Sept. 29, 1942. F. E. JOHNSON 2,297,654

CRANKSHAFT GRINDING MACHINE

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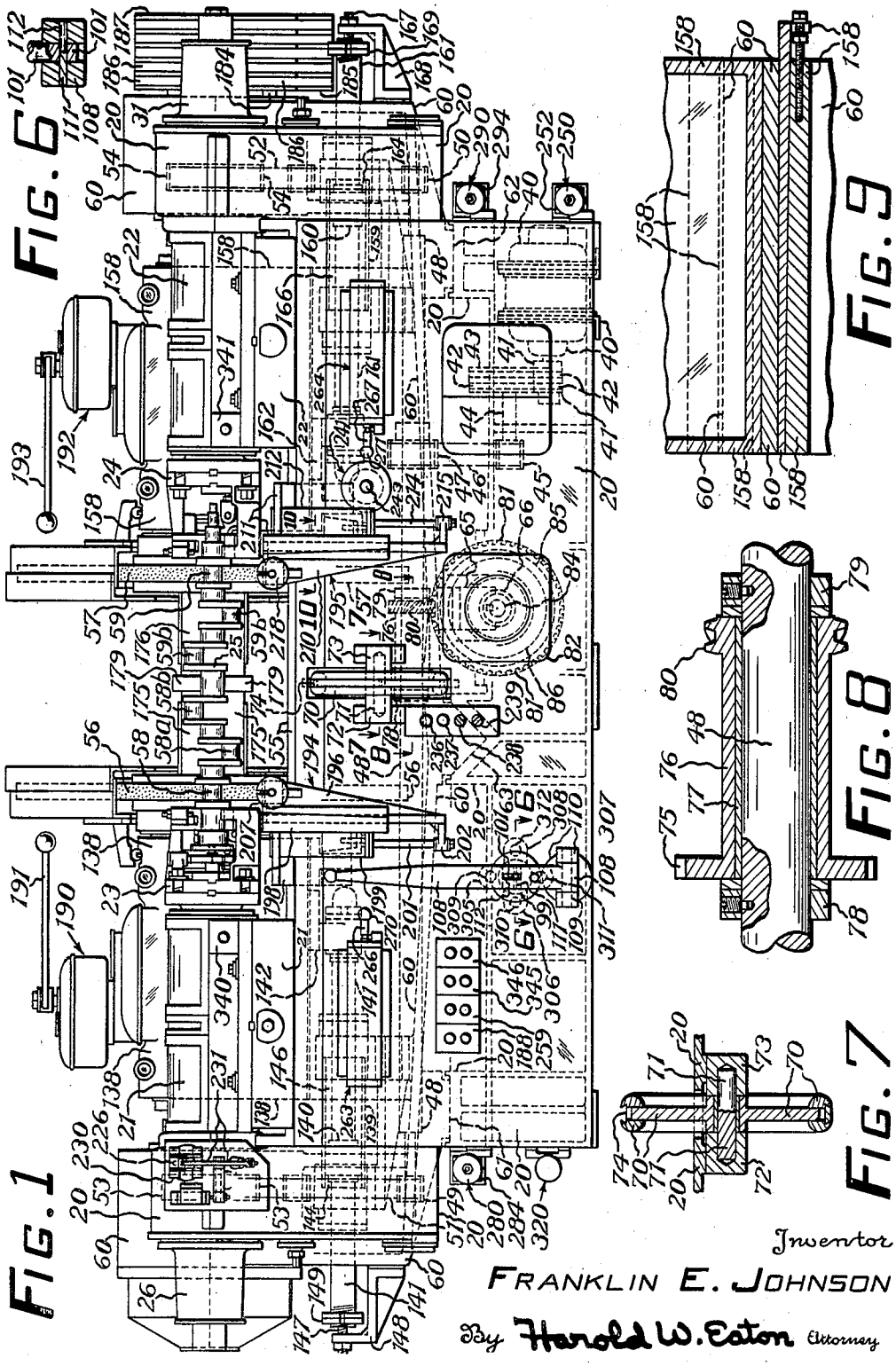


FIG. 1

FIG. 9

FIG. 8

FIG. 7

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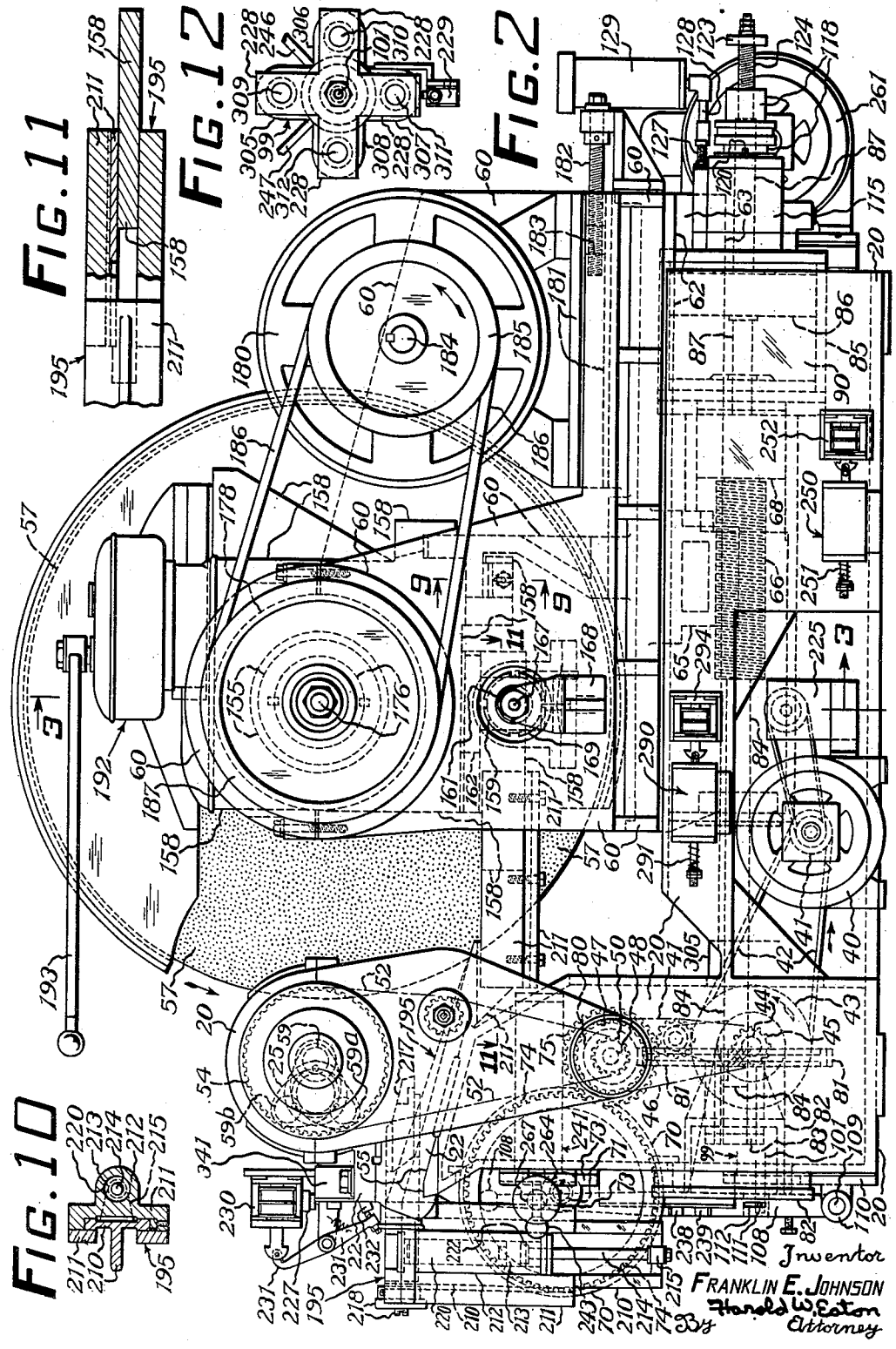
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FIG. 3

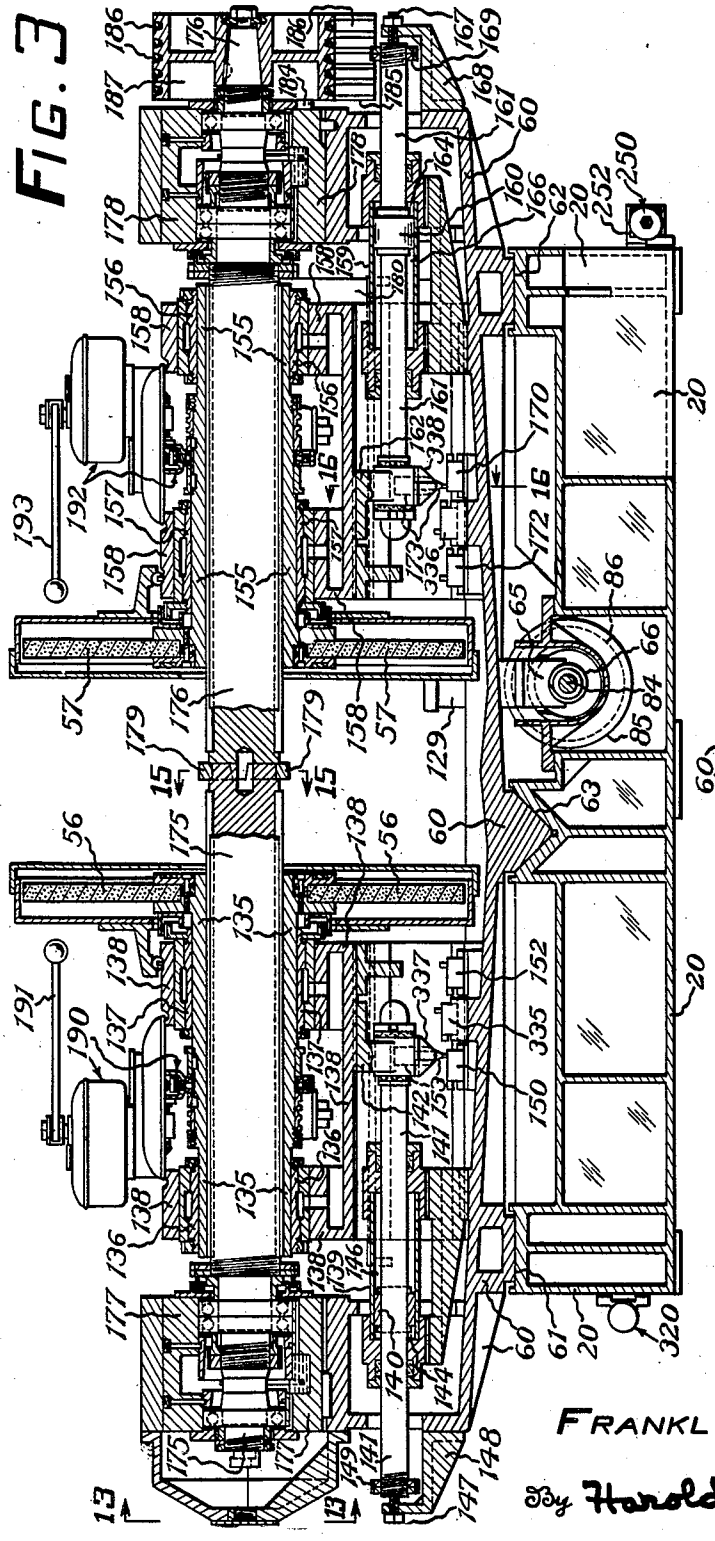


FIG. 16

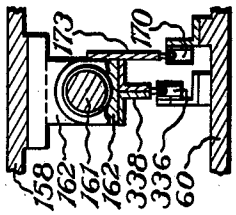


FIG. 15

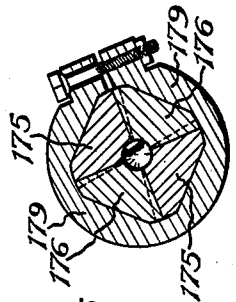


FIG. 14

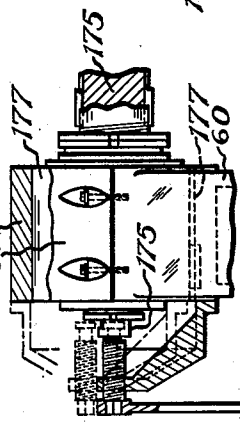
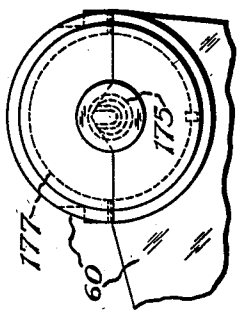


FIG. 13



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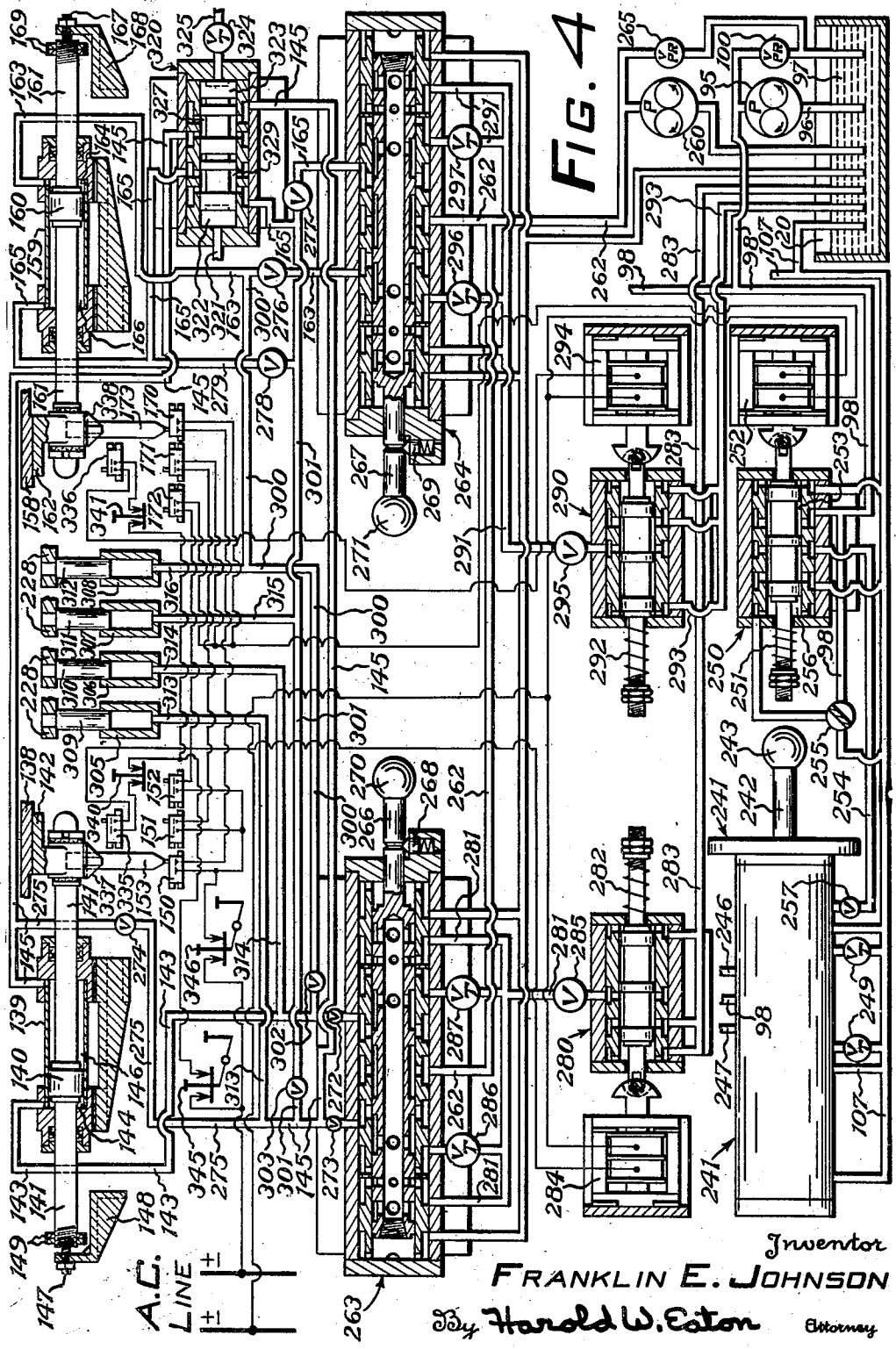
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FIG. 4



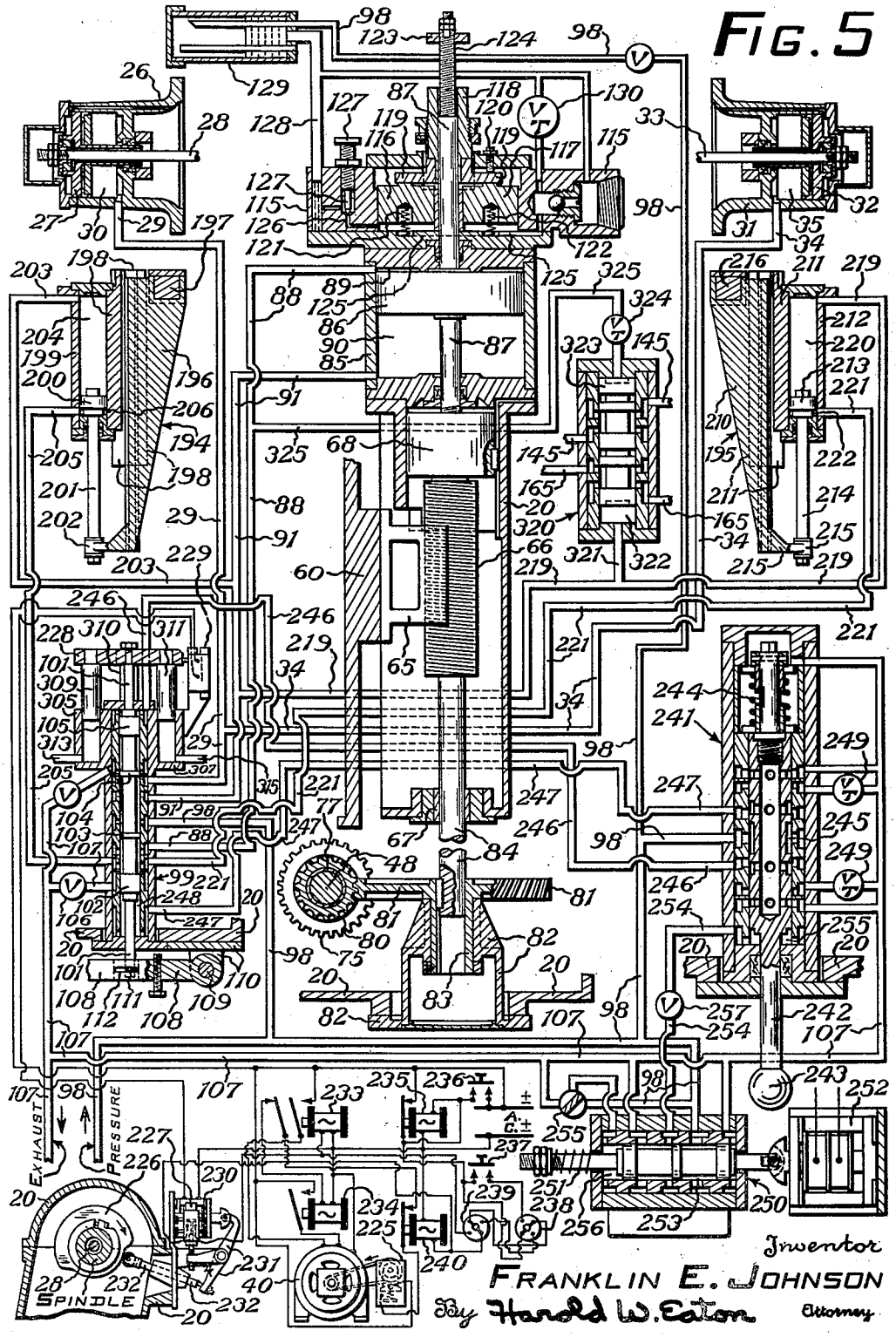
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FIG. 5



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Patented Sept. 29, 1942

2,297,654

UNITED STATES PATENT OFFICE

2,297,654

CRANKSHAFT GRINDING MACHINE

Franklin E. Johnson, Worcester, Mass., assignor to Norton Company, Worcester, Mass., a corporation of Massachusetts

Application November 5, 1941, Serial No. 417,918

12 Claims. (Cl. 51—72)

The invention relates to grinding machines, and more particularly to a double work head type multiple wheel crankshaft grinding machine.

One object of the invention is to provide a multiple wheel crankshaft grinding machine in which a pair of spaced grinding wheels are arranged simultaneously and successively to grind pairs of spaced aligned crankpins on a crankshaft. Another object of the invention is to provide a multiple wheel grinding machine in which a transversely movable wheel slide serves as a support for a pair of longitudinally movable grinding wheel heads which are arranged for a longitudinal indexing movement simultaneously to position the grinding wheels successively into operative relation with spaced pairs of aligned pins on a crankshaft. A further object of the invention is to provide a multiple wheel grinding machine in which an electrically controlled fluid pressure interlock is provided between the grinding wheel feeding mechanism and the grinding wheel traversing or indexing mechanism.

Another object of the invention is to provide a fluid pressure interlock between the longitudinal grinding wheel traversing or indexing mechanism and the grinding wheel feeding mechanism which is arranged so that when the index control valve is shifted to initiate an indexing movement of one or both of the grinding wheels, the grinding wheel feed control valve is automatically shifted to move the grinding wheel slide rearwardly to an inoperative position before the grinding wheel indexes longitudinally. A further object of the invention is to provide an electrically controlled interlock which is arranged so that a wheel feeding movement cannot be initiated until both of the grinding wheels are indexed into corresponding aligned positions relative to the crankpins to be ground. Other objects will be in part obvious or in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements, and arrangements of parts, as will be exemplified in the structure to be hereinafter described, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawings in which is shown one of many possible embodiments of the mechanical features of the invention,

Fig. 1 is a front elevation of the improved crankshaft grinding machine;

Fig. 2 is a right-hand elevation, on an enlarged scale, of the crankshaft grinding machine shown in Fig. 1;

Fig. 3 is a vertical sectional view, on a reduced scale, taken approximately on the line 3—3 of Fig. 2;

Fig. 4 is an electrical wiring and hydraulic diagram of a portion of the control for the machine, showing the controls for the longitudinal indexing movement of the grinding wheels;

Fig. 5 is an electrical wiring and hydraulic diagram of the remaining controls for the machine which supplements Fig. 4 and shows the hydraulic controls for the grinding wheel feed, steadyrest and work clamping mechanism together with the electric work stop control;

Fig. 6 is a fragmentary sectional view, on an enlarged scale, taken approximately on the line 6—6 of Fig. 1, showing the connection between the main control lever and the valve stem;

Fig. 7 is a fragmentary cross sectional view, on an enlarged scale, taken on the line 7—7 of Fig. 1;

Fig. 8 is a longitudinal horizontal sectional view, on an enlarged scale, taken approximately on the line 8—8 of Fig. 1, showing a portion of the grinding wheel feeding mechanism;

Fig. 9 is a fragmentary vertical sectional view, taken approximately on the line 9—9 of Fig. 2, showing the slideways between the wheel slide and the wheel head;

Fig. 10 is a fragmentary cross sectional view, on an enlarged scale, taken approximately on the line 10—10 of Fig. 1, showing a section through the steadyrest and its actuating mechanism;

Fig. 11 is a fragmentary horizontal sectional view, on an enlarged scale, taken approximately on the line 11—11 of Fig. 2;

Fig. 12 is a rear elevation of the main control valve, showing the fluid pressure interlock mechanism shown in rear elevation;

Fig. 13 is a fragmentary end elevation, taken on the line 13—13 of Fig. 3;

Fig. 14 is a fragmentary sectional view through the end thrust and radial bearing support for the right-hand grinding wheel;

Fig. 15 is a fragmentary sectional view, on an enlarged scale, taken approximately on the line 15—15 of Fig. 3, through the coupling connecting the two aligned grinding wheel drive shafts or spindles; and

Fig. 16 is a fragmentary vertical cross sectional view, on an enlarged scale, taken approximately on the line 16—16 of Fig. 3, through a portion of the grinding wheel longitudinal indexing control mechanism.

A double work head type multiple wheel crankshaft grinding machine has been illustrated in the drawings comprising a base 20 which serves as a support for a pair of spaced aligned work heads 21 and 22. The work heads 21 and 22 serve as supports for a pair of spring actuated hydraulically released pot chucks 23 and 24 which are arranged in opposed relationship with each other and are arranged to rotate about a common axis. The pot chucks 23 and 24 are arranged to support and clamp the opposite ends of a crankshaft 25 for a rotary motion during a grinding operation. The supporting spindles therefor have not been illustrated in detail since these features are not considered to be a part of the present invention. These pot chucks together with their supporting spindles are substantially the same as those disclosed in the prior U. S. Patent to Herbert A Silven and Albert G. Belden, No. 1,837,342, dated December 22, 1931, and the patent to Herbert A. Silven, No. 2,151,666 dated March 21, 1939, to which reference may be had for details of disclosure not contained herein. The work clamping jaws on each of the pot chucks 23 and 24 are actuated by a spring pressure mechanism substantially the same as that shown in the above-mentioned prior patents. The clamping jaws are released by a hydraulic mechanism comprising a hydraulic cylinder 26 which is provided with a slidably mounted piston 27. A piston rod 28 passes through the work head 21 and is arranged to release the clamping jaw, after a grinding operation has been completed, in a manner substantially the same as that shown in the above-mentioned prior patents.

When it is desired to release the clamping jaw of the pot chuck 23, fluid under pressure is admitted through the pipe 29 into a cylinder chamber 30 to cause the piston 27 to move toward the left (Fig. 5). Similarly, a hydraulic cylinder 31 is mounted on the right-hand end of the machine and contains a slidably mounted piston 32 which is connected by means of a piston rod 33 to actuate the clamping jaw of the pot chuck 24 so as to release the same when fluid under pressure is admitted through a pipe 34 into a cylinder chamber 35 to cause the piston 32 and the piston rod 33 to move toward the right (Fig. 5).

Work drive

A driving mechanism is provided synchronously to rotate the pot chucks 23 and 24. This mechanism may comprise an electric motor 40 which is provided with a multi-V-groove pulley 41. The pulley 41 is connected by multiple V-belts 42 with a multi-V-groove pulley 43 which is mounted on one end of a rotatable shaft 44. The shaft 44 (Figs. 1 and 2) is rotatably journalled in bearings (not shown) in the base 20. A sprocket 45 is mounted on the other end of the shaft 44 and is connected by means of a link chain 46 with a sprocket 47 which is mounted on a rotatable shaft 48 which is journalled in suitable bearings (not shown) within the base 20. The shaft 48 is provided at its opposite ends with sprockets 49 and 50. The sprockets 49 and 50 are connected by link chains 51 and 52, respectively, with sprockets 53 and 54 which are operatively connected synchronously to rotate the pot chucks 23 and 24, respectively, to rotate the crankshaft 25 to be ground. This driving mechanism has not been illustrated in minute detail since this mechanism is identical with that shown in the prior U. S. Patent to Herbert A. Silven, No. 2,151,666 dated March 21, 1939, to which reference may be had for details of disclosure not contained herein. The upper surface of the base 20 is provided with a longitudinally extending dovetailed slideway 55 which mates with correspondingly shaped ways formed on the under side of the work heads 21 and 22. The work heads 21 and 22 may be clamped in adjusted position on the slideway 55, and may be adjusted longitudinally along the slideway 55 to facilitate setting up the machine for grinding crankshafts of different lengths.

Manual grinding wheel feed

In order that pairs of aligned crankpins on a crankshaft may be simultaneously and successively ground, a pair of transversely movable rotatable grinding wheels 56 and 57 are provided for simultaneously grinding a pair of aligned crankpins 58 and 59. The grinding wheels 56 and 57 are rotatably and longitudinally supported on a transversely movable wheel slide 60 which is arranged to move transversely relative to the base 20 on a pair of spaced flat ways 61 and 62 and an intermediate V-shaped guiding way 63 formed on the upper surface of the base 20. The slideways 61, 62 and 63 mate with correspondingly shaped ways formed on the under side of the wheel slide 60.

A wheel feeding mechanism is provided for moving the wheel slide 60 transversely simultaneously to feed the grinding wheels 56 and 57 toward or from the crankshaft 25 to be ground. This feeding mechanism may comprise a half nut 65 depending from the under side of the wheel slide 60 which meshes with or engages a rotatable cross feed screw 66. The cross feed screw 66 is journalled in a bearing 67 which is fixed relative to the base 20. The rear end of the feed screw is journalled in a slidably mounted sleeve 68.

The feed screw 66 may be manually rotated to produce a manual transverse feeding movement of the wheel slide 60 either to produce a grinding feed or for use in setting up the machine for a grinding operation. A rotatable feed wheel 70 is rotatably supported on a stud 71 journalled in bearings 72 and 73 mounted on the front of the machine base 20. The hand wheel 70 is provided with gear teeth 74 which mesh with a gear 75. The gear 75 is preferably formed integral with a rotatable sleeve 76 having a sleeve bearing 77 which rotatably supports the sleeve 76 and gear 75 on a portion of the rotatable drive shaft 48. The sleeve 76 is held against endwise movement on the shaft 48 by a pair of collars 78 and 79 which are fixedly mounted with respect to the drive shaft 48. A spiral gear 80 is also formed integral with the sleeve 76 and meshes with a spiral gear 81. The spiral gear 81 is rotatably journalled in a bearing 82 which is fixedly mounted with respect to the base 20. The spiral gear 81 and a hub 83 formed integral therewith are slidably keyed to the forward reduced end portion 84 of the feed screw 66. It will be readily apparent from the foregoing disclosure that rotary motion of the manually operable feed wheel 70 will be transmitted through the gear mechanism above described to impart a rotary motion to the feed screw 66 to cause a transverse feeding movement of the wheel slide 60 and the pair of spaced grinding wheels 56 and 57.

Dash pot and positive stop

In order to move the wheel slide 60 trans-

versely to move the grinding wheels 56 and 57 transversely for a considerable distance, that is, in moving the grinding wheels to and from an operative grinding position and also to impart a power feeding, a hydraulically operated mechanism is provided comprising a cylinder 85 which is supported in fixed relation with the base 20. The cylinder 85 contains a slidably mounted piston 86 which is connected to a piston rod 87. The piston rod 87 extends in both directions from the piston 86 and is connected at its lower end (Fig. 5) to the slidably mounted sleeve 68. It will be readily apparent from the foregoing disclosure that if fluid under pressure is admitted through a pipe 88 into a cylinder chamber 89, the piston 86 will be moved downwardly (Fig. 2) to impart a transverse feeding movement through the feed screw 66 and half nut 65 to move the wheel slide 60 transversely to feed the grinding wheels 56 and 57 toward the crankshaft 25 to be ground. During this forward feeding movement of the wheel slide 60, fluid is exhausted from a cylinder chamber 90, through a pipe 91.

A fluid pressure system is provided for conveying fluid under pressure to the cylinder 85, comprising a motor driven fluid pump 95 which draws fluid through a pipe 96 from a reservoir 97 and forces fluid under pressure through a pipe 98, to a manually operable main control valve 99. A relief valve 100 is connected to the pipe line 98 and serves to exhaust excess fluid under pressure into the reservoir 97. The main control valve 99 is a piston type valve comprising a valve stem 101 having a plurality of valve pistons 102, 103, 104 and 105 formed integrally therewith. In the position of the parts shown in Fig. 5, fluid under pressure within the pipe 98 passes into a valve chamber located between the valve pistons 103 and 104 and passes out through the pipe 91, into the cylinder chamber 90 to move and hold the piston 86 in its rearward position so as to move the grinding wheels 56 and 57 rearwardly to an inoperative position. During this movement fluid under pressure exhaust from the cylinder chamber 89, through the pipe 93, into a valve chamber located between the valve pistons 102 and 103, and out through a variable throttle valve 106 and a pipe 107, into the reservoir 97.

A manually operable control lever 108 is pivotally mounted on a stud 109 which is in turn supported by a bracket 110 fastened to the front of the machine base 20. The valve stem 101 is provided with a transversely extending pin 111 the opposite ends of which ride in an elongated slot 112 formed in the control lever 108.

When it is desired to feed the grinding wheels transversely toward the crankshaft 25 to be ground, the control lever 108 is swung in a counterclockwise direction (Fig. 5) so that fluid under pressure passing through the pipe 98 into the valve chamber located between the valve pistons 103 and 104 passes outwardly through the pipe 88 into the cylinder chamber 89 to cause the piston 86 to move toward the left (Fig. 2) to impart a corresponding movement to the feed screw 66 and the wheel slide 60 which in turn transmits a corresponding transverse movement to the spaced rotatable grinding wheels 56 and 57.

In order to obtain a slow uniform grinding feed of the grinding wheels 56 and 57, a dash pot feed control mechanism is provided comprising a casing 115 which is mounted on the rear end of the cylinder 85. The dash pot casing 115 contains a pair of spaced slidably mounted dash pot pistons 116 and 117. A slidably mounted sleeve 118 is supported on the rear portion of the piston rod 87. The sleeve 118 has a flanged portion 119 which is fixedly secured thereto. The flange 119 is arranged to engage the rear end faces of the dash pot pistons 116 and 117, respectively. A stop screw 120 engages the flange 119 and thereby serves to limit the rearward movement of the dash pot pistons 116 and 117 under the influence of compression springs 121 and 122.

The rapid forward feeding movement of the grinding wheels 56 and 57 with the wheel slide 60 continues until an adjustable collar 123 on a threaded portion 124 of the piston rod 87 engages the rear end of the sleeve 118 (Fig. 2). Continued forward movement of the piston rod 87 moves the sleeve 118 and the flange 119 into engagement with ends of the dash pot pistons 116 and 117. The rapid approaching or feeding movement of the grinding wheels 56 and 57 toward the crankshaft 25, as produced by the piston 86, is reduced to a slower predetermined grinding feed due to the fact that fluid confined within the dash pots is interconnected by a passage 125 to exhaust fluid under pressure through a passage 126, a needle valve 127, and through a pipe 128 into a fluid reservoir 129. By adjusting the aperture of the needle valve 127 and the throttle valve 130, a desired and predetermined infeeding movement of the grinding wheels 56 and 57 and their supporting wheel slide 60 may be obtained. The dash pot feeding mechanism above described is substantially identical with that shown in the prior U. S. patent to Bernhard H. Goehring, No. 2,151,660 dated March 21, 1939, to which reference may be had for details of disclosure not contained herein.

Grinding wheel index control

The grinding wheels 56 and 57 are arranged so that they may be positively and synchronously rotated during a grinding operation. The grinding wheels 56 and 57 are also arranged so that they may be indexed longitudinally, successively to position the wheels opposite pairs of spaced aligned crankpins on the crankshaft 25 to grind the same.

The grinding wheel 56 is supported on a rotatable wheel spindle 135 (Fig. 3) which is journalled in bearings 136 and 137. The bearings 136 and 137 are supported in a longitudinally slidable wheel head 138 which is arranged to slide longitudinally relative to the wheel slide 60. A fluid pressure operated mechanism is provided for indexing the wheel head 138 longitudinally to position the grinding wheel 56 successively in operative position with the successive crankpins to be ground.

A hydraulic cylinder 139 is fixedly mounted on the wheel slide 60 (Fig. 3). A piston 140 is slidably supported within the cylinder 139 and is fixedly mounted on a piston rod 141. The right-hand end of the piston rod 141 is fixedly connected to a bracket 142 which is in turn fixedly mounted to the wheel head 138. It will be readily apparent from the foregoing disclosure that when fluid is admitted through a pipe 143, into a cylinder chamber 144, the piston 140 together with the piston rod 141, the bracket 142, and the wheel head 138 together with the grinding wheel 56 will be moved toward the right (Figs. 3 and 4). Similarly, when fluid under pressure

is admitted through a pipe 145, into a cylinder chamber 146, the piston 140 together with the connecting parts will move the wheel head 138 toward the left. A stop screw 147 is mounted on a bracket 143 which is in turn fixedly supported on the left-hand end of the wheel slide (Fig. 3) and serves to limit the movement of the piston 140 together with the wheel head 138 in a direction toward the left (Figs. 1 and 3). A pair of collars 149 are adjustably mounted on a threaded portion of the piston rod 141 adjacent to its left-hand end (Figs. 1, 3 and 4). The collars 149 are arranged to engage the end face of the cylinder 139 and serve to limit the movement of the piston 140 and the wheel head 138 toward the right (Figs. 1, 3 and 4) precisely to locate the grinding wheel 56 for grinding crankpin 58b (Fig. 1).

A plurality of normally open limit switches 150, 151 and 152 are arranged in the path of a cam 153 which is mounted on the bracket 142 (Figs. 3 and 4). The switches 150, 151 and 152 are mounted on the wheel slide 60 and serve in a manner to be hereinafter described successively to stop the wheel head 138 in successive predetermined grinding positions with the grinding wheel 56 located opposite successive crank-pins on the crankshaft 25 to be ground.

Similarly, the grinding wheel 57 is supported at one end of a rotatable wheel spindle 155 which is journalled in bearings 156 and 157 which are in turn supported in a longitudinally movable wheel head 158. The wheel head 158 is slidable longitudinally on suitable mating ways on the wheel slide 60 to maintain the wheel head 158 in its proper operating position, as shown in Figs. 2 and 9. A fluid pressure mechanism is provided for indexing the wheel head 158 longitudinally comprising a fluid pressure cylinder 159 which contains a slidably mounted piston 160. The piston 160 is connected by means of a piston rod 161 with a bracket 162 depending from and fixedly mounted on the under side of the wheel head 158. When fluid under pressure is admitted through a pipe 163 into a cylinder chamber 164, the piston 160 will be moved toward the left (Figs. 1, 3 and 4) to position the grinding wheel 57 in respect to the crankpins to be ground.

When fluid under pressure is admitted through a pipe 165 into a cylinder chamber 166, the piston 160 together with the wheel head 158 will be traversed or indexed toward the right (Figs. 1, 3 and 4). An adjustable stop screw 167 supported in a bracket 168 which is fixedly mounted on the right-hand end of the wheel slide 60 serves to limit the movement of the piston 160 and the wheel head 158 toward the right. A pair of spanner wrench collars 169 are adjustably mounted on a threaded portion at the right-hand end of the piston rod 161. The collars 169 are arranged to engage the right-hand face of the cylinder cover of the cylinder 159 and serve to limit the movement of the piston 160 and the wheel head 158 in a direction toward the left (Figs. 1, 3 and 4) precisely to locate the grinding wheel 57 for grinding a crankpin 59b (Fig. 1). A plurality of normally open limit switches 170, 171 and 172 mounted on the wheel slide 60 are arranged in the path of a cam 173 mounted on the bracket 162 (Figs. 3, 4 and 16) and serve in a manner to be hereinafter described to stop and position the grinding wheel 57 and wheel head 158 in the desired and predetermined positions for grinding successive crankpins on the crankshaft 25 being ground.

Grinding wheel drive

A motor driven mechanism is provided for synchronously driving the rotatable grinding wheels 56 and 57 together with their respective wheel spindles 135 and 155. The wheel spindles 135 and 155 are hollow spindles and contain slidably keyed driving shafts 175 and 176. The outer ends of the shafts 175 and 176 are supported in anti-friction bearings contained within the housings 177 and 178 mounted and clamped to the wheel slide 60. The inner ends of the drive shafts 175 and 176 are connected by a coupling 179 so that the driving spindles or shafts 175 and 176 may be separated when it is desired to mount a grinding wheel on either of the wheel spindles 135 and 155. An electric motor 180 is mounted on an adjustably positioned motor support 181 which is slidably supported on a portion of the wheel slide 60. A screw 182 and a nut 183 are interposed between the bracket mounted on the wheel slide 60 (Fig. 2) and the motor support 181 and serve to facilitate transverse adjustment of the electric motor 180 to tension the driving V-belts as desired. A motor shaft 184 of the electric motor 180 supports a multi-V-groove pulley 185 which is connected by multiple V-belts 186 with a multiple V-groove pulley 187 mounted on the right-hand end of the drive shaft 176. It will be readily apparent from the foregoing disclosure that when the electric motor 180 is started rotating by actuating the push button switch 188 on the base 20, a rotary motion will be transmitted through the pulley 185 driving the V-belts 186 and pulley 187 to rotate the shaft 176 which in turn rotates the wheel spindle 155 and the grinding wheel 57. Due to the coupling 179, rotation of the spindle 176 will be transmitted through the shaft 175 to impart a rotary motion to the wheel spindle 135, synchronously to rotate the grinding wheel 56 with the grinding wheel 57.

Spark splitting device

The grinding wheels 56 and 57 together with their supporting spindles 135 and 155, respectively, are arranged for an axial adjustment so that as the grinding wheels are fed toward a pair of crankpins to be ground, the wheels 56 and 57 may be moved axially to split the spark or equalize the side grinding on opposite corners of the peripheral faces of the grinding wheels. A spindle adjusting mechanism 190 is provided for axially moving the spindle 135 and grinding wheel 56 which is controlled by means of a manually operable lever 191. Similarly, a spindle adjusting mechanism 192 is provided for axially adjusting the spindle 155 and the grinding wheel 57 which is actuated by a manually operable lever 193. These spindle adjusting or spark splitting mechanisms have not been illustrated in detail in the present application since they are not considered to be a part of the present invention. These mechanisms are substantially identical to that shown in the prior U. S. patent to Herbert A. Silvan, No. 2,151,666 dated March 21, 1939, to which reference may be had for details of disclosure not contained herein.

Steadyrests

It is desirable to support the pair of spaced crankpins being ground during the grinding operation. A pair of spaced steadyrests 194 and 195 are provided. The steadyrests 194 and 195 are preferably of a hydraulically operated type such as, for example, that shown in the prior U. S. patent to Herbert A. Silvan, No. 2,053,878

dated September 8, 1936, to which reference may be had for details of disclosure not contained herein. The steadyrest 194 comprises a vertically movable slide 196 which serves as a support for a transversely movable steadyrest shoe carrying member 197. The slide 196 is arranged to slide vertically on a steadyrest frame 198 which is provided with suitable mating slideways. A fluid pressure cylinder 199 is formed integral with the steadyrest frame 198. The cylinder 199 contains a slidably mounted piston 200 which is connected by a piston rod 201 with a bracket 202 which is formed integral with or fixedly mounted on the lower end of the vertical slide 196.

When fluid under pressure is admitted through a pipe 203 which is connected to the pipe 91, into a cylinder chamber 204 to cause a downward movement of the piston 200, the slide 196 together with the shoe carrying slide 197 is moved downwardly to an inoperative position to facilitate longitudinal positioning by the wheel head 138. Similarly, when fluid under pressure is admitted through a pipe 205 into a cylinder chamber 206, the piston 200 together with the piston rod 201 and the slide 196 together with the shoe supporting member 197 are moved vertically to an operative position with the steadyrest shoe in operative engagement with the crankpin to be ground. A manually operable nut and screw mechanism 207 (Fig. 1) is provided to adjust the shoe carrying slide 197 transversely either toward or from the crankpin to be ground.

Similarly, the steadyrest 195 is provided with a vertically movable slide 210 which is arranged to be moved vertically relative to a steadyrest frame 211. A fluid pressure cylinder 212 is formed integral with the steadyrest frame 211 and contains a slidably mounted piston 213. The piston 213 is connected by a piston rod 214 with a bracket 215 which is integral with the lower end of the vertically movable slide 210. The slide 210 supports a transversely movable shoe carrying member 216 which is provided at its inner end with a work engaging shoe 217 (Fig. 2). A manually operable nut and screw feeding mechanism 218 is provided for manually adjusting the position of the shoe carrying slide 216 and the work engaging shoe 217 transversely into or away from operative engagement with the crankpin to be ground. When fluid under pressure is admitted through a pipe 219 which is connected to the pipe 91, into a cylinder chamber 220, the piston 213 together with the slide 210 and the shoe carrying slide 216 are moved downwardly to an inoperative position to facilitate longitudinal adjustment by the wheel head 158, of the steadyrest 195 during the grinding of successive crankpins on a crankshaft. Similarly, when fluid is admitted through a pipe 221 into a cylinder chamber 222, the piston 213 together with the piston rod 214, the slide 210, the shoe carrying slide 216, and the work steadyrest shoe 217 are moved upwardly into an operative position. During the grinding operation the work steadying shoes of the steadyrests 194 and 195 may be manually adjusted toward and from the surface of the work piece being ground and maintained in operative contact therewith during a grinding operation with the desired pressure by manual manipulation of the nut and screw actuating mechanisms 207 and 218, respectively.

Work rotation control

In a crankshaft grinding machine of the type illustrated, it is desirable to stop the pot chucks 23 and 24 in an upright position to facilitate the loading operation. A motor brake switch 225 is provided for stopping the electric motor 40 at the desired and predetermined time to stop the pot chucks 23 and 24 in predetermined upright positions. The motor brake switch 225 is controlled by a cam 226 which is mounted to rotate the work supporting spindle (Fig. 5) supporting the pot chuck 23 and a normally closed trip switch 227 mounted on a frame fixed to the base 20.

When the main control valve 99 is shifted to its rearward position, a cam surface on a cross-shaped head 228 mounted on the valve stem 101 opens a normally closed limit switch 229 to break the circuit. When the circuit through the limit switch 229 is broken, a solenoid 230 on the base 20 is deenergized to release the tension of a spring. This movement serves to rock a lever 231 to move a slidably mounted rod 232 so that the roller on the end of the rod 232 rides upon the periphery of the cam 226. The motor 40 for rotating the work supporting pot chucks 23 and 24 is preferably of a type which is controlled by a magnetic starter reverse relay 233 and a motor brake switch 225 so that the rotation of the motor 40 may be stopped in a predetermined position after a grinding operation has been completed. As shown in the electrical wiring diagram (Fig. 5), the motor 40 is controlled by a magnetic starter reverse relay 233 which controls the forward and reverse fields of the motor 40.

When the solenoid 230 is deenergized, the roller mounted on the rod 232 is moved by the spring actuated lever 231 into contact with the cam 226. The movement of the roller on the rod 232 into operative contact with the cam 226 serves to open a normally closed trip switch 227 which opens the circuit and cuts the power from the power field of the motor 40. This movement serves through the motor brake switch 225 to actuate a magnetic motor reverse relay 234 which serves instantaneously to reverse the current in the motor 40 and, through the motor brake switch 225, to stop the motor 40 so that the pot chucks 23 and 24 are in a predetermined upright loading position.

A safety relay 235 is so connected as to render the power circuit inoperative in case the electric current fails. Upon failure of the electric current supplied to the driving motor 40, the safety relay 235 opens and before the work rotation can be again started, a make contact reset push button 236 must be pushed to close the circuit. This movement in turn serves to close the safety relay 235 and thereby again to start the rotation of the motor 40. A make contact push button 237 serves as a jogging switch to jog the rotation of the work, if desired. A double pole snap switch 238 serves in one position to permit a jogging of the work rotation by the push button 237 or in the opposite direction serves to start the rotation of the motor 40. A double pole snap switch 239 serves in one position to render the automatic control of the work rotation inoperative to facilitate manual control to permit jogging of the work rotation as desired, and in the position shown in Fig. 5 serves to render the automatic control of the work rotation operative. By manipulation of the push buttons 236 and 237 and the snap switches 238 and 239, the rotation of the work driving motor 40 may be readily controlled as desired. A relay 240 serves to control the use of the motor brake switch 225 by breaking the circuit through one of the contacts in the starter reverse relay 233 which con-

trols the motor reverse relay 234. It is not deemed to be necessary to more fully describe the work rotation and stop control mechanism in the present case since this feature is substantially identical with that shown in the prior U. S. patent to Herbert A. Silven, No. 2,151,666 dated March 21, 1939, to which reference may be had for details of disclosure not contained herein.

The main control valve 99 and main control lever 108 are located on the left-hand portion of the front of the machine base 20. It is desirable in a machine of this type to be able to manipulate the controls from either end of the machine as occasion requires. A manually operable control valve 241 is provided having a valve stem 242 which has a control knob 243 projecting from the front of the machine base 20. The control valve 241 is a balanced piston type valve which is normally held in a central or neutral position by means of a spring 244. Fluid under pressure passing through the pipe 98 enters a centrally located valve chamber 245. When the control knob 243 is moved toward the operator, fluid entering the valve chamber 245 may pass through a pipe 246 into an end chamber in the main control valve 99 and serves to shift the valve stem 101 together with the valve pistons formed thereon toward the front of the machine.

Similarly, if the control knob 243 is moved away from the operator, fluid under pressure entering the valve chamber 245 passes through a pipe 247, into an end chamber 248 in the main control valve 99, to move the valve stem 101 in a direction toward the rear of the machine. It will be readily apparent from the foregoing disclosure that the control valve 241 as controlled by its control knob 243, serves hydraulically to shift the main control valve 99 in case such a movement is desired when the operator is adjacent to the right-hand end portion of the grinding machine. A pair of throttle valves 249 are provided in the exhaust pipe 107 to be used, if desired, for producing an adjustable controlled slow movement of the valve stem 101 of the main control valve 99.

Positioning indexing interlock

It is desirable to provide a fluid interlock between the grinding wheel feeding mechanism and the longitudinal traversing or indexing movement of the grinding wheels 56 and 57. As illustrated in the drawings, an electrically controlled fluid pressure interlock is provided, comprising a grinding wheel locating valve 250 which is biased to a left-hand end position by a compression spring 251. An electric solenoid 252 serves when energized to move the valve 250 to its right-hand end position (Fig. 5). The pipe 98 passes fluid under pressure from the pump 95 into a valve chamber 253. When the solenoid 252 is deenergized and the valve 250 is in its left-hand end position, fluid under pressure entering the valve chamber 253 passes outwardly through a pipe 254, into an end chamber 255 in the valve 241, to move the valve stem 242 together with the valve pistons formed thereon into its rearward position. In this position fluid under pressure entering the valve chamber 245 in the control valve 241 passes outwardly through pipe 247, into the end chamber 248 of the main control valve 99, to hold it in the position shown in Fig. 5. In this position the grinding wheels 56 and 57 are held in a rearward or inoperative position, the steadyrests are held in a downwardly or inoperative position, and the work clamps on the pot chucks 23 and 24 are released.

The limit switches 150, 151, 152 and 170, 171 and 172 are connected in series with each other, respectively, and are in turn connected so that when both of the grinding wheels 56 and 57 are located in any of the predetermined grinding positions opposite the crankpins 58—59, 58*a*—59*a*, or 58*b*—59*b*, respectively, the circuit will be closed to energize the solenoid 252 which serves to shift and maintain the valve 250 in the positions indicated in Figs. 4 and 5. In this position either the control knob 243 or the main control lever 108 may be actuated to start a grinding operation, namely, to exhaust fluid from the cylinder chambers 30 and 33, thus facilitating clamping of the crankshaft 25 in position within the pot chucks 23 and 24. The wheel slide 60 is then fed forward to move the grinding wheels 56 and 57 toward the crankpins 58 and 59 to be ground. The steadyrests 194 and 195 are then automatically moved upwardly into operative supporting engagement with the steadyrest shoes in operative supporting engagement with the crankpins 58 and 59. It will be readily apparent from the foregoing disclosure that when the grinding wheels 56 and 57 are both located in respective grinding positions and the pairs of normally open limit switches 150—170, 151—171, or 152—172 are closed, an infeed of the grinding wheels can be initiated.

A two-way valve 255 is provided whereby fluid under pressure may be passed into an end chamber 256 to maintain the valve 250 in a right-hand end position by fluid under pressure, if desired. A valve 257 is provided in the pipe line 254 whereby the rate of passage of fluid may be varied to control the speed of movement of the valve 241 as desired. The valve 257 may also be entirely closed to render the valve 250 inoperative, if desired.

Indexing control valves

An independent pump 260 is provided for supplying fluid under pressure for indexing the grinding wheels 56 and 57. The pump 260 and the pump 95 are preferably in the form of a duplex pump which is driven by an electric motor 261 (Fig. 2) which is controlled by the push button switch 259 mounted on the front of the machine base 20. The fluid pump 260 which draws fluid through a pipe from the reservoir 97 is arranged to convey fluid under pressure through a pipe 262 to a control valve 263 which controls the indexing or truing movement of the grinding wheel 56 and to a control valve 264 which controls the indexing or truing movement of the grinding wheel 57. A relief valve 265 is connected between the pipe 262 and the reservoir 97 by means of which the pressure in the system may be readily controlled and by means of which excess fluid under pressure may be directly exhausted into the reservoir 97. The grinding wheel indexing control valves 263 and 264 are mounted on the front of the machine base 20 and are both readily accessible from the operator's control station.

The index control valves 263 and 264 are balanced piston type valves having valve stems 266 and 267 which are held in a central or neutral position by means of spring-pressed detents 268 and 269, respectively. Actuating control knobs 270 and 271 are mounted on the ends of the valve stems 266 and 267, respectively, by means of

which the control valves 263 and 264 may be readily controlled manually.

The index control valve 263 is arranged to convey fluid under pressure through the pipe 143 into the cylinder chamber 144 at the right-hand end of the cylinder 139 or through the pipe 145 to the cylinder chamber 146 at the left-hand end of the cylinder 139. It will be readily apparent from the foregoing disclosure that the grinding wheel 56 may be indexed in either direction by manipulation of the control knob 270. The direction of movement of the control knob 270 determines the direction of indexing movement imparted to the grinding wheel 56.

Similarly, the index control valve 264 is connected by the pipe 163 which controls the passage of fluid to or from the cylinder chamber 164 at the right-hand end of the cylinder 159. The pipe 165 serves to pass fluid under pressure to or exhaust fluid from the cylinder chamber 166 at the left-hand end of the cylinder 159 (Fig. 4). The direction of movement of the control knob 271 will determine the direction of the indexing movement imparted to the grinding wheel 57.

A valve 280 is connected in an exhaust pipe 281 to control the exhaust of fluid from the cylinder 139 passing through the index control valve 263. The valve 280 is a piston type valve which is normally held in its right-hand end position (Fig. 4) by means of a compression spring 282. In the position of the valve 280 shown in Fig. 4, fluid exhausting from the index control valve 263 and cylinder 139 is free to pass unrestricted through an exhaust pipe 283 into the reservoir 97. An electric solenoid 284 is provided for shifting the valve 280 toward the right, which movement serves to cut off the exhaust of fluid from the cylinder 139 and serves when energized to stop the longitudinal indexing movement of the grinding wheel 56. An adjustable valve 285 is provided for controlling the exhaust of fluid from the index control valve 263 as desired for the indexing rate of travel of the grinding wheel 56. Also, adjustable throttle valves 286 and 287 are provided for producing a very slow longitudinal movement of the grinding wheel 56 when it is desired to true the grinding wheel 56.

Similarly, a valve 290 is provided in a pipe line 291 which exhausts fluid from the cylinder 159, through the index control valve 264. A spring 292 serves normally to hold the valve 290 in its left-hand end position, in which position fluid is free to exhaust unrestricted through the pipe 293, into the reservoir 97. A solenoid 294 is provided for shifting the valve 290 in a direction toward the right (Fig. 4), which movement serves to cut off the exhaust of fluid through the pipe 291 and thereby to stop the longitudinal indexing movement of the grinding wheel 57. An adjustable valve 295 in the pipe line 291 serves to facilitate regulation of the exhausting fluid from the cylinder 159 so that the speed of the indexing movement thereof may be readily controlled. Adjustable throttle valves 296 and 297 (Fig. 4) are provided to facilitate the control of exhausting fluid when the index control valve 264 is actuated to provide a slow longitudinal movement of the grinding wheel 57 for a truing operation.

The index control valves 263 and 264, as above described, are arranged to be independently operated to independently control the longitudinal indexing or truing movements of the grinding wheels 56 and 57, respectively. It may be desirable to provide an interconnection between the index control valves 263 and 264 so that the actuation of either one of the index control valves will simultaneously produce an indexing or truing control of both the grinding wheels 56 and 57. A pipe 300 interconnects the pipe 143 with the pipe 163. A pipe 301 interconnects the pipe 145 with the pipe 165. A valve 302 is provided in the pipe line 300 and a valve 303 is provided in the pipe line 301. If both of the valves 302 and 303 are opened, the valve 276 in the pipe 163 and the valve 277 in the pipe line 165, both adjacent to the index control valve 264, are closed to disconnect or render inoperative the index control valve 264. It is apparent that it is necessary to have the valves 276 and 277 to shut off, otherwise fluid will by-pass or exhaust directly to the reservoir 97 when the index control valve 263 is actuated to admit fluid to the cylinders 139 and 159 to control the simultaneous indexing or truing of the grinding wheels 56 and 57.

Similarly, if it is desired to have the index control valve 264 independently control the indexing or truing movement of the grinding wheels 56 and 57, the valves 302 and 303 are opened and the valves 276 and 277 remain open. The valve 272 in the pipe line 143 and the valve 273 in the pipe line 145, both adjacent to the index control valve 263, are closed to disconnect or render inoperative the index control valve 263. By closing the valves 272 and 273, fluid under pressure will not by-pass or exhaust directly into the reservoir 97 when the index control valve 264 is actuated to admit fluid to the cylinders 139 and 159 to control the simultaneous indexing or truing movement of the grinding wheels 56 and 57. If it is desired independently to control the longitudinal indexing of the wheels 56 and 57, the valves 302 and 303 are closed and the valves 272, 273, 276 and 277 are opened, so as to provide an independent indexing or truing control for each of the grinding wheels 56 and 57.

Interlock

A fluid pressure interlock is provided between the grinding wheel longitudinal indexing mechanism and the wheel feeding mechanism so that if either of the index control valves 263 or 264 is moved during a grinding wheel feeding operation, the wheel slide 60 will be moved to a rearward or inoperative position before a longitudinally movable indexing movement may take place. A plurality of small fluid pressure cylinders 305, 306, 307 and 308 are fixedly mounted or formed integral with the casing of the main control valve 99. These cylinders contain pistons 309, 310, 311 and 312 which are fixedly connected to the cross-shaped plate 228 which is fixedly mounted to the rear end of the valve stem 101. A pipe 313 is connected between the pipe line 145 and the cylinder 305. A pipe 314 is connected between the pipe line 143 and the cylinder 306. A pipe 315 is connected between the pipe line 301, which is connected to the pipe 165, and the cylinder 307. A pipe 316 is connected between the pipe line 300, which is connected to the pipe 163, and the cylinder 308. It will be readily apparent that if either the index control valves 263 or 264 are moved from their central or neutral positions to pass fluid through any of the pipe 143, 145, 163 and 165, fluid will be admitted to one of the cylinders 305, 306, 307 or 308 to cause a rearward movement of the valve stem 101 of the main control valve 99 to admit fluid to move the grinding wheels 56 and 57 to a rearward position. The cylinders 305, 306, 307 and 308 being of comparatively small diameter and requiring less

power to shift the main control valve 99 than to index the massive wheel heads, the feed control valve will be shifted first to move the grinding wheels 56 and 57 to a rearward positon before any longitudinal indexing movement may be imparted to either the wheel 56 or the wheel 57. It will be readily apparent from the foregoing that a definite interlock is provided between the longitudinal indexing movement for the grinding wheels 56 and 57 and the transverse movement thereof.

By-pass valve interlock

A further interlock is provided between the wheel feeding and the wheel indexing movements, comprising a fluid actuated by-pass valve 320. As shown in Fig. 5, fluid under pressure passing through the pipe 91 to the wheel feed cylinder 85 also passes through the pipe 219 and a pipe 321 into an end chamber 322. Fluid within the opposite end chamber, similar to the chamber 322, during this movement exhausts through a throttle valve 324 and a pipe 325 which connects with the pipe 88. The throttle valve 324 serves to regulate the speed of movement of the piston 323 as fluid under pressure is applied to either end chamber of the by-pass valve 320. In Fig. 4, if a valve 274 is closed in a pipe 275 shunted or by-passed around the by-pass valve 320, and the index control valve 263 is moved toward the left, fluid under pressure passing through the pipe 145 passes into a valve chamber 327 in the by-pass valve 320 and out through the other section of the pipe 145 which is connected to the right-hand end cylinder chamber 146 of the cylinder 139.

Similarly, if the index control valve 264 is moved toward the right (Fig. 4) to admit fluid through the pipe 165, this fluid passes through a valve chamber 329, out through the other section of the pipe 164, and into the left-hand end chamber 166 of the cylinder 159. If the by-pass valve 320 is rendered inoperative, the throttle valve 324 is closed so that the piston 323, mounted in a horizontal position, will remain in the position shown in Fig. 4. In this case the operator must move the grinding wheels 56 and 57 rearwardly before they are indexed.

To shorten the pipe lines between the index control valves 263 and 264, the piston 323 of the by-pass valve 320 may be locked in the reverse position to that shown in Fig. 4 by shutting off the throttle valve 324 and blocking the exhaust of fluid from the end chamber. In this position the by-pass valve 320 is inoperative and it is, therefore, necessary to open the valve 274 in the pipe line 275 and a valve 278 in a pipe 279 in order to index the grinding wheels 56 and 57. If the by-pass valve 320 is rendered operative, fluid must pass through the pipe 325 and valve 324 before the grinding wheels 56 and 57 may be moved in either direction. For indexing or truing, the adjustment of the throttle valve 324 allows the main control valve 99 to be moved to its rearward position before indexing takes place.

When the main control valve is shifted to cause an infeeding movement of the grinding wheels, fluid under pressure is passed through the pipe 88 to initiate a forward feeding movement of the grinding wheels. At the same time, fluid under pressure passes through the pipe 325 into the end chamber to shift the piston 323 of the by-pass valve 320 to its opposite end position from that illustrated in Figs. 4 and 5, which movement serves to prevent fluid under pressure from passing through the by-pass valve 320, thus preventing a longitudinal indexing movement of either of the grinding wheels 56 and 57.

Electrically controlled stop

The stop screws 147 and 157 determine the positions of the grinding wheels 56 and 57 for grinding the crankpins 58 and 59 (Fig. 1). Similarly, the set of collars 149 and 169 limit and position the grinding wheels 55 and 57 as they are indexed toward each other to locate the grinding wheels for grinding the crankpins 58*b* and 59*b*, respectively. In order to locate the grinding wheels for grinding the crankpins 58*a* and 59*a*, an electrical control mechanism is provided comprising a pair of limit switches 335 and 336 which are normally open and are mounted on the wheel slide 60. A pair of adjustable cams 337 and 338 are carried by the brackets 142 and 162, respectively. When the grinding wheels 56 and 57 are indexed toward each other, as they approach positions opposite the crankpins 58*a* and 59*a*, the cams 337 and 337 which move in the path of the actuating plungers of the limit switches 335 and 336 serve to close the switches, thus energizing the solenoids 284 and 294, respectively, to shift the valves 280 and 290, respectively, to cut off exhaust of fluid from the cylinders 139 and 159, respectively, thus stopping the indexing movement of the wheel heads 138 and 158 to locate the grinding wheels 56 and 57, respectively, in positions opposite the crankpins 58*a* and 59*a* for a grinding operation.

After the crankpins 58*a* and 59*a* have been ground and it is desired to again index the grinding wheels 56 and 57 for grinding the next pair of pins on the shaft, the indexing movement of the grinding wheels may be initiated by actuating either the push button switch 340 or the push button switch 341. Actuation of either the push button 340 or 341 serves to break the circuit, deenergizing the solenoids 284 and 294, thus releasing the compression of the springs 282 and 292 to return the valves 280 and 290, respectively, to the positions illustrated in Fig. 4 so that fluid may exhaust from the cylinders 139 and 159, respectively, thereby permitting a further longitudinal indexing movement of the grinding wheels 56 and 57.

A pair of push button switches 345 and 346 are provided for rendering the valves 280 and 290 and 250 operative or inoperative when desired. When it is desired to make valves 280, 290 and 250 inoperative, both of the switches 345 and 346 are opened. The opening of the push button switch 345 serves to break the electric circuit through the push button switches 340 and 341. The opening of the push button switch 346 breaks a circuit rendering the circuits controlling the valve 250, by the limit switches 150, 151, 152, 170, 171 and 173 inoperative, thus cutting off electric current to the solenoid 252.

The operation of the improved crankpin grinding machine will be readily apparent from the foregoing disclosure. The push button switches 188, 236 and 259 are closed to start the grinding wheel driving motor 180, to start the work drive motor 40, and to start the fluid pump driving motor 261. A crankshaft 25 is then placed in position with its opposite ends supported in the pot chucks 23 and 24, after which the main control lever 108 is moved forward toward the operator to shift the main control valve 99 to initiate an infeeding movement of the grinding wheels 56 and 57. The shifting of the main con-

trol valve 99 first opens the fluid confined within the cylinders 26 and 31 to the exhaust, thus releasing the compression of the springs to clamp the opposite ends of the crankshaft 25 in position on the pot chucks 23 and 24. Fluid next passes to the cylinder 85 to initiate the forward feeding movement of the grinding wheels 56 and 57 and at the same time passes through the pipe 325 to shift the by-pass valve 320 which prevents passage of fluid to the wheel head indexing cylinders 139 and 159 during the infeeding movement. After the forward movement of the grinding wheels 56 and 57 has been initiated, the main control valve 99 admits fluid under pressure to the steadyrest cylinders 199 and 212 to move the steadyrest frames 196 and 210, respectively, upwardly into an operative position so that the work steadying shoes engage and steady the crankpins 58 and 59 during a grinding operation.

After the crankpins 58 and 59 have been ground to the desired and predetermined size, the control lever 198 is moved rearwardly to stop the rotation of the work, to cause a rearward movement of the grinding wheels 56 and 57, and also to unclamp the pot chucks 23 and 24 so that the crankshaft 25 may be rotarily indexed to present the crankpins 58*a* and 59*a* with their axes in alignment with the axes of rotation of the pot chucks 23 and 24. During the rearward shifting movement of the main control valve 99, fluid under pressure is admitted through the pipe 321 to shift the interlock valve 320 into the position shown in Fig. 5. In this position of the valve 320, fluid may pass therethrough to the wheel head indexing cylinders 139 and 159, respectively.

The index control valves 263 and 264 may then be actuated to pass fluid under pressure to the wheel head indexing cylinders 139 and 159, respectively, to shift the grinding wheels 56 and 57 relatively toward each other into alignment with the crankpins 58*a* and 59*a*, respectively. As previously explained, the index control valves 263 and 264 may be operated independently of each other independently to control the indexing movement of the wheel heads 138 and 158, respectively, or, if desired, the index control valves 263 and 264 may be connected so that actuation of either serves simultaneously to control the admission of fluid to both of the wheel head indexing cylinders 139 and 159.

The grinding wheels 56 and 57 are stopped in operative positions aligned with the crankpins 58*a* and 59*a* by means of the cams 337 and 339 which close the limit switches 335 and 336, respectively. The closing of the limit switches 335 and 336 serves to energize the solenoids 284 and 294, respectively, to close the valves 280 and 290, respectively. The closing of the valves 280 and 290 cuts off exhaust of fluid from the index cylinders 139 and 159, respectively, to stop the longitudinal indexing movement of the wheel heads 138 and 158, respectively. The control lever 198 may then be moved forward to initiate a forward feeding movement of the grinding wheels 56 and 57. The cycle of events in this case is the same as in the grinding of the crankpins 58 and 59. The forward movement of the control lever 198 serves, as above explained, to clamp the crankshaft 25 in position to initiate a forward feeding movement of the grinding wheels 56 and 57 to shift the by-pass valve 320 to move the steadyrests 194 and 195 to an operative position.

During the forward feeding movement of the grinding wheels 56 and 57, as the grinding wheels approach the crankpins, the spark splitting devices actuated by the control levers 191 and 193 are actuated to split the spark or equalize the side grinding on the corners of the grinding wheels 56 and 57. The spark splitting control levers 191 and 193 serve, as above explained, to cause an endwise positioning movement to the grinding wheel spindles 135 and 155 which support the grinding wheels 56 and 57 and serve to facilitate a manual positioning of the grinding wheels so that each corner of the grinding wheels grinds equally on the opposite cheeks adjacent to the crankpin. After the crankpins 58*a* and 59*a* have been ground to the predetermined size, the control lever 198 is moved rearwardly and the push button switches 340 and 341 are actuated to break the circuits to deenergize the solenoids 284 and 294 so that the valves 280 and 290 return to the position shown in Fig. 4. This movement serves to position the valves 280 and 290 so that a longitudinal indexing movement of the wheel heads 138 and 158 may be readily effected.

The wheel heads 138 and 158 may then be indexed longitudinally toward each other into operative positions so that the grinding wheels 56 and 57 are positioned in operative relationship with the crankpins 58*b* and 59*b*. The control lever 198 may then be shifted forward again so that the parts operate in the manner previously described to grind the crankpins 58*b* and 59*b* to the desired and predetermined size.

After the crankpins 58*b* and 59*b* have been ground, the control lever 198 is again moved rearwardly to move the grinding wheels 56 and 57 to a rearward or inoperative position. This movement of the control lever 198 serves to release the crankshaft 25 so that it may be readily removed from the pot chucks 23 and 24 and a new crankshaft to be ground inserted thereinstead.

It will be readily apparent from the foregoing disclosure that on the second crankshaft to be ground, the grinding wheels 56 and 57 may remain in positions to first grind the crankpins 58*b* and 59*b*, after which they may be indexed away from each other to grind crankpins 58*a* and 59*a*, and lastly indexed to grind crankpins 58 and 59. This arrangement prevents undue loss of time in indexing the grinding wheels 56 and 57 from one end of their indexing stroke to the other before initiating a grinding operation on the next crankshaft.

It will thus be seen that there has been provided by this invention apparatus in which the various objects hereinabove set forth together with many thoroughly practical advantages are successfully achieved. As many possible embodiments may be made of the above invention and as many changes might be made in the embodiment above set forth, it is to be understood that all matter hereinbefore set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In a crankshaft grinding machine having a base, a rotatable work support including a pair of spaced aligned work heads on said base, a transversely movable grinding wheel slide on said base, a pair of spaced aligned longitudinally movable wheel heads on said slide, a rotatable grinding wheel on each of said heads, a wheel feeding mechanism to feed said slide transversely simultaneously to move said grinding wheels into operative grinding engagement with a pair of spaced aligned crankpins to be ground, and means on said slide to index said grinding wheel

heads longitudinally relative to said slide and successively into alignment with successive pairs of pins on a crankshaft.

2. In a crankpin grinding machine having a base, a rotatable work support including a pair of spaced aligned work heads on said base, a transversely movable wheel slide on said base, a pair of spaced longitudinally movable aligned grinding wheel heads on said wheel slide, a rotatable grinding wheel on each of said heads, means including a fluid pressure piston and cylinder to feed said wheel slide transversely relative to the base simultaneously to grind a pair of spaced aligned crankpins on a crankshaft, means including an independent piston and cylinder interposed between each of said wheel heads and said wheel slide independently to index said grinding wheel heads longitudinally relative to the wheel slide successively into alignment with pairs of aligned crankpins on a crankshaft.

3. In a crankshaft grinding machine having a base, a rotatable work support including a pair of spaced aligned work heads on said base, a transversely movable grinding wheel slide on said base, a pair of spaced aligned longitudinally movable work heads on said slide, a rotatable grinding wheel on each of said heads, a fluid pressure feeding mechanism for said slide including a piston and cylinder interposed between said slide and base to produce a simultaneous feeding movement of the wheels either toward or from said work support, a control valve therefor, a fluid pressure indexing mechanism for each of said wheel heads including a piston and cylinder interposed between each of the wheel heads and the slide, and a valve mechanism to control the admission of fluid under pressure simultaneously to index said grinding wheel longitudinally relative to said slide successively to position said grinding wheels in operative relation with pairs of aligned crankpins on a crankshaft to be ground.

4. In a grinding machine as claimed in claim 3, the combination with the parts and features therein specified, in which said valve mechanism comprises an independent, manually operable control valve for each of the grinding wheel indexing cylinders, and fluid pressure connections between said control valves whereby said control valves may be operated either independently or simultaneously.

5. In a crankshaft grinding machine as claimed in claim 3, the combination with the parts and features therein specified, of an independent manually operable valve for each of the grinding wheel indexing cylinders, and fluid pressure connections between said control valves and indexing cylinders whereby said valve may independently control the longitudinal indexing movement of the grinding wheels or whereby either of said valves may control the simultaneous longitudinal indexing movement of both of said grinding wheels.

6. In a crankshaft grinding machine as claimed in claim 2, the combination with the parts and features therein specified, of a plurality of adjustable stops to determine the opposite end positions of each of said wheel heads to locate the grinding wheels relative to the crankpins to be ground, and electrically actuated means to stop the longitudinal indexing movement of both of said grinding wheel heads when the grinding wheels move to an intermediate position to locate the grinding wheels in operative position successively to grind pairs of aligned crankpins on a crankshaft.

7. In a crankshaft grinding machine as claimed in claim 2, the combination with the parts and features therein specified, of a normally open shut-off valve in the exhaust pipe line from each of the grinding wheel head indexing cylinders, an independent solenoid to actuate each of said valves, and a pair of spaced normally open switches each of which is connected to one of said solenoids and a detent on each of said grinding wheel heads which is arranged to actuate said limit switches to energize said solenoid, so as to stop the longitudinal indexing movement of the grinding wheel heads when the grinding wheels are in operative position relative to the crankpins on a crankshaft.

8. In a crankshaft grinding machine as claimed in claim 2, the combination with the parts and features therein specified, of a main control valve for said slide cylinder and an electrically controlled fluid pressure interlocking mechanism including a valve which is arranged to render said main control valve inoperative so that a wheel feeding movement cannot be initiated until both of the grinding wheels are indexed longitudinally into corresponding positions relative to the crankpins to be ground.

9. In a crankpin grinding machine as claimed in claim 2, the combination with the parts and features therein specified, of a pair of spaced hydraulically operated steadyrests to support spaced aligned crankpins during a grinding operation, a fluid pressure cylinder to move said steadyrests to and from an operative position, a manually operable control valve which is arranged to control the admission to and exhaust of fluid from the wheel slide and steadyrest cylinders, and an interlock valve which is arranged normally to admit fluid under pressure to an end chamber in said main control valve to hold it in a rearward position so as to hold the grinding wheel slide and the steadyrests in inoperative positions during the longitudinal indexing movement of the grinding wheel head.

10. In a crankpin grinding machine as claimed in claim 2, the combination with the parts and features therein specified, of a manually operable control valve to control the admission to and exhaust of fluid under pressure from the wheel slide cylinder, an end chamber in said control valve, an interlock valve which is arranged normally to admit fluid under pressure to said end chamber to move and maintain the control valve in a rearward position to move and hold the wheel slide in a rearward or inoperative position during the longitudinal indexing movement of the grinding wheel, a solenoid to shift said interlock valve, and means including a limit switch and actuating detent interposed between the wheel slide and each of said wheel heads whereby said solenoid is energized when the wheel heads have been indexed to predetermined operative positions relative to the crankshaft to be ground so as to shift the interlock valve, thus rendering the main control valve operative to initiate an infeeding movement of the grinding wheels.

11. In a crankpin grinding machine as claimed in claim 2, the combination with the parts and features therein specified, of a manually operable control valve to control the admission to and exhaust of fluid under pressure from the wheel slide cylinder, an end chamber in said control valve, an interlock valve which is ar-

ranged normally to admit fluid under pressure to said end chamber to move and maintain the control valve in a rearward position to move and hold the wheel slide in a rearward or inoperative position during the longitudinal indexing movement of the grinding wheel, a solenoid to shift said interlock valve, and a limit switch and actuating detent therefor interposed between each of the wheel heads and the wheel slide, said limit switches being connected in series and connected with said solenoid so that when both of the wheel heads have been indexed to predetermined operative positions, the solenoid may be energized to shift the interlock valve so as to exhaust fluid from the end chamber, thus rendering the manually operable main control valve operative to initiate a grinding infeed of the grinding wheels.

12. In a crankshaft grinding machine as claimed in claim 2, the combination with the parts and features therein specified, of a main control valve for said slide cylinder, an interlock valve to control the admission of fluid under pressure to an end chamber of the main control valve, a spring normally to maintain said interlock valve in a position to admit fluid to maintain the main control valve in a rearward position so as to hold the wheel slide in a rearward or inoperative position, a solenoid to shift said interlock valve, a plurality of pairs of normally closed limit switches arranged in two sets, each of said pairs of switches being connected in series with said solenoid, said switches of each set being arranged in line and spaced from each other in accordance with the spacing of the crankpins to be ground, and means including a detent on each of said wheel heads for engaging and actuating successive pairs of switches when the grinding wheels are in predetermined indexed positions relative to the crankpins to be ground so as to energize said solenoid to shift the interlock valve so that fluid may exhaust from said end chamber, thus rendering said main control valve operative to facilitate effecting an infeed of the grinding wheels.

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