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E. V. FLANDERS ET AL

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MACHINE FOR GRINDING IMPELLER BUCKET SHANKS

Filed Aug. 14, 1948

5 Sheets-Sheet 1

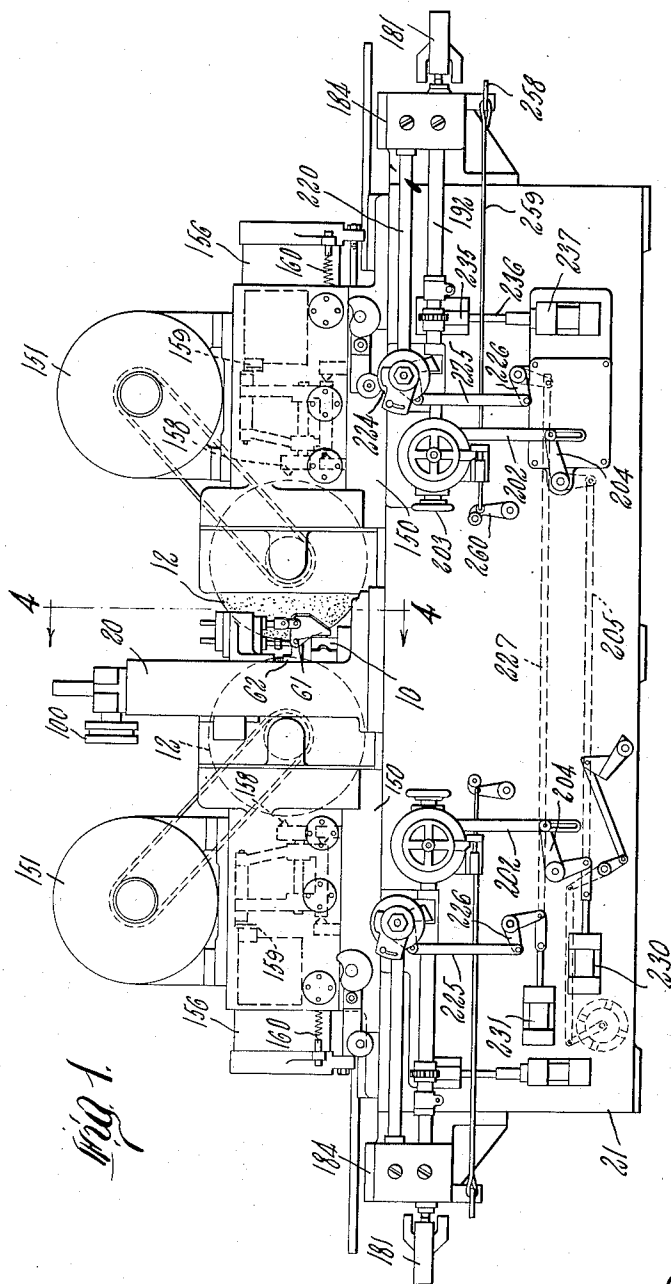


Fig. 1.

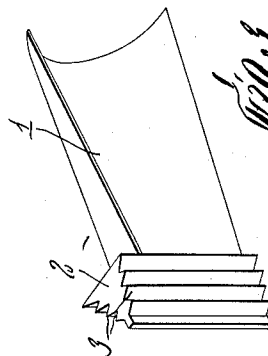


Fig. 2.

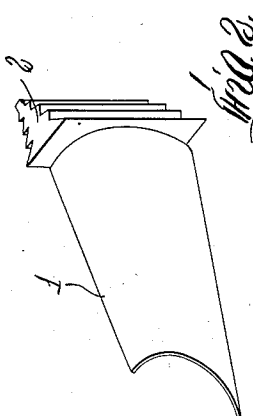


Fig. 3.

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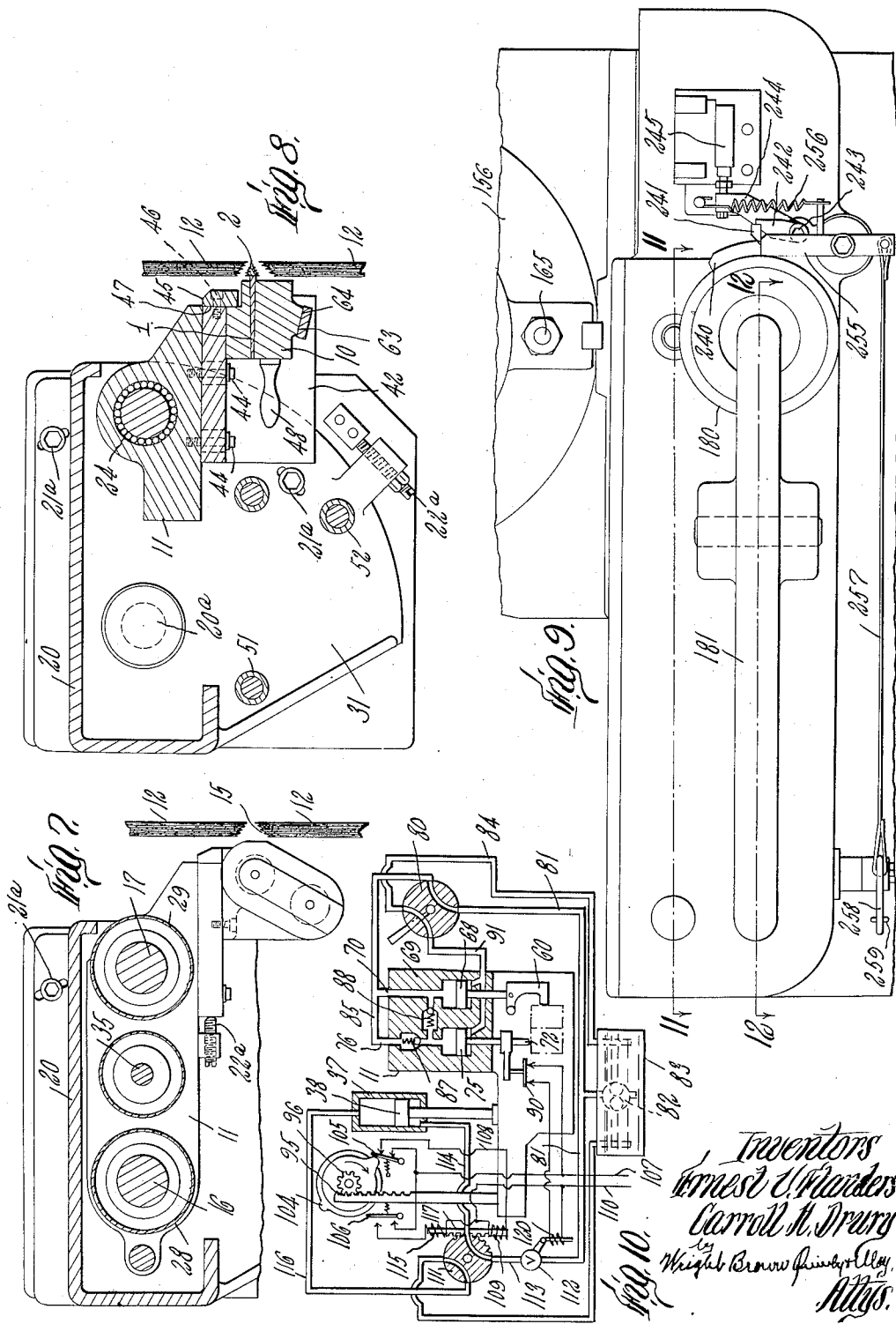
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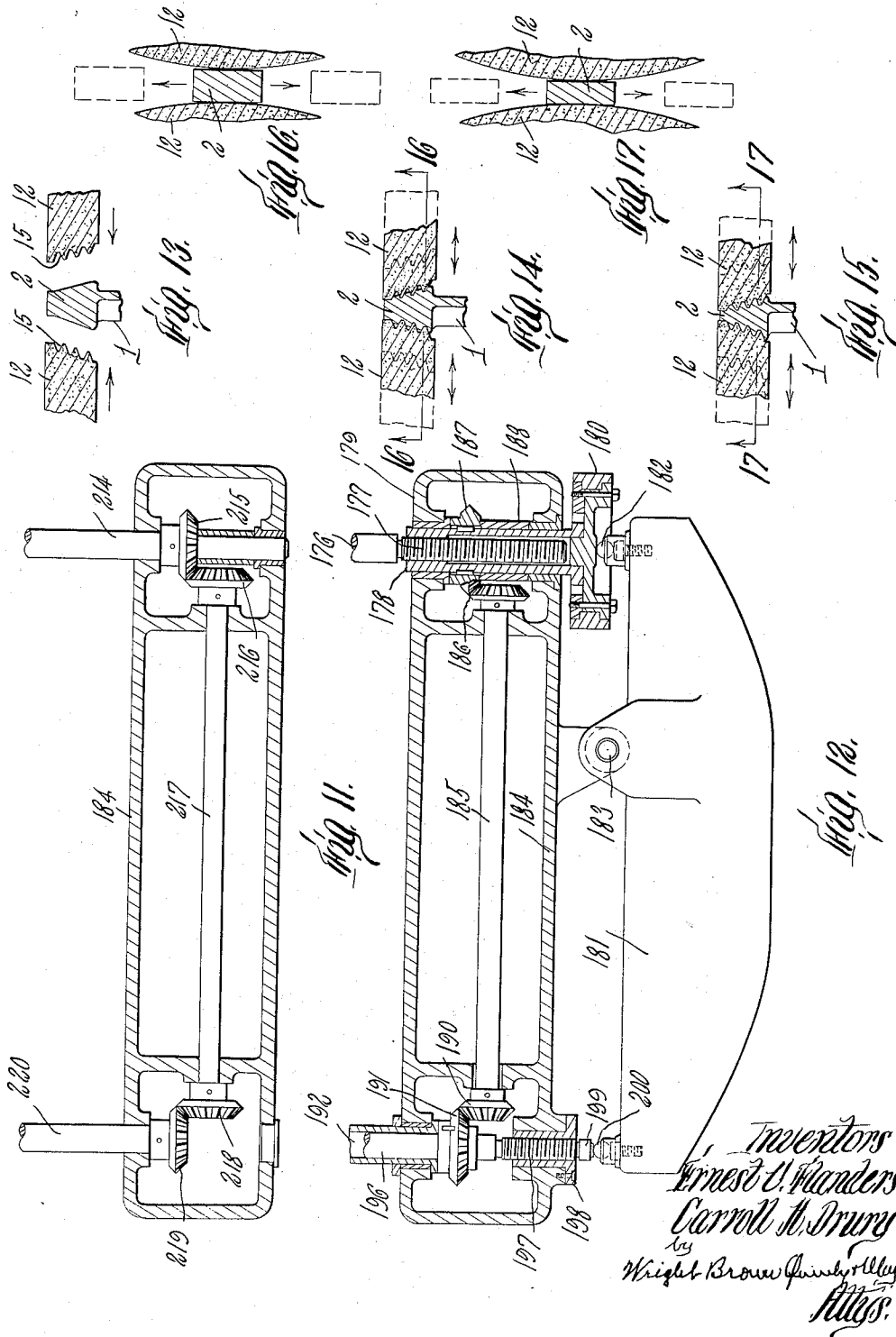
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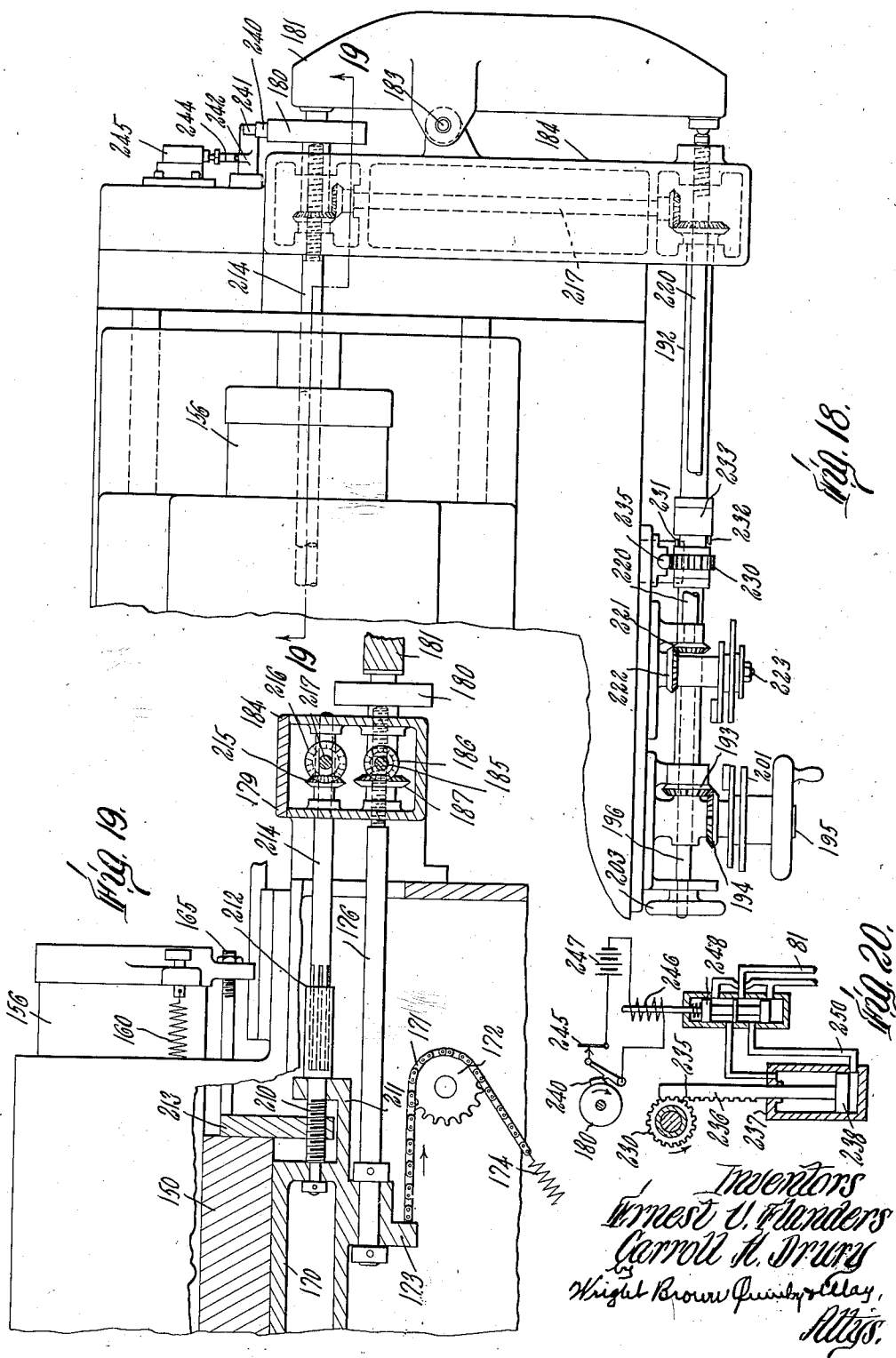
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UNITED STATES PATENT OFFICE

2,578,531

MACHINE FOR GRINDING IMPELLER
BUCKET SHANKS

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15 Claims. (Cl. 51—84)

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This invention relates to grinding machines, and more particularly to machines for grinding the shanks of turbine impeller blades or buckets to desired form for interlocking engagement with the hub members to which they are to be secured.

One of the objects of this invention is to grind opposite side faces of the bucket shanks simultaneously to the desired configuration and to close tolerances.

A further object is to provide means for reciprocating the bucket shanks laterally between a pair of spaced grinding wheels which are fed toward each other as the grinding proceeds until the shank has been reduced to the desired contour and dimensions.

A further object is to provide means for holding the bucket and readily locating and clamping it with reference to the grinding wheels for the grinding operation.

Another object is to provide means by which the work holder is securely clamped in correct position before traverse between the work piece and the grinding wheel may begin.

Still another object is to provide means facilitating the placing and removal of the buckets with relation to the wheels.

A further object is to provide for simultaneous wheel feeds and truing and for compensation for wheel wear and truing.

Still another object is to provide for individual wheel adjustment in setting up the machine, the automatic wheel movement being then simultaneous for both wheels.

Further objects and advantages will appear from a description of an embodiment of the invention shown in the accompanying drawings in which

Figure 1 is a front elevation of a machine embodying the invention.

Figures 2 and 3 are perspective back and face views, respectively, of a bucket, showing the ground shank configuration.

Figure 4 is a detail sectional view on line 4—4 of Figure 1.

Figures 5 to 8, inclusive, are detail sectional views on the correspondingly numbered section lines of Figure 4.

Figure 9 is a fragmentary top plan view of the front right hand end portion of the machine.

Figure 10 is a diagrammatic view of the work clamping and reciprocating mechanisms.

Figures 11 and 12 are detail sectional views on lines 11—11 and 12—12, respectively, of Figure 9.

Figures 13, 14 and 15 are fragmentary horizon-

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tal sectional views through the wheels and work showing successive stages in the operation of the machine.

Figures 16 and 17 are fragmentary vertical sectional views through the wheels and work showing rough and finish grinding and on lines 16—16 and 17—17 of Figures 14 and 15, respectively.

Figure 18 is a fragmentary top plan view showing the front and right hand end portions of the machine.

Figure 19 is a detail sectional view on line 19—19 of Figure 18.

Figure 20 is a diagrammatic view showing mechanism for stopping the grinding action and reversing the wheel feed at the end of a cycle of operation.

The work for which the machine of this invention has been particularly designed is illustrated in Figures 2, 3 and 13 to 17, inclusive. Referring to Figures 2 and 3, at 1 is shown the bucket or blade of a turbine, this being provided with a shank portion 2 so formed as to be fitted into a mating socket in the turbine rotor hub. The configurations of these shanks in completed form, which as shown in Figures 2 and 3, comprise a series of longitudinal ribs 3 on two sides of the shank portion, which is substantially triangular in cross section. This portion of the shank of the blade or bucket is commonly referred to in the art as the "Christmas tree."

These blades or buckets are made of a material with high heat resistance and are not easily machineable, so that grinding has been found to be the most satisfactory method of shaping the shanks, but as they have to be held with great rigidity in the rotor hubs, it is important that they be ground to close tolerances.

In accordance with this invention, therefore, the blade or bucket is arranged to be mounted in a suitable work holder 10, best shown in Figures 5 and 8, which is suitably clamped upon a carriage 11 mounted for reciprocation between a pair of grinding wheels 12 spaced apart and provided with opposed serrated grinding faces 15 as shown best in Figures 7, 13, 14 and 15. The carriage 11, upon which the bucket to be ground is mounted, is mounted on a pair of spaced vertical cylindrical bars 16 and 17 carried by a bracket 20 supported for slight angular adjustment on a pivot 20a upon the upper face of a bed 21 of the grinding machine. The bracket 20 may be fixed in adjusted angular position by tightening a screw 21a which extends through an arcuate slot in the base of the bracket 20 and is threaded into the bed 21. A screw 22a threaded through a lug

on the bracket 20 and engaging a stop on the bed facilitates angular adjustment of the base. As shown, the end portions of the bar 16 are fixed to stationary brackets 25 carried by the bracket 20 and the carriage 11 has a portion 26 provided with an internal ball bearing 27 which rides on the bar 16. This ball bearing is protected against the entry of dirt and other foreign matter by collapsible bellows 28 positioned between the extension 26 and the supporting brackets 25. The rod 17 passes through a longer opening through the carriage 11, and in its opening it is provided with a pair of spaced sets of ball bearings 24, and the entry of foreign matter into these ball bearings is prevented by collapsible bellows 29 surrounding the bar 17 and extending above and below the carriage 11 into contact with the top and bottom wall members 30 and 31 of the bracket 20. The carriage is thus mounted on three sets of ball bearings, two on the bar 17 and one on the bar 16, thus making a three point support for the carriage.

Between the bars 16 and 17, a piston rod 35 is suitably secured at its lower end to a cross flange 36 of the carriage, and this rod extends upwardly into a hydraulic cylinder 37 mounted upon the bracket 20 and having slidable therein a piston 38 connected to the piston rod 36. By introducing a suitable fluid into the cylinder 37 on opposite sides of the piston 38, the piston may be driven upwardly and downwardly as desired, thus producing a vertical reciprocation of the carriage 11, causing the shanks 2 of the bucket then in position to be traversed between the confronting grinding faces of the wheels 15.

Means are provided by which the bucket whose shank is to be ground is held in proper position with relation to the carriage for its shank to be properly presented to the grinding wheels for the grinding operation. As shown best in Figures 1, 5, and 8, the work holder comprises a suitable block having a slot 40 therein shaped to receive the blade of the bucket and with its shank projecting outwardly therefrom. The particular construction of this holder does not form a portion of this invention, except that it is provided with a base 41 adapted to rest upon a platform portion 42 of a work-holding bracket 43 secured to the face of the carriage 11 as by screws 44. The bracket 43 is also provided at one edge with a retaining strip 45 secured thereto as by screws 46 (see Figure 8).

The platform 42 provides one locating face for the work holder, a pair of angularly related locating faces being formed by the forward face of the bracket 43, and by the rear face 47 of the retaining strip 45, and the work holder 10 is provided with corresponding faces, which when in engagement with these locating faces, presents the shank of the bucket into proper relation to the grinding wheels for the grinding operation. The work holder may be provided with a handle 48 by which it may be grasped thereby to facilitate placing the work holder with the bucket held therein in proper position for the grinding operation and for removing it from the machine after this operation has been completed.

In order to facilitate the placing and removal of the work holder, the machine is provided with a table 50 (see Figure 4) mounted for vertical adjustment as on the jacks 51 and 52, this table presenting its top face 53 substantially in horizontal alinement with the top face of the platform 42 when the platform is at its lower limit of reciprocation, where it is placed at the end of a

grinding operation and before the commencement of a new grinding cycle. This table 50 extends substantially to the forward face of the machine where it is freely accessible to the operator who may place thereon the work holder with the bucket suitably held thereby and from which he may slide the holder onto the platform 42 and to the position shown in Figure 8, preparatory to starting the grinding cycle.

Means are provided for clamping the holder in this position, and such clamping means is so related to the controls of the machine that this clamping must be effected before the grinding cycle can be initiated. This clamping mechanism embodies two holder clamps. One of these clamps 60 is fulcrumed at 61 on a bracket 62 carried by the bracket 43 and has an inclined clamping face 63 for engagement with a mating face 64 on the work holder (Figure 8). This face 64 is arranged at an angle to both the locating faces on the bracket 43 and on the retaining strip 45 so that it presses the work holder against both of these faces. The clamp 60 is connected through a pivoted link 65 to a forked head 66 at the lower end of a piston rod 67 having a piston 68 slidable in one of a pair of cylinders in a casing 69, so that by introducing fluid pressure above the piston 68, as through the pipe 70, the clamp 60 may be turned downwardly into clamping position, or by introducing fluid pressure beneath the piston 68 it may be raised to release the clamp 60. The other clamp comprises a plunger 72 vertically movable and capable of being brought down against the top face of the holder, thus to press it against the platform 42. This plunger 72 comprises a piston rod having a piston 75 at its upper end slidable within a second cylinder in the cylinder block 69. Fluid under pressure to and from these cylinders may be controlled by a hand operated four way valve 80 shown diagrammatically in Figure 10, which receives fluid under pressure through the pipe 81 from a suitable source such as a pump 82. This takes fluid from a tank 83 and discharge from the cylinders in the casing 89 takes place through the pipe 84 back to the tank.

Assuming that the work holder with a bucket therein is in position on the platform, the operator turns the valve 80 to the position shown in Figure 10, whereupon pressure passes from the pressure pipe 81 through a valve port and a pipe 85 to the upper end of the casing 89 through a pair of passages 70 and 76. From the passage 70 the pressure immediately reaches the upper face of the piston 68 which is therefore driven downwardly, bringing the clamp 60 into engagement with the work holder and pressing it firmly against the two angularly related vertical located faces. Check valves 87 and 88 prevent the fluid under pressure from immediately reaching the top face of the piston 75, but when the pressure above the piston 68 builds up sufficiently, the check valve 88 is opened and fluid under pressure passes to the upper side of the piston 75, driving this piston downwardly and clamping the work holder against the platform. This, as will later appear, closes a switch at 89 which initiates the vertical traverse of the carriage. Moving the valve 80 to its other angular position connects the pressure line 81 to the pipe 91, admitting pressure beneath both pistons 68 and 75 while pipes 70 and 76 are opened to discharge through pipe 85, valve 89 and discharge pipe 84. This unclamps both clamps 60 and 72 and opens the switch 89.

As shown best in Figure 4, the carriage 11 has

secured thereto the lower end of a rack bar 95, the upper rack portion of which engages teeth of a pinion 96. This pinion 96 is carried by a shaft 97 (see Figure 6) within a casing 98 and outwardly of the casing 98, the shaft 97 has fixed thereto a cam drum 100. This cam drum is provided with a peripheral T slot 101 and a face T slot 102, and angularly adjustable in these slots are a pair of switch actuating dogs 103 and 104 movable in parallel planes, and which are adapted to close switches 105, 106, respectively. These switches, as shown best in Figure 10, are connected to one side of a power line 107 and are adapted to be closed alternately by the switch dogs 103 and 104 as these dogs are rocked by vertical reciprocation of the rack bar 95. The closing of the switch 105 closes a connection from the line 107 through the switch 105, lead 108, solenoid 109, back to the line 110. This solenoid 109 has a reciprocable core 111, a portion of which is formed as a rack bar and engages teeth on the stem of a four-way valve 111. When so energized the core is drawn downwardly, turning the control valve 111 to the position shown in Figure 10, where fluid under pressure from the line 81 passes through the control valve 112, passage 113, the valve 111, and passage 114 beneath the piston 39, thus lifting the piston and with it the carriage 11. When the piston 38 reaches its upper limit, carrying with it the rack bar 95, the other switch dog 104 closes the switch 106 which energizes the solenoid 115 on the same core 111, reversing the valve 111, so that now pressure from the line 81 passes through the valve 111 and the pipe 116 to the upper end of the cylinder 37 and drives the piston 38 downwardly. The normally closed valve 112 is controlled by the switch 99, closing of this switch 99 energizing a solenoid 120 from the lines 107 and 110, and moving the valve 112 to its open position, whereupon the carriage reciprocating means is allowed to function. Whenever the clamping means are open, however, the valve 112 is closed, and consequently no reciprocation of the carriage may take place.

On either side of the bracket 20 which carries the traversing carriage, the bed 21 carries a wheel carriage 150, these carriages being mounted in ways for movement from and toward each other. The wheels 12 are suitably journaled at the adjacent inner end portions of these wheel carriages and they may be rotated by motors 151, belt connected thereto, these motors being mounted on the upper faces of the carriages 150. Each of these carriages is provided with a longitudinally cylindrical opening running lengthwise thereof and back of the wheels, that is, on the side of the wheels remote from the work carriage, and within these cylindrical openings are mounted for lengthwise sliding motion, wheel truing mechanisms 156. These wheel truing mechanisms may be of any suitable description, but as shown are similar to those illustrated in the Flanders Patent No. 2,292,874, granted August 11, 1942, for Wheel Truing Mechanism. Each is provided with a truing diamond 158, and this diamond may be guided to follow the desired wheel contour by a suitable cam 159 in the manner shown in the Flanders patent. They are normally pressed toward their respective wheel peripheries as by springs 160. Each truing device is provided with an adjustable bar 165 which may be moved axially against the pressure of the spring 160 to withdraw the truing device from operative relation to the grinding wheel during the desired portions of the cycle and the actuation of these bars

165 may be as shown in that patent and in the Flanders Patent No. 2,184,011 for Grinding Machines, granted December 19, 1939. As this forms no part of the present invention it will not be described herein.

As shown best in Figure 19, the wheel carriage 150 is mounted directly on a second carriage 170 which directly contacts with the bed 21, both carriages being slidable in the same direction. Yielding means are provided for holding each carriage 170 retracted as far as permitted by controlling mechanism, and as shown this yielding means may comprise a chain 171 passing about a sprocket wheel 172 journaled in the bed and secured at its upper end to a lug 173 depending from the carriage 170. A spring 174 is secured to the lower portion of the chain 171 and to a fixed portion of the base and holds the carriage 170 backwardly as far as is permitted by a shaft 176 journaled in the lug 173 of the carriage 170 and having an outer end portion 177 in threaded engagement with a sleeve 178 slidably mounted in a fixed casing portion 179 and carrying on its outer end a cam drum 180. In line with the shaft 176 (see Figure 12), a lever 181 bears against the outer face of the cam drum 180 through a ball contact 182. This lever 181 is fulcrumed at 183 to a stationary side casing member 184 within which is journaled a shaft 185. At its rear end this shaft 185 carries a pinion 186 which meshes with a gear 187 carried by a sleeve 188 through which the sleeve 178 is slidably keyed. Thus by rotation of the shaft 185, the gear 187 is rotated, rotating the sleeve 178 and thus changing its lengthwise position with respect to the shaft 176, and this is done without changing the axial position of the sleeve 178 as determined by the angular position of the lever 181. The shaft 176 is thus adjustable lengthwise by rocking the lever 181, and independently of this adjustment by turning the sleeve 178. Turning the sleeve 178 is relied upon to provide the axial feed motion for each wheel toward and from the work, and this feed motion, as will later appear, is connected to both wheels for simultaneous adjustment. The wheel carriage motion produced by rocking the lever 181 is for adjustment individually of each wheel slide independently of the other, and is done by a manual operation as will later appear.

To this end, the shaft 185, there being one such at each end of the machine, carries at its forward end a bevel pinion 190 with which meshes a similar pinion 191 carried by a hollow shaft 192. The hollow shaft 192 extends toward the central portion of the machine and carries on its inner end a pinion 193 (see Figure 18) with which meshes a pinion 194 on a feed shaft 195. Extending through the hollow shaft 192, is a second shaft 196 (Figure 12), the outer end of which is threaded at 197 through a fixed nut 198 and carries an abutment 199 at its outer end engaging a ball abutment 200 on the forward end of the lever 181. By rotation of the shaft 196, it is evident that its axial position will be varied by reason of its threaded engagement in the fixed nut 198, and consequently the lever 181 will be rocked on its fulcrum, this adjusting the sleeve 178 axially and thus producing an adjustment of the wheel carriage independent of its motion by the rotation of the threaded sleeve 178. The shaft 196 extends through the hollow shaft 192 and carries on its inner end means such as a hand wheel 203 by which it may be rotated to any desired variable extent.

The shaft 195, by the turning of which the feed motion of the wheel carriage is produced, may carry thereon any suitable form of power ratchet feed mechanism such as is well known in the art and which is intermittently actuated, such a feed mechanism being shown generally at 201 and embodying a vertical link 202 which is raised and lowered intermittently. The links 202 for the two wheels may be connected together by crank and link work 204 and 205 for simultaneous operation.

An additional feed of the wheel carriage to provide for wear and truing of the wheel is provided by producing an additional motion to the carriage 150. This is produced by rotation of a shaft 210, which is journaled against axial motion in a bracket portion 211 of the carriage 170, shown best in Figure 19, and has threaded connection with a bracket 213 secured to and depending from the carriage 150. This shaft 210 has a splined or slip joint connection at 212 with a shaft 214 positioned above the shaft 176 and journaled in the stationary casing 184 above the shaft 176. Within the casing 184, the shaft 214 has fixed thereto a bevel pinion 215 which meshes with a similar pinion 216 on a shaft 217 positioned above the shaft 185. At its forward end the shaft 217 carries a bevel pinion 218 which meshes with a similar pinion 219 carried by a horizontal shaft 220. This shaft extends part way across the front of the machine, as shown best in Figures 1 and 18, and as shown in Figure 18, has a bevel pinion 221 at its inner end meshing with a bevel pinion 222 on a forwardly extending shaft 223 having an intermittent ratchet power feed mechanism 224 of usual type thereon. This intermittent feed mechanism includes a vertical link 225 and the two vertical links 255 are connected together through lever and link mechanism 226, 227 so that the feed motions of the wheels to compensate for wheel wear and truing are accomplished simultaneously.

Power means for actuating the main feed and the supplemental feed comprise the fluid pressure cylinders 230 and 231 suitably connected to the actuating linkages for one only of the wheels as shown in Figure 1. These may be actuated in the well known manner and no further description thereof is deemed necessary.

Means are provided by which when the main feed of the wheel carriages has reached a position where the work has been reduced to the desired finished size, the wheel carriages are automatically retracted preparatory to initiation of a subsequent grinding cycle. To this end there is provided, journaled on each of the feed shafts 192, the hub of a gear 230 and this hub provides for a lost motion driving connection between it and the shaft 192 by the provision of a pin 231 extending therefrom and in the path of motion of which is a similar pin 232 carried by a collar 233 fixed to the shaft 192. These parts thus provide a lost motion or one direction coupling between the gear 230 and the shaft 192. Meshing with each of these gears 230 is a vertical rack bar 235 mounted for axial motion and secured to the upper end of a piston rod 236, the fluid pressure cylinder 237 (see Fig. 20) for which having a double acting piston 238 therein. These parts are normally in their lowered position, shown in Figure 20, the gear 230 being stationary and the pins 231 and 232 being so disposed as to offer no obstruction to the turning of the shaft 192 in a direction to feed the wheel carriages toward each other.

As soon, however, as the feed shaft 176 has rotated sufficiently for a stop dog 240 carried to engage the beveled face of a switch actuating lug 241 and force this lug outwardly, rocking an arm 242 carried by a rock shaft 243 and rocking an arm 244 fixed thereto against a switch 245, this switch is closed (see Figure 9). As shown in Figure 20 the closing of this switch energizes a solenoid 246 from a source of power 247, moving a valve 248 to the position shown, allowing fluid under pressure from a suitable source to enter through the pressure pipe 31 past the valve 248 and into the cylinder 237 through the pipe 250, this acting to lift the piston 238 and rotate the gear 230 in a direction to engage and return the feed shaft 192 to its starting position. Retraction of this shaft also retracts the stop cam 240 and reverses the fluid connections to the cylinder 237, thus returning the gear 230 to its former position.

A positive stop arm 255 is normally held by a spring 256 in position to be contacted by the stop dog 240 but it may be rocked out of stopping position by exerting a pull on the cable 257 attached to the lower end of the arm 255. The forward end of the cable 257 is connected to one arm of a bell crank lever 258, the other arm being connected to a cable 259 extending to a hand lever 260 mounted on the front of the machine. While the stop switch 245 is actuated at each rotation of the shaft 176 when the grinding wheel is advanced by turning the hand wheel 203, the power is off when this is done so that it has no effect.

Assuming that the machine has been properly set up with the bracket 20 adjusted at the proper angular position so that when the bucket, carried by the work support, is in position with its locating faces in contact with the locating faces of the bracket 20, and with the initial positions of the grinding wheels properly adjusted, the operator places upon the work table 50 a work holder carrying a bucket, the shank of which is to be operated upon. The operator then slides the work holder, with the bucket therein, over against the locating faces of the bracket 20. He then turns the valve 80 in such a manner as to bring the clamping jaw 60 into position to press the work holder against the locating faces, after which the top clamp 72 descends to press the work holder firmly against the platform 2. As soon as this has been effected, the power means for reciprocating the platform vertically is started into action automatically, and between reciprocations the grinding wheels are moved step by step toward each other to engage the shank of the bucket therebetween. The initial relative positions of the grinding wheel edges and the bucket shank is shown in Figure 13, and the bucket shank is moved up and down between the wheels as shown in Figures 16 and 17, while these wheels are intermittently moved toward each other until finally the bucket shank is ground to the desired contour and dimensions, as shown in Figure 15. During the feed of the wheels, at suitable times, the truing devices are fed against their outer faces and the wheels are given a corresponding additional feed to compensate for the reduced wheel diameter caused by wear and truing. When the bucket shank has been reduced to desired dimensions, the stop switch 245 is energized by the action of the wheel feed mechanism, which acts to retract the feed mechanism to separate the wheels so that when the work piece has been lowered and unclamped

the work piece can be removed and a new one inserted in position preparatory to the start of the next cycle of operations.

The final configurations of the bucket shanks are as shown in Figures 2 and 3, forming what is known in the trade as the "Christmas tree." It will be understood that this shank portion is later on engaged in a correspondingly shaped recess in the wheel or hub portion to form the turbine wheel.

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

We claim:

1. A grinding machine comprising a pair of grinding wheels arranged with active edge portions spaced apart, a work support for supporting work with a portion in said space, said work support having a platform and a pair of angularly related faces above said platform, a work holder having a base and wall portions and means for clamping a work piece therein in fixed relation to said base and wall portions, means for clamping said work holder against said angularly related faces, and means for clamping said work holder against said platform.

2. A grinding machine comprising a pair of grinding wheels arranged with active edge portions spaced apart, a work support for supporting work with a portion in said space, said work support having a platform and a pair of angularly related faces above said platform, a work holder having a base and wall portions and means for clamping a work piece therein in fixed relation to said base and wall portions, means for clamping said work holder against said angularly related faces, means for clamping said work holder against said platform, and means for actuating said work holder clamping means in predetermined sequence.

3. A grinding machine comprising a pair of grinding wheels arranged with active edge portions spaced apart, means for rotating said wheels, a work support having a platform for supporting work with a portion in said space, means for reciprocating said support to cause said work portion to traverse said space, a work holder having a face for engagement on said platform and having means for locating a work piece in predetermined relation to said face, means for clamping said work holder in predetermined relation on said platform, and a table carried by said machine adjacent to the line of reciprocation of said work support and having a top face substantially at the level of said platform when said platform is in loading position, said table being in position to initially support said work holder and from which it may be slid onto said platform into position for the grinding operation.

4. A grinding machine comprising a pair of grinding wheels arranged with active edge portions spaced apart, means for rotating said wheels, a work support for supporting work with a portion extending into said space, means for moving said support in a direction perpendicular to a line joining the centers of said wheels, means for actuating said moving means alternately in opposite directions to reciprocate said support, means independent of said moving means for feeding said wheels simultaneously and equally toward each other to narrow said space, a truing device for each wheel on the opposite side of

each wheel from said space, and means for simultaneously feeding said truing devices equally toward the axis of the corresponding wheel.

5. A grinding machine comprising a pair of grinding wheels arranged with active edge portions spaced apart, means for rotating said wheels, a work support for supporting work with a portion extending into said space, means for moving said support in a direction perpendicular to a line joining the centers of said wheels, means for actuating said moving means alternately in opposite directions to reciprocate said support, means independent of said moving means for feeding said wheels simultaneously and equally toward each other to narrow said space, a truing device for each wheel on the opposite side of each wheel from said space, means for simultaneously feeding said truing devices equally toward the axis of the corresponding wheel, and means for adjusting each truing device independently of the other.

6. A machine of the class described comprising a reciprocable table, means for reciprocating said table, a work holder, means for clamping said work holder to said table, a tool with reference to which work carried by said holder when said holder is in said clamped position is reciprocated by the reciprocation of said table, operator actuable means for actuating said clamping means to clamp or release the work, and means actuated by the clamping of the work piece to initiate said reciprocating means.

7. A machine of the class described comprising a reciprocable table, means for reciprocating said table, a work holder, means for clamping said work holder to said table, a tool with reference to which work carried by said holder when said holder is in said clamped position is reciprocated by the reciprocation of said table, means for actuating said clamping means to clamp or release the work, and means preventing actuation of said reciprocating means until said clamping means has been placed in work-clamping condition actuated by the clamping of the work piece to initiate said reciprocating means.

8. A machine of the class described comprising a reciprocable work holder, a tool movable toward and from said work holder, means for so moving said tool including a shaft rotatable in one direction to move said tool toward the work and in the opposite direction to retract the tool from the work, a gear on said shaft, a one way clutch connection between said gear and shaft rotating said shaft in tool retracting direction on corresponding rotation of said gear, and means actuated on feed of said tool to a predetermined point to rotate said gear in said direction to retract said tool from the work.

9. A machine of the class described comprising a reciprocable work holder, a tool movable toward and from said work holder, means for so moving said tool including a shaft rotatable in one direction to move said tool toward the work and in the opposite direction to retract the tool from the work, a gear on said shaft, a one way clutch connection between said gear and shaft rotating said shaft in tool retracting direction on corresponding rotation of said gear, a reciprocable rack engaging said gear, power means for moving said rack in a direction to retract said tool from the work, and means actuated by the rotation of said shaft to a predetermined angular position in tool feed direction to actuate said power means.

10. In a machine of the class described, a re-

reciprocable tool carriage, means for reciprocating said carriage including parts comprising a lead screw and nut one of said parts being rotatable, means for rotating said rotatable part, the other of said parts being connected to said carriage, a member bearing coaxially on said rotary part, said rotary part being mounted for axial motion, and means for variably moving said member to adjust said rotary part axially to thereby adjust the position of said carriage corresponding to any specific angular position of rotation of said rotary part.

11. In a machine of the class described, a reciprocable tool carriage, means for reciprocating said carriage including parts comprising a lead screw and nut one of said parts being rotatable, means for rotating said rotatable part, the other of said parts being connected to said carriage, a lever bearing at one end coaxially on said rotary part, a hollow rotary shaft substantially parallel to the direction of reciprocation of said carriage, driving connections from said hollow shaft to said rotary part, an adjusting rotary and axially movable shaft within said hollow shaft and having a threaded portion, a fixed nut engaging said threaded portion, said adjusting shaft bearing against said lever, means for rotating said hollow shaft to thereby move said carriage, and means for rotating said adjusting shaft to thereby adjust said rotary part axially and thereby adjust the relation between said carriage position and the angular position of said hollow shaft.

12. A machine of the class described, comprising a work support having a platform and a pair of angularly related faces above said platform, a work holder having a base and wall portions and means for clamping a work piece therein in predetermined relation to said base and wall portions, means for clamping said work holder with its base against said platform and said wall portions against said angularly related faces, and means for performing a tooling operation on the work piece in predetermined relation to said platform and to said angularly related faces.

13. In a machine of the class described, a reciprocable tool carriage, means for reciprocating said carriage including parts comprising a lead screw and nut one of said parts being rotatable, means for rotating said rotatable part, the other of said parts being connected to said carriage, a member bearing coaxially on said rotary part, said rotary part being mounted for axial motion, and screw and nut means for adjusting said mem-

ber to adjust said rotary part axially to thereby adjust the position of said carriage corresponding to any specific angular position of rotation of said rotary part.

14. A machine of the class described comprising a work support having a platform and a pair of angularly related faces above said platform, a work holder having a base and wall portions and means for clamping a work piece therein in predetermined relation to said base and wall portions, a tool, means for clamping said work holder against said platform and against said angularly related faces and in predetermined relation to said tool, and means for relatively moving said work support and tool to cause said tool to perform a tooling operation on a work piece clamped in said holder.

15. A machine of the class described comprising a work support having a platform for supporting a work holder, a tool, means for reciprocating said support relative to said tool, a work holder having a face for engagement on said platform and having means for locating a work piece in predetermined relation to said face, means for clamping said work holder in predetermined relation on said platform, and a table carried by said machine adjacent to the line of reciprocation of said work support and having a top face substantially at the level of said platform when said platform is in loading position, said table being in position to initially support said work holder and from which it may be slid onto said platform into position for the tooling operation by said tool.

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