United States Patent

[11] **3,547,206**

[72] Inventor **Albert Phillips**
465 Kiwanis Ave., Morgantown, W. Va. 26585

[21] Appl. No. **807,388**
[22] Filed **March 14, 1969**
[45] Patented **Dec. 15, 1970**

[54] **ROTARY PERCUSSION DRILL HAVING A HYDRAULICALLY ACTUATED PERCUSSION DEVICE**
8 Claims, 13 Drawing Figs.

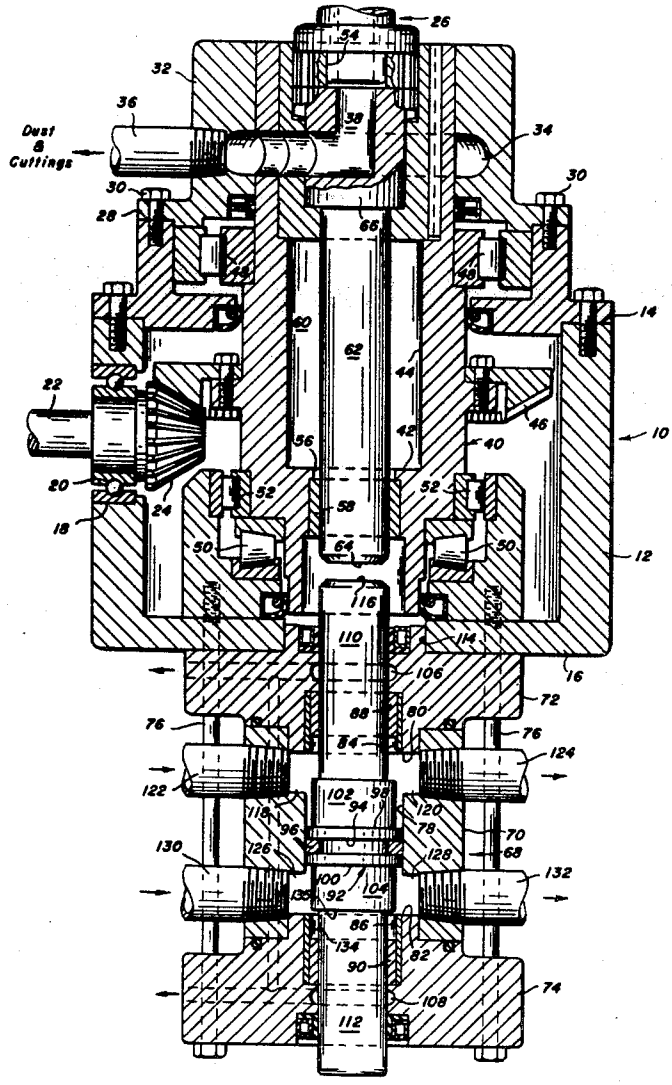
[52] U.S. Cl. **173/105,** 173/134, 173/57, 91/39
[51] Int. Cl. **E21c 1/12**
[50] Field of Search ..... 173/134-—138, 105; 91/39, 40

[56] **References Cited**
UNITED STATES PATENTS

3,005,442	10/1961	McMillan	91/40X
3,213,615	10/1965	Bjornberg	173/134X

Primary Examiner—Ernest R. Purser
Attorney—Stanley J. Price, Jr.

ABSTRACT: The percussive forces are imparted to the drill rod by a hydraulically actuated reciprocating piston housed in a cylinder having fluid openings on opposite sides of the piston. Fluid under pressure is supplied alternately to the respective openings to reciprocate the piston in the cylinder from a multivalve control device. A timing mechanism is included in the multivalve control device to open and close the valve ports within the valve to supply pressurized fluid alternately to the openings in the cylinder on opposite sides of the piston and to alternately vent the pressurized fluid from the cylinders. Pressure accumulators are employed as surge devices for excess fluid supplied to the cylinder for each stroke of the piston.



PATENTED DEC 15 1970

3,547,206

SHEET 1 OF 5

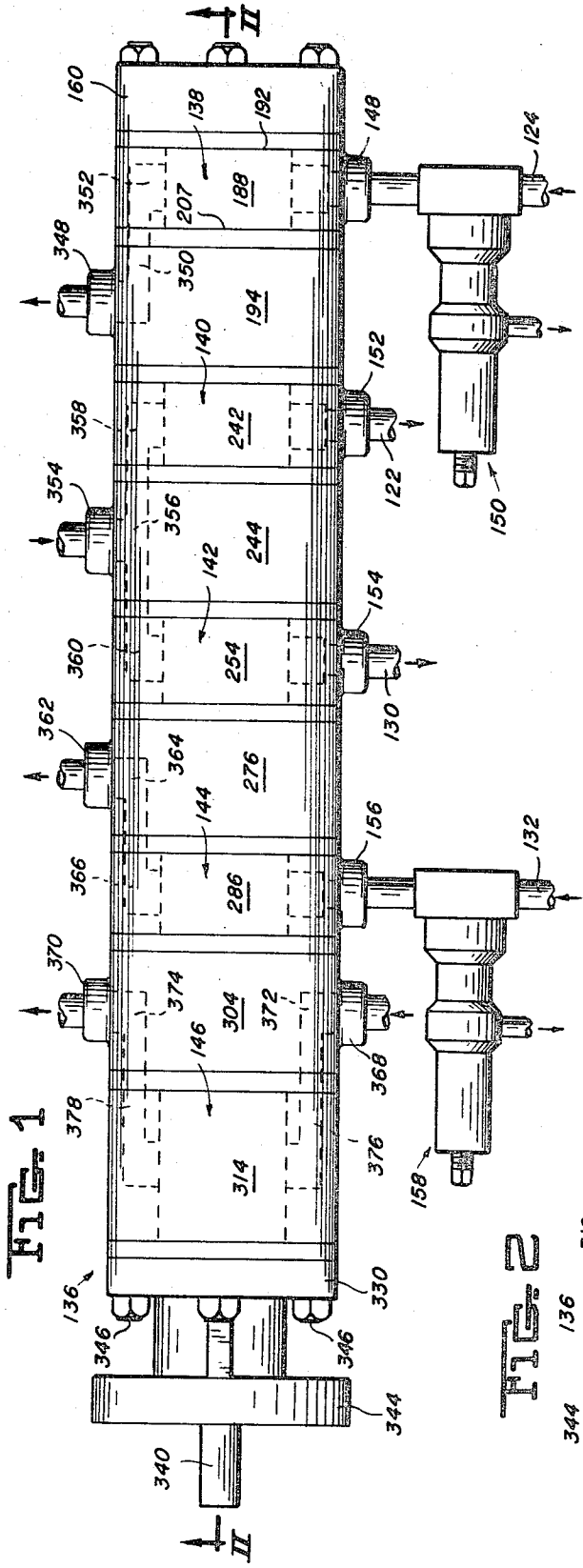


FIG. 1

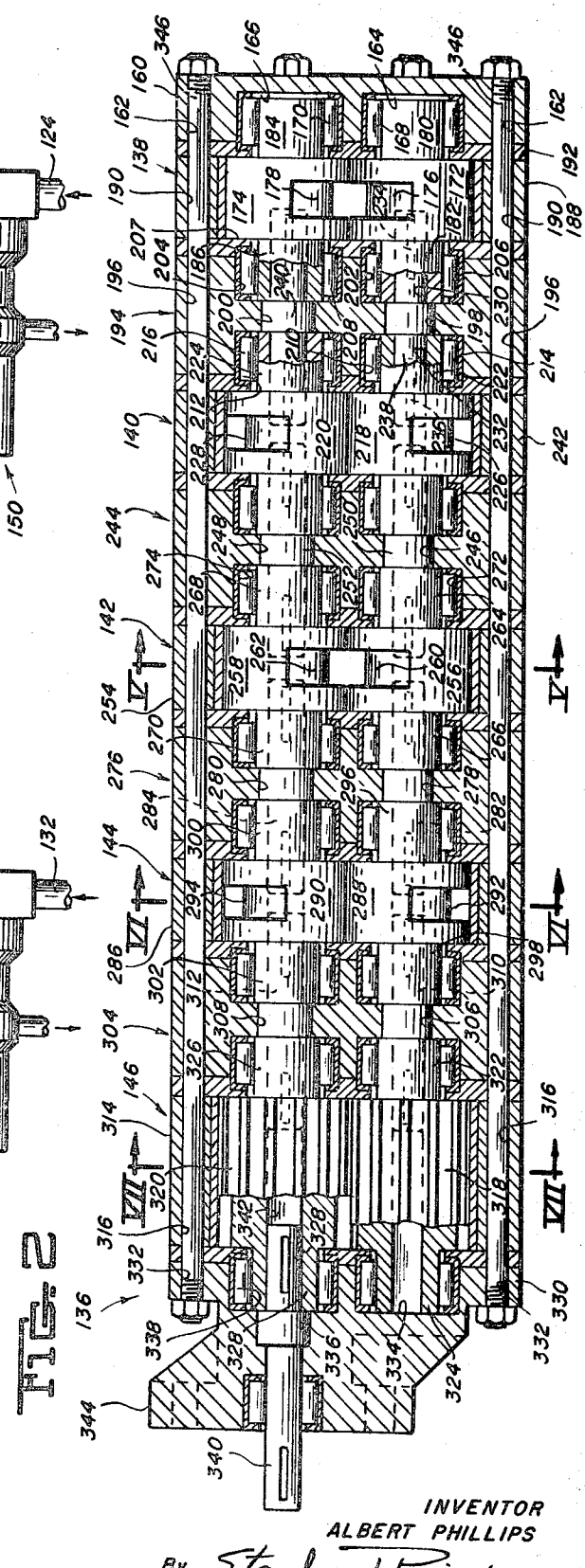
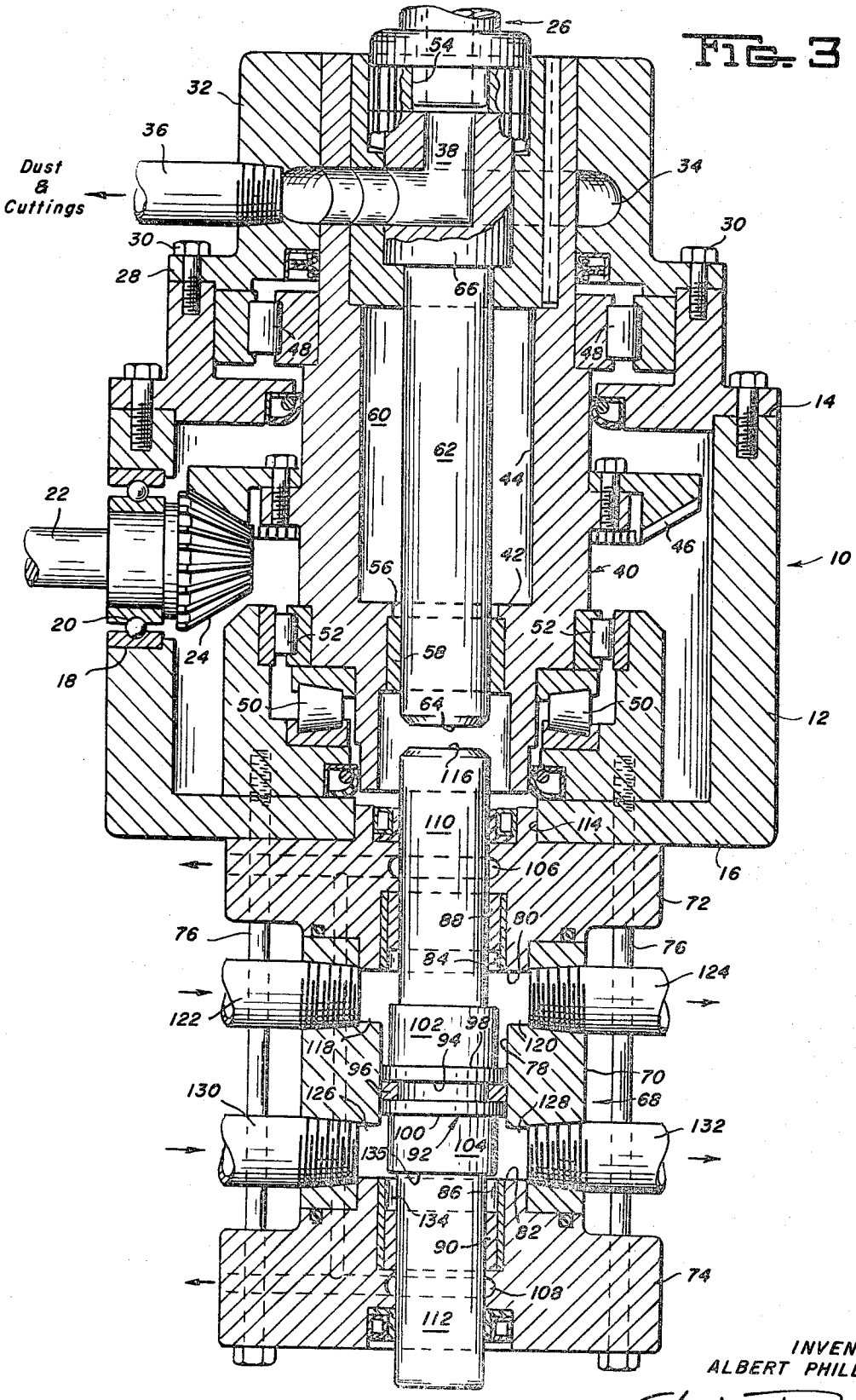


FIG. 2

INVENTOR
ALBERT PHILLIPS
By Stanley J. Price
his Attorney

FIG. 3



INVENTOR
ALBERT PHILLIPS

By Stanley J. Price

his Attorney

FIG. 4

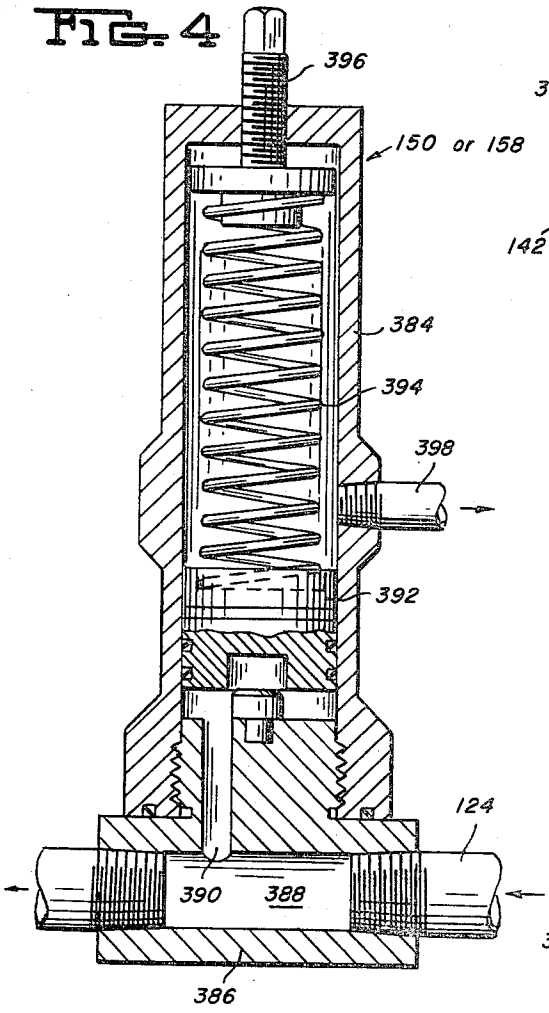


FIG. 5

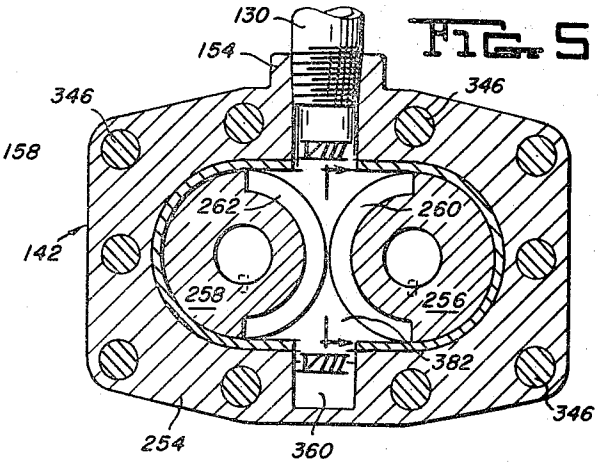


FIG. 8

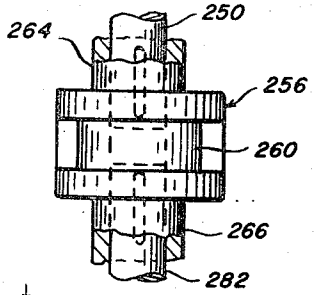


FIG. 6

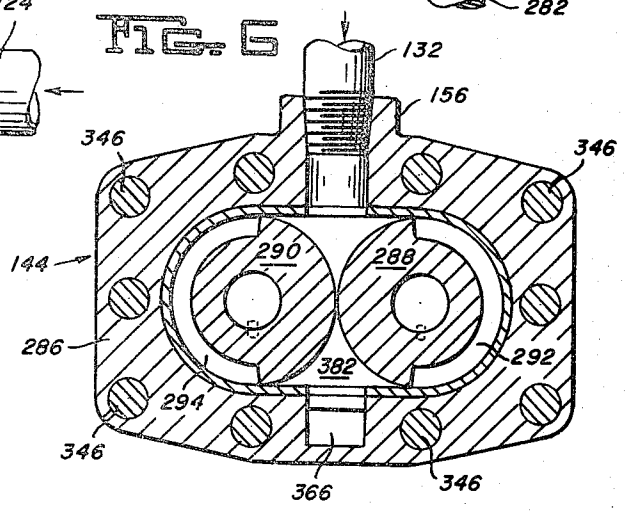
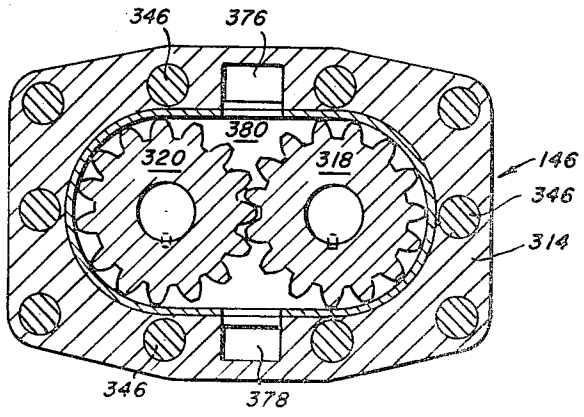


FIG. 7



INVENTOR
ALBERT PHILLIPS
By Stanley J. Price
his Attorney

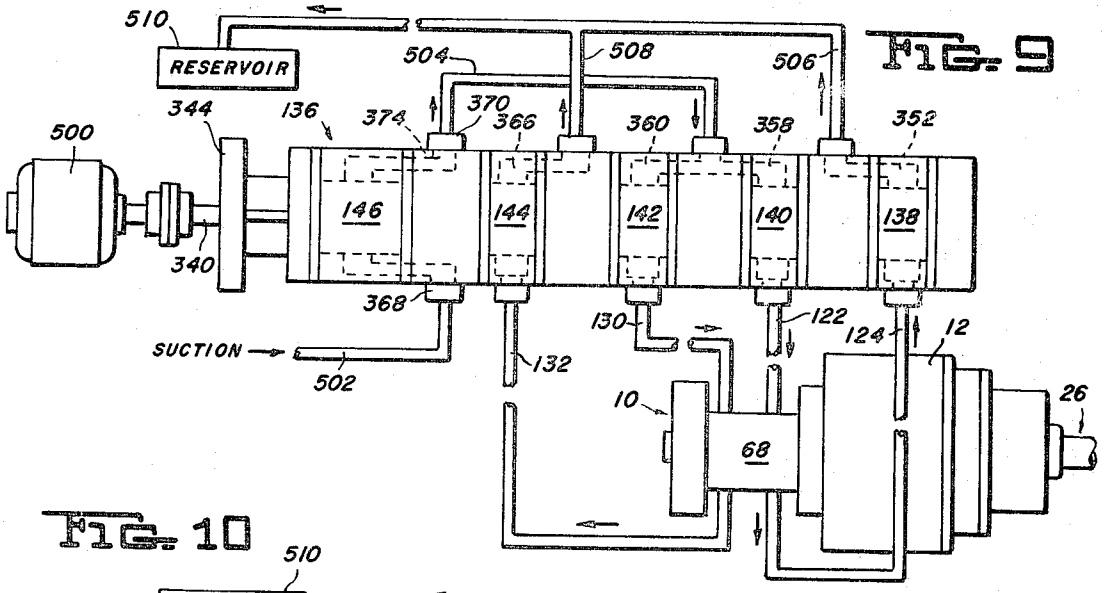


FIG. 9

FIG. 10

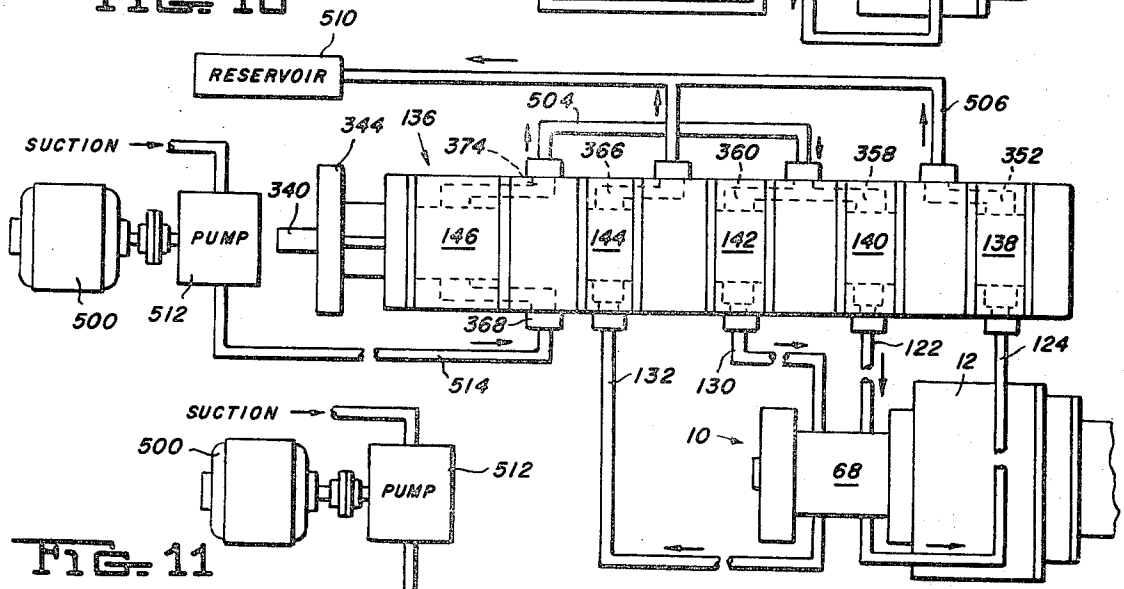
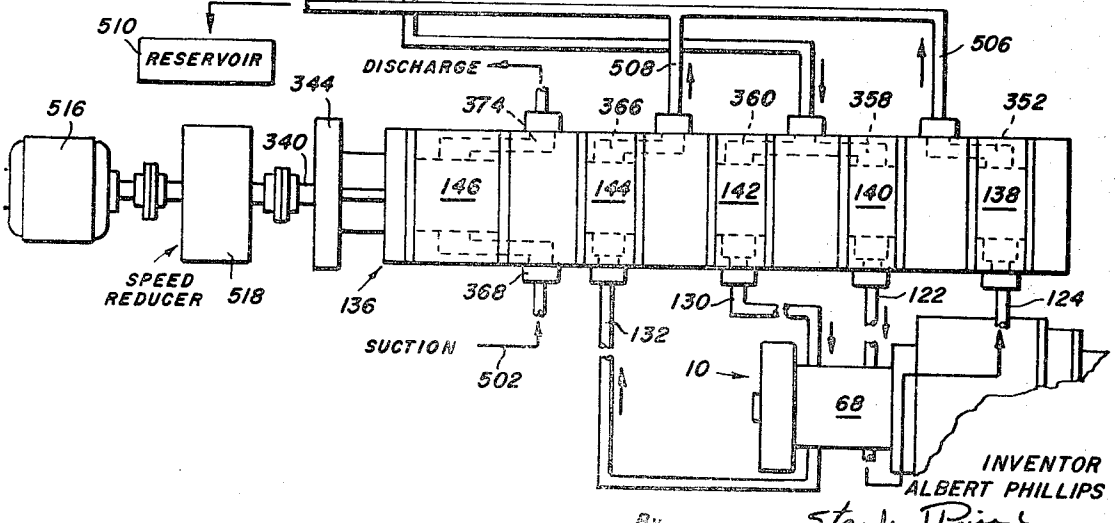


FIG. 11



INVENTOR
ALBERT PHILLIPS

By Stanley J. Price
his Attorney

FIG. 13

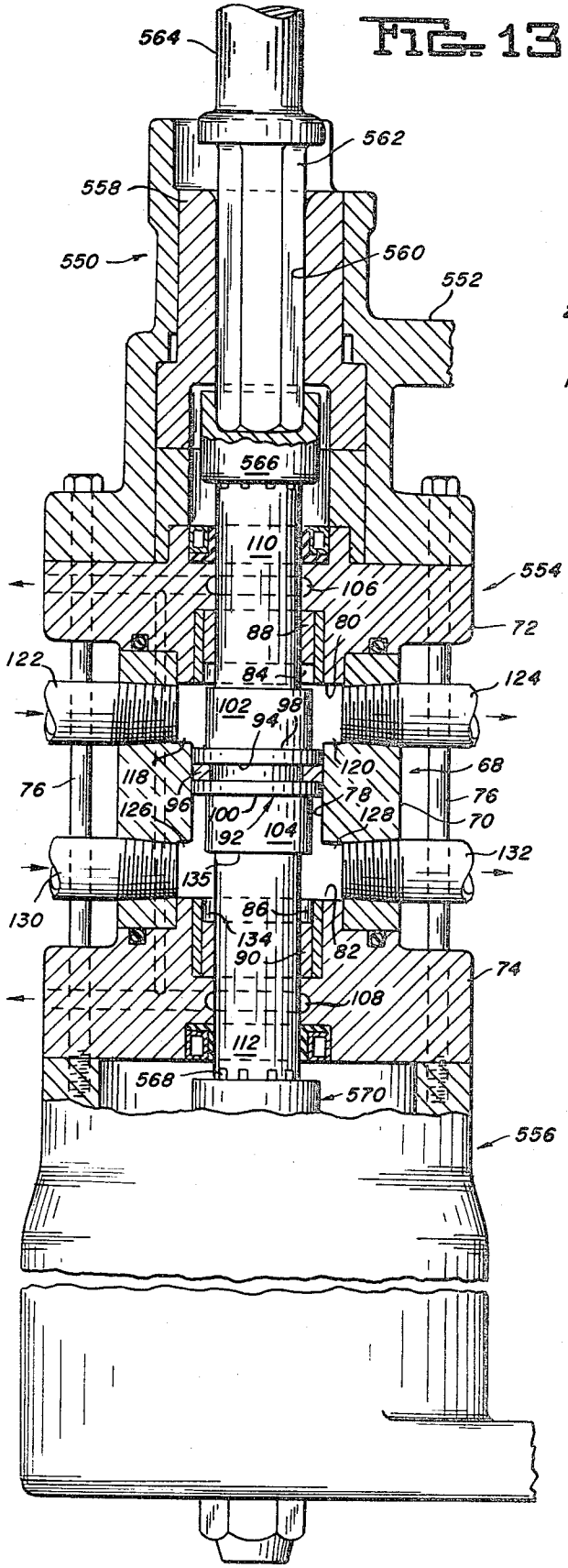
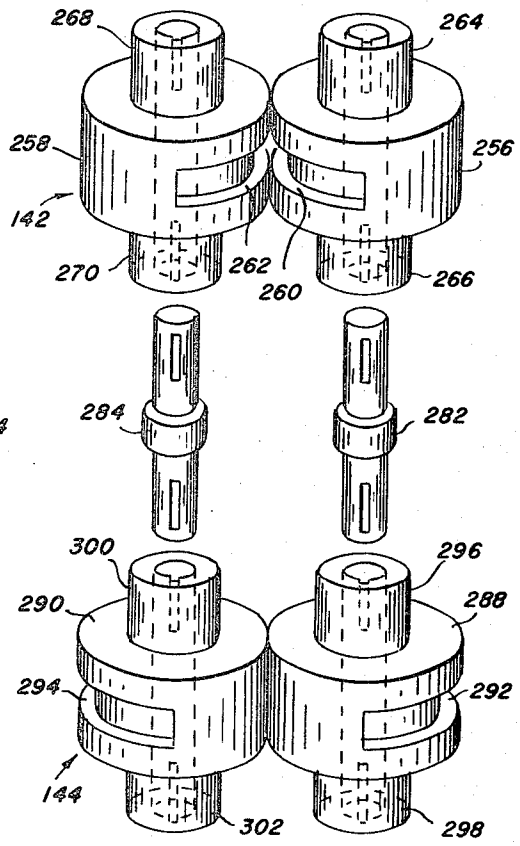


FIG. 12



INVENTOR
ALBERT PHILLIPS

By Stanley J. Price C.
his Attorney

ROTARY PERCUSSION DRILL HAVING A HYDRAULICALLY ACTUATED PERCUSSION DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a hydraulically actuated reciprocating device and more particularly to a hydraulically actuated reciprocating piston percussion device with control means to supply fluid under pressure alternately to opposite faces of a piston.

2. Description of the Prior Art

In underground mines the roof of the entries or tunnels are supported by expansion-type roof bolts. The bolts are inserted in drilled holes that are arranged in predetermined spaced patterns. The drilling of the boltholes consumes a substantial amount of time and contributes substantially to the overall cost of the mining operation. The boltholes were, in the past, drilled by rotary drills and it was found by using a high rotary speed and imparting percussive forces to the drill rod that it was possible to increase the rate of penetration of the drill rod and thus reduce the time required to drill the boltholes. The percussive forces applied to the drill rod were imparted either by the conventional air-type reciprocating devices well known in the percussive drill art or imparted by the action of eccentric weights. The use of air underground, especially in coal mines, is discouraged because the exhaust air adjacent the drill rod increases the dust hazards. There have been several proposals in the past of imparting the percussive forces to the drill rod by a hydraulically actuated device. To the best of my knowledge none of these devices have been commercially successful. There is a need, therefore, for a hydraulically actuated percussive device that may be used with a percussion drill or associated with a high-speed rotary drill to impart percussive forces thereto.

SUMMARY OF THE INVENTION

The herein described invention relates to a hydraulically actuated reciprocating piston. Hydraulic fluid under pressure is supplied alternately to the piston cylinder assembly on opposite sides of the piston from a multivalve control device to open and close the valve ports within the valve to supply pressurized fluid alternately to opposite sides of the piston and to alternately vent the cylinder on opposite sides of the piston so that the timing device controlling the opening and closing of the valves thereby control the rate of reciprocation of the piston. The timing device may also be employed as a positive displacement pump to supply the fluid to the control valves. The piston cylinder assembly may be connected to either a percussive drill or to high-speed rotary drill to impart percussive forces to the rotating drill rod.

The principal object of this invention is to provide a fluid-actuated device that includes a multivalve control device which alternately supplies fluid under pressure to opposite sides of a reciprocating piston within a cylinder.

Another object of this invention is to provide a reciprocating device wherein the timing device for supplying pressurized fluid to opposite sides of a reciprocating piston within a cylinder also functions as a positive displacement pump.

Another object of this invention is to provide a reciprocating device in which the cylinders on opposite sides of the piston are connected to pressure ports and vent ports of a multivalve control device and accumulator devices are provided to displace the excess fluid supplied to the cylinder.

Another object of this invention is to provide a reciprocating piston in which the cylinder is provided with a liquid shock-absorbing means for the piston at opposite ends of its stroke.

Another object of this invention is to provide a percussion drill with a hydraulically actuated percussion device.

Another object of this invention is to provide a reciprocating device wherein the volume of liquid displaced by a timing and metering device will correspond with the volume of liquid required to displace the piston in the cylinder for a complete stroke of the piston.

These and other objects and advantages of this invention will be more completely disclosed and described in the following specification, the accompanying drawings and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a view in elevation of the multivalve control device illustrating the plurality of inlet and outlet ports for the pressure and vent valves and the timing device.

FIG. 2 is a view in section taken along the line II–II of FIG. 1 illustrating in detail the plurality of valves in their operative positions and the gears of the timing device.

FIG. 3 is a view in section of a rotary percussion drill head with a cylinder housing the reciprocating piston and having pairs of openings on opposite sides of the piston.

FIG. 4 is a view in section of the pressure accumulators illustrated in FIG. 1 connected to the vent or return conduit.

FIG. 5 is a view in section taken along the line V–V of FIG. 2 illustrating one of the pressure valves in open position.

FIG. 6 is a view in section taken along the line VI–VI illustrating one of the vent valves in a closed position.

FIG. 7 is a view in section taken along the line VII–VII in FIG. 2 illustrating in detail the timing gears that may also function as a positive displacement pump.

FIG. 8 is a view taken along the line VIII–VIII of FIG. 5 illustrating one of the rotary disclike valve members with a peripheral flow recess passage through a portion thereof.

FIG. 9 is a schematic view illustrating the motor-driven valve where the timing device also functions as a positive displacement pump.

FIG. 10 is a schematic view similar to FIG. 9 where the fluid under pressure is supplied from a separate source to the timing portion of the multivalve control device. The timing gears are employed as a motor to open and close the respective valves. The rate of percussion imparted by the piston may be controlled with a flow control valve controlling the rate of flow to the timing gears.

FIG. 11 is a schematic view similar to FIG. 9 in which separate drive means are provided for the timing device to open and close the respective valves. With this arrangement, the percussion rate can be varied over a wide range.

FIG. 12 is a perspective view of pairs of the disclike valve elements with shafting connecting axially aligned pairs of disclike valve elements.

FIG. 13 is a view partially in section of a percussion drill head with the cylinder housing and a reciprocating piston having pairs of openings on opposite sides of the piston.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings and particularly to FIG. 3, there is illustrated a drill head generally designated by the numeral **10** that includes a cup-shaped housing **12** with an annular open top portion **14** and a base portion **16**. The sidewall of the housing **12** has an opening **18** in which bearings **20** are positioned to support a rotatable shaft **22**. A bevel gear **24** is connected to the shaft **22** within the housing **12**. Suitable means, not illustrated, are arranged to rotate the shaft **22** and thus impart rotation to a drill rod **26**, as later explained. A top plate **28** encloses the housing opening **14** and is secured to the housing **12** by means of bolts **30**. The plate **28** has an upstanding annular collar portion **32** with an annular passageway **34** connected to an outlet opening **36** for removing the dust and cuttings conveyed through the internal passageway **38** of the drill rod **26**.

Positioned within the housing **12** is a drill rod support member **40** that has a base portion **42** and a cylindrical sidewall **44**. A bevel gear **46** is secured to the outer portion of the cylindrical wall **44** and meshes with the bevel gear **24** to thereby rotate the drill rod support **40** within the housing **12**. Suitable thrust bearings **48**, **50** and **52** are arranged between the housing **12** and the drill rod support member **40** to permit rotation of the drill rod support member relative thereto. The upper portion of the drill rod support member has a socket **54**

for receiving a drill rod therein. The drill rod, however, is free to move axially in the socket **54** so that percussive forces imparted thereto are transmitted through the drill rod to a drill bit connected the opposite end thereof.

The drill rod support member **40** has an opening **56** in the base portion **42** in which there is positioned a bearing **58**. The support member **40** has an axial passageway **60** therethrough aligned with the opening **56** in which there is positioned a hammer shaft **62**. The end portion **64** of the hammer shaft **62** extends through the opening **56** in the support member **40** into the inner portion of housing **12**. The hammer shaft **62** has an enlarged other end portion **66** which is positioned in the upper portion of the drill rod support member and is in abutting relation with the base of the drill rod **26** and is operable upon axial reciprocatory movement to impart percussive strokes to the drill rod **26**.

A cylinder generally designated by the numeral **68** has a body portion **70** and end flange members **72** and **74**. The end flanges **72** and **74** are secured to the body portion **70** and to the housing base portion **16** by means of bolts **76** and are axially aligned with the hammer shaft **62**. The body portion **70** has an inner cylindrical chamber **78** with an upper annular shoulder portion **80** and a lower annular shoulder portion **82** that provides upper and lower cylindrical chamber portions **84** and **86** of reduced diameter. Positioned within the cylindrical chamber portions of reduced diameter are annular bearings **88** and **90**. A piston generally designated **92** has an annular recessed portion **94** in which a piston ring **96** is positioned. The piston **92** has substantially the same diameter as the cylindrical chamber **78** of cylinder **68** so that fluid under pressure acting on the upper annular surface **98** of piston **92** moves the piston **92** downwardly in the body portion **70**. Similarly, fluid pressure acting on the lower annular surface **100** moves the piston upwardly within the cylinder body portion **78**.

The piston **92** has a pair of oppositely extending cylindrical shafts with intermediate portions **102** and **104**. The diameter of the intermediate portions **102** and **104** is substantially the same as the diameter of the cylindrical chamber portions **84** and **86**. There is approximately .002 inch clearance between the surfaces of intermediate portions **102** and **104** and the inner cylindrical wall of chamber portions **84** and **86**. With this arrangement, as the cylinder **92** is reciprocated so that the intermediate shaft portions **102** or **104** are moved into the cylindrical chamber portions **84** or **86**, the fluid entrapped within the chamber portions serves as a liquid cushion for the piston. Because of the slight clearance between the intermediate shaft portions **102** or **104** and the sidewalls of the chamber portions **84** and **86** the fluid is slowly displaced to thereby provide a fluid cushion for the piston **92**. There are provided passageways **106** and **108** in the flanges **72** and **74** to receive and return to the tank, the fluid that has leaked past the bearings **88** and **90**.

The oppositely extending shafts of piston **92** have end shaft portions **110** and **112** extending therefrom. The end shaft portions are suitably positioned in the annular bearings **88** and **90** to maintain the piston **92** axially aligned within the cylinder **68**. The shaft end portion **110** extends through an opening **114** in the drillhead housing bottom portion **16** and has an end surface **116** in abutting relation with the end portion **64** of hammer shaft **62**. With this arrangement, upward movement imparted to the piston **92** is transmitted through the shaft end portion **110** to the end surface **116** which, in turn, strikes the end portion **64** of hammer shaft **62** and moves the hammer shaft upwardly within the drill rod support member **40**. Since the upper portion **66** of hammer shaft **62** is in abutting relation with the base of drill rod **26** this upward percussive force or motion is transmitted to the drill rod **26**. Since the drill rod is continually urged against the base of the hole being drilled by the drilling machine, the drill rod **26** and hammer shaft **62** are moved downwardly within the drill rod support **40** when the piston **92** is moved downwardly within the cylinder **68**. Thus, each upward movement of the piston **92** imparts an upward percussive blow to the drill hammer **62** which is, in turn, transmitted to the drill rod **26**. Positive fluid pressure is employed to move the piston **92** downwardly away from the drill hammer end portion **64**.

The cylinder body portion **70** has an upper inlet port **118** opening into the cylindrical passageway **78** within the body portion **70** and an upper outlet port **120**. It should be noted in the particular embodiment illustrated, the inlet port **118** and outlet port **120** both communicate with the cylindrical chamber **78**. An inlet conduit **122** is connected to inlet port **118** and vent conduit **124** is connected to outlet port **120**. Similarly, the cylinder **68** has a lower inlet port **126** below the piston **92** and an outlet port **128**. Conduits **130** and **132** are connected to the respective inlet and outlet ports **126** and **128**. With this arrangement, fluid supplied through inlet conduit **122** will fill the annular chamber between the cylindrical intermediate shaft portion **102** and the cylindrical walls of chamber **78** and displace or move the cylinder **92** downwardly. Since the lower portion of the cylinder is vented through outlet conduit **132**, fluid remains in the annular chamber between the shaft **112** and the cylindrical wall of chamber portion **86**. The intermediate shaft member **104** has a shoulder or secondary piston face **135** that contacts the fluid within the annular chamber designated by the numeral **134** and, with the clearance between the surface of intermediate shaft portion **104** and wall **86**, the fluid slowly flows therebetween and prevents metal-to-metal contact on the upward and downward strokes of the piston.

Referring to FIGS. **1** and **2**, there is illustrated a multiport control device generally designated by the numeral **136** that has an upper vent valve **138**, an upper pressure valve **140**, a lower pressure valve **142**, a lower vent valve **144** and a timing device pump combination **146**. The upper vent valve **138** has a port **148** to which conduit **124** is connected. The other end of conduit **124** is connected to vent port **120** of cylinder **68** (FIG. **3**). A pressure accumulator generally designated by the numeral **150** is connected in series with the conduit **124** and port **148**. The upper pressure valve **140** has a port **152**. Conduit **122** is connected to port **152** and to port **118** of the cylinder **68** (FIG. **3**).

The lower pressure valve **142** has a port **154** connected to conduit **130**. The other end of conduit **130** is connected to the lower pressure port **126** in cylinder **68**. The lower vent valve **144** has a port **156** that is connected to conduit **132**. The other end of conduit **132** is connected to the lower vent port **128** in cylinder **68**. A pressure accumulator **158** is connected in series with the conduit **132** and port **156** of vent valve **144**.

The multivalve control device **136** includes an end plate **160** with a plurality of longitudinal bolt passageways **162** therethrough adjacent the circumferential edge portion and a pair of recessed cup-shaped portions **164** and **166**. Annular bearings **168** and **170** are positioned in the recessed portions **164** and **166**. The upper vent valve **138** includes a pair of disclike valve members **172** and **174** with peripheral grooved portions **176** and **178** extending around about 180° to 190° of the periphery. The member **172** has oppositely extending shaft end portions **180** and **182**. The shaft end portion **180** is positioned in the bearing **168** in recess **164**. Similarly, the member **174** has oppositely extending shaft end portions **184** and **186**. The shaft end portion **184** is rotatably positioned in bearing **170** in recessed portion **176**. An annular valve housing **188** having port **148** therein extends around the pair of disclike members **172** and **174** and has a central chamber therein. The housing is similar to that illustrated in FIGS. **5** and **6**. The valve housing **188** has longitudinally extending bolt apertures **190** aligned with the bolt apertures **162**. The valve housing has one planar end wall **192** in abutting relation with a mating end wall of the end plate **160** to form a seal therebetween. A support housing **194** has a plurality of bolt passageways **196** aligned with bolt passageways **190** and **162** and has a pair of longitudinal passageways **198** and **200** with enlarged end portions **202** and **204** adjacent the opposite end wall **207** of valve housing **188**. Bearings **206** and **208** are positioned in enlarged portions **202** and **204** and shaft end portions **182** and **186** of

disclike valve members 172 and 174 are rotatably supported in the bearings 206 and 208. The passageways 198 and 200 have enlarged portions 210 and 212 in which bearings 214 and 216 are positioned.

The upper pressure valve 140 has a pair of disclike valve members 218 and 220 which are similar to the disclike valve members 172 and 174 previously described. The disclike valve member 218 has a shaft portion 222 positioned in the recessed portion 210 of support member 194 and disclike valve member 220 has a shaft end portion 224 positioned in the enlarged portion 212. The disclike valve members 218 and 220 have recessed peripheral portions 226 and 228 similar to the recessed portions 176 and 178 that extend around 190° of the periphery of both of the valve members 218 and 220. The shaft end portions 182 and 222 have axial passageways 230 and 232 therein with suitable keyways 234 and 236. A shaft 238 is positioned in the passageway 198 of support member 194 and extends into the recessed portions 230 and 232 and is suitably keyed to the end shafts 182 and 230 so that valve members 172 and 218 rotate in timed relation to each other.

The disclike valve member 220 is similarly connected to disclike valve member 174 by means of shaft 240 keyed to the shaft end portions 186 and 224. As illustrated in FIG. 2, the upper vent valve 138 is open in that the peripheral recessed portions 176 and 178 are facing each other and in overlying relation to form a passageway therebetween. The upper pressure valve 140 is closed in that the recessed portions 226 and 228 are spaced from each other. The upper pressure valve 140 has an external housing 242 which is similar in construction to the external housing 188 of the vent valve 138. The housings 188 and 242 and the disclike valve members housed therein are interchangeable.

Abutting the wall of valve housing 242 is a support member 244 which is similar to the support member 194 and is interchangeable therewith. The support member 244 has passageways 246 and 248 extending therethrough in which shafts 250 and 252 are positioned and extend into recessed portions within the shaft end portions of disclike valve members 218 and 220.

The lower pressure valve 142 is positioned adjacent the support member 244 and has a housing 254 which is similar to the housings 242 and 188. Within the housing 254 there are positioned a pair of disclike valve members 256 and 258 which have peripheral recessed portions 260 and 262. The disclike valve members 256 and 258 are of the same construction as the previously described disclike valve members and have shaft end portions 264 and 266, 268 and 270. The shaft end portions 264 and 268 extend into enlarged passageways in the support member 244 and have recessed portions 272 and 274 in which the shafts 250 and 252 are positioned and nonrotatably keyed thereto so that the disclike valve members 256 and 258 rotate in timed relation with the other previously described disclike valve members. A support member 276 similar to support members 244 and 194 is positioned in abutting relation with the upper pressure valve housing 254 and has passageways 278 and 280 therethrough in which shafts 282 and 284 are positioned. The shafts 282 and 284 extend into recessed portions of disclike valve member shaft end portions 266 and 270 and are keyed thereto.

The lower vent valve 144 has a housing 286 in which a pair of disclike valve members 288 and 290 are positioned with recessed peripheral portions 292 and 294. The disclike valve members have shaft end portions 296, 298, 311 and 302. All of the shaft end portions have recessed portions therein and shafts 282 and 284 extend into the recessed portion of shaft end portions 296 and 300 and are keyed therein to rotatably connect the disclike valve members 288 and 290 to the disclike valve members 256 and 258 and the other previously described valve members. It should be noted that the disclike valve members 256 and 258 of the lower vent valve have their recessed portions 260 and 262 abutting each other to form a passageway therebetween so that the lower vent valve as illustrated in FIG. 2 is open, whereas the lower pressure valve 144 is closed because the recessed portions 292 and 294 are spaced from each other.

FIG. 12 illustrates in detail the manner in which the pairs of disclike valve members 256 and 258 are connected to the adjacent pair of disclike valve members 288 and 290 by means of the shafts 282 and 284. It should be understood that the disclike valve members may have either a longitudinal bore therethrough or recessed portions to receive end portions of the shafts therein. The plurality of shafts connecting the adjacent axially aligned disclike valve members may be referred to as shafting connecting the respective disclike valve members.

Another support member 304 is positioned in abutting relation with the valve housing 286 and is similar in construction to the previously described support members. The support member 304 has passageways 306 and 308 in which shafts 310 and 312 are positioned. The shaft 310 extends into a recessed portion of shaft end portions 298 and is keyed therein. Similarly, shaft 312 extends into a recess in shaft end portion 302 and is also keyed therein.

The combination timing device and positive displacement pump 146 has a housing 314 positioned in abutting relation with the support member 304. The housing has longitudinal bolt passageways 316 and a pair of meshing gears 318 and 320 are positioned in the housing 314. The gear 318 has shaft end portions 322 and 324. Similarly, the gear 320 has shaft end portions 326 and 328. The shaft end portions 322 and 326 are positioned in the enlarged portions of passageways 306 and 308 and shafts 310 and 312 extend into recessed portions of the respective gears 318 and 320 and are keyed thereto so that gears 318 and 320 are connected to the previously described disclike valve members.

An end plate 330 has bolt-receiving apertures 332 and a cup-shaped recessed portion 334 for receiving the shaft end portion 324 of gear 318. The end plate 330 has a passageway 336 with an enlarged portion 338. The shaft end portion 328 of gear 320 is supported in the enlarged portion 338 of passageway 336. A drive shaft 340 has an end portion extending into an axial passageway 342 of gear 320 and is keyed thereto so that rotation of shaft 340 rotates both gears 318 and 320 and by the previously described connections all of the disclike valve members within the multiport control device 136. The end plate 330 has a motor mounting bracket 344 thereon arranged to support a drive motor or the like connected to the shaft 340. It should be understood, however, the use of the shaft 340 as a driving means is optional, as later described.

The previously described valve members are positioned in stacked relation as illustrated in FIGS. 1 and 2 and are secured in this position by the elongated bolts 346 extending through the bolt apertures previously described. Referring to FIG. 1, the support member 194 has an outlet port 348 therein and an internal passageway 350 that is connected to an internal passageway 352 in the upper vent valve housing 188. The support member 244 has a port 354 that opens into passageway 356. The passageway 356 is connected to passageways 358 and 360 in valve housing 242 and 254 of the upper and lower pressure valves 140 and 142 respectively. The support member 276 has a port 362 opening into passageway 364 which is connected to a passageway 366 in the housing 280 of lower vent valve 144. The support member 304 has a pair of ports 368 and 370 that open into respective passageways 372 and 374. The housing 314 has passageways 376 and 378 that are connected to the passageways 372 and 374 respectively.

As previously stated, the valves 138, 140, 142 and 144 are of similar construction and some of the elements thereof are interchangeable. Similarly, the support members 194 and 276 are of similar construction and are interchangeble. The support member 244 differs from support members 194 and 276 in that the passageway 356 opens into both valves 140 and 142. The support member 304 also has a pair of ports 368 and 370 and passageways 372 and 374.

FIG. 5 is a sectional view in elevation of the lower pressure valve 142 and illustrates the housing 254 with the peripheral

bolt passageways for bolts 346 and the disclike valve members 256 and 258 with the peripheral recessed portions 260 and 262. In FIG. 5, the recessed portions 260 and 262 are illustrated as extending around 180° of the disclike valve member periphery. In FIG. 6, however, the recessed portions 292 and 294 are, for illustrative purposes, illustrated as extending around about 190° of the disclike valve member periphery. It is preferred to have the same peripheral recessed portion for all the disclike valve members so that the plurality of valves will open and close in timed relation. Where the recessed portions extend around 180° of the periphery, the volume of liquid displaced by the timing gears 318 and 320 in one-half a revolution should be about 10 percent greater than the volume of liquid required to displace the piston in the cylinder for a complete stroke of the piston. The excess fluid enters an accumulator in the conduit connecting outlet port 370 from the timing device pump combination 146 and the inlet port 354 for pressure valves 140 and 142. The accumulator is not shown but may be similar to the accumulators 150 or 158. With this arrangement, an accumulator must be provided in the conduit between ports 370 and 354 because all of the valves in the control device are closed and the excess volume of fluid supplied by the timing device pump combination 146 must be displaced in the accumulator.

Where the recessed portions extend around 190°, the accumulator in the conduit connecting ports 370 and 354 is not necessary because there is an overlap where both pressure valves 140 and 142 are open for about 10° of the revolution. The metering gears should, however, be made larger to compensate for the loss of fluid while all valves are open during the 10° overlap. The dimension of the timing gears and the piston and cylinder may be varied to control the amount of fluid entering the accumulator 150 and the resilience of the spring 394 may be varied to control the force exerted by the piston in the cylinder.

In FIG. 5, the ports 154 and passageway 360 communicate through the mating recessed portions 260 and 262 of the disclike valve members 256 and 258 when positioned as illustrated in FIG. 5 so that liquid supplied to passageway 360 flows through the openings formed by the mating recessed portions 260 and 262 to the port 154. The disclike valve member 256 is illustrated in FIG. 8 with the recessed portion 260 and the shaft end portions 264 and 266. The shaft 250 is illustrated as extending into a recessed portion of shaft end portion 264 and is keyed therein. Similarly, the shaft 282 extends into a recessed portion of shaft end portions 266 and is keyed thereto.

FIG. 6 is a sectional view in elevation of the lower vent valve 144 and illustrates the disclike valve members 288 and 290 within the housing 286. The recessed portions 292 and 294 are spaced from each other and the passageway 366 does not communicate with the port 156 because the peripheral portions of the disclike valve members 288 and 290 are abutting each other and close the opening between the passageway 366 and port 156.

FIG. 7 is a sectional view in elevation of the metering pump device 146. The housing 314 has passageways 376 and 378 that open into a chamber 380 in which the gears 318 and 320 are positioned in meshing relation to each other. The gears 318 and 320 are arranged upon rotation to displace fluid between the meshing gear teeth and thereby positively displace fluid for flow from one passageway to the other through chamber 380. The valve housing, as for example, valve housing 254 and 286, also include a chamber 382 that communicates with the opposed passageways. The disclike valve members, as for example, valve members 256 and 258 in valve 142, are positioned in the chamber 382 and upon rotation permit the flow of fluid through the chamber from one port to the other or when in the position as illustrated in FIG. 6, close the chamber 382 and prevent the flow of fluid therethrough from one passageway to the other.

It should be noted as illustrated in FIG. 2, that the disclike valve members are so connected to the adjacent disclike valve members that when the upper vent valve is opened, as illustrated in FIG. 2, the upper pressure valve 140 is closed and the lower pressure valve 142 is open and the lower vent valve 144 is closed. With this arrangement, as illustrated in FIG. 2, fluid under pressure is being supplied through lower pressure valve 142, conduit 130, to the face 100 of piston 92 (FIG. 3) to move the piston 92 upwardly. When the lower vent valve 144 is closed the upper vent valve 138 is opened to permit the fluid within the cylinder above the piston 92 to be displaced through conduit 124. The upper pressure valve 242 is closed so that fluid under pressure is not being supplied to the upper portion of the cylinder 68. Where the peripheral recessed portions extend around more than 180° of the disclike valve member periphery, there is a slight overlap where, for a short period of time, both the vent and pressure valves are open.

A suitable pressure accumulator such as accumulator 150 or 158 is positioned in series with the conduits 124 and 132 and ports 148 and 156 of the vent valves 138 and 144 to displace fluid supplied to the cylinder in excess of the volume of the annular space between the piston and the cylinder. One of the pressure accumulators is illustrated in detail in FIG. 4 and includes a cylindrical housing 384 with a base portion 386 that has a longitudinal passageway 388 that is connected in series with the conduit 124 and the port 148. The housing 384 has an opening 390 into the passageway 388. Within the cylindrical housing 384 there is positioned a piston 392 and a coil spring 394 that urges the piston toward the base 386. An adjusting device 396 is provided to increase or decrease the tension on spring 294. An exhaust port 398 is provided above the piston 392 to vent the slight amount of fluid that leaks past the piston 392 within the housing 384. The piston 392 is displaced upwardly by the excess fluid supplied to the cylinder 68 (FIG. 3). When the vent valve is opened the piston 392 displaces the fluid within the housing 384 into the conduit 124.

In FIG. 13 there is illustrated a percussion drill that includes a piston cylinder assembly similar to that illustrated in FIG. 3. Similar numerals in FIG. 13 will designate similar parts of the piston cylinder assembly.

The percussion drill in FIG. 13 is generally designated by the numeral 550 and includes a chuck housing 552, a piston cylinder assembly 554 and a drill indexing housing generally designated by the numeral 556. The chuck housing 552 and drill indexing housing 556 are secured to the cylinder 68 by the bolts 76 and are axially aligned. The chuck housing 552 includes a chuck 558 with a central bore 560 in which the base 562 of drill rod 564 is positioned. The drill rod 564 is movable vertically in the chuck 558 and is rotatable by means of the indexing housing 556, later described. The piston cylinder assembly 554 has the piston end portion 110 in abutting relation with the end portion of drill rod 564. A sleeve member 566 nonrotatably secures the drill rod 564 to the piston end portion 110 so that rotation of piston 92 by means of indexing mechanism 56 is transmitted to the drill rod 564.

The cylinder 68 has a pressure inlet port 118 and a pressure outlet port 120 above the piston 92 and pressure inlet port 126 and pressure outlet port 128 below the piston 92 as previously described in reference to FIG. 3. With this arrangement fluid supplied through conduit 122 to the cylinder 68 moves the piston 92 downwardly and moves the end of the drill rod 564 away from the base of the hole being drilled. Fluid supplied through conduit 130 moves the piston 92 upwardly to transmit through the shaft 110 upward percussive movement to the drill rod 564. Thus, reciprocation of piston 92 within cylinder 68 provides the percussive blows to the base of the drill rod 564 to thereby dislodge material in the hole being drilled.

The end shaft section 112 has splined portions 568 which nonrotatably connect the piston 92 to an indexing mechanism generally designated by the numeral 570 that is housed within the drill indexing housing 556. The drill indexing mechanism 570 may be conventional and similar to the indexing mechanisms illustrated in U.S. Pat. No. 3,059,618 and U.S. Pat. No. 3,044,448. The indexing mechanism 570 is so arranged that on the return downward stroke of the piston 92

the piston rotates through a fraction of a revolution to thereby rotate and index the drill bit for the next percussive stroke. The rotation of the piston **92** is transmitted through the sleeve **566** to the drill rod **564**. Thus, with the above-discussed arrangement, it is now possible to provide percussive forces to a reciprocating percussion drill with a fluid supplied to the piston cylinder assembly **554** from the multiport control device **136** illustrated in FIGS. **1** and **2**.

The high-speed rotary percussion drill illustrated in FIG. **3** operates as follows. The drill rod support member **40** and the drill rod **26** nonrotatably connected thereto is rotated at high rotary speed by means of drive shaft **22** transmitting rotation through bevel gears **24** and **46**. The hammer shaft **62** and the piston **92** rotate at substantially the same speed as the drill rod support member **40**. The percussive forces are imparted to the drill rod **26** by supplying fluid under pressure alternately through conduits **122** and **130** from the multiport control device **136**.

It will be appreciated that the previously described multiport control device **136** can be utilized to provide reciprocatory motion for the piston **92** within cylinder **68**. FIGS. **9**, **10** and **11** schematically illustrate various arrangements for supplying the fluid under pressure to the opposite faces of the piston **92** within the cylinder **68**. Although not illustrated in FIGS. **9**, **10** and **11**, it should be understood that accumulators **150** and **158** are positioned in the conduits **124** and **132** as illustrated in FIG. **1**. In FIG. **9**, a motor **500** is connected to shaft **340** and is arranged to rotate the gears **318** and **320** within the combined pump and timing device **146**. In the embodiment illustrated in FIG. **9**, the timing device pump combination **146** serves both as a timing device and as a positive displacement pump. The port **370** is connected to a source of fluid by a conduit **502**. The fluid displaced by the gears **318** and **320** flows through conduit **504** into passageways **360** and **358** of the upper and lower pressure valves **142** and **140** respectively. Where the recessed portions of the valves extend around 180° of the periphery, a pressure accumulator is positioned in conduit **504**. The upper pressure valve **140** is connected by means of conduit **122** to the cylinder **68** and the lower pressure valve **142** is connected by conduit **130** to the cylinder **68** as previously described. The upper vent valve **138** is in turn connected by conduit **124** to the cylinder **68** and the lower vent valve **144** is connected by conduit **132** to the lower portion of cylinder **68**. The vent valves **138** and **144** are connected by means of conduits **506** and **508** to a reservoir or tank **510**. With this arrangement, the metering gears may be so sized that they will displace the same amount of fluid in one-half of a revolution as is displaced in one end of the cylinder. Where the metering gears have a greater displacement, a pressure accumulator must be positioned in conduit **504** to take up and displace the excess fluid supplied by the metering gears in one-half a revolution.

In FIG. **10**, a separate pump **512** is provided, driven by the motor **500**. The fluid under pressure from pump **512** is supplied through conduit **514** to the timing device **146**. The fluid under pressure rotates the gears and opens and closes the valves as previously discussed and supplies the fluid under pressure through conduit **514** to the pressure valves **140** and **142**. WIth this arrangement, the metering gears should have the same displacement in one-half revolution as the displacement in one end of the cylinder. Where the metering gears displace greater volumes of fluid, an accumulator should be positioned in conduit **504**.

FIG. **11** illustrates an arrangement where fluid under pressure is delivered from the pump **512** directly to the pressure valves **140** and **142**. A separate variable speed motor **516** is connected to a speed reducer **518** and the shaft **340** of the timing gears **318** and **320**. A separate source of lubricant is supplied to the timing gears in this embodiment. With this arrangement, the motor **516** controls the opening and closing of the pressure and vent valves and also controls the number of percussive strokes per unit of time so that one can vary the speed of motor **516** and thereby vary the percussive strokes over a relatively wide range.

According to the provisions of the patent statutes, I have explained the principle, preferred construction and mode of operation of my invention and have illustrated and described what I now consider to represent its best embodiments.

I claim:

1. A hydraulically actuated rotary percussion drill comprising:

a drill head housing;

a rotary drill rod support positioned in said housing and having a central passageway therethrough opening into a drill rod receiver at one end and into said housing at the other end;

a drill rod having an end portion nonrotatably secured in said receiver and extending longitudinally therefrom;

means to rotate said drill rod support in said housing and thereby impart rotary motion to said drill rod;

a hammer shaft positioned in said drill rod support central passageway and having one end portion extend into said receiver and the other end portion extend into said housing;

said housing having a cylinder portion with a cylindrical chamber axially aligned with said drill rod support central passageway;

a piston positioned in said cylinder portion and having a rod end portion abutting said hammer shaft end portion;

said cylinder portion having openings on opposite sides of said piston;

a control valve assembly having an upper pressure valve, an upper vent valve, a lower pressure valve and a lower vent valve, said upper pressure valve and said upper vent valve connected to said cylinder above said piston, said lower pressure valve and said lower vent valve connected to said cylinder below said piston;

means to supply liquid under pressure to said upper and lower pressure valves; and

means connecting said valves so that said upper pressure valve and said lower pressure valve alternately open and close to alternately supply fluid under pressure to the upper and lower portions of said cylinder and reciprocate said piston therein to thereby impart percussive blows to said drill rod through said hammer shaft by said piston rod end portion.

2. A hydraulically actuated rotary percussion drill as set forth in claim **1** in which, said means connecting said valves includes timing means to control the rate of opening and closing of said valve members to thereby control the number of percussive blows imparted to the drill rod per unit time.

3. A hydraulically actuated rotary percussion drill as set forth in claim **1** in which, said means connecting said valve includes metering means to control the volume of liquid supplied through said pressure valves to said cylinder.

4. A hydraulically actuated rotary percussion drill as set forth in claim **1** in which, said means connecting said valves includes a timing means and a metering means, said timing means operable to control the time that the respective valves remain open and said metering means controls the volume of liquid supplied through said pressure valves to said cylinder while said pressure valves are open.

5. A hydraulically actuated rotary percussion drill as set forth in claim **1** in which, said means connecting said valves includes positive displacement pump means operable upon actuation to supply liquid to said pressure valve.

6. A hydraulically actuated rotary percussion drill as set forth in claim **1** in which, said cylinder portion includes:

a chamber, a first pressure opening into said chamber above said piston and a first vent opening into said chamber above said piston, a second pressure opening into said chamber below said piston and a second vent opening into said chamber below said piston;

conduit means connecting said upper pressure valve to said first pressure opening, said upper vent valve to said first vent opening, said lower pressure valve to said second pressure opening and said lower vent valve to said lower vent opening; and

liquid displacement means in said conduit means between said upper vent valve and said first vent opening and in said conduit means between said lower vent valve and said second opening.

7. A hydraulically actuated rotary percussion drill as set forth in claim 6 in which said liquid displacement means includes a pressure accumulator operable to receive fluid supplied to said cylinder in excess of the fluid required to displace said piston, said pressure accumulator having resilient means to exert a pressure on the fluid contained therein.

8. A hydraulically actuated reciprocating drill comprising:

a drill head housing having a drill support portion, a cylinder portion having a cylindrical chamber, and a drill indexing portion;

said drill support having a central drill rod receiving passageway;

a drill rod having an end portion positioned in said receiving passageway;

a piston positioned in said cylinder portion and having a rod end portion abutting said drill rod end portion;

said cylinder portion having openings into said chamber on opposite sides of said piston;

a control valve assembly having an upper pressure valve, an upper vent valve, a lower pressure valve and a lower vent valve, said upper pressure valve and said upper vent valve connected to said cylinder portion above said piston, said lower pressure valve and said lower vent valve connected to said cylinder portion below said piston;

means to supply liquid under pressure to said upper and lower pressure valves;

means connecting said valve members so that said upper pressure valve and said lower pressure valve alternately open and close to alternately supply liquid under pressure to the upper and lower portions of said cylinder and reciprocate said piston therein to thereby impart percussive blows to said drill rod end portion by said piston rod end portion; and

means in said indexing portion of said drill head housing to rotate said piston and said drill rod a portion of a revolution with each stroke of said piston.