adjusted in accordance with the number of blades in the cutter which is to be sharpened.

When all of the adjustments have been made, the operator starts the hydraulic pump motor 430 (Fig. 18) by pushing in the start button 431. He may then start the wheel drive motor 35 (Figs. 4 and 18) by pushing in the start button 435. This causes the grinding wheel W to be rotated through the pulleys 36 and 37 and belt 38, and the gears 41, 42, 45, and 46 (Figs. 4 and 2).

The carriage 25 is at this time out of its operating path in full withdrawn position. With the hydraulic and wheel drive motors running, the operator may now move the carriage 25 into operative position by depressing the valve 265 (Fig. 17). This causes the duct 266, that leads to the cylinder 263, to be put on supply from the line 280 and the duct 264 leading from this cylinder 263 to be put on exhaust through the line 410. Thus the piston 260 is moved to the left from the position shown in Fig. 17 and the carriage 25 is carried on into operative position.

When the operator depresses the valve 265, the detent 275 engages over the collar 276 of the valve, holding the valve down in its lower position against the resistance of the coil spring 269.

At the same time that the duct 286 is put on supply, the line 303, which leads to the cylinder 330, is put on supply from the line 286 through the ducts 325 and 383. This causes the pawl 375 to advance the ratchet wheel 376 and through the shafting 392, 394, 395 and the gears 396 and 397 (Fig. 2) to rotate the screw shaft 398. This causes the head 146 and the sleeve 30 which rests thereon and the grinding wheel head 28, which is secured to the sleeve, to be lowered. Thus the grinding wheel support is fed downwardly in a direction perpendicular to the plane of grinding to compensate for wear of the wheel.

The diamond 295 is at this time in operative position. Hence, as the carriage 25 moves in to operative position, the grinding wheel W is carried over the diamond and dressed. As the carriage 25 nears the end of its movement inwardly, the dog 314 (Figs. 17 and 7) strikes the lever 308 and moves the lever from the position shown in Fig. 17 to that shown in Fig. 7. This shifts the valve 305 from the position shown in Fig. 17 to that shown in Fig. 7. The pressure fluid now flows to the upper end of the dresser cylinder 301 from the line 320 through the ducts 340 and 336. At the same time the motive fluid exhausts from the lower end of the cylinder 301 through the ducts 335, 329, 324, 413, 343 and 290. Thus, the

diamond 295 is withdrawn from operative position.

At the same time, the pusher 360 (Figs. 17, 9 and 10), which has been locking the crank 50 against rotation, is withdrawn from operative position. The pressure fluid flows from the duct 336 to the left hand end of the cylinder 364 through the duct 371 and the motive fluid exhausts from the right hand end of this cylinder through the duct 370 to the duct 329.

As the pusher piston 363 returns to the right to the position shown in Fig. 3, the plunger 416 rides up on the high part of the cam slot 419 of the piston rod head 420 and closes the normally open limit switch 415. As the carriage 25 moves into operative position also, the roller 427 (Fig. 3) of the normally open limit switch 425 also rides up on to the high part of the cam 426 and this limit switch 425 is also closed.

The operator can now start the main drive motor 70 (Figs. 6 and 18). He does this by pushing in the start button 465. The electrical circuit to this motor has already been described. When this motor is started, the crank 50 is driven through the gearing 71, 72, 74, 75, 76, 78, 82, and 84 (Figs. 6, 5 and 4). The crank oscillates the grinding wheel head 28 back and forth to swing the grinding wheel to and fro about the axis of the shaft 43 (Fig. 2). At the same time, the motor 70 drives the index cam 180, withdrawal cam 162, feed cam 131 and automatic stop trip cam 259 (Fig. 2), through the gearing 77, 78, 150, 152, 153, 155, 157 and 158 (Figs. 6, 4 and 2).

As these four cams rotate, the cam 162 first causes the carriage 25 to be moved into operative position to engage the rotating and oscillating grinding wheel with a blade of the cutter that is to be sharpened. The cam 162 actuates the carriage 25 by swinging the lever 170 (Figs. 7 and 8) about its fulcrum 171. During this inward movement, the follower 140 (Fig. 2) will be riding upon the dwell portion 166 of the track 133 of the cam 131 (Fig. 11). When the rotating and swinging grinding wheel has moved into operative engagement with the cutting blade, however, the follower 140 will move off the dwell of the cam track 133 onto the portions 167 and 168 of the cam-track, successively, and, as the rotating wheel swings back and forth across the face of the blade, the wheel will be fed into the blade by operation of the cam track 133. Thus on successive passes of the grinding wheel across the face of the blade, more and more stock will be ground off of the face of the blade.

When the blade has been sharpened down to the predetermined extent, the cam 162 will swing the lever 170 (Figs. 7 and 8) back about the fulcrum 171 to withdraw the grinding wheel out of operative position. When the wheel has cleared the cutter, the cam 180 will operate to swing the lever 182 (Figs. 2, 4 and 17) about its pivot 183 to shift the piston 192 to the right from the position shown in Figs. 4 and 17. This will cause the piston 214 to be moved upwardly in its cylinder 210 to cause the arm 228 (Fig. 15) to be moved in a clockwise direction through operation of the rack 220 and segment 223. The locking dog 240 will thus be disengaged from the index plate 233 and the pawl 229 will drop into a notch of this plate and index the work spindle 90 to bring a new blade of the cutter into position to be ground.

While the indexing is taking place, the cam 259 (Fig. 2) will be advancing the automatic stop device 258.

When the indexing of the work spindle has been completed, the cam 162 will operate to again return the carriage 25 to operative position, causing the grinding wheel W to engage the front face of the blade which has newly been indexed into grinding position. During the return movement of the carriage 25, the index mechanism will be reset, for the cam 180 will shift the lever 182 back to the position shown in Figs. 4 and 17, to put the upper end of the piston 210 on supply and lower this piston to the position shown in Figs. 15 and 17. This will cause the arm 228 to be moved back in a counterclockwise direction to the position shown in Fig. 15. During this return movement of the arm 228, the trip rail 245 will simply rock the trip dog 250 about its pivot 251 against the resistance of the spring-pressed plunger 252 and the pawl 229 will simply ratchet over the teeth of the index plate.

The new blade of the cutter is ground in the same way as before.

The alternate grinding and indexing proceeds until all of the blades of the cutter or all of the blades which cut on one side of a tooth slot of a gear have been ground. Then the automatic stop device 258 trips. This breaks the circuit to the main drive motor 70 and it also breaks the circuit to the solenoid 495 (Fig. 18), releasing the double arm switch 498. The release of the switch 498 causes a circuit to be closed to the solenoid 277 (Figs. 18 and 17), withdrawing the detent 275 from operative engagement with the valve 265. The valve 265 is therefore moved upwardly to the position shown in Fig. 17 by the coil spring 269. This places the line 284, which leads to the cylinder 263, (Fig. 17) on supply and the line 286 of this cylinder on exhaust. Thus the slide 172 (Figs. 17, 7 and 8) is moved rearwardly to displace the fulcrum 171 of the lever 170 and cause the lever 170 to swing about the roller 174. This causes the carriage 25 to be moved out to full-withdrawn position.

When the motor 70 is stopped, the circuit to the solenoid 473 of the controller 440 (Fig. 18) is broken and the switch 486 is closed. The motor is stopped when the carriage 25 is at the withdrawn end of its working path. Hence the roller 513 of limit switch 511 (Figs. 4 and 18) will be riding on top of the cam lug 514. When the motor stops, then, the limit switch 511 will also be closed. With both switches 511 and 485 closed, the light 510 will be lighted.

During the rearward movement of the carriage 25 to fully withdrawn position, the cylinder 380 (Fig. 17) is put on exhaust through the ducts 383, 386, 286 and 290. This permits the spring 381 to reset the pawl 375 which during the resetting movement simply ratchets idly over the ratchet wheel 376.

Just before the carriage 25 reaches the end of its movement to full-withdrawn position, the stop 312 (Figs. 17 and 7) strikes the arm 308 and shifts the valve 305. If the cam 180 (Figs. 17, 4 and 2) has stopped, when the motor 70 stops, in the position shown in Fig. 17, the safety valve 334 will occupy the position shown in Fig. 17. Hence, when the valve 305 is shifted, the pressure fluid will flow from the duct 320 through the ducts 324, 329 and 335 to the lower end of the dresser cylinder 301 to move the diamond 295 up to operative position. At the same time, the duct 370 is put on supply to cause the pusher 360 to be moved outwardly into operative position.

If the crank 28 has not stopped with the grind-

ing wheel at the center of its swing, when the main drive motor 70 stops, then the pusher 360 by engagement with the slabbled off portion 366 (Fig. 9) of the crank plate rotates the crank plate on far enough to bring the wheel to central position and lock it in that position.

When the carriage 25 has reached its fully withdrawn position, the operator moves the lever 143 (Fig. 2) to shift the sleeve 137 axially and move the roughing cam track 133 out of operative engagement with the follower 140 and move the finishing cam track 132 into operative engagement therewith.

The hydraulic pump motor 430 and the grinding wheel drive motor 35 (Fig. 18) are still running. The operator then depresses the valve 265 (Fig. 17) to again return the carriage 25 to its working path. Again, the ratchet wheel 376 is advanced to move the sleeve 30 and the grinding wheel W downwardly to compensate for the wear of the wheel and again, as the carriage 25 returns to operative position, the grinding wheel is passed over the diamond 295 and the wheel is dressed. Again, just before the carriage 25 has returned into operative position, the dog 314 strikes the arm 308 and shifts the valve 305 from the position shown in Fig. 17 to that shown in Fig. 7. Thus, again, prior to the return of the carriage 25 to operative position, the diamond 295 is withdrawn from operative position and the pusher 360 is withdrawn from operative position. Again, also, the normally open switches 415 and 425 (Figs. 18 and 3) are closed by the cams 426 and 419.

When the carriage is again in operative position, therefore, the operator may again restart the main drive motor 70. When the motor 70 is restarted, the rotating grinding wheel is again oscillated back and forth and alternately moved into engagement with a blade of the cutter to sharpen that blade and withdrawn to permit the cutter to be indexed. During the sharpening of each blade, also, the wheel is fed into the blade to grind off the desired amount of stock and produce the final, keen finishing edge. Again, after all of the blades of the cutter or all of the blades which cut on one side, have been ground, the automatic stop trips. This stops the main drive motor and causes the solenoid 277 (Figs. 17 and 18) to be energized to withdraw the detent 275 from operative engagement with the valve 265. The valve 265, therefore, is again moved upwardly to the position shown in Fig. 17, causing the carriage 25 to be moved to fully withdrawn position as previously described. Toward the end of the withdrawal movement, as before, the arm 308 is again rocked to shift the valve 305 and the dressing diamond is again moved up into operative position. The safety valve 334 and the pusher 360 will again function to insure that the grinding wheel will be in proper position to be dressed when the carriage 25 is again returned into operative position.

At the end of the withdrawal movement, when the grinding wheel is in full withdrawn position, the operator can remove the now sharpened cutter and chuck a new cutter on the machine.

While the invention has been described in connection with a particular embodiment and in connection with the particular uses for such embodiment, it will be understood that the invention is capable of further modification and use and this application is intended to cover any variations, uses, or adaptations of the invention following, in general, the principles of the in-

vention and including such departures from the present disclosure as come within known or customary practice in the art to which the invention pertains and as may be applied to the essential features hereinbefore set forth and as fall within the limits of the appended claims.

Having thus described my invention, what I claim is:

1. In a machine for sharpening cutters, a grinding wheel having a conical grinding surface, a work support adapted to support a cutter, means for rotating the grinding wheel on its axis, means for simultaneously swinging the wheel about an axis inclined to the axis of the wheel, means for periodically indexing the work support to bring different blades of the cutter into position to be sharpened, and means operable to produce a continuous feed movement between the wheel and work in the direction of axis of swing of the wheel, during grinding of a blade of the cutter, and to withdraw the wheel the distance it has previously been fed, during indexing of the work support.

2. In a machine for sharpening cutters, a rotary grinding wheel having a conical grinding surface, a work support adapted to support a cutter, means for rotating the wheel, a rotatable crank for simultaneously swinging the wheel about an axis inclined to the wheel axis to pass the wheel back and forth across a blade of a cutter, means for periodically indexing the work support to bring successive blades of the cutter into position to be sharpened, a rotary cam for producing feed of the wheel into the work in the direction of the axis of swing of the wheel during grinding of a blade and for withdrawing the wheel from the work during indexing of the work, and means for driving the crank and cam in timed relation.

3. In a machine for sharpening a gear cutter, a work support, a rotary grinding wheel having a conical grinding surface, means for rotating the wheel on its axis, means for simultaneously swinging the wheel about an axis inclined to the axis of the wheel and perpendicular to a plane tangent to the active surface of the wheel at the line of contact of the wheel with the work, means for moving the wheel relative to the work in the direction of said line of contact to move the wheel into and out of operative relation with the work, and means for indexing the work support when the wheel is out of operative position.

4. In a machine for sharpening a gear cutter, a grinding wheel, a work support, a carriage on which one of said parts is mounted, means for rotating the wheel, means for moving the carriage periodically in opposite directions to move the wheel into and out of operative relation with the work comprising a cam and a follower engaged therewith, a lever which is fulcrumed intermediate its ends and which is connected at one end to said carriage and which carries said follower at its opposite end, means for indexing the work support when the grinding wheel is out of operative relation with the work to bring the different blades of the cutter into position to be sharpened, and means for moving the fulcrum of said lever, when the sharpening operations on a cutter have been completed, to withdraw the grinding wheel an extended distance away from the work.

5. In a machine for sharpening a gear cutter, a grinding wheel, a work support, means for rotating the wheel, means for reciprocating the wheel in a limited path to and from operative

relation with the work, means for indexing the work support when the wheel is out of operative position, means for moving the wheel an extended distance beyond said limited path but in the plane of said reciprocating movement to a fully withdrawn position when grinding operations on a cutter have been completed, means for feeding the grinding wheel in a direction perpendicular to the plane of its reciprocating movement when the wheel has reached fully withdrawn position, a dressing tool and means operatively connected to the last named means to move the dressing tool to operative position when the wheel has reached its fully withdrawn position so that when the wheel is returned from fully withdrawn position to its working position again, it will pass over the dressing tool to cause the wheel to be dressed, and means for moving the dressing tool to inoperative position again when the wheel has been returned to working position.

6. In a grinding machine, a rotary grinding wheel, means for rotating the wheel, means for simultaneously oscillating the wheel to pass it back and forth across the work, a dressing tool, means for stopping the oscillating means, when a predetermined number of operations on the work have been completed, to permit dressing the wheel and auxiliary means operable automatically on stoppage of said oscillating means for moving the wheel to a predetermined point in its oscillatory movement if it has not stopped at said point.

7. In a grinding machine, a rotary grinding wheel, means for rotating the wheel, means including a rotary crank for simultaneously oscillating the wheel to pass it back and forth across the work, a dressing tool, means for stopping the crank, when a predetermined number of operations on the work have been completed, to permit dressing the wheel, and auxiliary means for moving the crank automatically to move the wheel to a predetermined point in its path of swing if it does not stop at that point.

8. In a grinding machine, a conical grinding wheel, means for rotating the wheel, means for simultaneously oscillating the wheel about an axis inclined to its own axis to pass the wheel back and forth across the work, means for moving the wheel into and out of operative relation with the work, means for indexing the work when the wheel is out of operative position, means for stopping the last three means when a predetermined number of operations on the work have been completed, a diamond, means for actuating the diamond to dress the wheel when the three named actuating means are stopped, and means for insuring that said actuating means are stopped in predetermined positions before said wheel may be dressed.

9. In a machine for sharpening cutters, a tool support, a rotary grinding wheel journaled thereon, a work support, means for rotating the wheel, means for reciprocating the wheel to pass it back and forth across a blade of the cutter, reciprocating means for periodically moving one of said supports to move the wheel into and out of engagement with the work, means for indexing the work when said movable support is in withdrawn position, means for stopping the two reciprocating means when a predetermined number of operations have been performed on the work, means operative on said stoppage to move the movable support an extended distance beyond

its normal path of movement, and means preventing restarting of said two reciprocating means until the movable support has returned to its normal path of movement.

5 10. In a machine of the class described, a tool support, a work support, a reciprocable carriage upon which one of said supports is mounted, a lever pivotally connected at one end to said carriage, a follower carried by the opposite end of
10 said lever, a rotary cam with which said follower is engaged, a slide on which the lever is fulcrumed intermediate its ends, means for rotating the cam to impart movement to the carriage in a limited path to move the tool into and out
15 of operative relation with the work, and fluid-pressure operated means, operable after a predetermined number of operations have been completed on the work, to shift said slide to move said carriage an extended distance beyond said
20 limited path.

11. In a machine of the class described, a tool support, a work support, a grinding wheel mounted on said tool support, means for oscillating the grinding wheel to pass the wheel back
25 and forth across the work, a carriage upon which the tool support is mounted, means for moving the carriage in a limited path to move the tool into and out of operative relation with the work, means for indexing the work when the carriage
30 is at the inoperative end of its limited path of movement, means for stopping the first two named means when a predetermined number of operations on the work have been completed, and means, operable upon stopping of said first two
35 means, for moving the carriage beyond said working path to its withdrawn position, a dressing tool, and means operable by said last named means for moving the dressing tool to operative position.

12. In a machine for sharpening cutters, a
40 frame, a slide mounted on the frame for lateral adjustment thereon, a post adjustable vertically on the slide, a support mounted on the post for pivotal adjustment about a vertical axis, a second support mounted on the first for adjustment
45 about a horizontal axis, a work spindle journaled in the second support for movement about an axis perpendicular to the last named axis, a grinding wheel, and means for actuating the grinding
50 wheel.

13. In a grinding machine, a work support, a grinding wheel, means for rotating the wheel on its axis, means for oscillating the wheel about
55 an axis inclined to the wheel axis to pass the wheel back and forth across the work, said means including a rotary member which is provided with a chordal surface, a dressing tool, means for stopping the oscillating means to permit dressing of the wheel, a pusher member having one end adapted to engage the chordal surface
60 of said rotary member to move the rotary member to a definite angular position if it has not stopped in said position and having a side adapted to engage the chordal surface of the rotary member to lock the member in said position,
65 and means for automatically actuating the pusher member on stoppage of the oscillating means.

14. In a machine for sharpening multi-bladed rotary gear cutters, a frame, a rotary tool spindle, a grinding wheel secured to the tool spindle and having a conical active surface, a tool support oscillatably mounted on the frame and having its axis of oscillation perpendicular to a plane tangent to the conical surface of the
70 wheel, a work support mounted on the frame

for adjustment angularly about an axis perpendicular to the axis of swing of the tool support, a work spindle journaled in the work support, means for adjusting the work support on its axis to position a cutter so that the front face
5 of a blade of the cutter will lie in said tangent plane, means for rotating the grinding wheel, and means for simultaneously oscillating the tool support.

15. In a machine for sharpening multi-bladed
10 rotary gear cutters, a frame, a tool support oscillatably mounted on the frame, a tool spindle journaled in the tool support with its axis inclined to the axis of swing of the tool support, a grinding wheel secured to the tool support and
15 having a conical active surface, a work support mounted on the frame for adjustment angularly about an axis perpendicular to the axis of the tool support, a work spindle journaled in the work support, means for adjusting the work sup-
20 port on its axis to position a cutter so that a plane tangent to the front face of a blade of the cutter is perpendicular to the axis of swing of the tool support, means for rotating the grinding wheel, means for oscillating the tool
25 support, and means for producing a relative feed movement between the grinding wheel and work support in the direction of the axis of swing of the tool support.

16. In a machine for sharpening multi-bladed
30 rotary gear cutters, a tool spindle, a grinding wheel secured to the tool spindle and having a conical grinding surface, a base, a rotary support in which the tool spindle is journaled, said support being mounted on the base for rotation
35 about an axis inclined to the axis of the tool spindle at an angle which is the complement of the cone angle of the wheel, a work support mounted on the base for adjustment about an axis extending parallel to the axis of the tool
40 support and for adjustment about an axis extending perpendicular to the last named axis, a work spindle journaled in the work support, means for rotating the grinding wheel on its axis, and means for swinging the tool support on
45 its axis.

17. In a machine for sharpening a rotary multi-bladed gear cutter, a grinding wheel, a carriage on which the wheel is journaled, a work support, means for rotating the wheel, means
50 for moving the carriage in a limited path to move the wheel to and from operative relation with the work, means for indexing the work support when the wheel is out of operative position, means for moving the carriage beyond said limited
55 path to fully withdrawn position when the grinding operations on a cutter have been completed, a dressing tool, fluid-pressure operated means for moving the dressing tool to and from operative position, a valve controlling the operation of
60 said fluid-pressure operated means, and means for tripping said valve at opposite ends of the movement of the carriage to move the dressing tool to operative position when the carriage reaches fully withdrawn position and to return
65 the dressing tool to inoperative position when the carriage has returned again to normal working position.

18. In a machine for sharpening multi-bladed rotary gear cutters, an oscillatory tool support, a
70 carrier on which the tool support is mounted, a frame on which the carrier is mounted for slidable movement in the direction of the axis of oscillation of the tool support, a tool spindle journaled in the carrier, a grinding wheel se- 75

cured to the tool spindle, a work support, a rotary cam; a follower engaging said cam and secured to the carrier for transmitting motion from said cam to said carrier to effect the sliding movement of the carrier, means for rotating the tool spindle, means for oscillating the tool sup-

port, means for rotating the cam, and means for adjusting the follower relative to the carrier in the direction of movement of the carrier to compensate for wear of the grinding wheel.

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