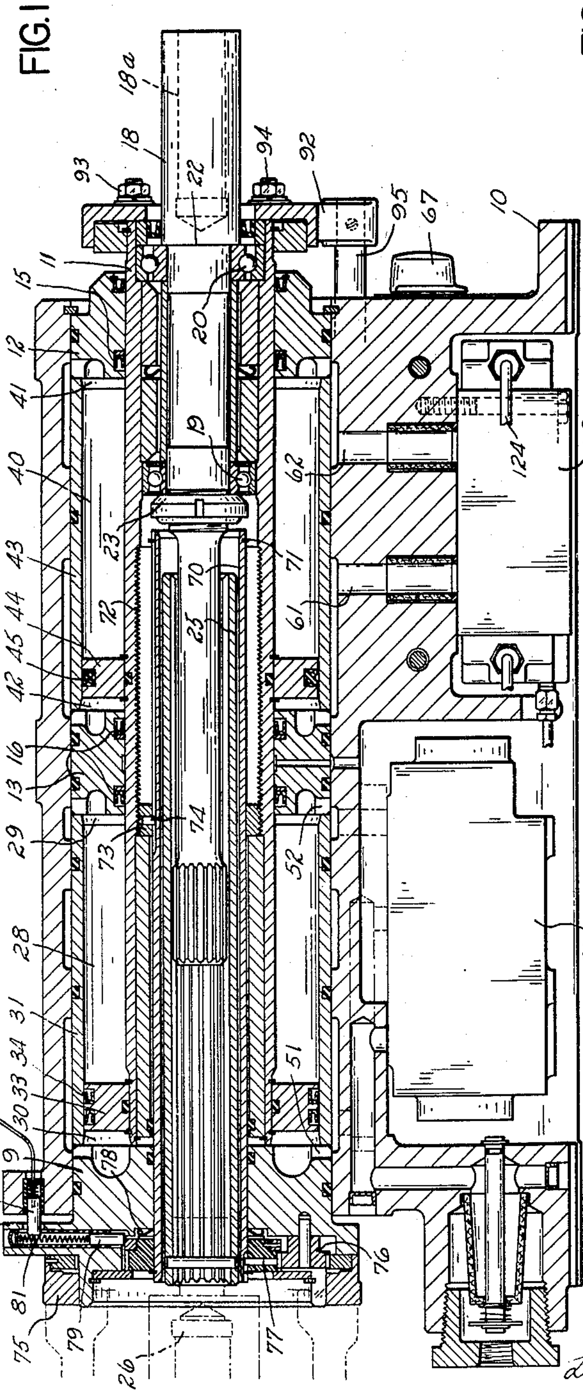
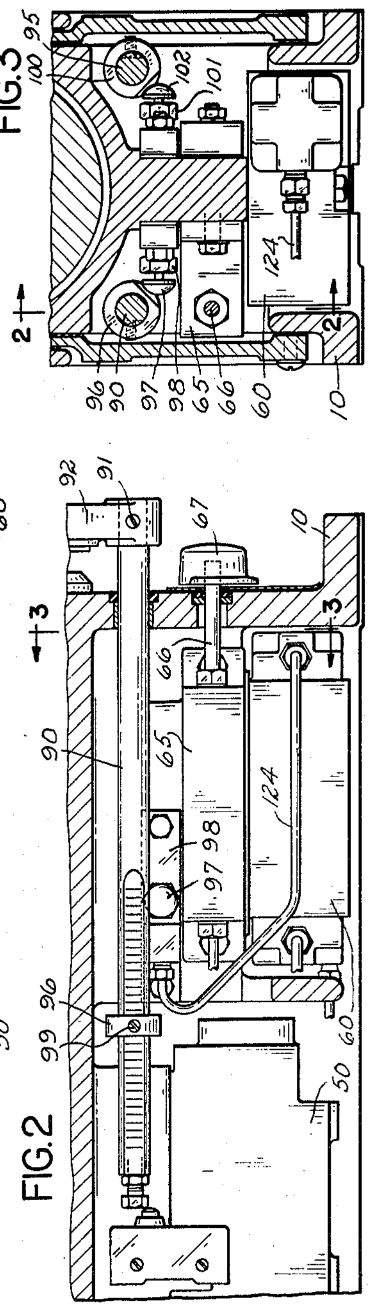
HYDRO-PNEUMATIC POWER MECHANISM

Filed Nov. 7, 1958 3 Sheets-Sheet 1





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HYDRO-PNEUMATIC POWER MECHANISM

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FIG. 4

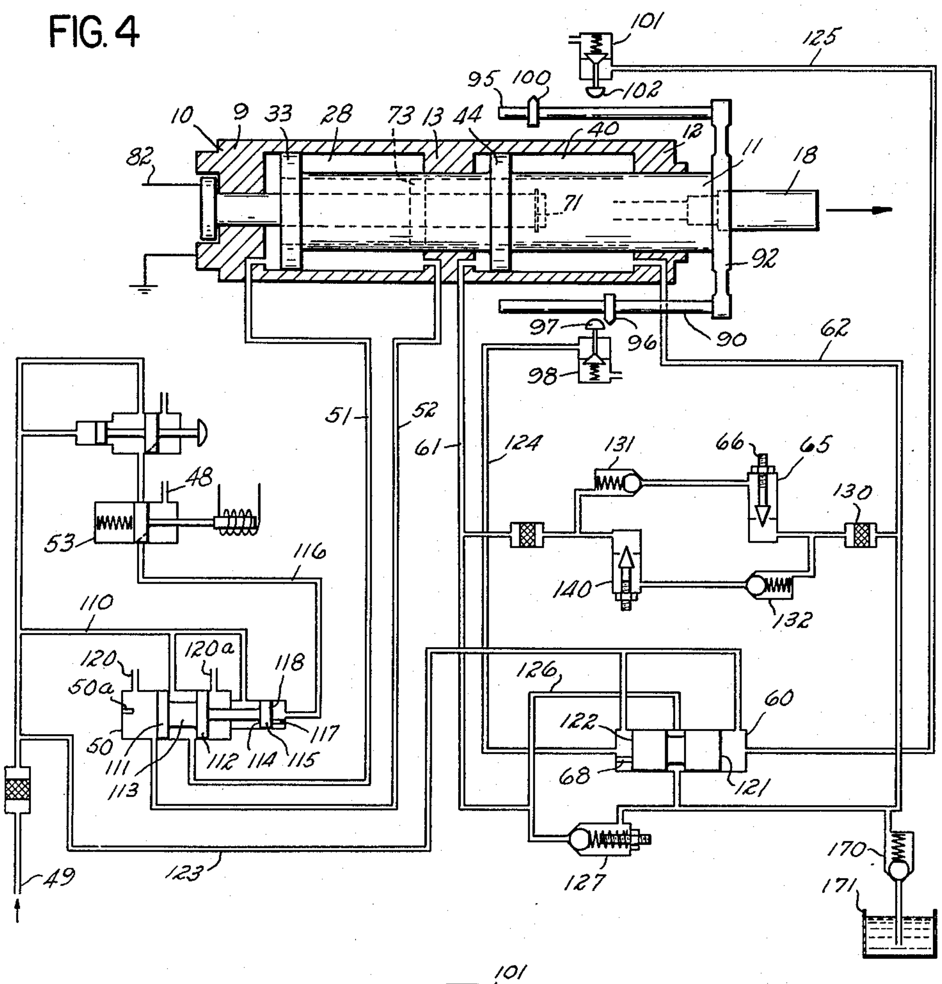
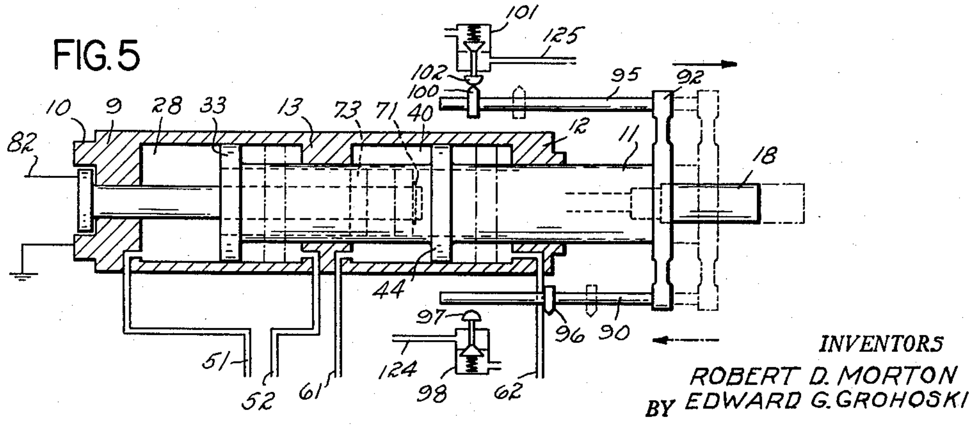


FIG. 5



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Nov. 29, 1960 R. D. MORTON ET AL 2,962,001

HYDRO-PNEUMATIC POWER MECHANISM

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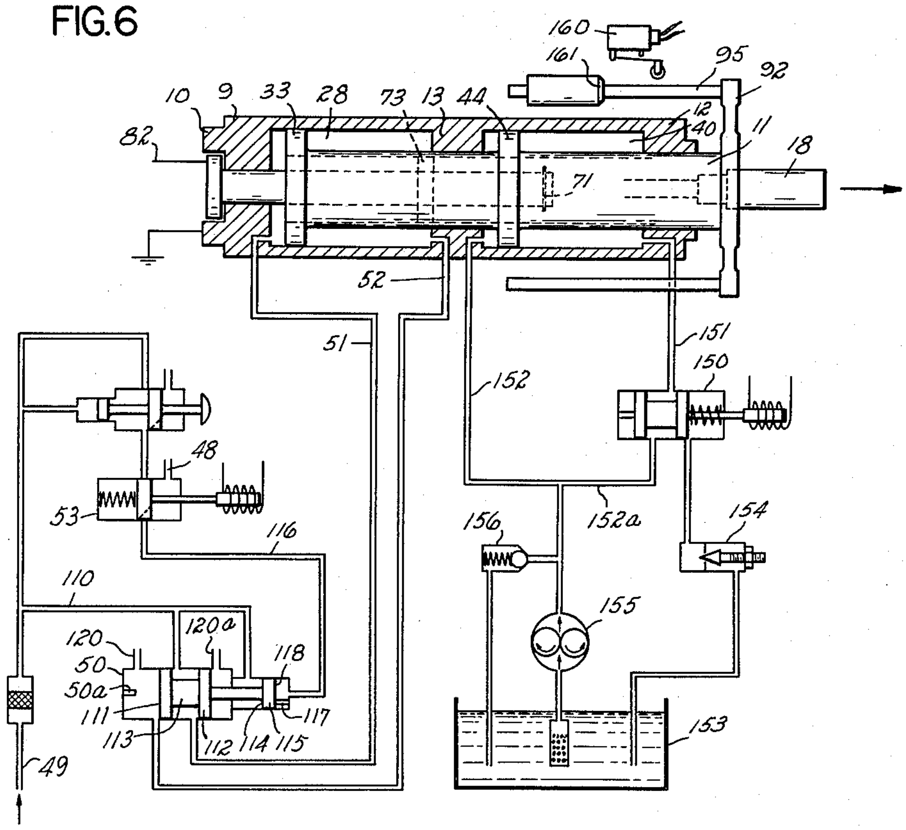
FIG. 6



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2,962,001

HYDRO-PNEUMATIC POWER MECHANISM

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The present invention generally relates to hydro-pneumatic power mechanisms and more particularly to an improved construction and control system therefor.

It is an object of this invention to provide a power mechanism having an improved air and hydraulic piston and cylinder arrangement which permits substantial reduction in the over-all dimensions of the mechanism as well as a greatly simplified control arrangement.

It is a further object of this invention to provide a hydro-pneumatic power mechanism having an improved positive shaft-travel stop that is concentric with the spindle so as to avoid bending moments as it stops shaft travel and to provide a wide range of adjustment for this stop in a greatly simplified manner.

It is an additional object of this invention to provide a hydro-pneumatic power mechanism in which separate pistons are provided for the hydraulic and pneumatic sections and in which the pistons and cylinders are concentric with the power shaft so as to avoid shaft bending moments and permit placing of the valving and tubing relating to each section adjacent its concerned piston and cylinder.

It is a still further object of this invention to provide a power mechanism having an improved hydro-pneumatic power and control system which is easily adaptable to provide hydraulic as well as air feed for the power shaft.

Other objects will be in part obvious and in part pointed out more in detail hereinafter.

The invention accordingly consists in the features of construction, combination of elements and arrangement of parts which will be exemplified in the construction hereafter set forth and the scope of the application of which will be indicated in the appended claims.

In the drawings:

Fig. 1 is a longitudinal cross-sectional view of a preferred embodiment of the power mechanism of this invention;

Fig. 2 is a partial cross-section view showing a portion of the hydraulic control mechanism of Fig. 1 taken generally along the lines 2—2 of Fig. 3;

Fig. 3 is a partial cross-section view of the mechanism of Fig. 1 taken along the lines 3—3 of Fig. 2;

Fig. 4 is a schematic representation of the mechanism of this invention and a preferred control circuit therefor;

Fig. 5 is a schematic representation of the power mechanism of this invention during a portion of its operative cycle; and

Fig 6 is a schematic representation of an additional embodiment of this invention showing a modified control system therefor.

In accordance with the objects of this invention, a mechanism, as shown in Figs. 1, 2, and 3, is provided with a main frame or housing **10** which slidably supports a longitudinally movable quill or carriage member **11** on support pedestals **12** and **13**. Power shaft **18** is rotatably supported in coaxial alignment with quill **11** by bearings **19** and **20** which are suitably fixed in position and longitudinal movement of shaft **18** relative to quill **11** is prevented by enlarged shoulders **22** and **23** which abut the sides of the bearings. Shaft **18** is splined to drive tube **25** which is adapted to engage the drive shaft of an electric motor or other suitable power source **26** (shown in dotted lines). Drive tube **25** is of such length as to maintain splined engagement with shaft **18** throughout the length of travel of quill **11**.

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In order to provide for powered movement of quill **11** and shaft **18**, a first or air cylinder **28** is provided within frame **10** and having end walls **29** and **30** and peripheral wall **31** arranged coaxially with quill **11**. Air piston **33** is secured to quill **11** and is provided with packing **34** around its outer periphery to effect a sliding seal with peripheral wall **31** of air cylinder **28**. Suitable packing is also provided at points **15** and **16** to effect a sliding seal between quill **11** and support pedestals **12** and **13**. End walls **29** and **30** of cylinder **28** are spaced to permit the desired amount of spindle **18** (and therefore quill **11**) travel under air pressure exerted on piston **33** as is subsequently explained.

The control of movement of quill **11** by air pressure on piston **33** is accomplished by the provision of a second cylinder **40** within frame **10** and coaxial with quill **11**. Cylinder **40** is provided with end walls **41** and **42** and peripheral wall **43** all arranged coaxially with quill **11**. A second or hydraulic piston **44** is secured to quill **11** and is provided with peripheral packing **45** which effects a sliding seal with peripheral wall **43**. Hydraulic cylinder end walls **41** and **42** are also spaced apart by an amount at least equal to the desired amount of longitudinal travel of spindle **18**.

The coaxial arrangement of spindle **18**, quill **11**, air cylinder **28** and hydraulic cylinder **40** provides a very compact arrangement of mechanical parts and greatly simplifies the arrangement of control valving and piping. As most clearly seen in Figs. 1 and 4, a main air valve **50** is positioned in frame **10** directly below air cylinder **28** so that line **51** directly communicates with the front face of air piston **33** and line **52** directly communicates with the rear face of air piston **33** thereby enabling these lines to be very short in length.

In a similar manner to the main valve of the air circuit, the main hydraulic valve **60** is positioned in frame **10** directly beneath hydraulic cylinder **40** so that hydraulic lines **61** and **62** have a short direct path of communication therewith. In addition, forward feed valve **65** is also conveniently positioned adjacent hydraulic valve **60** in frame **10** and is arranged so that control shaft **66** extends through the front of frame **10** so that forward feed rate adjusting knob **67** is easily accessible to the machine operator.

The forward travel limit of quill **11** is determined by an adjustable stop mechanism most clearly seen in Fig. 1. A stop tube **70** is positioned coaxial with quill **11** at a point intermediate quill **11** and drive tube **25**. Stop tube **70** is rotatably supported by rear pedestal **9** of frame **10** and is provided with stop ring or abutment **71** adjacent its forward end. The internal surface of quill **11** is partially threaded along portion **72** so that these threads engage complementary threads formed on stop nut **73** which is keyed to stop tube **70** at point **74**. Thus, rotation of stop tube **70** rotates stop nut **73** so as to selectively position it along threaded portion **72** of quill **11**. As is apparent, the closer stop nut **73** is positioned to stop abutment **71**, the shorter the amount of travel possible for quill **11** before stop nut **73** and stop abutment **71** engage each other. Adjustment of stop nut **73** is accomplished by rotating knurled adjusting ring **75** which is rotatably supported by rear abutment **9** and which is internally threaded so as to engage pinion **76** which, in turn, engages gear **77** secured to the rear end of stop tube **70**. In the preferred embodiment, gear **77** is formed of a nonconducting material and is provided with a conductive ring which is normally held away from engagement with support **9** by a small leaf spring **78**. The conductive ring on gear **77** engages brush **79** to establish electrical contact with spring **81** thereafter to contact brush **82** so as to establish an external electrical connection point. As will be hereinafter described, engagement of stop nut **73** with stop abutment **71** causes slight axial movement of the conductive ring on gear **77** against the force of spring **78** and into contact with rear support **9** thereby to ground brush **82** and the external connection point to frame **10**.

The normal operation of the aforementioned air and hydraulic control structure calls for a two-step pattern of quill movement. For example, if quill **11** is assumed to be in the position illustrated in Fig. 1 and to be carrying a work tool such as a drill in chuck portion **18***a* (shown dotted) of spindle **18**, it is most desirable that the power mechanism rapidly advance quill **11** to a point at which the drilling operation is to commence. When this drilling point is reached, it is desirable to automatically stop such rapid feed and then to provide a slower controlled feed rate of advance for quill **11** which is predetermined as an optimum drill advance speed. At the completion of the drill travel as determined by the stop nut adjustment, it is desirable to rapidly return the spindle to the position shown in Fig. 1.

In furtherance of these control aims, a pair of control rods (most clearly seen in Figs. 1, 2, and 3) are provided for travel with quill **11**. Control rod **90** is secured by screw **91** to control rod frame **92** which, in turn, is supported on quill **11** by threaded fasteners **93** and **94**. Control rod **95** is positioned on the other side of frame **10** and is supported thereon by control rod frame **92** in a manner similar to that described for rod **90**. Rod **90** carries trip dog **96** which is slidably positioned along flat portion by set screw **99**. Axial movement of quill **11** will bring trip dog **96** into contact with operating button **97** of poppet valve **98**. In a similar manner, rod **95** adjustably carries trip dog **100** which controls the operation of poppet valve **101** as it contacts operating button **102**. It is worth while to briefly note at this point that each poppet is connected by air tubing to respective ends of hydraulic valve **60** and that air pressure is applied at all times to the opposite ends of the valve spool. Since the ends of the valve spool are of the same diameter, the spool will remain stationary until the air is suddenly exhausted from one end. For this purpose, the poppet valves are vented to the atmosphere so that actuation of one or the other of the poppet valves momentarily lowers the pressure on that end of the hydraulic valve so as to cause the spool to shift in position to open and close the valve as a function of quill position.

The operation of the power mechanism of the preferred embodiment of this invention is best understood by referring to Figs. 4 and 5. Starting with quill **11** in its fully retracted position and solenoid valve **53** in its normally energized position (as shown), it is seen that air pressure from any suitable supply source **49** is supplied to main air valve **50** through line **110** to a point intermediate pistons **111** and **112** of valve spool **113** as well as to face **114** of piston **115**. Since line **116** (and therefore face **118** of piston **115**) is vented through exhaust port **48** of solenoid valve **53**, spool **113** is driven against stop **117** because of the pressure differential between faces **114** and **118** of spool **113**. With the air valve in this position, air under pressure is supplied from line **110** through line **51** to the forward face of piston **33** and line **52** is vented through exhaust port **120** on valve **50**. Air is also supplied to the opposed equal area faces **121** and **122** of hydraulic valve **60** through line **123**. Because of the equal areas of these faces and the equal pressures applied thereto, valve **60** remains against stop **68** in the position shown. In addition, face **122** directly communicates with poppet valve **98** through line **124** and face **121** directly communicates with poppet valve **101** through line **125**.

The hydraulic system including cylinder **40**, lines **61** and **62**, and the intermediate valving, is filled with an appropriate fluid and it is seen that movement of piston **33** under air pressure tends to force that hydraulic fluid from in front of hydraulic piston **44** and through line **62**. As seen in Fig. 4, check valve **170** prevents fluid flow into reservoir **171** and check valve **127** prevents fluid return directly to cylinder **40** around valve **60**. In addition, considerable resistance is offered to fluid flow through feed valve **65** and check valve **131** because of the restricted orifice in valve **65**. However, because hydraulic valve **60** is in a position wherein line **62** directly communicates with line **61** through line **126**, there is no impediment to the movement of quill **11** in the directon of the arrow of Fig. 4. The spindle, therefore, starts the rapid advance portion of its cycle. As the advance continues to the point where trip dog **100** engages operator **102** of poppet valve **101** (see Fig. 5, solid line position) so as to vent line **125**, it is seen that an unbalanced pressure condition on the spindle of valve **60** exists which moves the spool of valve **60** to the right so as to close the unobstructed path of communication between lines **62** and **61**, namely, line **126**. The hydraulic fluid that is pushed out by movement of piston **44** must now pass through filter **130**, then metered orifice of forward feed valve **65** and check valve **131** since check valves **132**, **127** and **170** close the only other paths for escape of fluid from cylinder **40**. Quill **11** then commences the feed portion of its cycle wherein the rate of movement of quill **11** is determined by the rate of fluid flow through the orifice of forward feed valve **65**. This orifice is adjustable in size so as to provide for variation in forward feed rate.

As the feed stroke continues, quill **11** carries the prepositioned stop nut **73** (see Fig. 1 and dotted line position of Fig. 5) into contact with stop abutment **71** on stop tube **70** so as to compress spring **78** and ground the circuit from external contact **82** through conductive ring **78** to the frame of the machine and commence the return stroke of quill **11**. Grounding of this connection point is arranged through any suitable circuit to deenergize solenoid valve **53** to permit line **110** to directly communicate with face **118** of air control valve spool **113** through line **116**. Spool **113** then moves to the left against stop **50***a* so as to vent line **51** through exhaust port **120***a* and supply air pressure to line **52**, thereby reversing the direction of movement of quill **11**.

The hydraulic fluid which is now being driven through line **61** by movement of piston **44** in the direction opposite to the arrow of Fig. 4, finds an unimpeded path through check valve **127** to the other side of piston **44** in cylinder **40** permitting a rapid return stroke.

It is noted at this point that use of a solenoid valve whose de-energized position causes a return stroke of the quill, provides a device which is failsafe insofar as its electrical circuit is concerned.

As the return stroke progresses, dog **100** contacts operator **102** of valve **101** to vent line **125**. However, since the spool of valve **60** does not control the return stroke in this embodiment and the spool has already been moved to the right, the operation of valve **101** has no effect. Continued return of quill **11** and piston **44** brings dog **96** into contact with operator **97** of poppet valve **98** so as to vent line **124**, thereby enabling the pressure against face **121** of the spool of hydraulic valve **60** to return the spool to the solid line position of Fig. 4 in which it abuts stop **68**. Quill **11** has now been returned to its starting position and the hydraulic system is ready for a forward stroke. Re-energization of solenoid valve **53** will start another cycle of forward movement by venting line **116** through port **48** so as to move spool **113** of air valve **50** to the right against stop **117**.

The air-hydraulic control circuit of this invention is readily adaptable to applications which require reverse feeding of quill 11 over a portion of its return cycle rather than the rapid return cycle previously described. Referring again to Figs. 4 and 5, it is seen that check valve 132 and reverse feed valve 140 are provided between lines 61 and 62 of the hydraulic circuit. If check valve 127 is manually locked closed, thereby closing the return path utilized for the quick return stroke previously described, it is seen that the hydraulic fluid then must pass through the metered orifice of reverse feed valve 140 and through check valve 132, thereby controlling the rate at which spindle 44 is allowed to return to its normal or starting position.

If it is desirable to obtain a value of thrust on quill 11 which is not obtainable through the air circuit supply 49, the modified control system of Fig. 6 permits hydraulic thrust to be added to the available air thrust through the use of a modified hydraulic circuit. The air circuit utilized with this embodiment of the invention is nearly identical with that utilized with Fig. 4 and like numbers refer to like parts of this control system. However, unlike the circuit of Fig. 4, no air is supplied to the main hydraulic valve. Instead, a solenoid operated hydraulic valve 150 is provided to control the hydraulic fluid flow from one side of piston 44 to the other side through lines 151 and 152. Solenoid valve 150 is shown in the de-energized or quick advance or return position which permits unimpeded flow of the hydraulic fluid from line 152 through line 151 and vice versa. In addition to hydraulic valve 150, there is provided the hydraulic fluid sump or reservoir 153, a forward feed valve 154, a hydraulic pump 155 and a check valve 156. Instead of using the poppet valves and trip dogs of the embodiment of Fig. 4 to control quill movement, a limit switch 160 is provided and is positioned to be operated by cam surface 161 which is adjustably positioned on control rod 95.

In operation, air pressure against piston 33 causes rapid advance of quill 11 until limit switch 160 is closed by cam 161. Closing of limit switch 160 energizes the solenoid of valve 150 through any suitable electrical circuit, thereby closing line 152*a* and forcing the hydraulic fluid to flow through the controlled orifice of forward feed valve 140 and into sump 153. Check valve 156 prevents direct return of the hydraulic fluid to line 152. However, pump 155 provides the necessary fluid return and also functions to increase the pressure applied by this fluid to the rear face of piston 44, thereby adding such additional thrust to the controlled forward stroke as is determined by the pressure increase effected by pump 155. Check valve 156 acts as an escape valve in the event that pressure in line 152 exceeds a predetermined limit.

Stop nut 73 cooperates with stop abutment 71 to reverse the direction of quill movement in the same manner as described previously for the preferred embodiment.

From the foregoing description, it is apparent that the power mechanism provided by this invention utilizes component structures which permit an exceptionally compact mechanism which is versatile and easily adaptable to a variety of control systems. In addition, it is seen that the control systems of the instant invention produce a degree of reliability and flexibility hereto unobtainable by prior art systems.

As will be apparent to persons skilled in the art, various modifications and adaptations of the structure above described will become readily apparent without departure from the spirit and scope of the invention, the scope of which is defined in the appended claims.

We claim:

1. An oscillatory power mechanism comprising a shaft, a carriage member coaxial with said shaft, means supporting said shaft for rotation within said carriage member, means supporting said carriage member for axial movement, a first piston carried by said carriage member and coaxial therewith, a first cylinder carried by the carriage member supporting means and cooperatively arranged with said first piston, a second piston carried by said carriage member and coaxial therewith, a second cylinder carried by the carriage member supporting means and cooperatively arranged with said second piston, means for supplying air under pressure to said first cylinder to effect axial movement of said first piston, carriage member and shaft, a hydraulic fluid in said second cylinder, and means controlling the rate at which movement of said carriage member causes said second piston to force said fluid out of said second cylinder, thereby to control the rate at which said shaft is moved by air pressure acting upon said first piston.

2. An oscillatory power mechanism comprising a frame having a longitudinal axis, a carriage member supported for movement relative to said frame along said longitudinal axis, a power shaft supported for rotation within said frame, a drive tube rotatably supported by said frame and splined to said shaft to effect rotation of said shaft while permitting relative sliding movement between said shaft and said drive tube, a stop tube supported by said frame disposed intermediate said drive tube and said carriage and coaxial therewith, an abutment on said stop tube adjacent one end thereof, a second abutment carried by said carriage member and disposed relative to the abutment on said stop tube so as to be engageable therewith by relative axial movement therebetween, a first piston supported by said carriage and coaxial with said shaft, a first cylinder carried by said frame and cooperatively arranged with said first piston, a second piston supported by said carriage and arranged coaxially with said power shaft, a second cylinder supported by said frame and cooperatively arranged with said second piston, means for supplying air to said first cylinder to move said first piston, a hydraulic fluid in said second cylinder, means controlling the rate at which said second piston forces said fluid out of said second cylinder, thereby to control the rate at which said second piston and said shaft are moved by air pressure acting upon said first piston, and means controlling the supply of air to said first piston, said means being operable by engagement of the abutment on said stop tube with the abutment supported by said carriage, thereby to limit the amount of axial movement accorded to said shaft.

3. The oscillatory control mechanism as set forth in claim 2 wherein the stop abutment supported by said carriage is adjustable relative to said abutment on said stop tube along the longitudinal axis of said frame, thereby to permit variable control of the longitudinal movement permitted said shaft.

4. A power mechanism comprising a shaft, means supporting said shaft for axial movement, a first piston coaxial with and operatively connected to said shaft, a first cylinder cooperatively arranged with said first piston, a second piston coaxial with and operatively connected to said shaft, a second cylinder operatively arranged with said piston, means for supplying air under pressure to said first cylinder to effect movement of said first piston, a hydraulic fluid in said second cylinder, means controlling the rate at which movement of said second piston forces said fluid out of said second cylinder, thereby to control the rate at which said second piston and said shaft are moved by air pressure acting upon said first piston, and means for selectively supplying additional hydraulic fluid under pressure to said second cylinder on the other side of said piston, thereby to impart a hydraulic force acting to move said shaft in an axial direction.

5. An oscillatory power mechanism comprising a frame having a longitudinal axis, a carriage member supported for movement relative to said frame along said longitudinal axis, a power shaft supported for rotation within said frame, a drive tube rotatably supported by said frame and splined to said shaft to effect rotation of said shaft while permitting relative sliding movement between said shaft and said drive tube, a stop tube supported by said frame disposed intermediate said drive

tube and said carriage and coaxial therewith, an abutment on said stop tube adjacent one end thereof, a second abutment carried by said carriage member and disposed relative to the abutment on said stop tube so as to be engageable therewith by relative axial movement therebetween, a first piston supported by said carriage and coaxial with said shaft, a first cylinder carried by said frame and cooperatively arranged with said first piston, a second piston supported by said carriage and arranged coaxially with said power shaft, a second cylinder supported by said frame and cooperatively arranged with said second piston, means for selectively supplying air to either end of said first cylinder to move said first piston, a hydraulic fluid in said second cylinder, means controlling the rate at which said piston forces said fluid out of said second cylinder, thereby to control the rate at which said second piston and said shaft are moved by air pressure acting upon said first piston, and means operable by engagement of the abutment on said stop tube with the abutment supported by said carriage to reverse the supply of air from one end of said first cylinder to the other, thereby to limit the amount of axial movement permitted said shaft in accordance with the longitudinal positon of said carriage member.

6. An oscillatory power mechanism comprising a shaft, a carriage member coaxial with said shaft, means supporting said shaft for rotation within said carriage member, means supporting said carriage member for axial

movement, a first piston carried by said carriage member and coaxial therewith, a first cylinder carried by the carriage member supporting means and cooperatively arranged with said first piston, a second piston carried by said carriage member and coaxial therewith, a second cylinder carried by the carriage member supporting means and cooperatively arranged with said second piston, means for supplying air to said first cylinder to effect axial movement of said first piston, a hydraulic fluid in said second cylinder, means for controlling the rate of fluid flow out of said second cylinder, and a control member adjustably positioned on said carriage member and arranged to actuate the means controlling the rate of fluid flow out of said second cylinder, thereby to control carraige speed as a function of carriage position.

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