July 31, 1945. L. A. MAXSON 2,380,457

AUTOMATIC CONTROL MEANS

Filed Dec. 30, 1941 4 Sheets-Sheet 1

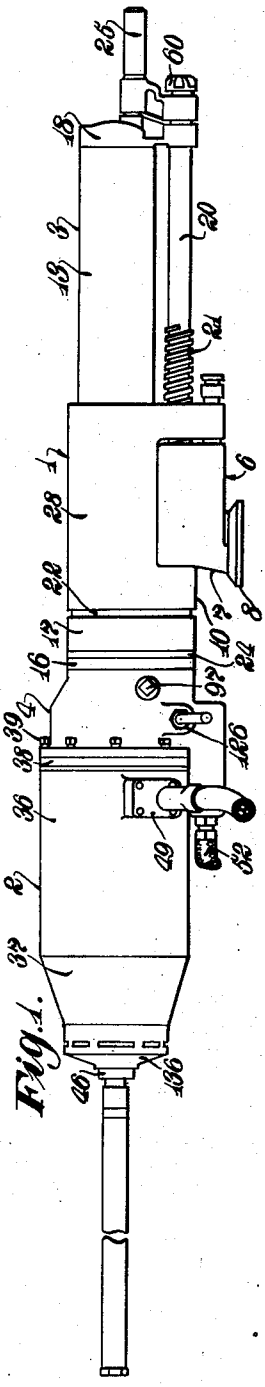

Fig. 1.

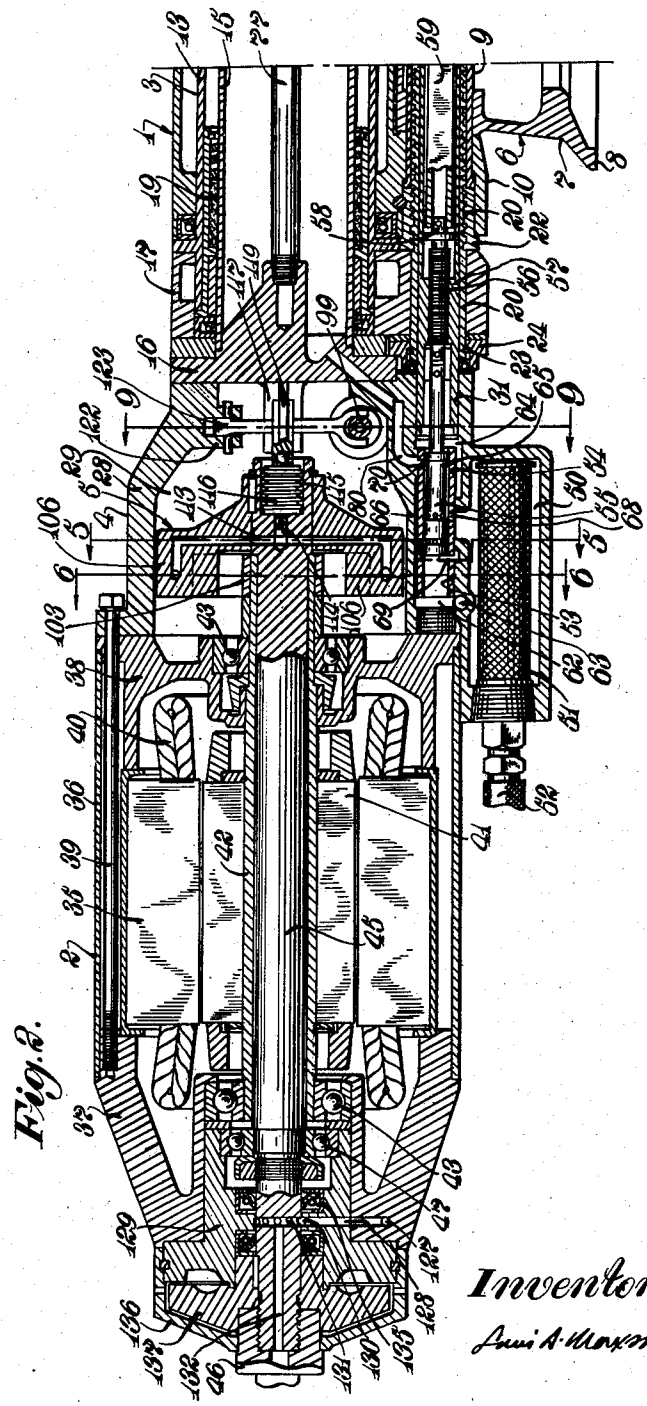

Fig. 2.

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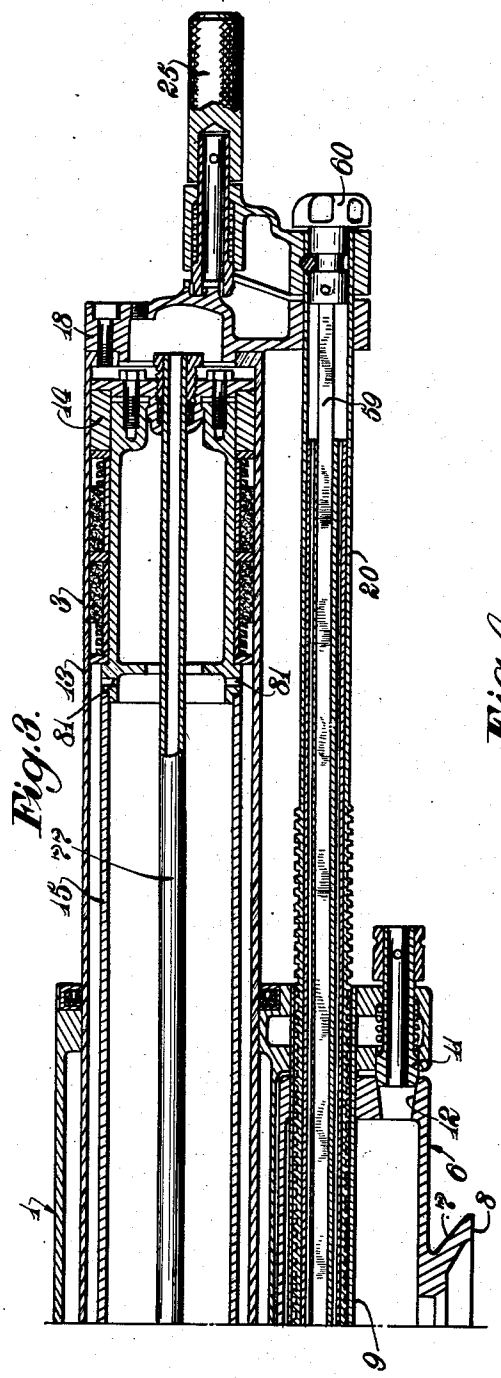

Fig. 3.

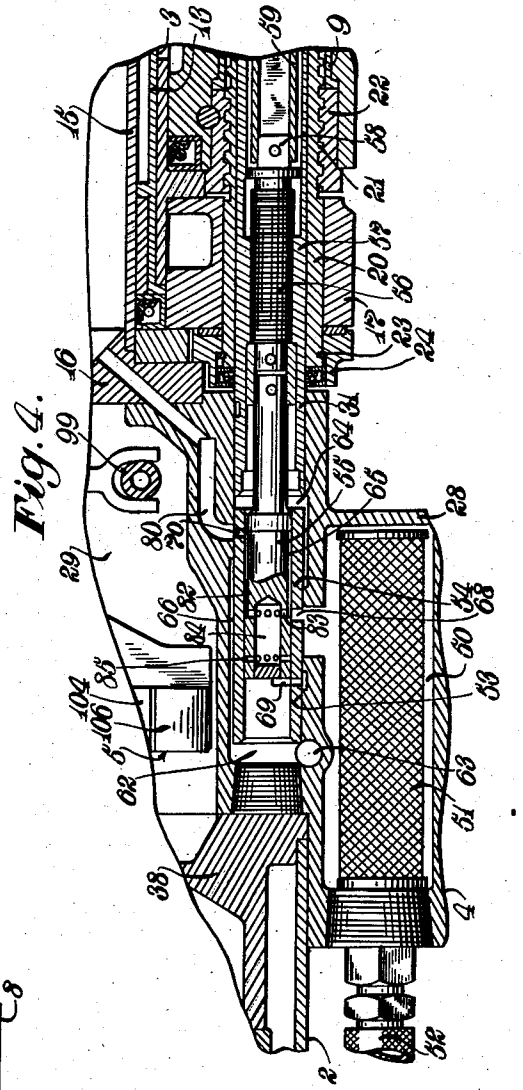

Fig. 4.

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Fig. 5.

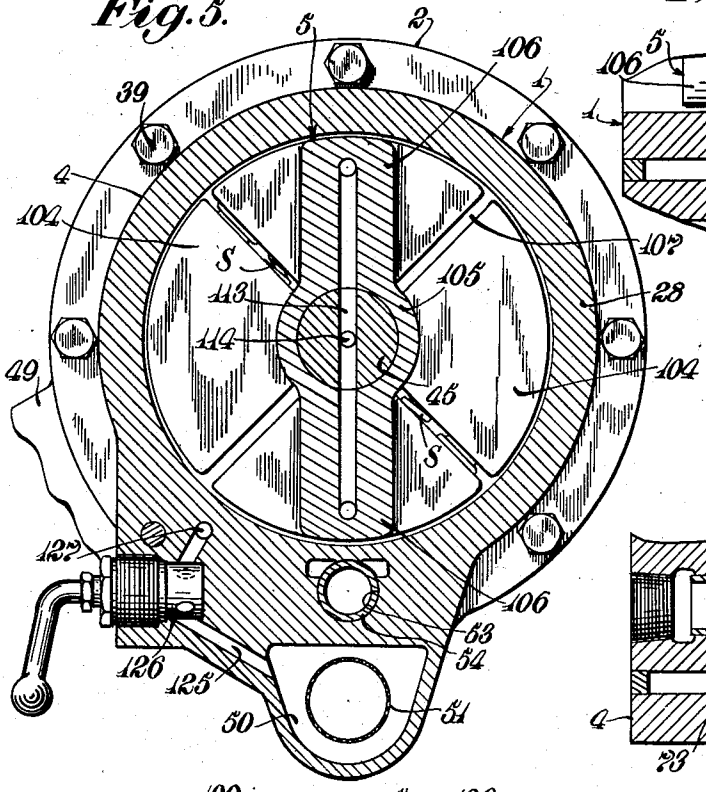

Fig. 7.

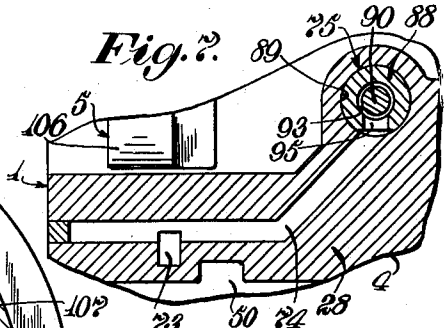

Fig. 8.

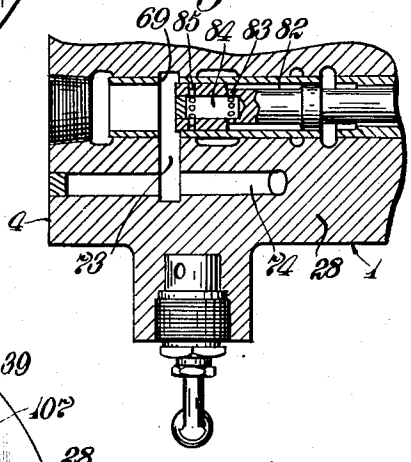

Fig. 6.

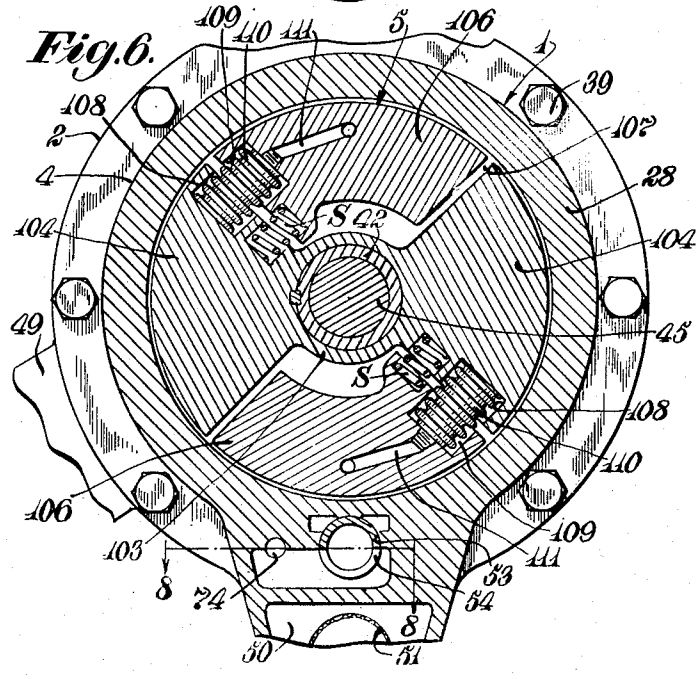

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Fig. 9.

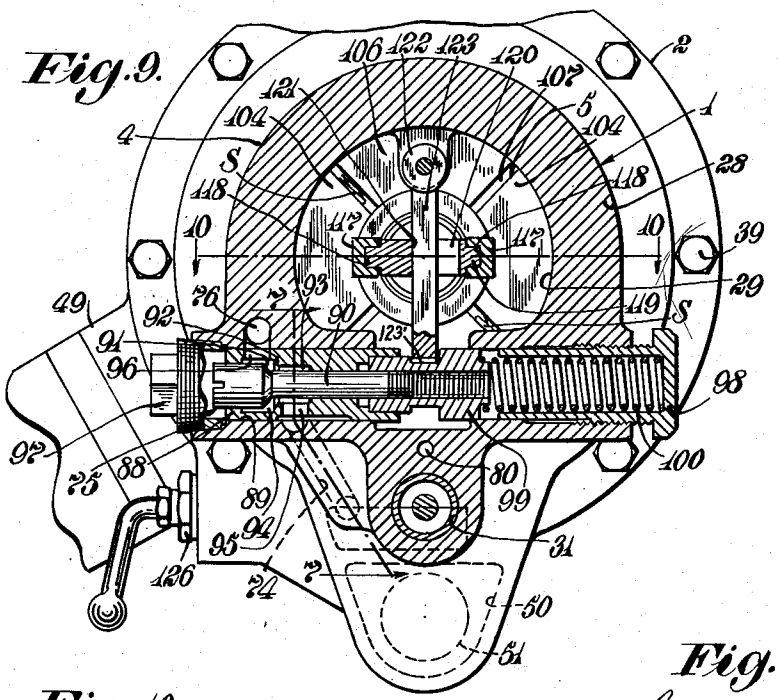


Fig. 10.

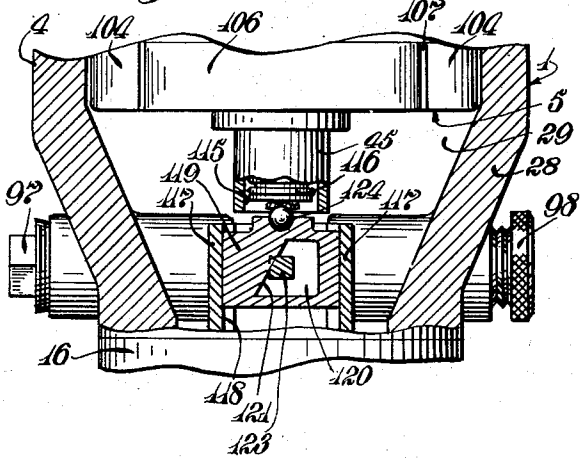
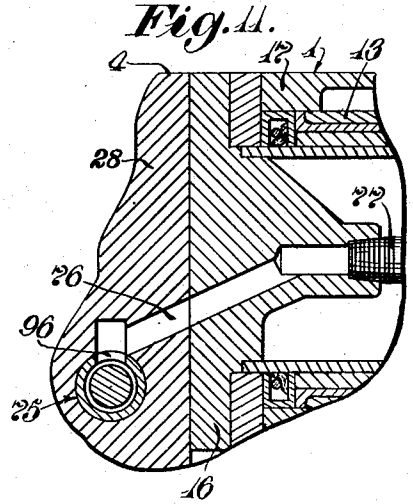


Fig. 11.



Inventor:

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Patented July 31, 1945 2,380,457

UNITED STATES PATENT OFFICE

2,380,457

AUTOMATIC CONTROL MEANS

Louis A. Maxson, Claremont, N. H., assignor to Sullivan Machinery Company, a corporation of Massachusetts

Application December 30, 1941, Serial No. 424,971

14 Claims. (Cl. 255—47)

This invention relates to automatic controlling means for automatically fed work performing devices and especially, though not exclusively, to automatically controlled drilling apparatus, and still more particularly, from one aspect, to improved feed control means for drilling apparatus of the high speed rotary type.

It is an object of this invention to provide an improved automatic feed controlling means. It is another object to provide an improved automatically controlled power-fed work performing device. Another object of this invention is to provide improved feed control means for a drilling apparatus of the rotary type. Still another object is to provide improved means responsive to the torque on a drill or other tool rotating shaft for controlling the supply of pressure fluid to pressure fluid operated feeding means for the apparatus of which such shaft is a part. Still a further object is to provide improved means for yieldably connecting the drive shaft of a rotary type drill or other tool driving motor to a drill or other tool, and operative at predetermined loads on the drill or other tool shaft for cutting off the supply of pressure fluid to pressure responsive feeding means. Another object is to provide improved means connected between the power shaft of a rotary type drill or other tool operating motor and a drill shaft for controlling a torque-controlled valve in a pressure fluid supply line of a pressure operated feeding device. Still a further object is to provide an improved hydraulically operated, torque responsive, feed control mechanism. Other objects and advantages of this invention will appear in the course of the following description.

In the accompanying drawings there is shown for purposes of illustration one form which the invention may assume in practice.

In these drawings:

Fig. 1 is a side elevational view of a drilling apparatus in which an illustrative form of the improved feed control means is incorporated.

Figs. 2 and 3, when taken together, constitute an enlarged view in central, longitudinal, vertical section through the drilling apparatus shown in Fig. 1.

Fig. 4 is an enlarged fragmentary view taken in the plane of Fig. 2 and showing details of construction.

Fig. 5 is an enlarged cross sectional view taken on the plane of the line 5—5 of Fig. 2.

Fig. 6 is an enlarged cross sectional view taken on the plane of the line 6—6 of Fig. 2.

Fig. 7 is a detail sectional view taken on the planes of the line 7—7 of Fig. 9.

Fig. 8 is a fragmentary horizontal sectional view taken on the plane of the line 8—8 of Fig. 6.

Fig. 9 is an enlarged vertical cross sectional view taken on the line 9—9 of Fig. 2.

Fig. 10 is a fragmentary horizontal sectional view taken on the line 10—10 of Fig. 9.

Fig. 11 is a detail sectional view showing portions of the forward feed passages.

In this illustrative embodiment of the invention, which shows the latter incorporated in a drill operating mechanism, a drilling mechanism, generally designated 1, of the high speed, rotary type adapted for use with core or plug-type bits, generally comprises drill bit rotation means 2, drill bit feeding means 3, a control head 4 containing improved feed control means, generally designated 5, and drill guiding and supporting means, generally designated 6. This drill mechanism, except for the operative connections between the drilling motor and the drilling implement and the feed control means, is similar to that shown and described in a copending application of Win W. Paget, Serial No. 268,792, now matured into Patent No. 2,288,541, which is also owned by the assignee of this present application.

The drill supporting and guiding means 6 comprises a trunnion member 7 having a swivel plate 8 adapted to be clamped in the saddle mounting of a mine column or any other suitable support. Extending longitudinally through the trunnion member is a bore which receives a cylindrical tube 9 having its ends fixed within a support member 10 and providing a pivotal mounting for the support member so that the latter may be swung laterally to move the drill into a position at one side of the drill hole. Carried by the support member 10 is a plunger 11 adapted to be received within an opening 12 in the trunnion member for locking the support member in its upright drilling position. Extending longitudinally through the support member is a bore which slidingly receives and guides a feed cylinder 13 of the feeding means 3.

The feed cylinder 13 contains a reciprocable feed piston 14 having a tubular piston rod 15 extending forwardly through the cylinder and having fixed to its forward end a plate 16, as shown in Fig. 2. The feed cylinder 13 has front and rear heads 17 and 18, the former carrying a packing 19 sealingly engaging the exterior periphery of the piston rod and the latter head being detachably secured, as by screws, to the rear end of the feed cylinder. The front and

rear cylinder heads 17 and 18 have depending bosses provided with bores in which is rotatably mounted a cylindrical tube 20 extending centrally through the pivot tube 9 and having formed along a portion of the length thereof screw threads 21 coacting with the threads of a non-rotatable feed nut 22 secured within the support member 10. The forward end of the tube 20 is fixed against axial displacement with respect to the feed cylinder by a split ring 23 seated in external and internal grooves on the tube 20 and a detachable end plate 24 respectively, the latter secured to the front head 17 of the feed cylinder 13. The tube 20 projects rearwardly through the rear head boss and has secured thereto a handle 25 by means of which the tube may be manually rotated to feed the cylinder 13 relative to the support member 10.

Secured in any suitable manner to the plate 16 is a cylindrically shaped housing 28, the housing and the plate cooperating to form the control head 4 and providing a chamber 29 within which the improved torque transmitting and control means are located. Formed in the wall of the housing 28 is a bore containing a tube 31 which extends coaxially with and in telescopic relation within the feed screw tube 20 in the manner shown. The tube 31 is fixed within the bore in the housing and has a sliding fit with the walls of the tube 20 to hold the feed cylinder against rotation within its bore in the support member and to provide a sliding guide for the drill.

The drill bit rotating means comprises an electric motor 35 having a cylindrical motor casing 36 provided with front and rear heads 37 and 38, the motor parts being held in assembled relation and secured to the housing 28 by tie bolts 39. The motor has a usual field 40 and an armature rotor 41, the latter being secured to a tubular shaft 42 journaled in bearings 43 suitably supported by the front and rear motor heads The shaft 42 extends through the rear motor head into the chamber 29 as shown in Fig. 2. Extending through the tubular shaft 42 is a shaft 45 carrying a chuck 46 at its forward end for receiving a drill rod and having its rear end extending into the chamber 29 where it is operatively connected, through means more fully to be described, to the tubular shaft 42. As will be clear from the later description, the shaft 45 is rotatable through a small angle relative to the shaft 42, and it is held in any suitable way against longitudinal movement relative to shaft 42, as by a thrust bearing 47. Electrical energy may be conducted to the windings of the motor from any convenient source through a conventional conductor plug 48 mounted on the motor casing, as shown in Fig. 1.

The means for supplying fluid, preferably liquid under pressure, to the fluid actuated feeding means 3 comprises a liquid supply chamber 50 formed in the housing 28, and liquid may be conducted to this chamber through a strainer 51 from a supply conduit 52. Also formed in the housing 28 is a longitudinal bore 53 having arranged therein a ported valve bushing 54 in which a control valve 55 is reciprocably mounted. This valve is of the sliding spool type and is operated by a valve adjusting screw 56 engaging a stationary non-rotatable nut 57 formed within the guide tube 31. The screw 56 is rigidly secured to an operating rod 58 which has a sliding but non-rotatable telescopic engagement with an operating rod 59. The rod 59 extends rearwardly within the tubular feed screw, and has secured to its rear end a control handle 60. It will be seen that by rotating the handle 60, the control valve 55 may be moved longitudinally within the valve bushing bore through the rotatable screw 56 engaging the non-rotatable nut 57, and by the provision of the telescopically arranged rods the valve may be operated irrespective of the position of the control head relative to the trunnion support. Communicating with the forward end of the bore of the valve bushing is an exhaust chamber 62 connected to an exhaust port 63, and communicating with the bore of the bushing at its rear end is a chamber 64 connected to the chamber 62 through grooves 65 and 66 extending along the outer surface of the valve bushing. The supply chamber 50 is connected through a port slot 68 in the valve bushing to the interior of the latter, and formed in the valve bushing at opposite sides of the port 68 are ports 69 and 70 communicating, respectively, with forward and reverse feed passages to be described. The port 69 opens into a groove 73 communicating with a passage 74, as shown in Figs. 7 and 8, and the passage 74 is connected, past a torque-controlled valve means, generally designated 75, to a passage 76 (Fig. 11) which opens into a liquid conducting tube 77 extending longitudinally through the tubular piston rod 15 and opening through the feed piston 14 into the bore of the feed cylinder 13 at the rear of the piston. The port 70 opens into a passage 80 in the control head 4, as shown in Figs. 2 and 4, and the passage 80 communicates with the interior of the tubular piston rod 15 at its forward end. Extending radially through the tubular piston rod adjacent the piston 14, are ports 81 for conducting liquid from the interior of the piston rod to the bore of the feed cylinder 13 at the forward side of the feed piston. When the control valve 55 is moved to its rearward position, as shown in Fig. 4, liquid is vented from the forward feed passages through the port 69 to the chamber 62 and the exhaust port 63. At the same time, the liquid supply chamber 50 is connected through the port 68 and a groove 82 on the control valve to the passage 80 so that liquid is supplied under pressure to the feed cylinder at the forward side of the feed piston for moving the latter toward the rear end of the feed cylinder. When the valve 55 is moved to its extreme forward position, the reverse feed passages are vented through the port 70 to the chamber 64 which is connected to exhaust through the grooves 65, 66, the chamber 62 and the port 63. The supply chamber 50 is connected at this time through the port 68 to ports 83 opening into a chamber 84 in the control valve, and the chamber 84 is connected through ports 85 to the port 69 communicating with the forward feed passages which conduct liquid, under control of the torque-controlled valve 75, to the feed cylinder at the rear side of the feed piston for effecting movement of the latter in a forward direction.

The torque-controlled valve 75 comprises, as shown in Fig. 9, a valve sleeve 88 arranged within a transverse bore 89 in the housing 28 of the control head 4. Extending longitudinally through the valve sleeve is a valve member 90 having a beveled shoulder 91 adapted to cooperate with a beveled valve seat 92 on the sleeve. Formed in the valve sleeve at opposite sides of the valve seat are bores 93 and 94, the bore 93 communicating through a port 95 with the passage 74, and the bore 94 communicating through a port 96 with the passage 76. When the valve member 90

is moved to its unseated position, as in Fig. 9, the forward feed passages 74 and 76 are connected in communication with each other through the port 95, the bores 93 and 94, and the port 96. With the valve member in its seated position, communication between the passages 74 and 76 is cut off, and forward feed is immediately stopped since there is no expansion of the liquid by means of which the feeding pressure is transmitted. The ends of the bore 89 are closed by plugs 97 and 98, and arranged between the plug 98 and a sleeve 99 threaded on the valve member is a coil spring 100 for continuously urging the valve member toward its unseated position.

Improved means, generally designated 5, is provided for transmitting the torque from the rotor shaft 42 to the shaft 45 and for moving the valve member 90 to its seated position when the torque transmitted from the rotor shaft 42 to the shaft 45 exceeds a predetermined amount. This means comprises, as shown in Figs. 2, 5 and 6, a member 103 suitably splined or keyed to the rear end of the tubular shaft 42 and herein having diametrically opposite quadrantal portions 104 projecting outwardly at opposite sides of the shaft. Keyed to the rear end of the shaft 45 is a member 105 having diametrically opposite quadrantal portions 106 extending outwardly in opposite directions from the shaft and fitting freely between the quadrantal portions 104. The portions 104 and 106 are so proportioned as to provide clearances 107 between them whereby a slight relative rotation between the shafts 42 and 45 is permitted. Force transmitting means actuated by the relative movements between the portions 104 and 106 upon the transmission of driving forces from one to the other may assume various forms and herein I have shown for purposes of illustration a hydraulic system. Formed in certain of the adjacent faces of the quadrantal portions 104 and 106, as shown in Fig. 6, are recesses 108 and 109 opening into each other other and cooperating to form chambers receiving hollow yieldable elements or bellows 110 whose interiors communicate with passages 111 formed in the quadrantal portions 106. The passages 111 are connected, as shown in Fig. 5, through radial passages 113 in the shaft 45 to a passage 114 extending axially within the shaft. Arranged in a recess 115 in the rear end of the shaft 45, is a yieldable element or bellows 116 connected in communication with the passage 114. It will be understood that the entire driving torque may be transmitted through the fluid system formed by the interconnected bellows, but it may be desirable to provide suitable means, such as springs S received in pockets formed in the same faces of the members 104 and 106 that receive the bellows 110, to absorb a part of the driving torque, both arrangements being within the contemplation of my invention. The springs may be of such strength and length as normally to be received full length (fully extended) within the pockets in the absence of driving torque.

Mechanism actuated by the bellows 116 for controlling the feed may now be described. Formed on the plate 16 and projecting forwardly into the housing 28, as shown in Figs. 2 and 10, are spaced guide members 117 providing longitudinally extending guide surfaces 118 for a sliding cam element 119. The guide members 117 and the guide surfaces 118 are so arranged as to support the cam element 119 in axial alinement with the shaft 45 for longitudinal sliding movement relative to the latter. Extending vertically through the cam element is an opening 120 bounded at one side by an inclined cam surface 121. Pivotally connected to depending lugs 122 formed on the housing 28 above the cam element 119, is a lever 123 projecting downwardly through the opening 120 in the cam element and having a forked lower end fitting within a groove 123' in the sleeve 99 threaded on the valve member 90. It will be noted that the pivotal connection for the lever 123 is such as to provide for a swinging of the lever transversely of the housing, and the lever is continuously held against the cam surface 121 by the action of the spring 100 urging the valve member 90 toward its unseated position. The parts of the control means are so related that, for normal loads on the drill motor, the valve member 90 is held in its open position, and the cam element is moved forwardly by the action of the lever 123 on its cam surface 121, to engage the rear end of the bellows 116 through a friction reducing element, such as a ball 124. The interior of the bellows 110 and 116, and the passages 111, 113 and 114 provide a closed system which is filled with a fluid, preferably a liquid whereby operating pressures are transmitted to one part of the system when another part of the system reacts to pressures to be controlled.

When the load on the bit rotating means exceeds a predetermined amount, i. e. if the resistance to drill bit rotation becomes excessive, the shaft 45 is caused to lag behind the shaft 42 and the quadrantal portions 104 and 106 are moved relative to each other in a direction to compress the bellows 110. The gaseous fluid or liquid contained within the bellows 110 is forced into the passages 111, 113, 114, and the bellows 116, increasing the pressure therein and causing the bellows 116 to expand, moving ahead of it the cam element 119. As the cam element is forced rearwardly, the cam surface 121 acts against the lever 123 forcing the latter in a direction to move the valve member towards its seated position against the tension of the spring 100 and reduce or completely cut off the supply of liquid to the feed cylinder.

In order to prevent an overheating of the bit during drilling, there are provided means for delivering a cooling liquid to the drill hole. This means comprises a passage 125 opening into the liquid supply chamber, as shown in Fig. 5, and conducting liquid past a manually operated valve 126 to a passage 127 extending longitudinally through the motor casing. The passage 127 is connected, as shown in Fig. 2, through a radial passage 128, formed in a collar 129 surrounding the shaft 45, to a groove 130 communicating with radial passages 131 and an axial passage 132 formed in the shaft 45. The passage 132 extends through the forward end of the shaft 45 and delivers the cooling liquid to a passage extending longitudinally through the drill shaft in a usual manner. Surrounding the shaft 45 at opposite sides of the groove 130, are packing leathers 135 held firmly in engagement with the periphery of the shaft to prevent the escape of cooling liquid along the shaft to the bearings 43, and to the interior of a fan housing 136 containing a fan 137 which is driven by the shaft 45 for forcing cooling air through the motor casing.

Returning to the specific improvements disclosed in this application, it will be observed that with the use of springs such as those shown at S a large part of the torque may be transmitted through the springs and by providing springs of appropriate characteristics the pressure within

the closed fluid system necessary to effect the desired controls will not need to be so high as if the spring 100 had to be made strong enough to withstand in the necessary manner the pressure which would build up in the bellows if the full driving force had to be transmitted through the latter. It will be observed, however, that at least in part the fluid system which controls the feed serves to transmit the driving torque, in the specific structure shown in the drawings, and with appropriately proportioned and adequately strong bellows 110, 116 and spring 100 the entire driving load may be carried through the hydraulic system, and this is within the contemplation of my invention.

As a result of this invention it will be noted that there is provided an improved drilling apparatus of the rotary type. It will be noted that there is also provided improved means for controlling the feeding of the drill, the control means being operative at a predetermined torque on the drill bit for cutting off the supply of operating fluid to fluid actuated feeding means for the drill. And there is provided an improved driving and feed controlling means adapted to the feeding and driving of a very wide variety of mechanisms. Other advantages of the improved drilling apparatus will be clearly apparent to those skilled in the art.

While there is in this application specifically described one form which the invention may assume in practice, it will be understood that this form of the same is shown for purposes of illustration and that the invention may be modified and embodied in various other forms without departing from its spirit or the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent is:

1. In a drilling apparatus, in combination, a motor for rotating a drill bit, driving connections between said motor and the drill bit including a driven shaft and a fluid containing system yieldingly connecting said motor to said shaft, power operated feeding means for the drill bit, and means for controlling said feeding means in accordance with the load on said motor, said controlling means including means operatively connected to said fluid containing system.

2. In a drilling apparatus, in combination, a motor for rotating a drill bit, said motor having a power shaft, driving connections between said power shaft and the drill bit including a driven shaft, and means including a closed fluid containing system yieldingly connecting said power shaft to said driven shaft, fluid actuated feeding means for the drill bit, and means for controlling the supply of fluid to said feeding means in accordance with the resistance to drill bit rotation, said controlling means including means actuated by said fluid containing system on relative rotation between said shafts.

3. In a drilling apparatus, in combination, a motor for rotating a drill bit, said motor having a power shaft, driving connections between said power shaft and the drill bit including a driven shaft, and means including a closed fluid containing system yieldingly connecting said power shaft to said driven shaft, fluid actuated feeding means for the drill bit, and means for controlling the supply of fluid to said feeding means in accordance with the load changes on said motor, said controlling means comprising a torque controlled valve, and means controlled by said fluid containing system on relative rotation between said power shaft and said driven shaft for actuating said valve.

4. In a drilling apparatus, in combination, a motor for rotating a drill bit, said motor having a power shaft, driving connections between said power shaft and the drill bit including a driven shaft, members fixed to said shafts and having projecting portions interfitting freely with each other, yielding chamber providing elements arranged between said projecting portions, a yielding chamber providing element arranged at an end of one of said shafts, passage means connecting said chamber providing elements, said chamber providing elements and said passage means forming a closed system for containing a fluid which acts to expand one of said elements when another is compressed, fluid actuated feeding means for the drill bit, and means responsive to the action of one of said yielding chamber providing elements for controlling the supply of fluid to said feeding means.

5. In a drilling apparatus, in combination, a motor for rotating a drill bit, said motor having a power shaft, driving connections between said power shaft and the drill bit including a driven shaft, members fixed to said shafts and having projecting portions interfitting freely with each other, yielding chamber providing elements arranged between said projecting portions, a yielding chamber providing element arranged at an end of one of said shafts, passage means connecting said chamber providing elements, said chamber providing elements and said passage means forming a closed system for containing a fluid which acts to expand one of said elements when another is compressed, fluid actuated feeding means for the drill bit, valve means for controlling the supply of fluid to said feeding means, and means actuated by one of said yielding chamber providing elements for controlling said valve means.

6. In a drilling apparatus, in combination, a motor for rotating a drill bit, said motor having a power shaft, driving connections between said power shaft and the drill bit including a driven shaft, members fixed to said shafts and having projecting portions interfitting freely with each other, yielding chamber providing elements arranged between said projecting portions, a yielding chamber providing element arranged at an end of one of said shafts, passage means connecting said chamber providing elements, said chamber providing elements and said passage means forming a closed system for containing a fluid which acts to expand one of said elements when another is compressed, fluid actuated feeding means for the drill bit, valve means for controlling the supply of fluid to said feeding means, and means actuated by one of said yielding chamber providing elements when others of said elements are compressed due to relative rotation of said shafts for effecting closure of said valve means.

7. In a drilling apparatus, in combination, a motor for rotating a drill bit, said motor having a tubular power shaft, driving connections between said power shaft and the drill bit including a driven shaft extending through said tubular power shaft, a member fixed to said power shaft and having radially projecting portions, a member fixed to said driven shaft and having radially projecting portions extending between the projecting portions on said member fixed to said power shaft, yielding chamber providing elements arranged between said projecting portions, a

yielding chamber providing element arranged at one end of said driven shaft, passage means connecting said chamber providing elements, said chamber providing elements and said passage means forming a closed system for containing a fluid through which energy may be transmitted, fluid actuated feeding means for the drill bit, and means actuated by one of said chamber providing elements when others are compressed on relative rotation of said shafts for controlling the supply of fluid to said feeding means.

8. In a drilling apparatus, in combination, a motor for rotating a drill bit, said motor having a tubular power shaft, driving connections between said power shaft and the drill bit including a driven shaft extending through said tubular power shaft, a member fixed to said power shaft and having radially projecting portions, a member fixed to said driven shaft and having radially projecting portions extending between the projecting portions on said member fixed to said power shaft, yielding chamber providing elements arranged between said projecting portions, a yielding chamber providing element arranged at one end of said driven shaft, passage means connecting said chamber providing elements, said chamber providing elements and said passage means forming a closed system for containing a fluid through which energy may be transmitted, fluid actuated feeding means for the drill bit, valve means for controlling the supply of fluid to said feeding means, and means actuated by said chamber providing element at the end of said driven shaft when fluid is forced thereto by compression of said chamber providing elements between said projections for closing said valve means.

9. In combination, an implement, a shaft connected in driving relation with said implement, a motor, means including a fluid containing system connecting said motor to said shaft, said fluid containing system so constructed and so related to said motor and said shaft that said fluid is placed under pressure when said motor exerts a torque on said shaft, power operated means for feeding said implement, and means responsive to the pressure changes in said fluid for controlling the delivery of power to said feeding means.

10. In combination, in a controlling apparatus, an expansible chamber forming means, another expansible chamber forming means, means connecting said expansible chamber forming means together to form a closed, self-contained fluid system, one of said expansible chamber forming means varying in volume in accordance with the pressures acting thereon and causing fluid to flow relative to the other expansible chamber forming means for effecting changes in the volume of the latter, means for exerting on one of said expansible chamber forming means a pressure varying with a load to be controlled, and means actuated by changes in volume of the other of said expansible chamber forming means for effecting a control of such load.

11. In combination, a motor for rotating an implement, power operated means for feeding said motor, and means for connecting said motor in driving relation with the implement to be rotated thereby and for controlling the feeding force exerted by said feeding means including a closed liquid system having movable walls, one of said walls subjected to a pressure varying with the resistance to implement rotation and another of said walls exerting a corresponding pressure to control the delivery of power to said feeding means.

12. In combination, an implement, a motor for driving said implement, said driving motor having a power shaft, a shaft to be driven by said power shaft and connected to said implement, at least one radial arm on each of said shafts, yieldable means connected between said radial arms for transmitting power from said power shaft to said driven shaft, power operated means for feeding said implement, and means including a system actuated by relative angular movement between said arms for controlling the delivery of power to said feeding means.

13. In combination, power operated means for rotating a tool, power operated means for feeding the tool rotated by said first mentioned means longitudinally of its axis, means including a yieldable power transmitting means for yieldingly connecting one of said power operated means to the tool, and means responsive to the yielding of said yieldable connecting means and having pressure fluid operated controlling means for controlling the delivery of power to the other of said power operated means.

14. In combination, power operated means for rotating a tool, power operated means for feeding the tool rotated by said first mentioned means longitudinally of its axis, means including a closed fluid containing system for yieldingly connecting one of said power operated means to the tool, said fluid containing system so constructed and so related to the one of said power operated means it connects to the tool that the fluid therein is placed under pressure varying with the power delivered, and means responsive to the pressures of the fluid in said system for controlling the delivery of power to the other of said power operated means.

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