United States Patent

Hanson et al.

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[45] **June 20, 1972**

[54] CONTROL SYSTEM FOR DRILLS

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[73] Assignee: **Gardner-Denver Company**, Quincy, Ill.

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[21] Appl. No.: **71,403**

Related U.S. Application Data

[62] Division of Ser. No. 808,925, March 20, 1969, Pat. No. 3,561,542.

[52] **U.S. Cl.** **173/4**

[51] **Int. Cl.** **E21c 5/10**

[58] **Field of Search** 173/4, 9, 10, 159

[56] **References Cited**

UNITED STATES PATENTS

2,125,287 11/1971 Gartin 173/4

Primary Examiner—Ernest R. Purser
Attorney—Michael E. Martin

[57] **ABSTRACT**

An automatic control system for a guide shell mounted rock drill including a control circuit having pneumatically operated valves for providing pressure fluid to the drill hammer, rotation motor and feed motor and for controlling drill hole flushing medium. Sensors mounted on the drill guide shell provide for reversal of the feed motor and reduced drill power upon reaching the forward end of the guide shell, and shutdown of the drill upon reaching the rearward end of the guide shell. The control circuit includes a series of control valves for selection, at will, by the drill operator of a particular operating sequence or condition of the drill. A control valve is included for providing an operating sequence which includes operation of the drill at reduced power for a predetermined period of time for collaring a drill hole. The control system also includes pressure proportioning valves for automatically regulating the feed motor pressure to be proportional to the drill percussion motor supply pressure.

4 Claims, 5 Drawing Figures

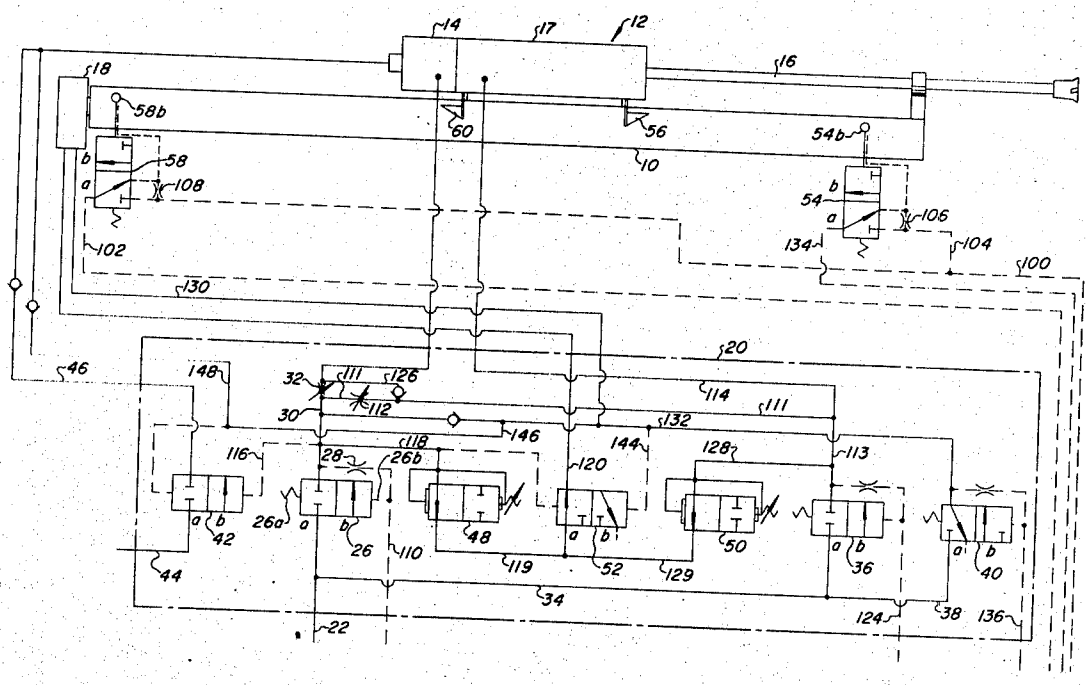
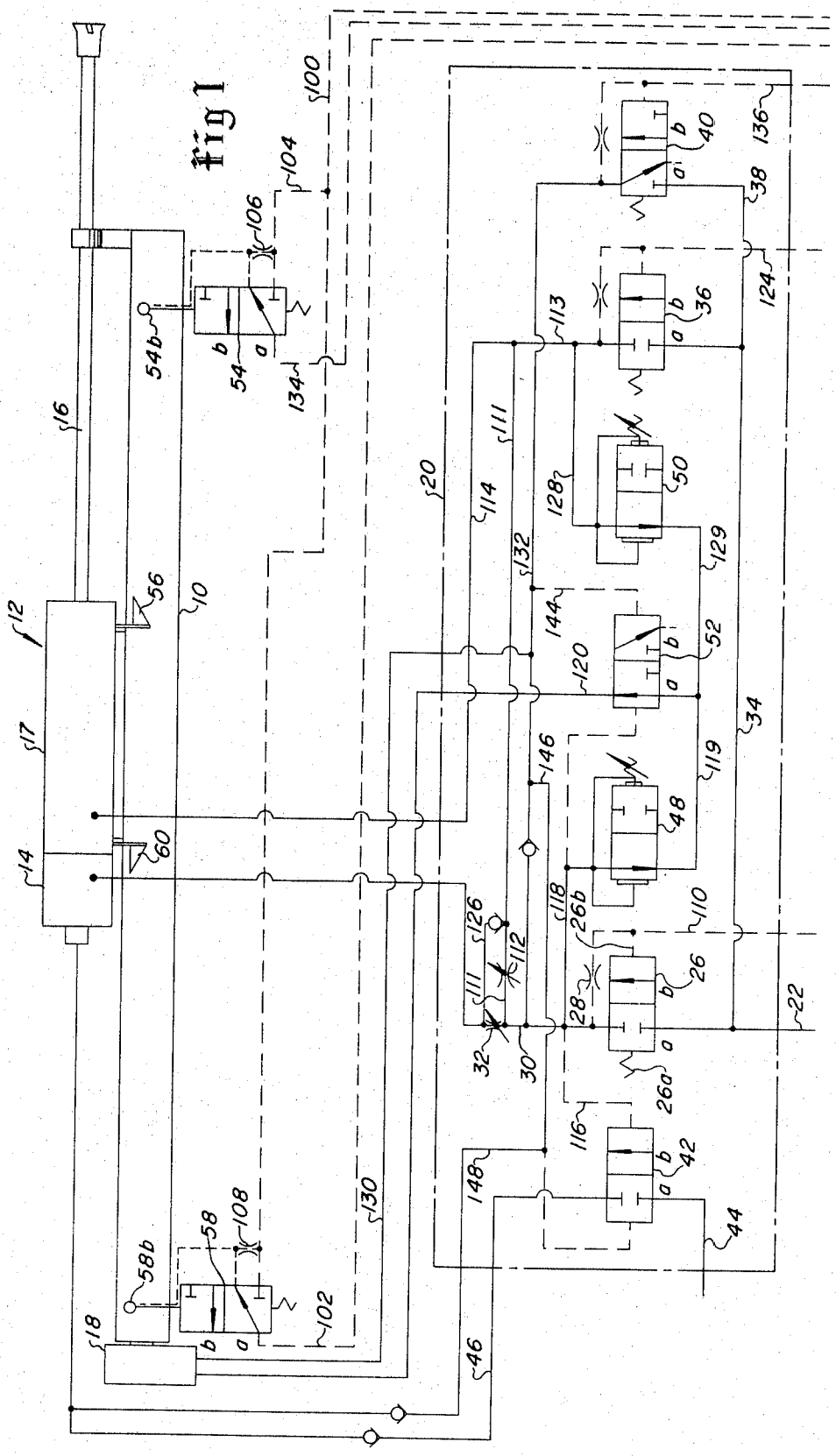


Fig 1


100
104
106
54b
54
134
16
136
40
38
124
36
113
111
20
114
128
50
129
132
144
52
120
34
12
56
10
17
146
48
119
14
60
118
26b
110
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108
58b
102
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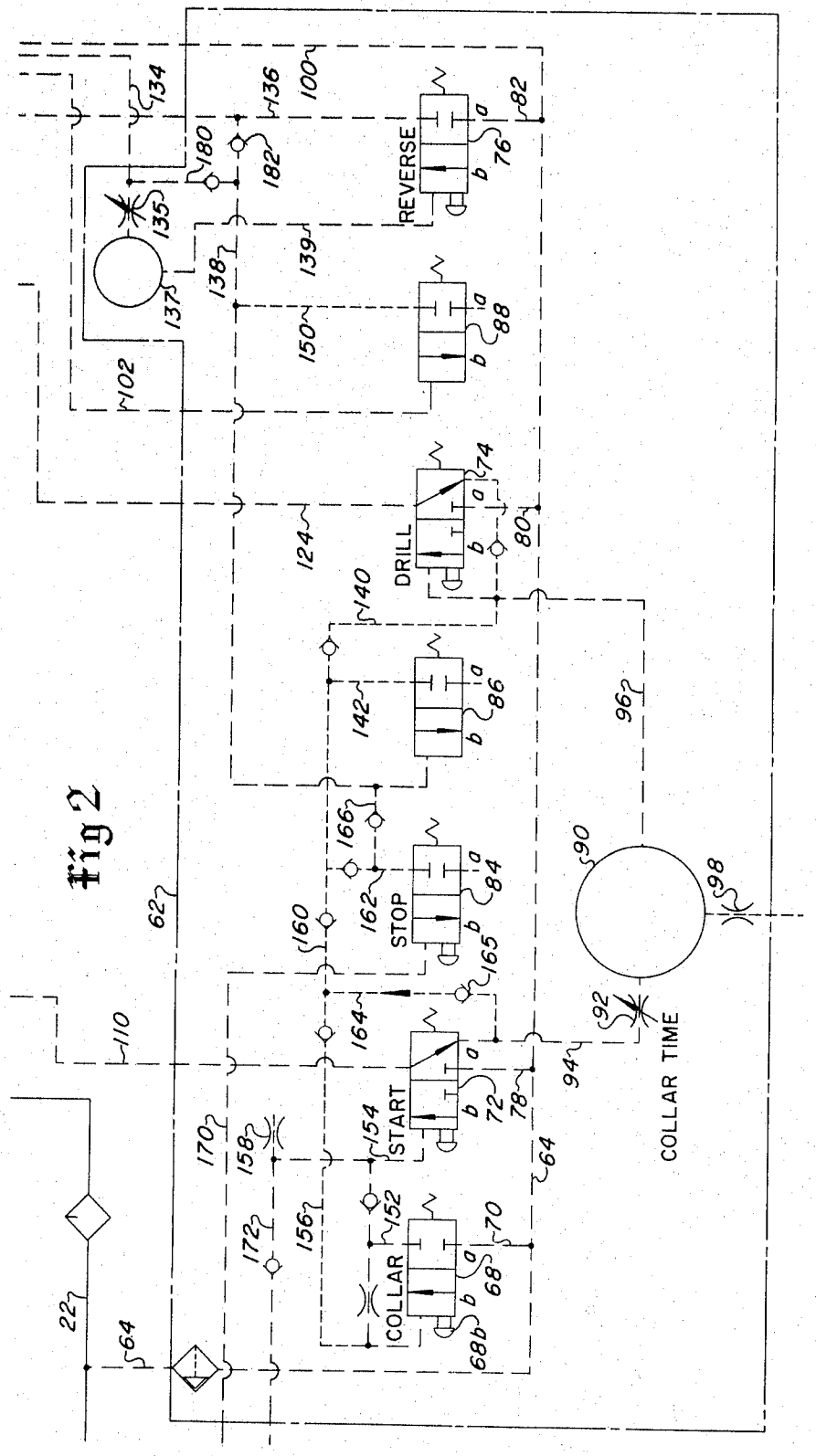


Fig 2

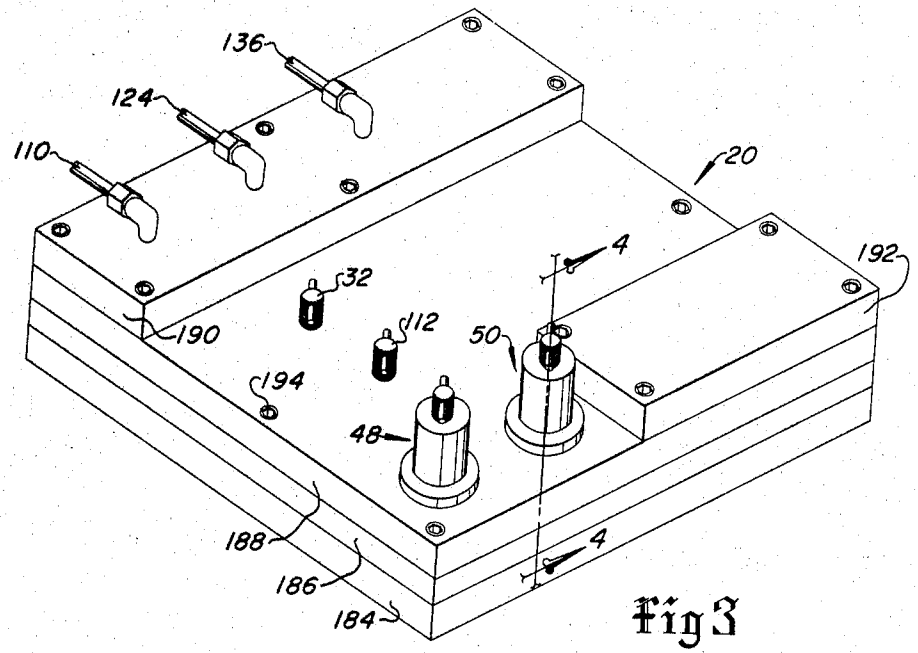


Fig 3

Fig 4

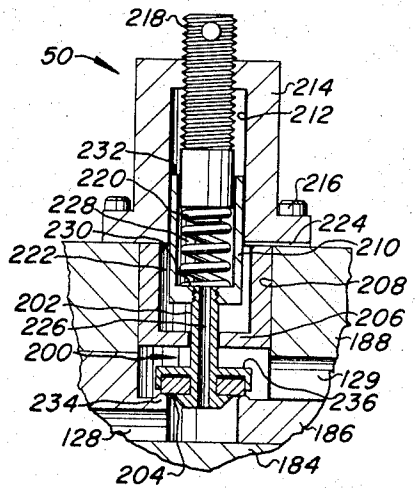
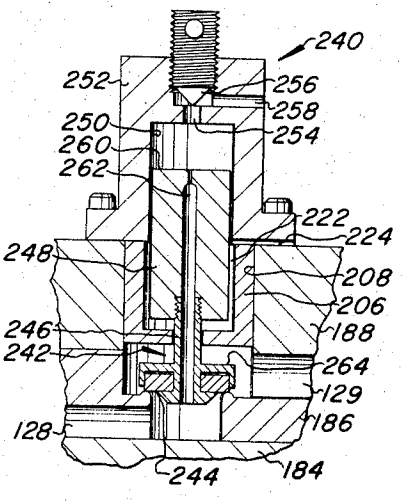


Fig 5



CONTROL SYSTEM FOR DRILLS

This is a division of application, Ser. No. 808,925 and now Pat. No. 3,561,542 filed Mar. 20, 1969.

BACKGROUND OF THE INVENTION

In underground mining and tunnel construction it is common practice to drill blast holes with multiple rock drill units commonly known in the art as jumbos. Jumbos usually comprise a plurality of pressure fluid operated percussion rock drills slidably mounted on elongated supports known as guide shells which in turn are mounted on positionable booms. Operation of the rock drills is normally controlled from a remote operator station or control panel mounted on a vehicle or undercarriage carrying the boom and drill assemblies.

Heretofore control of plural drills has been largely a manual operation carried out by manipulation of a number of control valves located on the operator control panel to feed and retract the drills along their respective guide shells and to regulate feed pressure and drill motor impact and rotation. As the number of drills mounted on a jumbo is increased, it becomes difficult for an operator to monitor and control all drills simultaneously and accordingly drilling rates decrease and efficiency is impaired. It therefore becomes desirable to provide an automatic control system for each drill so that a greater number of drills can be monitored by one operator.

An example of an automatic control system for a guide shell mounted rock drill is disclosed in U.S. Pat. No. 3,381,761 to C.A. Hansson. In addition to the automatic functions performed by the Hansson system it is desirable to provide for operating the drill at reduced percussion motor impact power, feed rate, and drill steel rotation rate at the beginning of the drilling cycle to collar or spot the hole.

Another problem associated with the operation of a guide shell mounted drill is the regulation of the feed force to prevent overfeeding or underfeeding the drill during penetration of the rock face. In large mines and tunneling operations the pressure fluid supply systems from which jumbo units operate are often subject to supply pressure fluctuations which in turn make necessary the adjustment of the supply pressure to the feed motor to keep the feed rate of the drill at a proportional rate relative to the drill percussion motor power which will prevent overfeeding or underfeeding of the drill.

SUMMARY OF THE INVENTION

The present invention provides for a rock drilling apparatus having a control system which is operable to control automatically a predetermined operating cycle of the drill. The control system of the present invention provides for an operating cycle which commences with operation of the drill percussion motor, feed motor, and drill steel rotation motor at reduced power for a predetermined period of time to collar or spot a hole. After the collaring operation is completed, the drill is automatically fed to the desired hole depth, then retracted along the support while operating at reduced power, and finally shut off upon being fully retracted along the support.

The present invention also provides for control valve means which may be actuated to provide for continuous operation at reduced power to the drill. The present invention also provides for control means operable to provide full power to the drill percussion motor at any phase of the drill operating cycle, reversing of the drill feed motor at any point in the forward feed phase of the operating cycle, and stopping all functions at any phase in the drill operating cycle.

An important aspect of the present invention is the provision of valve means for automatically maintaining a regulated pressure to a drill feed motor which is proportional to the drill percussion motor supply pressure to prevent underfeeding or overfeeding the drill due to variations in pressure of the working fluid supply system.

Another aspect of the present invention is the provision of automatic time delay means operable to delay the retraction of the drill upon completion of the drill hole until sufficient hole cleansing medium has been provided to flush the drill hole completely free of drill cuttings which could interfere with removal of the drill steel and bit, and so that a clean hole is provided for ease in placing blasting charges therein.

The apparatus of the present invention further provides for an improved method of drilling blast holes wherein a complete cycle comprising collaring, drilling, cleaning the hole, and withdrawal of the drill steel is accomplished automatically with predetermined time intervals for the collaring and hole cleaning phases.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 and FIG. 2 comprise a schematic view of the automatic control system and are intended to be read together.

FIG. 3 is a perspective view of an enclosure for the pilot operated supply valves.

25 FIG. 4 is a sectional view of an embodiment of a proportional pressure regulator valve for controlling pressure to a rock drill feed motor.

FIG. 5 is a sectional view of an alternate embodiment of a proportional pressure regulator valve.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The schematic representation of the automatic control system shown in FIGS. 1 and 2 is for the purpose of ease in understanding the circuitry of the system. Generally, diagrams of valve and flow control elements are in accordance with accepted standards for graphic symbols for fluid power diagramming. Exceptions have been made for nonstandard components and where standard symbols are not particularly descriptive.

Referring to FIG. 1 an elongated drill support **10** is shown having slidably mounted thereon a pressure fluid operated rock drill **12**. The rock drill **12** includes a fluid operated rotation motor **14** operable to rotate a hollow drill steel **16**. The rock drill **12** is of a well known type which operates to deliver percussion blows to the drill steel **16** by means of a fluid actuated percussion motor **17** housed within the drill. The drill **12** is operable to use compressed air as the working fluid although the present control system with obvious modifications could be used with hydraulic working fluid. The drill support **10** also includes a fluid operated feed motor **18** which is operable to feed the drill **12** reversibly along the support **10** by one of several well known mechanisms, not shown.

A portion of the automatic control system of the instant invention is diagrammatically shown as being contained in an enclosure **20** which could take many forms. One practical embodiment of such an enclosure is described later herein in some detail.

The enclosure **20** has a main pressure air supply conduit **22** (see FIG. 2) leading from a source, not shown, into a first supply valve **26** having a position *a* and a position *b*. All two position valves will be designated as having a position *a* and position *b*. As an example to define the symbols, the valve **26** has a spring actuator **26***a* to maintain the position *a* and a pilot actuator **26***b* to maintain the position *b* when energized with pressure fluid. When pressure fluid is exhausted from the pilot actuator to deenergize the valve the spring actuator returns the valve to the position *a*. Quite conceivably, the pilot actuated valves of FIG. 1 could have pilot actuators using a hydraulic or electric signal if the control circuit were so designed to operate with these mediums. Numeral **28** designates the flow restrictor and conduit which comprises an internal pilot supply for pilot actuator **26***b*. A conduit **30** leads from supply valve **26** through an adjustable flow control valve **32** to the drill rotation motor **14**. The main supply air conduit **22** has a branch **34** which supplies a second supply valve **36** comprising means to supply the drill **12** with fluid at substantially supply pressure. The valve **36** is also pilot air actuated and has an internal pilot conduit. The branch **34** is also in communication via conduit **38** with a third pilot actuated supply valve **40** having an internal pilot conduit. The valve **40** comprises means for operating the drill and feed motor in the

reverse condition. Also mounted in the enclosure **20** is a two-position pilot actuated valve **42** for controlling the supply of drill hole flushing water to the drill via conduits **44** and **46**. Drill hole flushing water is supplied internally through the drill **12** to the hollow drill steel **16** in a manner well known.

The enclosure **20** further includes valves **48** and **50** which comprise proportional pressure regulator means for regulating pressure fluid to the feed motor. Valves **48** and **50** are shown schematically in FIG. **1** and structurally in FIGS. **4** and **5**. A forward feed supply valve **52** which is pilot actuated to be in positions *a* or *b* is also included in the enclosure **20**.

FIG. **1** also illustrates schematically a front position sensing element comprising a two-position mechanically actuated valve **54** having an actuator **54***b* engageable by the projection **56** on the drill **12**. A rear position sensing valve **58** similarly has an actuator **58***b* engageable by the projection **60**. The sensing valves **54** and **58** may be positioned as desired along the length of the drill support **10** and mounted thereon for actuation by the drill projections **56** and **60** to limit the forward and rearward movement of said drill by the automatic control system as explained below.

Referring to FIG. **2**, the remainder of the automatic control system is schematically illustrated as comprising a plurality of control valves and associated circuitry housed within an enclosure **62** which would preferably be mounted at the drill operator control station of the rock drilling unit, not shown. The enclosure **62** has a branch conduit **64** leading thereto which is in communication with the main air supply line **22** and leads to the several control valves to be described. The operator control enclosure **62** houses a two-position valve **68** labeled COLLAR which receives supply air at line pressure from conduit **70** connected to branch supply conduit **64**. A typical manual operator or push button is depicted by the symbol **68***b*. The valve **68** may be actuated manually to the position *b* or by a supply of pilot pressure fluid. Release of operator force or pilot pressure will result in the return to the position *a*. The control enclosure **62** similarly includes two-position manual and pilot actuated valves **72**, **74**, and **76** labeled START DRILL and REVERSE, respectively. The valves **72**, **74** and **76** are respectively connected to the branch supply conduit **64** by conduits **78**, **80** and **82**. A manual and pilot actuated valve **84** labeled STOP is also within the enclosure **62** for actuation by the operator. The enclosure **62** further includes a pilot actuated exhaust valve **86** and a similar exhaust valve **88**.

An important aspect of the present invention includes a variable timing means which is provided for by the reservoir **90** and the adjustable timing valve **92** labeled COLLAR TIME. The reservoir **90** is in communication with the start valve **72** via the conduit **94**, and with the pilot actuator of the drill control valve **74** by way of the conduit **96**. The reservoir **90** also includes an orificed exhaust line **98**. The conduit **164**, in communication with conduit **94**, includes a typical check valve **165**. Flow is one way only as indicated by the arrow in conduit **164**.

The circuitry can be easily traced and the control system can be best understood by an explanation of the improved operating cycles which the drill can be controlled to perform. From the accompanying drawings it will be evident how the circuitry is interconnected to the various components. Referring to FIGS. **1** and **2** a normal drilling cycle begins with the drill **12** retracted over the rear position sensing valve **58** so that the valve is actuated to be in the position *b*. All valves labeled for positions *a* and *b* will be in position *a* pressure except as noted. Water control valve **42** is assisted to the position *a* by water pressure in line **44** due to internal construction of the valve.

With pressure air supplied to conduit **22** and its branch conduit **64**, air will flow through conduit **100** to the rear sensing valve **58** and through conduit **102** to the pilot actuator of exhaust valve **88** to hold the same in position *b*. Conduit **104** leading from conduit **100** to the front position sensor **54** will be bleeding through orificed conduit **106** to continually air wash the actuator **54***b* to prevent debris from collecting thereon. Air washing of the rear sensing valve actuator **58***b* occurs similarly through orificed conduit **108**. To commence a complete drill operating cycle the operator will momentarily manually actuate the START valve **72** shifting the same to position *b* which permits pilot air to flow from conduit **78** through conduit **110** to shift the first or collaring supply valve **26** to position *b* (FIG. **1**). Valve **26** then supplies air through its internal pilot **28** to maintain position *b* and pressure air flows through conduit **30** to operate the drill rotation motor at reduced speed as controlled by the adjustable valve **32**. Pressure air will also flow through conduit **111** through an adjustable flow control valve **112** to conduit **114** and to the drill **12** for operation of the percussion motor **17** at reduced power. Valve **26** also supplies pilot air through conduit **116** to hold the drill hole flushing water valve **42** open in position *b* to provide water to the drill hole, and through conduit **118** to hold the forward feed valve **52** in position *a*. Supply air from conduit **118** also flows through the proportional pressure regulator **48** and conduit **119** to supply fluid at proportionately reduced pressure through the forward feed valve **52** and conduit **120** to the feed motor **18**. Referring to FIG. **1** it appears that air can flow through conduit **111** and conduit **113** to operate the internal pilot of the second or drilling supply valve **36** to shift same to position *b* and provide full power to the drill. However, the pilot actuator of valve **36** is set to operate at line pressure only and therefore will not actuate at the reduced pressure set by the adjustable valve **112**. The drill **12** thus commences to operate at reduced forward force feeding for collaring the hole. Such operation is particularly desired to prevent deflection of the drill steel when the steel and bit are inclined to the surface of the rock face. As the projection **60** moves off the actuator **58***b* of the rear sensing valve **58**, said valve returns to position *a* and exhaust valve **88** returns to position *a*.

As previously mentioned the operator need only actuate the START valve **72** momentarily whereupon release of the manual actuator the start valve returns to position *a*.

The collaring supply valve **26**, having shifted to position *b*, now also supplies air at line pressure from its internal pilot conduit **28**, through conduit **110**, valve **72** and conduit **94** to the reservoir **90** at a rate controlled primarily by the timing valve **92**. The setting of valve **92** will regulate the amount of time required for pressure to increase in the reservoir sufficiently to cause the drill control valve **74** to shift to position *b*. The reservoir **90** may take many forms including being embodied in conduit **96** depending on the volume thereof. When the control valve **74** has shifted to position *b* air at line supply pressure will flow through conduit **80** and conduit **124** to actuate the drilling supply valve **36** to position *b* to supply air at substantially line supply pressure to the drill percussion motor **17** through conduits **113** and **114**. Air at line supply pressure will also flow through conduit **111** and bypass conduit **126** to conduit **30** to operate the drill rotation motor **14** at full power. Conduit **113** will also supply air through conduit **128** and the proportional pressure regulator **50** which in turn will provide a regulated supply of pressure air through conduit **129**, the forward feed valve **52**, and conduit **120** to the feed motor **18**. The feed motor will be exhausting through conduits **130** and **132** and the third or reverse supply valve **40** which is in position *a*.

The drill **12** will proceed to operate at full power and will feed forward along the support **10** until the projection **56** strikes actuator **54***b* causing the front position sensing valve **54** to shift to position *b* which in turn will provide pressure air to flow through conduit **134**. Conduit **134** is in communication with an adjustable flow control valve **135** and a reservoir **137** located in the control enclosure **62**. A conduit **139** leads from the reservoir **137** to the pilot actuator of the REVERSE control valve **76**. The flow control valve **135** and the reservoir **137** comprise a variable time delay means to delay the shifting of the control valve **76** to position *b* for reasons to be explained below. The REVERSE control valve **76**, when shifted to position *b* by pilot pressure fluid from conduits **134** and **139**, will

cause pressure air to flow through conduits **82** and **136** to the pilot actuator of reverse supply valve **40** shifting same to position *b*. The REVERSE control valve **76** will also cause a pressure signal in conduit **138** to shift the exhaust valve **86** to position *b* exhausting air from the pilot actuator of the DRILL control valve **74** by way of conduits **140** and **142** causing valve **74** to shift to position *a* which will cause a shift of the drilling supply valve **36** to position *a* interrupting the full power supply to the drill percussion motor, rotation motor and proportional regulator **50**. Collar supply valve **26** will also actuate to position *a* having exhausted its pilot actuator through conduit **110**, START valve **72** in position *a*, conduit **165,160**, and **142** to the exhaust valve **86**. The reverse supply valve **40** will also now supply pressure air through conduit **132** to conduit **144** shifting the forward feed supply valve **52** to position *b* exhausting conduit **120**. Pressure air will also now flow through conduit **130** at full supply pressure to the feed motor **18** running the same in reverse to retract the drill along the support. Pressure air is further now being supplied to conduit **146** and **148** simultaneously shifting the flushing water valve **42** to position *a* shutting off the flow of water and changing the flushing medium to air for drying the hole as the drill steel is withdrawn. Hole cleaning air is not required to be controlled by valve **42** with the system of the present invention. The drill **12** is now also being supplied with a reduced supply of air through conduit **132** to adjustable valves **32** and **112** to operate the rotation motor **14** and drill percussion motor **17** at reduced power to facilitate withdrawal of the drill steel from the hole. After the drill projection **56** moves off the front position sensing actuator **54***b* the valve **54** returns to position *a* causing the pilot actuator of the REVERSE control valve **76** to exhaust through conduit **134** and a shift of said valve to position *a*. The reverse supply valve **40** remains in position *b* due to its own internal pilot supply.

The drill **12** continues to retract along the support **10** until the projection **60** strikes the rear position sensing actuator **58***b* causing the valve **58** to shift to position *b* which in turn will send a pressure signal through conduit **102** to the pilot actuator of the exhaust valve **88** shifting the same to position *b*. The reverse supply valve **40** will now shift to position *a* having exhausted its pilot actuator through conduits **136**, **138**, and **150** and the exhaust valve **88**. All supply air to the drill and feed motor is now interrupted and the drill is shut down. The exhaust valve **86** will also return to position *a* having exhausted its pilot actuator through conduits **138**. The drill will thus have operated through a completely automatic cycle of operation with regulated pressure on the feed motor **18** automatically compensating for variations in supply line pressure during the collaring and drilling phase of the cycle.

Various other operational modes are selectable, at will, by the operator with the control system of the present invention For example, if it is desired to prolong operation of the drill at collaring power, that is prior to the drill engaging the front position sensing valve **54**, manual actuation of the COLLAR control valve **68** to move to position *b* will operate the pilot actuator of the START valve **72** by supplying pressure air through conduits **70**, **152**, and **154** to move the START valve to position *b*. *The collaring supply valve 26 will then be actuated as previously described and the drill will operate at collaring power. Upon actuation of the exhaust valve 86 to position b*, caused by the drill actuating the front position sensing valve **54**, the collar control valve pilot actuator would be exhausted through conduits **156**, **160**, **142** and the valve **86** and the START valve **72** would return to position *a* after bleeding its pilot actuator through conduit **154** and orifice **158**. During any operating mode of the control system, full power to the drill percussion motor and rotation motor may be applied by manual actuation of the drill control valve **74** to position *b* which will supply line pressure air to the pilot actuator of the drill supply valve position **36** as previously described.

If the drill is in the reverse feed mode, however, the DRILL control valve **74** must be manually held in position *b* to operate the percussion motor and rotation motor at full power, otherwise the drill supply valve pilot actuator would exhaust through the DRILL control valve, in position *a*, and conduits **140** and **142** and the exhaust valve **86** which, during reverse feed of the drill, is in position *b*.

The control system may also be operated to commence the reverse feed mode at any point in the forward collaring or drilling mode by manual actuation of the REVERSE control valve **76** to position *b*. Such actuation would cause a pressure signal to be sent to the reverse supply valve **40** and via conduit **138** to exhaust valve **86** shifting both valves to position *b* and resulting in operation previously described. With the control system of the present invention only one control valve is required for reversing the feed motor which thereby eliminates the need for a so-called five-port four-way valve as found in certain prior art systems.

Also, at any operating condition of the control system all pressure air to the drill and feed motor may be interrupted by manual actuation of the STOP control valve **84** to position *b* which will cause the COLLAR control valve **68** to exhaust its pilot actuator through conduits **156**, **160**, and **162**. The START valve **72** will exhaust through conduits **164**, **160** and **162** and the DRILL control valve **74** will exhaust its pilot actuator through conduits **140** and **162**. The valves **68**, **72**, and **74** will thus return to position *a*. The collar supply valve **26** and drill supply valve **36** will, with their respective control valves **72** and **74** in position *a*, exhaust their pilot actuators through STOP valve **84** and return to position *a*. Reverse supply valve **40** will also exhaust its pilot actuator through conduits **136**, **138**, **166** and **162**, and through the STOP valve to return to position *a*. Therefore, regardless of the operating mode, actuation of the STOP valve to position *b* will result in the interruption of the flow of pressure fluid to the drill, rotation motor, and feed motor. As shown in FIG. **2** the STOP valve may be operated from a remote pilot pressure air supply through conduit **170** as may the START valve **72** by way of a pilot supply through conduit **172**.

As previously mentioned, the adjustable valve **135** and reservoir **137** operate as a variable time delay means to delay the pressure signal necessary to shift the REVERSE control valve **76** to position *b* when the drill projection **56** has actuated the position sensing valve **54** to position *b*. This delay in operation of the REVERSE control valve and, consequently, the reverse supply valve **40** permits through flushing of the drill hole to assure the removal of all drill cuttings while the drill steel is still at the bottom of the hole. As pressure fluid flows through conduit **134** into the reservoir **137** the pressure would eventually increase to a predetermined value required to operate the pilot actuator of the REVERSE control valve **76** to shift said valve to position *b* and the drill would be operated to retract along the support as hereinbefore described. A conduit **180** is connected to conduits **134** and **138** so that pilot pressure fluid is supplied to the actuator of exhaust valve **86** to effect the closure of the drilling supply valve **36** without delay when the front sensing valve **54** is actuated to position *b*. A check valve **182** prevents pressure fluid from flowing into conduit **136**.

A preferred construction of the enclosures **20** and **62** is illustrated in FIG. **3**. The enclosure **20** is shown as consisting of a series of flat plate elements **184**, **186**, **188**, **190** and **192** assembled and fastened together by fasteners **194**. All of the hereinbefore described conduits within the enclosure **20**, as shown on the schematic of FIG. **1**, would be drilled or machined into the matching surfaces of the plates. All valve elements would also be housed within the enclosure formed by the assemblage of plates. This construction provides for a compact arrangement of valves and conduits and also eliminates a large number of tube and pipe fittings. The operator adjustment handles for valves **32** and **112** are shown protruding from plate **188** and the connections of pilot actuator conduits **110**, **124**, and **136** are shown. The remaining eight connections required as shown by the schematic of FIG. **1** would be made on the bottom of plate **184**, not shown.

The section view of FIG. 4 illustrates an embodiment of the proportional pressure regulator valve 50 previously described and illustrated schematically in FIG. 1. The valve 48 of FIG. 1 is of similar construction. Referring to FIG. 4, the valve 50 comprises a movable closure member 200 having a stem portion 202 and a resilient seating member having an area forming a pressure surface 204. The closure member 200 is interposed between conduits 128 and 129 formed by plates 184, 186, and 188. The upper end of stem 202 projects through the end wall of a spacer 206 pressed into the bore 208 in plate 188 and is threadedly secured to a hollow piston 210. The piston 210, forming a part of member 200, extends into the bore 212 of a cap 214 which is secured to plate 188 by fasteners 216. An adjusting screw 218 is operative to vary the compression of a coil spring 220 which is operable to bias the closure member 200 in the closed position. The space 222 within the spacer 206 is vented to atmosphere through passage 224. A passage 226 in the stem of closure member 200 communicates pressure fluid from conduit 128 to the interior space 228 of the hollow piston 210 and to the bore 212 of the cap 214. The piston 210 is slidably housed in the bore 212 in close fitting relationship thereto and leakage of pressure fluid into space 222 is desirably kept to a minimum. The piston 210 includes an area 230 and an annular area 232 forming a second pressure surface operable to oppose the pressure acting on the surface 204 bounded by the seat 234. An annular area 236 formed on the closure member 200 comprises a third pressure surface and is operable to bias the closure member to the closed position under the action of pressure fluid at the reduced pressure in conduit 129 acting thereon.

As previously mentioned it is desirable to maintain the feed motor pressure at a proportional value to the supply pressure to the drill percussion motor to prevent underfeeding or overfeeding the drill when fluctuations in supply pressure occur. In prior art drills it is often a problem which requires the constant attention of the drill operator to adjust a manual valve to maintain the proper proportion. However, with the use of the proportional pressure regulator 50 in the feed control system of FIGS. 1 and 2 feed motor pressure is automatically maintained at the desired proportional value. The valve 50 or its equivalent may, of course, be used with other rock drill control systems.

A single proportional pressure regulator valve of the type disclosed could be used in the control system shown in FIG. 1. However, a system of the type disclosed, having provisions for operating the drill at reduced pressure for collaring the hole, desirably has a separate pressure regulator due to the fact that the proportionality or percentage value of feed motor pressure to supply pressure for collaring a hole is usually less than the value desired for operation at full drilling power. The provision of two regulator valves is therefore desirable in a completely automatic system to eliminate the need for adjustment of a single valve after the collaring phase of operation.

In operation of the valve 50, pressure fluid at supply pressure introduced into conduit 128 would act on surface 204 to open the valve closure member 200 permitting flow past the valve seat 234 to be throttled to a reduced pressure into conduit 129. Pressure fluid at supply pressure would also flow through passage 226 into space 228 and between the adjusting screw 218 and the inner wall of piston 210 into the bore 212 to act on the annular area 232. Fluid at supply pressure acting on areas 230 and 232 and fluid at the reduced pressure in conduit 129 acting on area 236 will operate to close the closure member 200. By an algebraic summation of pressure forces acting on the valve closure member 200 it may be seen that the areas 230, 232, and 236 may be proportioned such that the closure member will move to throttle flow across the orifice formed by the closure member and the seat 234 until a balanced position is reached. Accordingly, the pressure in conduit 129 may be regulated to a fixed percentage of the supply pressure in conduit 128 regardless of what value the supply pressure may be. For example, if the sum of areas 230 and 232 is 70 percent of area 204 and the area 236 is 90 percent of area 204 by setting the pressure forces on area 204 equal to the pressure forces acting on the reduced areas 230, 232, and 236 it may be realized that pressure will be regulated to be 33 percent of supply pressure. The areas 230, 232 and 236, of course, may be altered in proportion to alter the reduced pressure. The spring 220 is used to provide a light biasing force to overcome friction of the close fitted piston 210 to close the valve. The biasing force of the spring 228 may be increased by the adjusting screw to reduce the value of the reduced pressure, however, increasing the biasing force of the spring 220 will also change the proportionality from a fixed percentage to a variable percentage. However, within the range of supply pressures normally encountered the variation in the reduced pressure will not adversely affect drill performance.

An alternate embodiment of a proportional pressure regulator valve is illustrated in FIG. 5. The proportional pressure regulator valve 240 includes a closure member 242 having a resilient seating member forming pressure surface 244 and a stem portion 246 threadedly attached to a piston 248 slidably housed in the bore 250 of cap 252. A passage 254 leads from the bore 250 past an adjustable needle valve 256 to a passage 258 opening to the exterior of cap 252. The piston 248 includes an area 260 forming a second pressure surface, and an orificed passage 262 opening into the bore 250 from the conduit 128. The principle of operation of the valve 240 is similar to the valve 50, that is, a force caused by pressure fluid acting on area 244 of the closure member is opposed by pressure fluid acting on the piston area 260 and pressure fluid in conduit 129 acting on the annular area 264 forming a third pressure surface on the closure member 242. In operation, if the needle valve 256 is closed the pressure in the bore 250 will be equal to supply pressure, and the reduced pressure in conduit 129 will be a fixed percentage of the supply pressure in conduit 128 as determined by the proportioning of areas 260 and 264. If the needle valve 256 is opened to bleed pressure fluid from the bore 250 the pressure therein will be reduced and the proportionality of the reduced pressure in conduit 129 to the supply pressure in conduit 128 will be changed and will no longer be a fixed percentage, but as with the proportional regulator valve 50 in the range of pressures normally encountered the proper feed pressure can still be obtained. Moreover, some adjustment of the proportionality must be provided for so that the drill operator can change the feed pressure for a given supply pressure to compensate for variations in the drillability of different rock formations.

However, it should be noted that the biasing means of the respective regulator valves 50 and 240, that is, the spring 220 and the adjustment screw 218, and the pressure chamber and needle valves 256 operate in a somewhat different manner. The maximum value of reduced pressure that can be obtained with the valve 50 occurs when no biasing force is applied by the spring 220, and an increase in the bias force acting to close the member 200 will reduce the value of the regulated pressure which the valve 50 will operate to produce in conduit 129. In the valve 240 the minimum value of reduced pressure is obtained when the needle valve 256 is closed and the pressure acting on the surface 260 is equal to the supply pressure in conduit 128. By opening the needle valve to reduce the pressure in the chamber formed by the bore 250 the valve closure member 242 will operate to balance at a higher value of reduced pressure in conduit 129.

What is claimed is:

1. Improved rock drilling means comprising:
an elongated support;
a pressure fluid operated rock drill slidably mounted on said support and having a percussion motor operable to actuate a drill steel;
a fluid operated feed motor mounted on said support operable to feed said drill reversibly therealong;
a source of pressure fluid;
a supply means in communication with said cource and said drill for supplying pressure fluid to operate said percussion motor;

conduit means in communication with said source and said feed motor for supplying pressure fluid to feed said drill along said support, and the improvement comprising:

pressure regulator means comprising a valve interposed in said conduit means and including a closure member for throttling the flow of pressure fluid supplied to said feed motor to maintain a reduced pressure proportional to the pressure of said fluid supplied to said percussion motor, said closure member including a first pressure surface operable to be acted on by fluid at supply pressure to open said valve, a second pressure surface operable to be acted on by fluid at supply pressure to close said valve, and a third pressure surface operable to be acted on by pressure fluid at the pressure reduced by said valve to close said valve, and said valve including biasing means comprising piston means connected to said closure member and slidably housed in a bore forming a pressure chamber, passage means in communication with said bore for supplying pressure fluid thereto, and a valve in communication with said bore for controlling the pressure of said fluid in said chamber to vary the proportionality of said reduced pressure to said supply pressure, and said piston means is operable in response to pressure fluid acting thereon to bias said closure member to the closed position.

2. Improved rock drilling means comprising:

an elongated support;

a pressure fluid operated rock drill slidably mounted on said support and having a percussion motor operable to actuate a drill steel;

a fluid operated feed motor mounted on said support operable to feed said drill reversibly therealong;

a source of pressure fluid;

supply means in communication with said source and said drill for supplying pressure fluid to operate said percussion motor;

conduit means in communication with said source and said feed motor for supplying pressure fluid to feed said drill along said support, and the improvement comprising:

pressure regulator means comprising a valve interposed in said conduit means for throttling the flow of pressure fluid supplied to said feed motor to a reduced pressure proportional to the pressure of said fluid supplied to said percussion motor, said valve including a closure member having a first pressure surface operable to be acted on by fluid at supply pressure to open said valve, a second pressure surface operable to be acted on by fluid at supply pressure to close said valve, and a third pressure surface operable to be acted on by fluid at the pressure reduced by said valve to close said valve.

3. The invention set forth in claim **2** wherein: said second pressure surface and said third pressure surface on said closure member have areas proportional to the area of said first pressure surface whereby the pressure of said fluid reduced by said regulator valve is a fixed percentage of the pressure of said fluid supplied to said valve.

4. Improved rock drilling means comprising:

an elongated support;

a pressure fluid operated rock drill slidably mounted on said support and having a percussion motor operable to actuate a drill steel;

a fluid operated feed motor mounted on said support operable to feed said drill reversibly therealong;

a source of pressure fluid;

supply means comprising a first fluid circuit in communication with said source and said drill for supplying pressure fluid to said percussion motor at reduced pressure forcollaring a hole;

a second fluid circuit in communication with said source and said drill for supplying pressure fluid to said percussion motor at substantially supply pressure; and,

pressure regulating means comprising a first pressure regulating valve in communication with said first fluid circuit and said feed motor and operable to automatically supply pressure fluid to said feed motor at a pressure proportional to said pressure fluid supplied to said percussion motor at said reduced pressure, and a second pressure regulating valve in communication with said second fluid circuit and said feed motor and operable to automatically supply pressure fluid to said feed motor at a pressure proportional to said pressure fluid supplied to said percussion motor at substantially supply pressure.

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