July 11, 1939. W. H. WOOD 2,166,086

CRANKSHAFT LAPPING MACHINE

Filed Feb. 18, 1939 5 Sheets-Sheet 1

FIG. 1

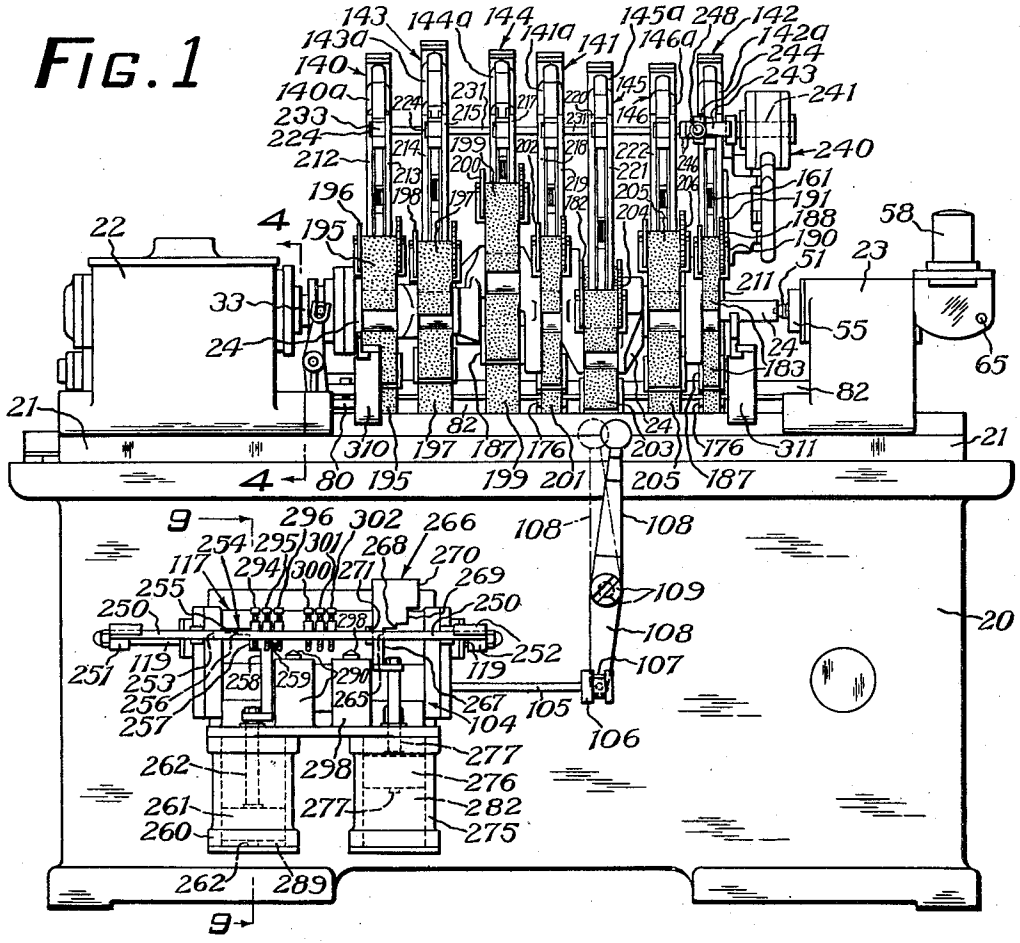
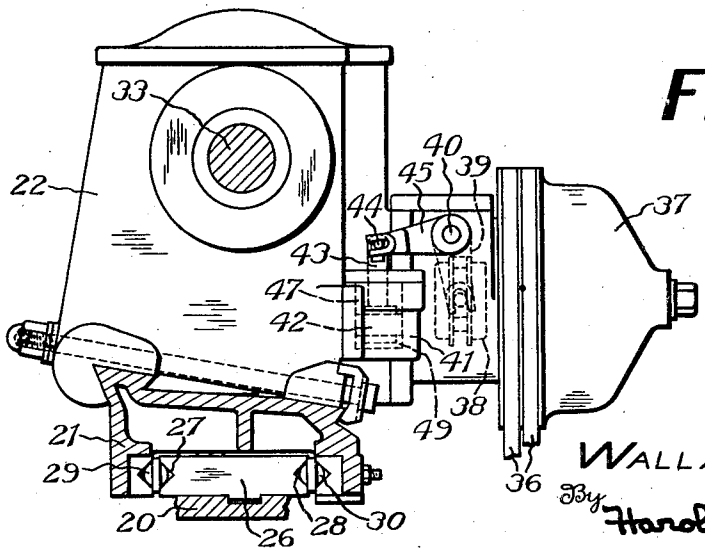


FIG. 4



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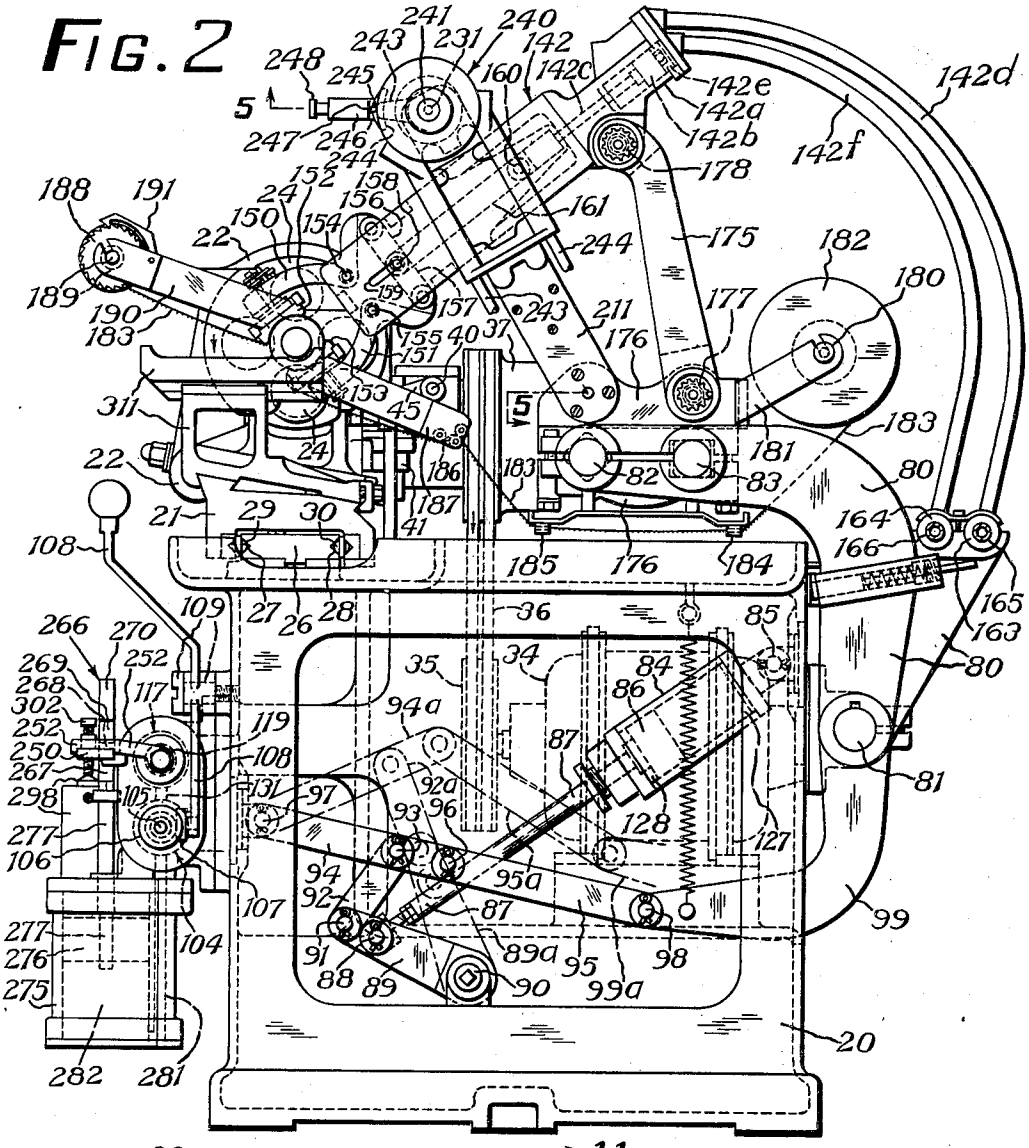
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CRANKSHAFT LAPPING MACHINE

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FIG. 2



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CRANKSHAFT LAPPING MACHINE

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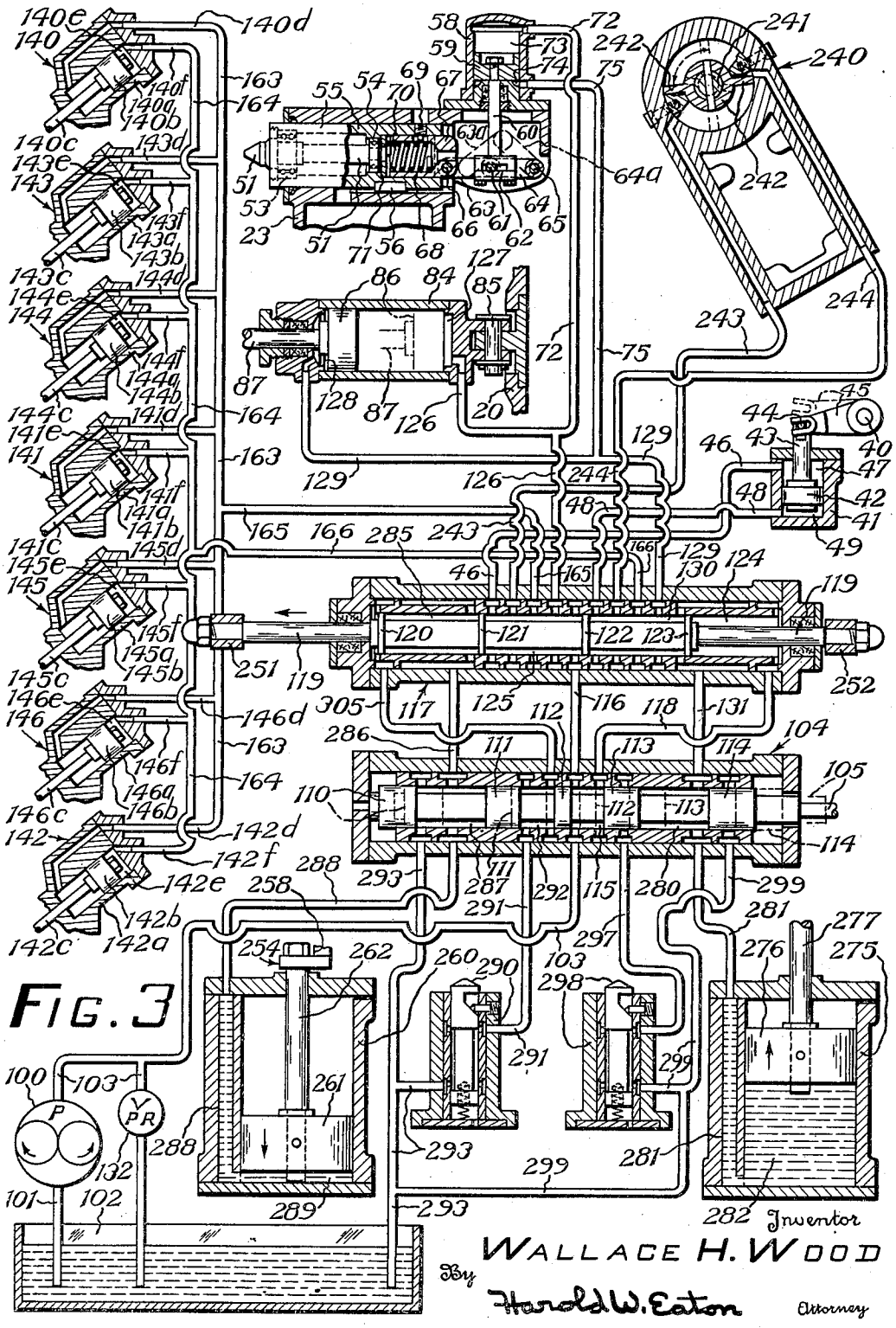


FIG. 3

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CRANKSHAFT LAPPING MACHINE

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FIG. 5

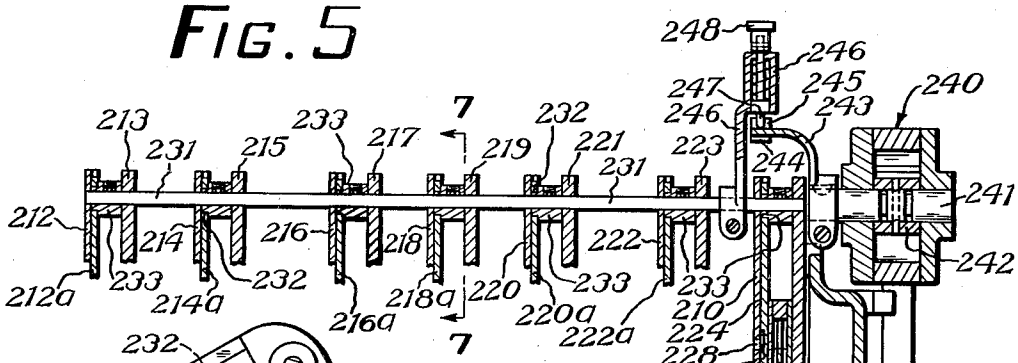


FIG. 7

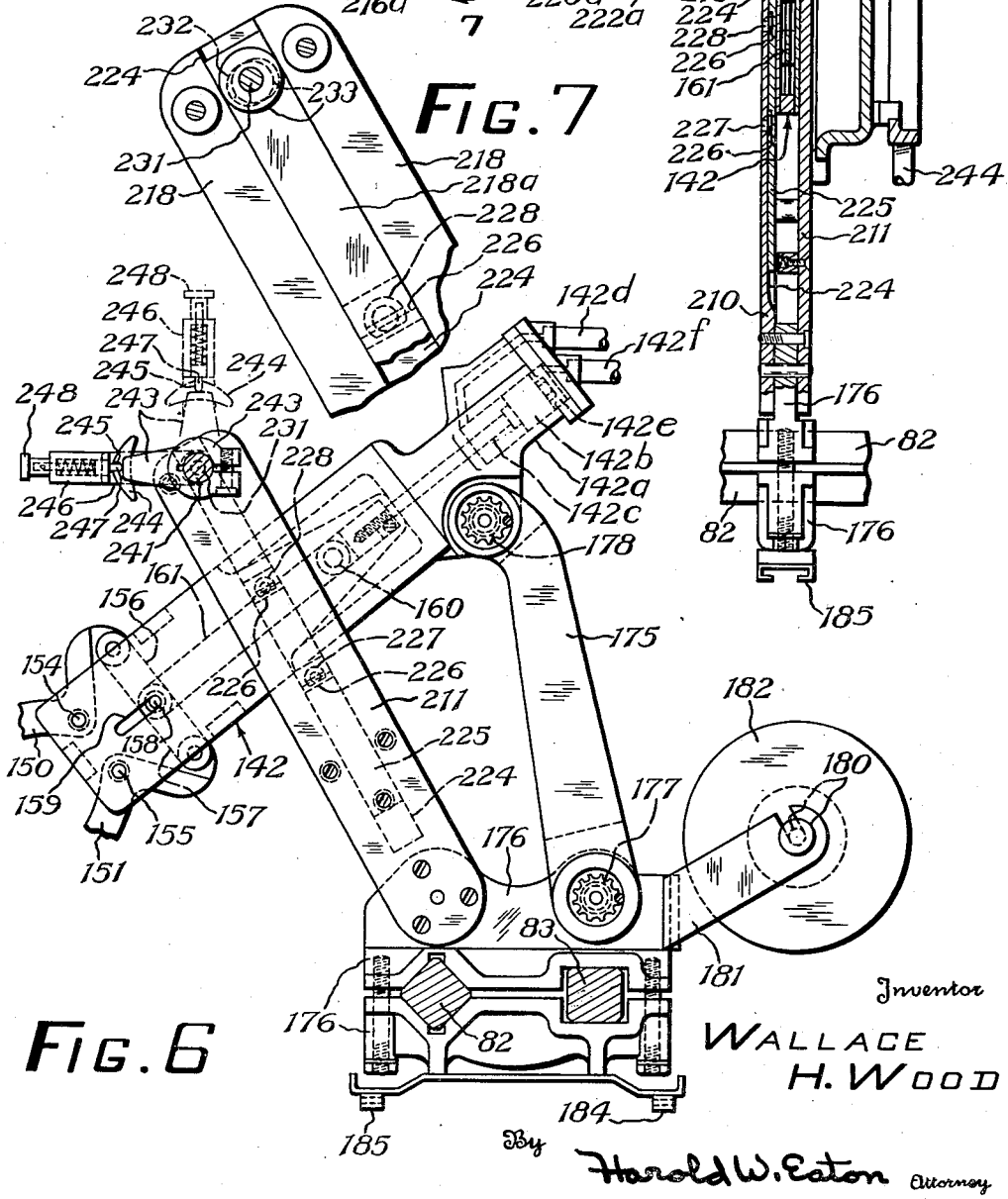


FIG. 6

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CRANKSHAFT LAPPING MACHINE

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FIG. 9

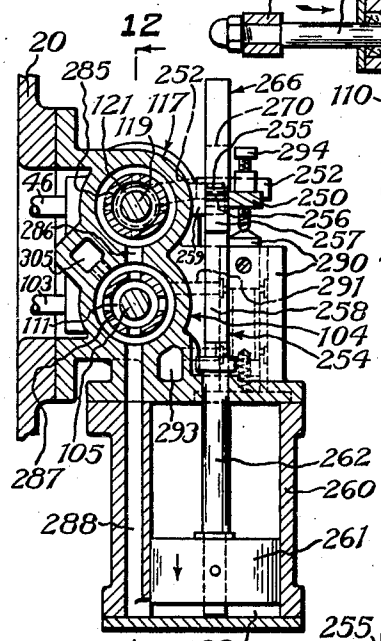


FIG. 12

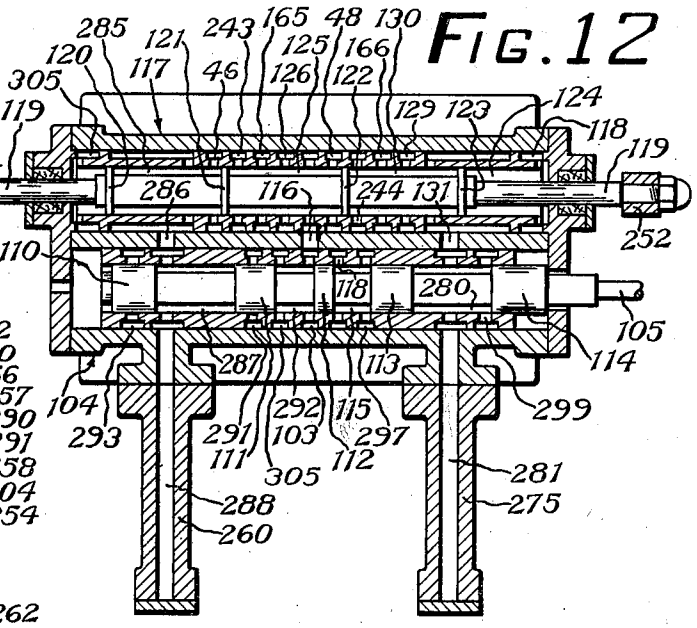


FIG. 13

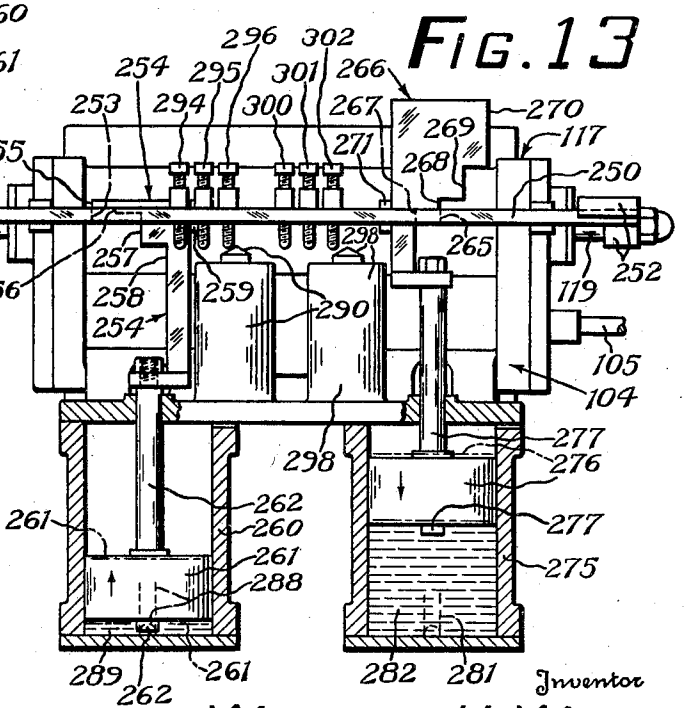


FIG. 10

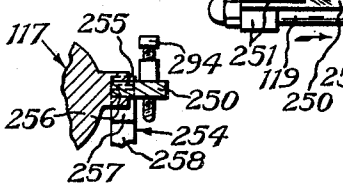
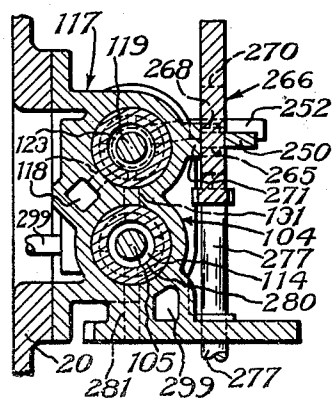


FIG. 11



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Patented July 11, 1939 2,166,086

UNITED STATES PATENT OFFICE

2,166,086

CRANKSHAFT LAPPING MACHINE

Wallace H. Wood, Worcester, Mass., assignor to Norton Company, Worcester, Mass., a corporation of Massachusetts

Application February 18, 1939, Serial No. 257,059

11 Claims. (Cl. 51—73)

The invention relates to abrading machines, and more particularly to a crankshaft lapping machine.

One object of the invention is to provide a simple and thoroughly practical lapping machine for simultaneously lapping or polishing a plurality of crankpins and main bearings on a crankshaft. A further object of the invention is to provide a crankshaft lapping machine in which all of the crankpins and main bearings may be simultaneously lapped. Another object of the invention is to provide a crankshaft lapping machine for simultaneously lapping the crankpins and bearings of the crankshaft, in which a plurality of lapping arms are hydraulically operated. A further object of the invention is to provide a crankshaft lapping machine in which all of the bearing and crank lapping arms are mounted on a movable frame which is movable to and from an operating position by a hydraulically operated mechanism. A further object of the invention is to provide a hydraulically operated clamping mechanism for clamping the lapping arms in an indexed position during the loading operation.

A further object of the invention is to provide a hydraulically operated footstock for aiding in supporting the work. A further object of the invention is to provide a single control valve for interlocking the various hydraulic mechanisms of the machine. Another object of the invention is to provide a plurality of stops or latches to restrict the movement of the control valve so as to interlock the various hydraulically operated mechanisms of the machine, whereby all must be operated in a definite and predetermined cycle. 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 various possible embodiments of the mechanical features of this invention,

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

Fig. 2 is an end elevation, on an enlarged scale, of the improved crankshaft lapping machine;

Fig. 3 is a diagrammatic illustration of the hydraulic actuating mechanism and piping together with the control valve and the interlocking stop or latch mechanism therefor;

Fig. 4 is a cross sectional view, on an enlarged scale, taken approximately on the line 4—4 of Fig. 1;

Fig. 5 is a fragmentary sectional view, taken approximately on the line 5—5 of Fig. 2, showing the lapping arm clamping mechanism;

Fig. 6 is a fragmentary end elevation of a crank lapping arm and its supporting and clamping mechanism;

Fig. 7 is a fragmentary cross sectional view, on an enlarged scale, taken approximately on the line 7—7 of Fig. 5;

Fig. 8 is a fragmentary plan view, partly in section, of the control valve mechanism shown in Fig. 1;

Fig. 9 is a vertical sectional view, on an enlarged scale, taken approximately on the line 9—9 of Fig. 1;

Fig. 10 is a fragmentary cross sectional view, taken approximately on the line 10—10 of Fig. 8;

Fig. 11 is a fragmentary cross sectional view, taken approximately on the line 11—11 of Fig. 8;

Fig. 12 is a vertical sectional view, taken approximately on the line 12—12 of Fig. 9; and

Fig. 13 is a fragmentary front elevation, on an enlarged scale, of the valve controlling mechanism, having the displacement cylinders broken away and shown in section.

A crankshaft lapping machine has been illustrated in the drawings comprising a base 20 which supports a longitudinally reciprocable work supporting table 21. Table ways are provided between the base 20 and the table 21 which in the preferred form are of an anti-friction type. The base 20 is provided with a plate 26 which is fixed to the base 20 and is provided at its edge portions with grooves 27 and 28 which serve as inner raceways for a pair of spaced rows of anti-friction balls 29 and 30, respectively. A cage is provided between the races to space the balls 29 and 30 longitudinally, as desired. This construction forms an anti-friction way whereby the table 21 together with a headstock 22 and a footstock 23 may be readily reciprocated during the lapping operation.

Headstock

The headstock 22 is provided with a rotatable spindle 33 which is supported in bearings (not shown). The spindle 33 is rotated from any suitable source of power, such as an overhead belt drive or a self-contained electric motor. In the preferred construction, an electric motor 34 is mounted in the base 20 of the machine. The motor 34 is provided with a driving pulley 35 which is connected by multiple V-belts 36 with a

pulley 37 on the headstock 22. The headstock construction has not been illustrated in detail in the present application since this headstock is not considered to be a part of the present invention and, furthermore, it is identical with that shown in the prior U. S. Patent No. 2,092,734 dated September 7, 1937, to which reference may be had for details of disclosure not found herein.

A clutch 38 (Figs. 3 and 4) within the headstock 22 serves to connect the pulley 37 to rotate the spindle 33 and also to reciprocate the table 21. A clutch shifting yoke 39 is pivotally mounted on a rock shaft 40 in the headstock. It is desirable to provide an automatic control for the headstock clutch 38 which in the preferred form comprises a fluid pressure operated cylinder 41 having a piston 42 slidably mounted therein. A piston rod 43 is connected at its lower end to the piston 42 and at its upper end by pin 44 with a yoked end of the arm 45 which is fixedly mounted on the rock shaft 40. When fluid under pressure is admitted through a pipe 46 into a cylinder chamber 47 above the piston 42, it thereby causes a downward movement of the piston 42 and a counterclockwise movement of the arms 45 and 39 to move the clutch member 38 toward the right to engage the power drive to start the rotation of the headstock spindle 33 and the reciprocation of the table 21. Similarly, when fluid under pressure is admitted through a pipe 48 into a cylinder chamber 49 below the piston 42, thus causing an upward movement of the piston 42 and a rocking of the levers 45 and 39 in a clockwise direction to shift the clutch member 38 toward the left (Fig. 4), the clutch 38 is disengaged, thus disconnecting the power drive and stopping the rotation of the headstock spindle 33 and thereby stopping the oscillation or reciprocation of the work supporting table 21.

Table reciprocation

In the lapping of crankpins and main bearing of an automotive camshaft, it is desirable to provide a relative reciprocatory movement between the crankshaft or camshaft being lapped and the lapping or abrading elements to prevent production of abrasive grain markings on the pins and bearings of the crankshafts or the cams and bearings of the camshafts. In the present case, the work table 21 is arranged for a longitudinal reciprocatory movement which is preferably accomplished by transmission of the rotary motion of the headstock spindle 33 into a reciprocatory movement of the table 21. The specific mechanism for reciprocating the table 21 has not been illustrated in the present case, since this mechanism is identical with that shown in the prior U. S. Patent No. 2,092,734 dated September 7, 1937, to which reference may be had for details of the table reciprocating mechanism not found herein.

Footstock

One end of the crankshaft 24 is supported by a footstock 23 which is provided with a footstock center 51 which is journalled in bearings 53 and 54 within a hollow slidably mounted sleeve 55. The sleeve 55 is slidably keyed by means of a key 56 within an aperture in the footstock frame.

A fluid pressure actuating mechanism is provided for moving the footstock center 51 rapidly to and from an operative position to support one end of the crankshaft 24 within the machine. This mechanism comprises a fluid pressure cylinder 58 having a slidably mounted piston 59 contained therein. The piston 59 is connected to one end of a piston rod 60 which is connected to a pin 61. The central portion of the pin 61 is slabbed off on opposite sides so as to slide within an elongated slot 62 formed in an enlarged end portion of the piston rod 60. The pin 61 serves as a central pivotal connection between a pair of toggle levers 63 and 64. The toggle lever 64 is connected to the footstock frame by means of a stud 65. The other end of the toggle lever 63 is connected by a stud 66 with a slidably mounted hollow sleeve 67 which slides within an aperture 68 within the sleeve 55. The sleeve 67 is held against rotation by means of a pin 69 which is carried by the sleeve 67 and rides within an elongated slot in the sleeve 55. A spring 70 is contained within the sleeve 67 and is interposed between the end of an aperture of the sleeve 67 and a thrust collar 71.

When fluid under pressure is admitted through a pipe 72 to a cylinder chamber 73, the piston 59 is moved downwardly and the toggle levers 63 and 64 are moved from dotted line positions 63*a* and 64*a* into the full line positions 63 and 64 (Fig. 3) which serves to move the sleeve 67 into the position illustrated. This movement serves to compress the spring 70 and, through the connecting parts, moves the sleeve 55 and the footstock center 51 into operative supporting engagement with the end of the crankshaft 24. During this movement, fluid is exhausted from a cylinder chamber 74 through a pipe 75. The admission to and exhaust of fluid from the footstock operating cylinder 58 will be hereinafter described. The footstock is identical with that shown in the prior United States Patent No. 2,117,960 dated May 17, 1938, to which reference may be had for details of disclosure not contained herein.

Lapping arm support

It is desirable to provide a movable support for a plurality of lapping arms so that they may simultaneously and quickly be moved into an operative or inoperative position as desired. A pair of spaced arms 80, only one of which has been illustrated in the drawings (Fig. 2), are mounted on a rock shaft 81 which is supported in bearings on the rear of the machine base 20. The arms 80 are provided with horizontally extending portions which are connected by two spaced bars 82 and 83 which serve as slide bars or ways for supporting a plurality of lapping arms to be hereinafter described. The lapping arm assembly supported by the arms 80 is arranged so that it may be automatically moved to and from an operating position to facilitate loading of crankshafts into the machine and removing them therefrom after a lapping operation has been completed. In order to move the entire lapping arm assembly to and from an operative position, a fluid pressure mechanism is provided including a fluid pressure cylinder 84 which is pivotally mounted by means of a stud 85 within the base 20 of the machine. A piston 86 is slidably mounted within the cylinder 84 and is connected to one end of a piston rod 87. The other end of the piston rod 87 is connected by means of a stud 88 with an arm 89 pivotally mounted on a shaft 90 supported within the base 20. The other end of the arm 89 is connected by a stud 91 to one end of a link 92.

The other end of the link 92 is connected by means of a stud 93 with a toggle lever 94. The adjacent ends of the toggle lever 94 and a toggle lever 95 are connected by means of a stud 96. The toggle lever 94 is connected at its other end by means of a stud 97 with the base 20. The toggle lever 95 is connected by a stud 98 with an arm 99 which is fixedly mounted on the rock shaft 81 and is arranged to rock the shaft 81 together with the arms 80 and all of the crankpin and bearing lapping arms together with their supporting and actuating mechanisms either into or away from an operating position.

The levers 89, 92, 94 and 95, as shown in full line positions (Fig. 2), are in a position to hold the arm 99 together with the entire lapping arm assembly in operating position. After the lapping operation has been completed, fluid under pressure is admitted to the cylinder 84 to cause the piston 86 and piston rod 87 to move toward the right (Fig. 2) to shift the levers 89, 92, 94 and 95 and also the arm 99 into the dotted line positions, 89*a*, 92*a*, 94*a* and 95*a* and 99*a*. This movement serves to rock the arms 80 in a clockwise direction (Fig. 2) to move the entire lapping arm assembly to an inoperative position.

Fluid pressure system

A fluid pressure system is provided to control the admission of fluid under preesure to the cylinder 84. A pump 100 in the base 20 of the machine draws fluid through a pipe 101 from a reservoir 102 within the base 20 of the machine and passes fluid under pressure through a pipe 103 to a manually operable control valve 104. The valve 104 is of a piston type having a valve stem 105 which is provided at its outer end with a spool-shaped member 106 and is connected by means of a stud or pin 107 mounted on one end of a control lever 108. The control lever 108 is pivotally mounted on the front of the machine base by means of a stud 109 which is supported on the base 20 of the machine. A plurality of valve pistons 110, 111, 112, 113 and 114 are formed integral with the valve stem 105. Fluid under pressure passing through the pipe 103 passes into a valve chamber 115 located between the valve pistons 112 and 113 and passes out through a pipe 116 into a cycle control valve 117. The manually operated control valve 104 serves also as a stop and start valve for the cycle control valve 117. At the same time, fluid under pressure is admitted through the pipe 116, and fluid under pressure also passes through a pipe 118 into the right-hand end chamber of the cycle control valve 117. The cycle control valve 117 is a piston type valve comprising a valve stem 119 which has formed integrally therewith valve pistons 120, 121, 122 and 123. When fluid under pressure is admitted through the pipe 118 into a chamber 124 between the valve piston 123 and the end cap of the valve 117, the valve stem 119 is moved in a manner to be hereinafter described into its extreme left-hand position (Fig. 3).

Fluid under pressure passing through the pipe 103 into the valve chamber 115 passes out through the pipe 116 into a valve chamber 125 located between the valve pistons 121 and 122 and passes out through a pipe 126 into a cylinder chamber 127 to move the piston 86 into the position illustrated in Figs. 2 and 3 so that the lapping arm assembly is in an operative position.

During the admission of fluid under pressure to the cylinder chamber 127, fluid is exhausted from a cylinder chamber 128 at the other end of the cylinder 84 through a pipe 129, through a valve chamber 130 located between the valve pistons 122 and 123, and passes out through a pipe 131 into a hydraulic control mechanism to be hereinafter described. A fluid pressure relief valve 132 is connected in the pipe line 103 and serves to by-pass excess fluid under pressure within the pipe 103 to the reservoir 102.

The cycle control valve 117 also serves to control the admission of fluid under pressure to the footstock actuating cylinder 58. The pipe 72 is connected to the pipe 126 and serves to convey fluid under pressure to the footstock cylinder chamber 73 simultaneously with the passage of fluid under pressure to the cylinder chamber 127 of the cylinder 84. The pipe 75, which is connected to the cylinder chamber 74 of the cylinder 58, is connected with the pipe 129 so that in the position of the cycle control valve 117 (Fig. 3), fluid will exhaust simultaneously from the cylinder chamber 74 in the cylinder 58 and from the cylinder chamber 128 in the cylinder 84.

When the cycle control valve 104 is shifted into the position illustrated in Fig. 3, fluid under pressure simultaneously enters both the cylinders 58 and the cylinder 84 and, due to the fact that less power is required to move the footstock center than the lapping arm assembly, the footstock center 51 moves first into an operative position in engagement with the end of the work piece 24, after which the lapping arm assembly moves into an operative position adjacent to the crankpins and bearings to be lapped.

Lapping arms

In order that all of the crank pins and main bearings on the crankshaft 24 may be simultaneously lapped, a plurality of crankpin and bearing lapping arms are provided which correspond in number with the crankpins and bearings to be lapped. As illustrated, there are three main bearing lapping arms 140, 141 and 142. There are four crank lapping arms 143, 144, 145 and 146. The main bearing and crankpin lapping arms are supported in spaced relationship with each other so as to simultaneously engage and lap the three main bearings and the four crankpins on the crankshaft 24.

The bearing lapping arms and crankpin lapping arms are substantially identical in construction. The bearing lapping arms are stationary while lapping the main bearings which are concentric with the axis of rotation of the crankshaft 24, whereas the crankpin lapping arms are rocked during the lapping operation due to the fact that they engage a crankpin which revolves about the axis of rotation of the crankshaft 24.

A side elevation of the lapping arm 142 is shown in Figs. 2 and 6. The lapping arm 142 as well as all of the other lapping arms are each provided with a pair of pivotally mounted lap supporting arms 150 and 151 which are provided at their operative ends with partial cylindrical lap supporting blocks 152 and 153, respectively. The arms 150 and 151 are pivotally supported by the studs 154 and 155 on the lapping arm 142. The other ends of the arms 150 and 151 are interconnected by means of a pair of toggle levers 156 and 157 which are connected together at their inner ends by means of a stud 158. The stud 158 slides in an elongated slot 159 in the side plate of the lapping arm 142. When the toggle levers 156 and 157 are in a straight line position (Figs. 2 and 6), the lap supporting members 152 and 153 are maintained in operative engagement

to hold an abrasive or lapping element in operative contact with a portion of the crankshaft 24. The lap supporting arms 150 and 151 are arranged to be automatically moved into and away from an operative position, and in the preferred construction a hydraulically operated mechanism is provided for actuating the same comprising a fluid pressure cylinder 142a which is either fixedly mounted on or formed integral with the upper end of the lapping arm 142. A piston 142b is slidably mounted therein and is connected to one end of a piston rod 142c. The other end of the piston rod 142b is connected by a stud 160 with a link 161. The other end of the link 161 is connected to the stud 158 which pivotally connects the adjacent ends of the toggle levers 156 and 157.

It will be readily apparent from the foregoing disclosure that when the piston 142b is moved downwardly, that is, toward the left (Fig. 2), the piston rod 142c and the connecting link 161 will be moved also in a downward direction toward the left which serves to unlock the toggle levers 156 and 157 and thereby to rock the lap supporting arms 150 and 151 together with the lap supporting elements 152 and 153 to an inoperative position out of engagement with the crankshaft 24. When fluid under pressure is passed through a flexible pipe 142f into a cylinder chamber 142e, the piston 142b will be moved downwardly to move the toggle levers 156 and 157 into a straight-line position (Figs. 2 and 6) to move the abrasive lapping element into an operative position in engagement with the work piece 24 for a lapping operation. Similarly, when fluid under pressure is admitted to a flexible pipe 142f to cause an upward movement of the piston 142b toward the right (Figs. 2 and 6), the toggle levers 156 and 157 will be unlocked to move the lapping elements to an inoperative position.

It is to be noted in the drawings (Fig. 3) that each of the lapping arms is provided with an independent fluid operated piston and cylinder as well as piston rods which have been designated in the diagram with the same reference numerals as the lapping arm on which it is mounted, the cylinders being designated by the letter *a*, the pistons by the letter *b*, the piston rods by the letter *c*, and the cylinder chambers by the letter *e*.

It is desirable that all of the lapping elements represented by the supporting members 152 and 153 (Fig. 2) be moved into and away from an operative position simultaneously. This is preferably accomplished by providing a pair of longitudinally extending pipes or manifolds 163 and 164 which are fixedly supported on the spaced arms 89 and serve as a common source of fluid under pressure which may be forced either through the flexible pipe 142d to move the lapping elements into an operative position, or when the fluid under pressure is reversed, to flow through the flexible pipe 142f simultaneously to move all of the lapping elements to an inoperative position after the lapping operation has been completed. The admission to and exhaust of fluid from the manifold or pipes 163 and 164 is controlled by the cycle control valve 117. A pipe 165 is connected between the manifold or pipe 163 and the valve chamber 125 and serves in the position of the valve 117 (Fig. 3) to admit fluid under pressure to the manifold or pipe 163, into the cylinder chamber 142e, and simultaneously to all of the other corresponding cylinder chambers in the cylinders on each of the lapping arms to move and hold said lap supporting arms in an operative position for a lapping operation. A pipe 166 is connected between the manifold or pipe 164 and the valve chamber 130 so that in the position of the valve 117 (Fig. 3), fluid may be exhausted from the upper cylinder chambers on each of the lapping arms, through the manifold 164 and the valve chamber 130, into the pipe 131 into a fluid control system to be hereinafter described.

Each of the lapping arms 140 to 146 inclusive is pivotally supported. The details of the support for the lapping arms being identical, only one support has been illustrated in detail. An arm 175 is pivotally mounted on a supporting member 176 which is clamped in adjusted position on the guide rods 82 and 83. The lower end of the arm 175 is pivotally mounted to the supporting member 176 by means of a pivotal connection 177. A pivotal connection 178 serves to connect the arm 175 with the lapping arm 142 so that the arm 142 is free to move. All of the lapping arms, both crankpin and main bearings, are mounted in the same manner so that when the lapping elements are clamped in engagement with a crankpin and main bearing, the crank lapping arms may follow as the crankpin is revolved to produce the desired lapping action.

A flexible abrasive paper or cloth is preferably utilized as an abrading or lapping medium. Each of the lapping arms is provided with a separate strip of continuous abrasive paper which wraps around the crankpin or main bearing and is held in position thereagainst by the lap supporting members 152 and 153. A rod 180 is supported on the rear of each of the supporting members 176 by means of a bracket 181 and serves as a support for a reel 182 of flexible abrasive paper 183. The abrasive paper 183 passes through guides 184 and 185 supported on the under side of the supporting member 176 and passes through a series of rollers 186 carried by a bracket 187. The abrasive paper above described wraps around a main bearing or a crankpin of the crankshaft 24 and is supported by the lap supporting members 152 and 153. The worn or used abrasive paper is wound up on a reel 188 which is supported by a stud 189 carried by a bracket 190 supported on the lap supporting arm 150.

The lap supporting members 152 and 153 are mounted so that they may float or move relative to the arms 150 and 151, so that the lap supporting members 152 and 153 are self-aligning when brought into operative engagement to support the abrasive paper on a crankpin on the main bearing for a lapping operation.

The brackets 187 and 190 are fixedly mounted to the floating lap supporting members 152 and 153. A holding pawl 191 cooperating with a ratchet wheel on the end of the reel 188 serves to prevent unreeling of the worn abrasive paper 183 wound up on the reel 188 when the lap supporting arms 150 and 151 are moved to and from an operating position. As illustrated in the drawings, the abrasive paper is fed manually when desired by the operator by manually turning the reel 188. Only one of the reels 188 and the associated parts to guide the abrasive lapping paper 183 through the reel 188 has been illustrated in detail. Each lapping arm is provided with similar equipment supported on a separate supporting member 176. The abrasive paper and wind-up reels for each of the lapping arms are illustrated in the front elevation of the machine (Fig. 1).

The lapping arm 140 is supplied with a strip of abrasive paper 195 which is wound up on a reel 196. The lapping arm 143 is provided with a strip

of abrasive paper 197 and the used portion thereof is wound up on a reel 198. The lapping arm 144 is supplied with a strip of abrasive paper 199, the used portion of which is wound up on a reel 200. The lapping arm 141 is supplied with a strip of abrasive paper 201, the used portion of which is wound up on a reel 202. The lapping arm 145 is provided with a strip of abrasive paper 203, the used portion of which is wound up on a reel 204. The lapping arm 146 is supplied with a strip of abrasive paper 205, the used portion of which is wound up on a reel 206. Inasmuch as the abrasive paper supporting reels and guide means are identical for each of the lapping arms, only one of these mechanisms has been completely illustrated, as shown in Fig. 2.

It is desirable to provide a guiding means for guiding the lapping arms during their swinging movement as they follow the revolving crankpins, and to provide a clamping mechanism to clamp all of the lapping arms in their indexed position relative to the supports 176 before the lap supporting members 152 and 153 are released from operative position and the lapping arm assembly is swung to an inoperative position to facilitate loading of the machine. It is desirable to provide such a clamping device so that when the arms 80 are moved to an inoperative position after a new crankshaft has been loaded into the machine, all of the lapping arms will be in proper indexed position so that the lap supporting members 152 and 153 may be automatically brought into engagement simultaneously with each of the crankpins and main bearings of the crankshaft 24.

In order that the lapping elements may be guided in their swinging movement and held against lateral movement during reciprocation or oscillation of the crankshaft 24 during the lapping operation, a pair of parallel guiding plates 210 and 211 are fixedly mounted on the supporting bracket 176 and are spaced apart by a distance equal to the thickness of the lapping arm 142. The lapping arm 142 is guided thereby and is held against lateral movement by the guide plates 210 and 211. The lapping arm 140 is similarly guided by guide plates 212 and 213. The lapping arm 143 is guided by guiding plates 214 and 215. The lapping arm 144 is guided by the guiding plates 216 and 217. The lapping arm 141 is guided by guide plates 218 and 219. The lapping arm 145 is guided by guide plates 220 and 221, and the lapping arm 146 is guided by the guiding plates 222 and 223.

Lap arm—clamping device

In order to provide means for simultaneously clamping all of the crankpins and the bearing lapping arms in their respective indexed positions, the guide plates 210, 212, 214, 216, 218, 220 and 222 are each provided with a groove or guideway 224 which supports a slidably mounted member 225 having cam surface depressions 226 formed in the slidably mounted member 225. It will be readily apparent that if the slide 225 is moved upwardly (Figs. 5 and 7) relative to the guiding plate 210, the cam depression 226 engaging the fixed cams 227 and 228 will cause the slide member 225 to move toward the right (Fig. 6) and thereby bind or clamp the lapping arm 142 in a fixed position relative to the guiding plates 210 and 211. Each of the lapping arms 140 to 146 inclusive is provided with an identical clamping means, consequently only one of these clamps has been illustrated in detail. The guide plates 212, 214, 216, 218, 220 and 222 are each provided with a clamping slide 212*a*, 214*a*, 216*a*, 218*a*, 220*a* and 222*a*, respectively.

In order to simultaneously clamp all of the lapping arms, a mechanism is provided for simultaneously actuating the clamping slides 225, 212*a*, 214*a*, 216*a* 218*a*, 220*a* and 222*a*. As illustrated in the drawings, a shaft 231 is rotatably supported in apertures in the guiding plates 210 to 223 inclusive. Each of the clamping slides is provided with an elongated slot 232 (Fig. 7). The shaft 231 carries an eccentric 233 which rides within the elongated slot 232. When the shaft 231 is rotated, the eccentric 233 rotating within the elongated slot 232 causes the clamping slide 225 to move relative to the guiding plates 210 and 211, so as to clamp the lapping arm 142 in an indexed position relative to the plate. The shaft 231 is provided with a plurality of eccentric members corresponding to the eccentric 233, each of which is arranged to engage elongated slots in the respective clamping slides 212*a*, 214*a*, 216*a*, 218*a*, 220*a* and 222*a*.

Clamp actuating motor

A vane type fluid pressure motor 240 is provided for rocking the shaft 231 simultaneously to clamp and release all of the lapping arms. The motor 240 is provided with a rotor shaft 241 which supports a rotary vane 242. The rotor shaft 241 projects from the motor casing toward the left (Fig. 5). An arm 243 is supported on one end of the rotor shaft 241. The arm 243 is provided with an enlarged head 244 having a notch 245 formed in the outer end thereof. A lever 246 is fixedly mounted on the shaft 231 and is provided with a spring-pressed plunger 247 which is arranged to engage the notch 245 to lock the lever 246 to the lever 243 so that the rotation of the vane 242 of the motor 240 will be transmitted to rotate the shaft 231 to clamp or release all of the lapping arms. The plunger 247 is connected with a knob 248 by means of which the plunger 247 may be withdrawn from the notch 245 so that the clamping mechanism may be operated manually if desired.

Interlocks

In order to attain one object of the invention, it is desirable to provide suitable interlocks so that various mechanisms of the machine will operate in a predetermined sequence. When a crankshaft has been loaded into the machine, the control lever 108 is moved to shift the valve 104 to start the cycle of operation. The movement of the valve 104 serves to shift the cycle control valve 117 by an intermittent stepped movement controlled by a mechanism to be hereinafter described, so that the moving parts of the machine operate in the following sequence:

(*a*) Footstock center 51 moves in to grip work.
(*b*) Arms 80 which support the crankpin bearing lapping arms swing forward into an operating position.
(*c*) Jaws close onto work.
(*d*) Lapping arms are unclamped.
(*e*) Headstock starts rotating.
(*f*) Headstock stops rotation.
(*g*) Lapping arms are clamped in an index position.
(*h*) Jaws open.
(*i*) Arms 80 swing back to an inoperative position.
(*j*) Footstock center moves out of engagement with the work to release the same, after which the crankshaft may be unloaded from the machine.

The cycle control valve 117 is shifted from one end position to another by fluid under pressure conveyed to end chambers at opposite ends of said valve. In order to obtain the desired operating cycle, the ports from the valve 117 to the various hydraulically operated units, namely footstock cylinder 58, lap arm engaging cylinders, clamp rotary motor 240, and headstock clutch cylinder 41, are arranged so that fluid under pressure is admitted to the various units in the desired sequence so as to obtain a predetermined cycle of operation. It is desirable to control the shifting of the valve stem 119 of the valve 117 so that it moves intermittently to allow each individual mechanism sufficient time to operate before the valve shifts to admit fluid to the next mechanism. In order to control the movement of the valve 117, a stop plate 250 is supported by brackets 251 and 252 which are connected to opposite ends of the valve stem 119. The stop plate 250 is provided with a stop abutment 253 which engages a stepped plate 254 when the valve stem 119 moves toward the right at the end of a lapping cycle. The stepped plate 254 is provided with stepped stops 255, 256, 257 and 258 which are engaged by the stop abutment 253 of the plate 250 successively to limit the movement of the valve stem 119 toward the right. The stepped plate 254 is supported by a guide 259 which serves to take the thrust of the valve stem 119.

The stepped plate 254 is moved vertically in timed relation with the operation of the various mechanisms of the machine successively to present successive stops into operative relation with the stop abutment 253 which moves with the valve stem 119. The vertical movement of the plate 254 is preferably controlled by a fluid operated cylinder 260 having a piston 261 slidably mounted therein. The piston 261 is connected to the lower end of a piston rod 262, the upper end of which is connected to the stepped stop plate 254.

A similar stop abutment 265 is provided on the plate 250. The stop abutment 265 is arranged in the path of a vertically movable stepped stop plate 266 having a plurality of stepped stop abutments 267, 268, 269 and 270. A guide 271 is provided for the vertically movable stepped plate 266. This guide block is supported in fixed relation with the base of the machine and serves to take up the thrust of the moving valve stem 119 when the valve is being moved toward the left at the start of a lapping cycle. The stepped stop plate 266 is similarly moved vertically in a manner to be hereinafter described by means of a fluid pressure mechanism comprising a cylinder 275 having a piston 276 slidably mounted therein. A piston rod 277 is connected at its lower end to the piston 276 and at its upper end is connected to move the stepped stop plate 266 to produce an intermittent stepped movement of the cycle control valve 117 as the valve moves toward the left at the start of a lapping cycle.

The cylinders 260 and 275 are connected to receive the exhaust of fluid from each side of the system. The shape of the stepped stop plates 254 and 266 is determined by the fluid volume contained in the various fluid pressure operated mechanisms of the machine so that when fluid exhausts from one mechanism, the volume will be sufficient to raise the pistons 261 or 276, as the case may be, a sufficient distance to bring the next stop on the stepped stop plate into operative position with the stop plate 250. Fluid under pressure exhausting from the foodstock cylinder 58, the lapping arm assembly cylinder, a lapping arm clamping motor 240, the lapping jaw closing cylinders, and the headstock cylinder 41, exhausts through the valve chamber 130 located between the valve pistons 122 and 123 in the valve 117, out through a pipe 131, through a valve chamber 280 located between the valve pistons 113 and 114 of the valve 104, and passes out through a pipe or passage 281 into a cylinder chamber 282 below the piston 276 intermittently to raise the piston, thus moving the stepped stop plate 266 vertically to bring successive steps into operative relation with the stop abutment 265 of the plate 250.

Similarly, when the cycle control valve 117 is moved into its reverse position, fluid is exhausted from the various hydraulically controlled units into a valve chamber 285 located between the valve pistons 120 and 121 in the cycle control valve 117, through a pipe 286, into a valve chamber 287 located between the valve pistons 110 and 111 of the manually operated valve 104. Fluid passes from the valve chamber 287 through a pipe or passage 288, into a cylinder chamber 289 to raise the piston 261 a distance governed by the volumetric exhaust of fluid from the operating mechanism.

The stepped stop plates 254 and 266 serves to limit the movement of the valve stem 119 either toward the right or toward the left, respectively, so that the various hydraulically operated mechanisms will operate in a definite sequence. In order to slow down the movement of the valve piston 119 before the stop abutments 256, 257 and 258, respectively, are engaged by the stop abutment 253, a throttle valve 290 is placed in the exhaust pipe line 291 so that when the valve stem 119 is moved toward the left, fluid which is exhausted from the left-hand end chamber of the valve 117 through the pipe 305 passes out through a valve chamber 292 located between the valve pistons 111 and 112 and out through the pipe 291, throttle valve 290 and pipe 293 into the reservoir 102. The valve 290 is normally held in an upward position by means of a spring and may be partially closed automatically by means of the adjustable screws 294, 295 and 296 carried by the plate 250 engaging the head of the valve 290 and throttling the fluid to slow down the movement of the valve stem 119.

Similarly, when the valve stem 119 of the valve 117 is moved toward the right by fluid under pressure after a lapping operation has been completed, fluid exhausts from the end chamber 124, through a pipe 116, into a valve chamber 115 located between the valve pistons 112 and 113, and passes out through a pipe 297, a throttle valve 298, and a pipe 299 into the reservoir 102. The throttle valve 298 is similarly closed automatically by means of a plurality of adjustable screws 300, 301 and 302 which are carried by the plate 250 and which serve to slow down the movement of the valve stem 119 as the abutment 265 on the plate 250 is moved into the various steps on the stepped stop plate 266. The operation of this improved machine will be readily apparent from the foregoing disclosure. The positions of the parts show the machine in an operating position and the lapping elements in operative engagement with the crankshaft being lapped. The lapping operation proceeds to the desired extent. After a predetermined lapping operation has been completed, the control lever 198 is rocked in a counterclockwise direction. This movement serves to

shift the valve stem 105 toward the right, thus changing the direction of flow of fluid. Fluid under pressure passing through the pipe 103 enters a valve chamber 292 located between the valve pistons 111 and 112 and passes out through a pipe 305 into the left-hand end chamber in the cycle control valve 117 to start the valve stem 119 moving toward the right.

In the position of the valve shown in Fig. 3, the stop abutment 265 bears against the stop surface 267 of the stepped stop plate 266. When fluid under pressure is admitted through the pipe 305 into the left-hand end chamber of the valve 117, the valve stem 119 moves toward the right into the position illustrated in Figs. 12 and 13 with the stop abutment 253 of the plate 250 engaging the step 255 on the stepped plate 254. This movement of the valve 117 shifts the valve piston 121 so that fluid within the headstock clutch cylinder chamber 47 may exhaust through the pipe 46 into the valve chamber 285 and through the valve chamber 287 and out through the pipe or passage 288 into the cylinder chamber 289. The volume of fluid within the cylinder chamber 47 raises the piston 261 slightly from the bottom of the cylinder 260 into the position illustrated in Fig. 13, in which position the fluid within the left-hand end chamber of the valve 117 may continue the movement of the valve stem 119 toward the right. At the same time fluid is exhausted through the pipe 46, the valve piston 122 has moved toward the right sufficiently to admit fluid under pressure through the pipe 48 to raise the piston 42 and disengage the headstock clutch 38, thereby stopping the rotation of the headstock 22 and the reciprocation of the work supporting table 21.

The pressure within the left-hand end chamber of the valve 117 then shifts the valve stem 119 a further distance toward the right until the stop abutment 253 of the plate 250 engages the step 256 of the plate 254 which temporarily prevents further shifting of the valve stem 119. During this shifting movement of the valve stem 119, the adjustable screw 302 engages and actuates the throttle valve 298 to retard the exhaust of fluid from the end chamber 124 of the valve 117 to slow down the shifting movement of the valve stem 119.

When the valve stem 119 slows down as it approaches a second predetermined position, fluid within the clamping motor may exhaust through the pipe 243 and through the valve chamber 285, the valve chamber 287, and passage 288, into the cylinder chamber 289 below the piston 261, thus raising the piston 261 and stepped stop plate 254. During this exhausting movement, the valve piston 122 has moved sufficiently toward the right to uncover the port at the end of the pipe 244 so as to admit fluid under pressure through the pipe 244 into the clamping motor 240 to rotate the vane 242 in a clockwise direction to clamp all the lapping arms in an indexed position.

The exhaust fluid from the clamping motor 240 is sufficient to raise the plate 254 so that the valve stem 119 may continue its movement toward the right until the stop abutment 253 of the plate 250 and the valve stem 119 slows down as it approaches the step 257 of the stepped plate 254. During this movement the adjustable screw 301 engages and actuates the throttle valve 298 to slow down the movement of the valve stem 119 and prevent the stop abutment 253 from engaging the stepped plate 254 at a rapid rate. This movement of the valve stem 119 shifts the valve piston 121 a sufficient distance toward the right to uncover a port at the end of the pipe 165 which allows fluid within all of the lapping arm lap shoe actuating cylinders to exhaust from below the pistons. This exhaust fluid passes through the valve chamber 285, the valve chamber 287, through the pipe or passage 288 into the cylinder chamber 289 to raise the piston 261. The fluid volume within the lapping arm lap actuating cylinders is sufficient to raise the piston 261 and the stepped plate 254 a sufficient distance so that the valve stem 119 continues its movement a further distance toward the right. During this exhaust of fluid from the lap arm lap actuating cylinders, the piston 122 has moved a sufficient distance toward the right to uncover the port at the end of the pipe 166 so as to admit fluid under pressure through the pipe 166 simultaneously to release all of the lap elements from engagement with the crankpins and main bearings of the crankshaft 24.

The stepped plate 254 having been raised a sufficient distance, allows the valve stem 119 to move to its extreme right-hand position with the abutment 253 in engagement with the step 258 on the stepped plate 254. During movement into this position, the screw 300 engages the throttle valve 298 and slows down the movement of the valve stem 119. This latter movement of the valve stem 119 into its extreme right-hand position serves to move the valve piston 121 toward the right a sufficient distance to uncover the port at the end of the pipe 126, thereby allowing fluid simultaneously to exhaust from the chamber 73 of the footstock actuating cylinder 58 and from the cylinder chamber 127 of the lap arm assembly actuating cylinder 84. At the same time, the valve piston 122 has moved a sufficient distance toward the right to uncover the port at the end of the pipe 129 so that fluid under pressure within the chamber 125 is admitted through the pipe 129 simultaneously into a cylinder chamber 74 below the piston 59 of the footstock actuating cylinder 58 and into the chamber 128 at the left-hand end of the lap arm assembly actuating cylinder 84 which serves to withdraw the footstock center 51 and then to move the lapping arm assembly to its inoperative position to facilitate unloading the lapped crankshaft and to allow a new shaft to be placed in the machine.

During this stopping of the lapping cycle, the valve piston 114 of the valve 104 has moved toward the right so that fluid within the cylinder chamber 282 of the cylinder 275 may exhaust through the pipe 281 into the valve chamber 280 and out through the pipe 299 into the reservoir 102 so that when the parts are positioned at the end of the lapping cycle, the piston 276 will be in its extreme downward position ready for the next lapping cycle.

The crankshaft 24 which has been lapped is then removed from the machine and a new shaft to be lapped is placed in position on the work supporting cradles 310 and 311 and rolled into an operating position in vertical alignment with the work centers. The control lever 108 is then rocked in a clockwise direction to shift the valve 104 toward the left to initiate a lapping cycle. At the start of the lapping cycle, the stop abutment 253 is in engagement with the step 258 of the stepped plate 254. When the valve stem 105 is moved to its left-hand end position, fluid under pressure is admitted through pipe 118 to end chamber 124 to start the valve stem 119 moving toward the position illustrated in Fig. 3. The

valve stem 119 moves toward the left and its movement is slowed down as the abutment 265 approaches the step 270 on the stepped plate 266. This movement serves to admit fluid under pressure to operate the footstock piston 59 and to admit fluid under pressure to the lap arm assembly cylinder 84 to move the lapping arm assembly into operative position. During this movement fluid is exhausted from the opposite ends of the lap arm assembly cylinder 84 and the footstock cylinder 58 through the pipe 129 and into the cylinder chamber 282 to raise the stepped plate 266 so that the valve stem 119 may continue its movement toward the left until the stop abutment 265 approaches the step 269 of the stepped plate 266, which movement uncovers a port to admit fluid through the pipe 165 which moves all of the lap arm pistons upwardly to clamp the lapping elements in operative position on the pins and main bearings of the crankshaft 24. During this movement fluid within the other side of the lap arm cylinders passes out through the pipe 166 and into the cylinder chamber 282 again to raise the piston 276 and the stepped plate 266 so that the valve stem 119 may move so that the abutment 265 approaches the step 268. This further movement of the valve stem 119 serves to admit fluid under pressure through the pipe 243 to unclamp the lapping arms. During the unclamping movement fluid exhausts from the other side of the clamping motor 240 through the pipe 244 and into the cylinder chamber 282 to again raise the stepped plate 266. The plate 266 rises a sufficient distance so that the valve stem 119 may continue its movement toward the left until the abutment 265 approaches the step 267 of the plate 266 which uncovers a port to admit fluid under pressure through the pipe 46 into the chamber 47 of the headstock clutch cylinder 41 to engage the clutch 38 and start the work rotation and work support reciprocation, after which the lapping operation proceeds for the desired time interval. This cycle of operation is then repeated.

During the shifting of the valve stem 119 toward the left, the screws 294, 295 and 296 successively actuate the throttle valve 290 to throttle the exhaust of fluid from the left-hand cylinder chamber of the cycle control valve 117 to slow down the movement of the valve stem 119 during the various steps thereof.

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 hydraulically operated crankshaft lapping machine having a plurality of fluid motors independently to operate the footstock, the lap arm assembly frame, the opposed lapping elements, the clamping mechanism and the headstock clutch, a cycle control valve, end chambers in said cycle control valve whereby the valve may be shifted in either direction by fluid under pressure, a manually operable valve to admit fluid under pressure to either end chamber of said control valve, a throttle valve to control the exhaust of fluid from said end chambers, and means including a plurality of spaced adjustable members whereby the throttle valve may be actuated intermittently to slow down the control valve movement sufficiently so that one mechanism may complete its operation before the next mechanism starts whereby the footstock, lap arm assembly, lap elements, lap arm clamping mechanism and headstock clutch operate in the desired and predetermined sequence.

2. In a hydraulically operated crankshaft lapping machine having a plurality of fluid motors independently to operate the footstock, the lap arm assembly frame, the opposed lapping elements, the clamping mechanism and the headstock clutch, a cycle control valve, end chambers in said cycle control valve whereby the valve may be shifted in either direction by fluid under pressure, a manually operable valve to admit fluid under pressure to either end chamber of said control valve at the start or finish of a lapping operation, an independent throttle valve associated with each of said end chambers to control the exhaust of fluid therefrom and thereby to control the speed of movement of the cycle control valve, and means including a plurality of spaced adjustable members whereby the throttle valves may be actuated in timed relation with the cycle control valve movement to slow down the movement of the control valve sufficiently so that one mechanism may complete its operation before the next movement starts so that the footstock, lap arm assembly, lapping elements, lapping arm clamping mechanism and headstock clutch may be operated in the desired and predetermined sequence.

3. In a hydraulically operated crankshaft lapping machine having independent fluid motors to operate each mechanism, a cycle control mechanism including a control valve, said control valve being arranged successively to admit fluid under pressure to said motors independently to actuate the several mechanisms in a predetermined sequence, a manually operable valve to admit fluid under pressure to either end of said control valve at the start or finish of a lapping operation, a safety device including a stepped plate so as to prevent a continuous rapid shifting of said control valve, and a displacement piston and cylinder operatively connected to actuate said plate, said displacement piston being actuated intermittently by exhaust of fluid from said motors.

4. In a hydraulically operated crankshaft lapping machine having a plurality of fluid motors independently to actuate a footstock, a lap arm assembly frame, opposed lapping elements, a lap arm clamping mechanism and a headstock clutch, a cycle control valve, said control valve having end chambers whereby the valve is actuated by fluid under pressure, a manually operable valve to admit fluid under pressure to either end of said control valve at the start or finish of a lapping operation, a stepped plate which is arranged to prevent a continuous movement of the control valve, an independent throttle valve associated with each of said end chambers to control the exhaust of fluid therefrom, a displacement piston and cylinder operatively connected to move said plate, said displacement cylinder being displaced successively by exhaust of fluid from said motors, said displacement piston and cylinder and stepped plate serving as a safety device to prevent shifting of the cycle control valve unless said motors have functioned, and means actuated in timed relation with the move-

ment of said cycle control valve intermittently to actuate said throttle valves to slow down the shifting movement of the cycle valve to allow a sufficient time interval for each successive mechanism to function.

5. In a lapping machine having a plurality of lapping arms, a movable frame to support said arms, a clamping mechanism for clamping said arms relative to said frame, a rotatable work support including a motor driven headstock and footstock, means including a clutch to start said headstock, a plurality of fluid motors respectively connected to actuate said footstock, said frame, said lapping arms, said clamping mechanism and said headstock clutch, a control valve to control the admission to and exhaust of fluid from all of said motors, end chambers in said control valve, a manually operable start and stop valve to admit fluid under pressure to either one or the other of said end chambers, and means including an intermittently actuated stepped stop plate to produce an intermittent stepped movement of the control valve so as to interlock the several mechanisms of the machine.

6. In a lapping machine as claimed in claim 1, the combination with the parts and features therein specified, of a stepped plate which serves as a safety device during the stepped movement of said control valve when moved in either direction, a displacement cylinder and piston operatively connected independently to actuate each of said stepped plates, said displacement cylinder being arranged successively to receive exhaust fluid from said motors whereby the stepped plate is intermittently raised, the exhaust fluid from each of said motors being sufficient to displace said piston to raise the stepped plate a predetermined extent to allow the control valve to move to its next position.

7. In a crankshaft lapping machine as claimed in claim 1, the combination with the parts and features therein specified, of a safety device for controlling the intermittent movement of the control valve comprising a stepped plate, a displacement piston and cylinder actuated during the shifting of the control valve at the start of the lapping cycle by fluid exhausting successively from said motors to control the intermittent shifting of the control valve so as to provide an interlocking of the mechanism.

8. In a crankshaft lapping machine as claimed in claim 1, the combination with the parts and features therein specified, of a stepped plate, a displacement piston and cylinder to actuate said plate at the start of the lapping cycle by fluid exhausting successively from said motors, a second stepped plate, and displacement piston and cylinder to actuate said second plate during the shifting of the control valve at the end of a lapping cycle by fluid exhausting successively from the opposed sides of said motors to control the intermittent shifting of the control valve so as to interlock the actuation of the mechanisms during the stopping of the machine at the end of the lapping cycle.

9. In a lapping machine as claimed in claim 1, the combination with the parts and features therein specified, of a displacement piston and cylinder, connections between said piston and said stepped plate, and fluid connections between all of said motors, said control valve and displacement cylinder whereby the exhaust fluid from said motors serves to actuate said stepped plate.

10. In a lapping machine as claimed in claim 1, the combination with the parts and features therein specified, of a safety device including a stepped plate, a displacement piston and cylinder, connections between said piston and stepped plate, and fluid connections between all of said motors, said control valve and displacement cylinder, whereby exhaust fluid from said motors serves to displace said piston and thereby actuate the stepped plate, said steps on the plate being arranged so that exhaust fluid from one or more of said motors serves to raise the plate sufficiently to facilitate a further continued movement of the control valve.

11. In a lapping machine having a plurality of lapping arms, a movable frame to support said arms, a clamping mechanism for clamping said arms relative to said frame, a rotatable work support including a motor driven headstock and a footstock, means including a clutch to start said headstock, a plurality of fluid motors respectively connected to actuate said footstock, said frame, said lapping arms, said clamping mechanism and said headstock clutch, a control valve to control the admission to and exhaust of fluid from all of said motors, end chambers in said control valve, a manually operable start and stop valve to admit fluid under pressure to either one or the other of said end chambers, an independent throttle valve operatively connected independently to control the exhaust of fluid from each of said end chambers so as to control the speed of movement of the control valve in either direction, and a plurality of spaced adjustable screws which are movable with said valve to actuate said throttle valves periodically to slow down the shifting movement of the control valve so as to allow sufficient time for successive fluid motors to actuate their respective mechanisms before the control valve admits fluid under pressure to successive motors.

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