

April 5, 1960

W. W. SIMMONDS ET AL

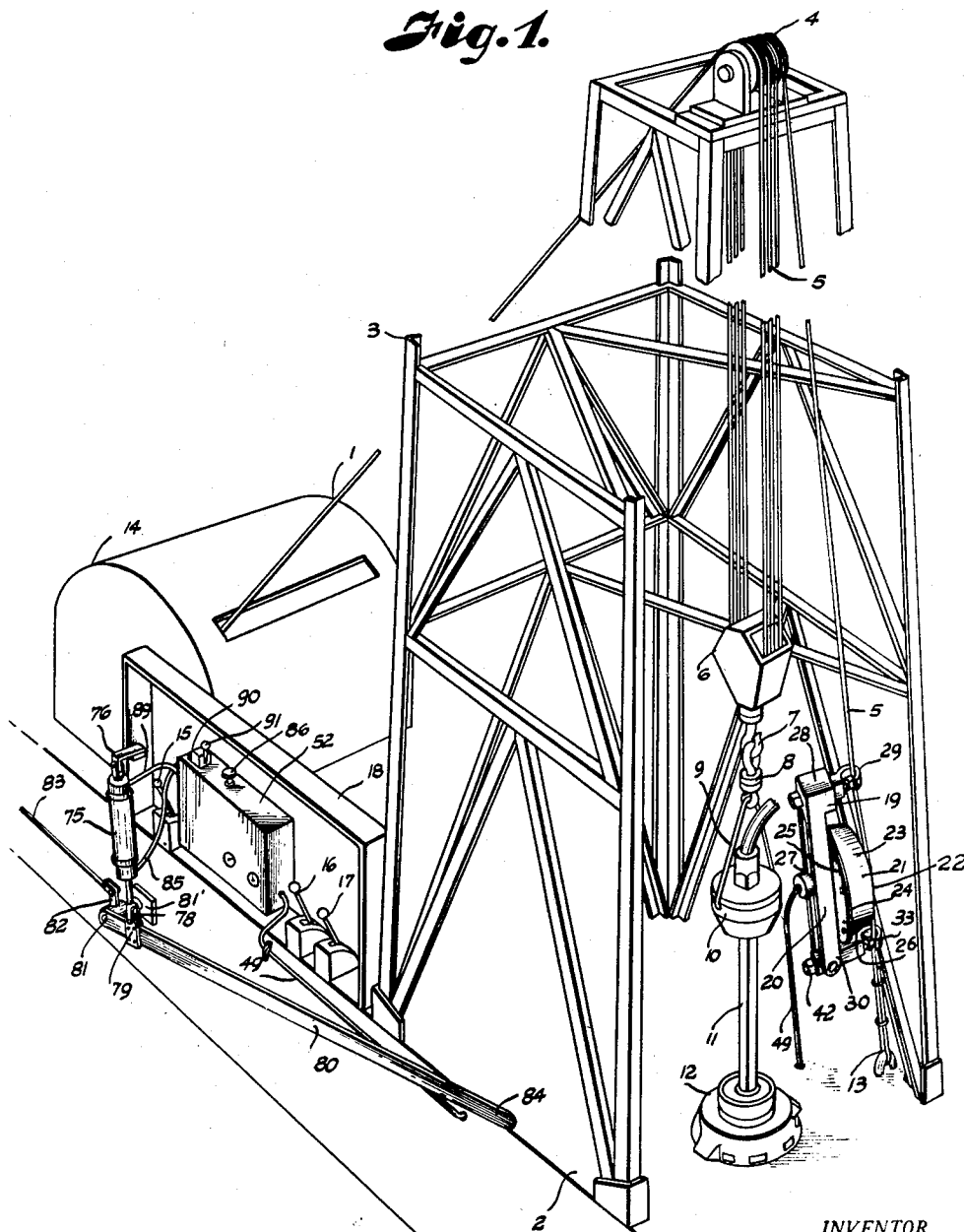
2,931,628

WEIGHT CONTROL UNIT SYSTEM FOR DRILLING RIGS

Filed Dec. 31, 1956

4 Sheets-Sheet 1

Fig. 1.



INVENTOR.
Wayne W. Simmonds and
Arlie J. Simmonds.
BY
Fischburn and Gold
ATTORNEYS.

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Fig. 2.

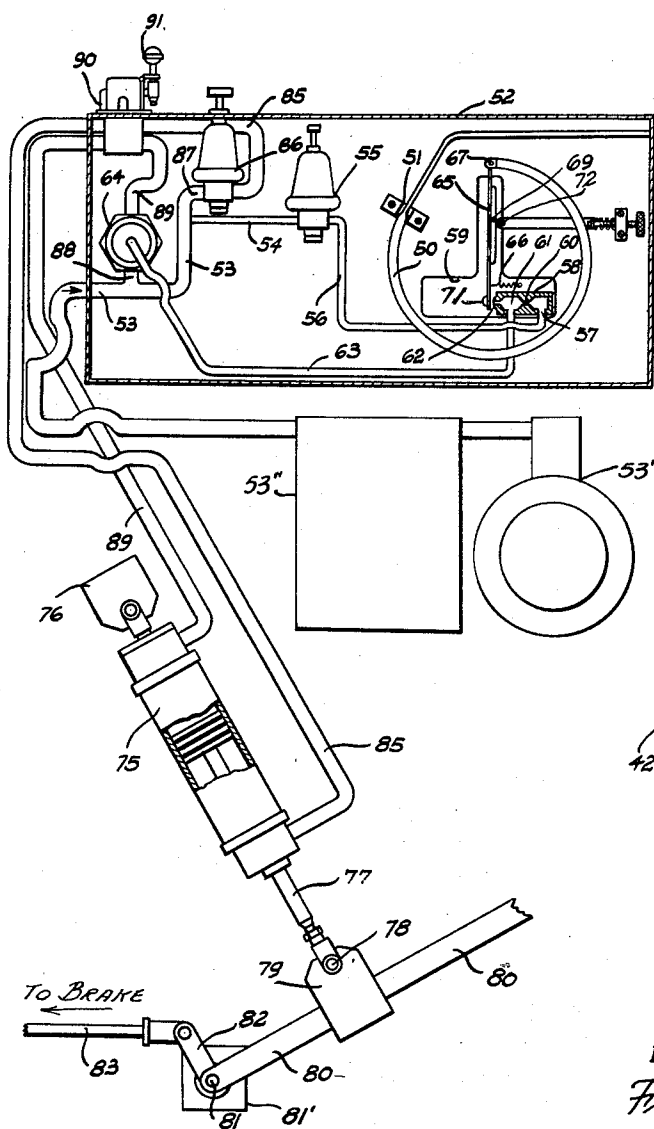
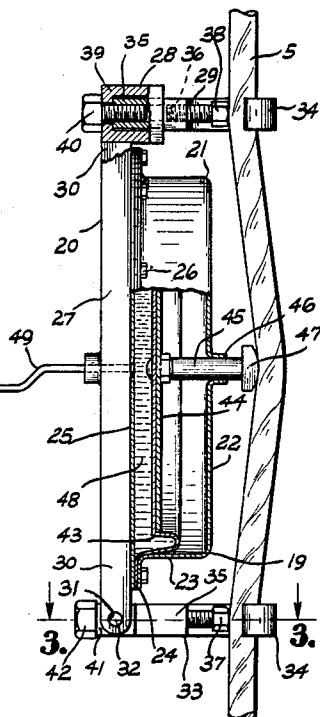
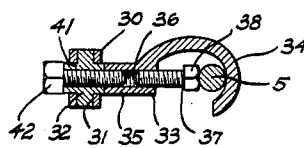


Fig. 3.



INVENTOR.
Wayne W. Simmonds and
Archie J. Simmonds.

BY

Frishbourn and Gold
ATTORNEYS.

April 5, 1960

W. W. SIMMONDS ET AL

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Fig. 4.

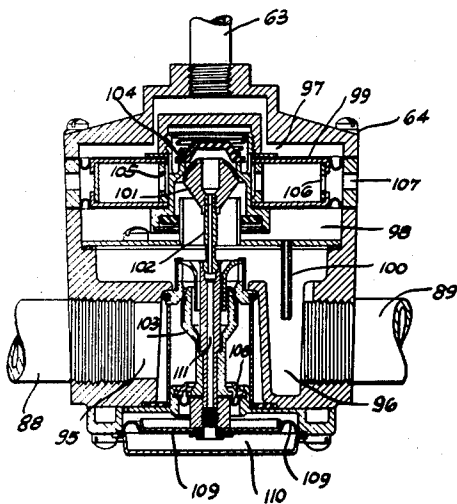


Fig. 5.

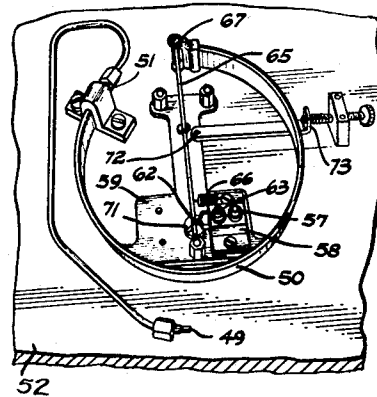
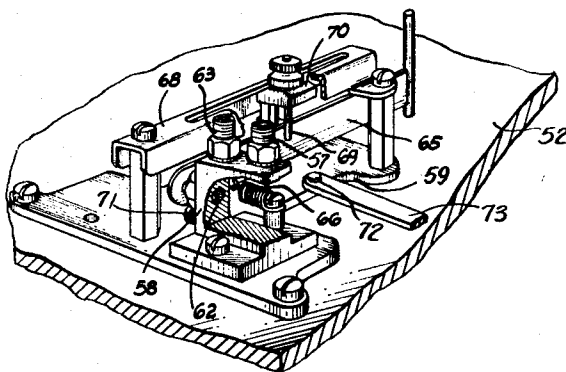


Fig. 6.



INVENTOR.
Wayne W. Simmonds and
Arle J. Simmonds.

BY
Fishburn and Gold
ATTORNEYS.

April 5, 1960

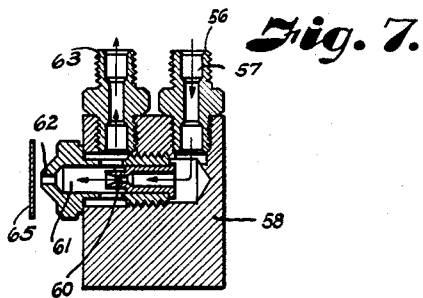
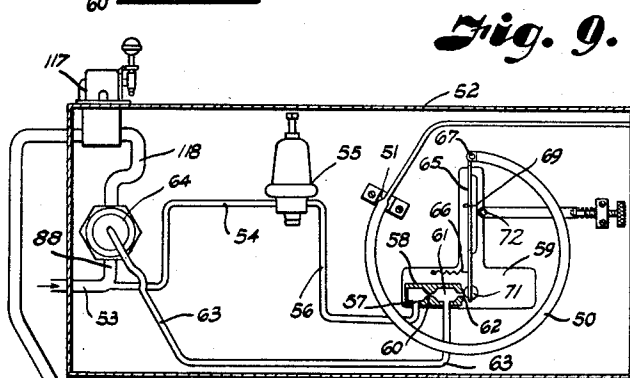
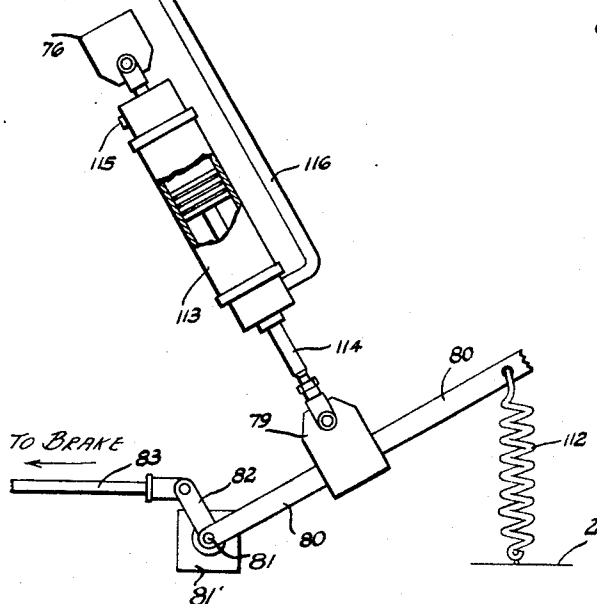
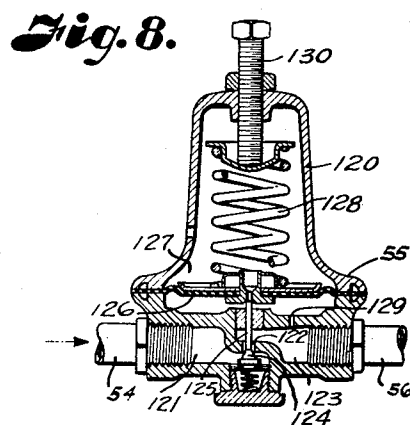
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INVENTOR.
Wayne W. Simmonds and
Arlie J. Simmonds.

BY
Fichtner and Gled
ATTORNEYS.

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WEIGHT CONTROL UNIT SYSTEM FOR DRILLING RIGS

Wayne W. Simmonds, Tulsa, Okla., and Arlie J. Simmonds, Glendale, Calif., assignors to John H. Lucas, Kansas City, Mo., trustee

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1 Claim. (Cl. 254—173)

This invention relates to weight control units for rotary drilling rigs, and more particularly to control units for automatically feeding the cable for lowering drill tools into a well hole during drilling operations.

The principal objects of the present invention are to provide fluid controlled apparatus responsive to tension on a drilling cable for automatically paying out said cable with drilling tools thereon as the formation is drilled; to provide apparatus with maximum sensitivity to variation of the weight of the tools on the cable for varying the braking of the cable drum whereby the cable is payed out from the winding drum automatically to maintain substantially uniform pressure of the drill bit on the formation being drilled; to provide a closed liquid pressure system with a large cross section piston movable in response to deflection of the cable to move liquid in the system to a pressure responsive member therein which varies the fluid pressure in apparatus that actuates the winding drum brake; to provide such apparatus wherein the pressure responsive member includes apparatus wherein operating fluid flows through two orifices, one fixed and the other having a closure associated therewith for varying flow therethrough, with a Bourdon tube connected with the valve for controlling the extent of closure of said other orifice and the pressure of the operating fluid; to provide a drilling cable winding drum with a brake actuating member that is operated by fluid pressure to hold and pay out the cable to maintain uniform weight acting on the drill bit with a cable tension responsive pressure medium for varying the operating fluid pressure.

In accomplishing these and other objects of the present invention, we have provided improved details of structure, the preferred forms of which are illustrated in the accompanying drawings, wherein:

Fig. 1 is a partial perspective view of a drilling rig and derrick with a control unit embodying the features of the present invention.

Fig. 2 is a diagrammatic view of the control unit with portions broken away to illustrate the arrangement of components thereof.

Fig. 3 is a horizontal sectional view through a cable clamp member on the line 3—3, Fig. 2.

Fig. 4 is a diagrammatic sectional view through a suitable conventional relay or pressure amplifier valve.

Fig. 5 is a perspective view of the pressure responsive orifice control.

Fig. 6 is a partial perspective view showing the adjustable fulcrum of the orifice valve.

Fig. 7 is a vertical sectional view through the fixed and controlled orifices of the signal pressure control.

Fig. 8 is a diagrammatic sectional view through a suitable pressure regulator.

Fig. 9 is a diagrammatic view of a modified form of control unit.

Referring more in detail to the drawings:

1 designates a portion of a drilling rig in connection with which our invention is adapted to be used and which

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includes a platform 2 on which a derrick 3 is mounted. A crown block 4 is mounted on the derrick and has a drilling cable 5 reeved thereon, the cable 5 also being reeved on a traveling block 6 provided with a hook 7 connected to a swivel 8 which in turn is attached to a bail 9 of a swivel head 10 as in conventional practice. The swivel head is connected to a drill stem 11 to which is attached a string of drill pipe and bit (not shown). The drill stem 11 extends through a rotary turntable 12 such as is usually employed with drilling apparatus of this character. The cable 5 has one end dead ended or fixed relative to the derrick as, for example, by being attached to a derrick floor as indicated at 13 (Fig. 1). The cable extends upwardly from the dead end and is reeved over the crown and traveling blocks 4 and 6 and has its other end portion secured to and wound on a cable drum (not shown) in a drum housing 14 also mounted on the derrick floor and provided with the usual operating levers 15, 16 and 17, mounted upon a valve rack or board 18, as is common practice.

The weight control unit 19 includes a cable tension responsive member 20 having a housing 21. The housing has a front wall 22 connected to side walls 23 which terminate in an outwardly extending flange 24 suitably secured to a rear wall 25 by fastening devices 26. The rear wall 25 is mounted on a frame 27 having a boss 28 at the upper end thereof to which an upper cable clamp structure 29 is connected. The lower end of the frame 27 has spaced arms 30 provided with aligned apertures 31 for rotatably mounting trunnions 32 of a pivoted member 41 secured to a lower cable clamp member 33 whereby said lower cable clamp is pivotally mounted on the frame for swinging movement longitudinally relative to the dead ended portion of the cable 5 to which the upper and lower cable clamp members are secured. Each of the cable clamp members 29 and 33 include hook-like portions 34 extending from base portions 35 having threaded bores 36 therein. A clamp jaw 37, which in the illustrated structure is a cap screw, is screwed into the threaded bores 36 whereby the heads 38 of the screws cooperate with the hook portions 34 to clamp the cable 5 therebetween. The upper cable clamp member is arranged whereby the base portion 35 is slidably mounted in a socket 39 of the boss 28 and a suitable fastening device such as a screw 40 removably secures said base member to the boss, as illustrated in Fig. 2. In the lower clamp member, the base member 35 is drawn against the pivoted member 41 having the trunnions 32 thereon by means of a suitable fastening device such as a screw 42. A diaphragm 43 is arranged in the housing 21 with the marginal portions of the diaphragm clamped between the flanges 24 and the rear wall 25. The inner portion of the diaphragm is suitably secured to a plate 44 suitably secured to an axial stem 45 slidably mounted in a bearing sleeve 46 in the front wall 22, the end of the stem having a head 47 adapted to engage the cable 5 between the upper and lower cable clamp members 29 and 33, as illustrated in Fig. 2.

The portion of the housing 21 between the diaphragm 43 and the rear wall 25 defines a chamber 48 which is preferably filled with a liquid and communicates through a duct or pressure transmitting line 49 with a pressure responsive member 50 which in the illustrated structure is a Bourdon tube, the duct 49 being connected with the fixed end 51 of said Bourdon tube. With this arrangement, the tension responsive member 20 is actuated by variation in the tension on the cable 5 to transmit a signal pressure to the Bourdon tube 50. Gas could be utilized for the signal transmitting media; however, it is preferred to use liquid for maximum sensitivity.

The Bourdon tube 50 is preferably arranged in a housing 52 mounted on the board 18, which housing 52 also

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preferably contains various valves of the control unit. A high pressure fluid line 53 leads to the housing 52 from a suitable source of supply such as an air compressor 53' and tank 53". The main high pressure fluid line has a branch 54 to the inlet of a relieving type spring-loaded pressure regulator 55 which maintains a constant fluid pressure in a duct or flow line 56 connecting the outlet of the regulator 55 with the inlet 57 of an orifice block 58 fixed on a bracket 59 in the housing 52. The regulator 55 is of a conventional type having a housing 120 with an inlet chamber 121 receiving fluid pressure from the high pressure fluid line 54. The inlet chamber communicates through a port 122 with an outlet chamber 123 that is connected with the flow line 56. The flow through the port 122 is controlled by a valve 124 having a stem 125 engaged with a diaphragm 126 in a bonnet 127 whereby atmospheric pressure and pressure from a spring 128 act on the diaphragm tending to open the port 122 and pressure from the outlet chamber 123 passes through an orifice 129 to act on the other side of the diaphragm tending to move the valve to close the port 122. The spring 128 is adjusted by a screw 130 to set the pressure maintained in the flow line 56. The orifice block 58 has an orifice 60 discharging into a chamber 61 which has an orifice nozzle 62 discharging to the atmosphere, said orifice in the nozzle 62 being larger than the orifice 60. The chamber 61 has communication through a duct or flow line 63 to a relay valve 64. The relay valve 64 may be any suitable relay or pressure amplifying valve and an example of such a suitable conventional relay valve is illustrated in Fig. 4; however, the structure per se of the relay valve is not the subject of the present invention. A flapper or leaf valve 65 has one end positioned to engage the end of the orifice nozzle 62 to close same, a spring 66 being connected to the flapper valve and base plate 59 to urge said end toward the orifice nozzle. The other end of the flapper valve 65 is connected as at 67 to the free or movable end of the Bourdon tube 50. A bar 68 is supported on the base member 59 and extends over the flapper valve and a fulcrum pin 69 is carried on a bracket 70 adjustable longitudinally of the bar 68 and extending downwardly therefrom alongside of the flapper valve to provide a fulcrum pin therefor. The fulcrum pin serves as a bearing point on which the flapper valve operates, and in effect, this pin is a proportional band adjustment to vary the degree of angular movement of the free end of the flapper valve that engages the orifice nozzle. When the fulcrum pin is toward the free end of the Bourdon tube, the free end of the flapper valve will move a greater distance per unit change in the Bourdon tube tip movement than when the fulcrum pin is toward the orifice nozzle.

The base plate or bracket 59 is pivotally mounted on a pivot member 71 fixed to the housing 52 and the portion of the base plate towards the free end of the Bourdon tube is connected as at 72 with an adjustment mechanism 73 on the housing 52 for pivoting or swinging the base plate about the pivot member 71. Swinging the base plate to the right or clockwise (Fig. 2) about the pivot member 71 increases the pressure in the Bourdon tube required to operate the flapper valve and swinging said base plate counter clockwise or to the left (Fig. 2) decreases the signal pressure required. The gas pressure is delivered to the regulator 55 which preferably maintains approximately 20 pounds pressure at the fixed orifice 60. An increase in the signal pressure causes the Bourdon tube to expand moving the free end of the tube to the right (Fig. 2). This action causes the flapper valve 65 and orifice nozzle 62 to act as a bleed valve bleeding pressure from the chamber 61 by moving the flapper valve away from the orifice nozzle 62 resulting in a leakage or increase of flow of gas therefrom with the resultant decrease in the fluid pressure delivered through the line 63. A decrease in the signal pressure

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will cause the Bourdon tube to contract and the free end of the tube to move to the left (Fig. 2). This action moves the flapper toward the nozzle causing a decrease in the leakage or flow of gas from the nozzle opening and a build-up of pressure in the chamber 61 and line 63, and if the nozzle is completely closed the pressure in the line 63 will increase to the maximum which is preferably approximately 20 pounds.

In order to provide for operating the brake (not shown) for the cable drum to hold or pay out the cable to the well hole, we provide a fluid pressure brake actuator consisting of an extensible member such as an air cylinder 75 having one end pivotally connected to a bracket 76 and having a piston rod 77 extending from the other end thereof and pivotally connected as at 78 to a bracket 79 on a brake lever 80. The brake lever 80 has one end pivotally mounted on a pivot pin 81 of a bracket 81' mounted on the platform 2. An arm 82 is fixed to said one end of the brake lever 80 to form a bell crank structure and said arm 82 is connected to a suitable rod 83 leading to the braking mechanism (not shown) connected to the cable drum, as is the usual practice. The brake lever 80 is of substantial length with the other end provided with a suitably shaped handle 84 for an operator to hold and apply power to said lever 80 for manual operating of the cable brake mechanism when desired. A fluid line 85 communicates with the lower end of the cylinder 75 and is connected with the outlet of a relieving type spring loaded pressure regulator 86, the inlet of said regulator being supplied through a branch 87 connected with the main pressure supply line 53. A branch 88 connects the main pressure supply line with the inlet of the relay valve 64, the outlet of said valve being connected by a line 89 communicating with the upper end of the cylinder 75 (Fig. 2). A double line three-way valve 90 having a control lever 91 is interposed in the lines 85 and 89 between the pressure regulator 86 and relay valve 64 respectively and the cylinder 75. The valve 90 is of conventional structure and is such that it normally provides for communication from the pressure regulator 86 and relay valve 64 through the lines 85 and 89 respectively to the cylinder. When it is desired to use the hand brake levers 80, the lever 91 is moved to operate the valve 90 whereby the lines to the regulator 86 and relay valve 64 are closed and the lines from the cylinder 75 are vented to the atmosphere thereby removing all pressure from the cylinder 75 which would otherwise resist operation of the hand brake lever 80.

An example of a suitable relay or pressure amplifying valve 64 is illustrated in Fig. 4. It is preferable that the pressure amplification be in the order of a ratio of 3 to 1 to provide the desired power in the system. The air line branch 88 has communication with the inlet chamber 95 and the line 89 has communication with the outlet chamber 96. The body of the valve 64 has a chamber 97 and a chamber 98 on opposite sides of a diaphragm assembly 99. The operating air is supplied through the line 63 which communicates with the chamber 97. The chamber 98 communicates through a small passage or tube 100 with the outlet chamber 96 whereby said pressure in the outlet chamber is supplied to the diaphragm assembly 99. When the operating pressure through the line 63 is increased, the diaphragm assembly 99 is forced downwardly, and through the relief valve 101 and connecting tube 102 the valve assembly 103 is forced downwardly to unseat same whereby air will flow from the inlet chamber 95 to the outlet chamber 96 and through the line 89 to the cylinder 75 until the pressure in the line 89 and applied through the tube 100 to the chamber 98 arrives at a pressure necessary to balance the diaphragm 99 to close the valve assembly 103. If the pressure supplied through the line 63 to the chamber 97 is decreased, the pressure in the chamber 98, which is the same as the pressure in the line 89, unbalances the diaphragm 99 to move same up-

wardly to open the relief valve 101 whereby air pressure is bled from the chamber 96 through the relief valve opening, raising the relief poppet assembly 104 whereby said air is bled through the ports 105, 106 and 107 to the atmosphere until the pressures acting on the diaphragm 99 are again in balanced position to effect closing of the relief port.

The pressure in the inlet chamber 95 acts on a balanced diaphragm 108 and a pilot diaphragm 109 is acted on by pressure in the pilot chamber 110 which communicates through passage 111 with the space between the relief valve 101 and the relief poppet assembly 104. In accordance with the designed ratio of pressure amplification, increase of pressure through the line 63 effects a corresponding ratio of increase of pressure in the line 89 and a decrease in pressure in the line 63 effects a decrease in pressure in the line 89 in accordance with said ratio.

In operation of an apparatus constructed and assembled as described, the drill stem and drill bit are lowered into the hole and during the lowering operation the entire weight of the stem and bit are on the cable. When the drill bit reaches the bottom of the hole, a portion of the weight will be supported by the formation, and it is desirable that the weight of the bit and stem supported by the formation be retained within certain limits and that the remainder of the weight be supported by the cable 5. The portion of the weight of the drill stem and tools supported by the cable is determined by the pressure shown on a gauge (not shown) usually present in drilling apparatus of this character. The adjusting mechanism 73 of the base plate 59 is then moved until the flapper valve closes the nozzle 62 when the portion of the weight supported by the cable is at a predetermined minimum for drilling operations and the flapper valve in nozzle opening position when the portion of the weight supported by the cable is at a predetermined maximum. Air from the pressure supply is then delivered through the line 53, branch 87 to the pressure regulator 86 and line 85. Air also flows through the branch 88 to the relay valve 64 and through branch 54, pressure regulator 55, line 56, to the orifice block 58, through the orifice 60 into the chamber 61. The valve lever 91 is then operated to open the valve 90 whereby the pressure determined by the setting of the pressure regulator 86 is supplied through the line 85 to the lower end of the cylinder 75. Air flows through the line 89 from the relay valve 64 to the upper end of the cylinder 75. Assuming the weight on the cable 5 is at the minimum desired, the pressure transmitted by the diaphragm 43 to the liquid between said diaphragm and the rear wall 25 of the housing 21, is transmitted through the line 49 to the Bourdon tube 50 which responsive to said pressure moves the flapper valve 65 into closing position relative to the nozzle 62. The pressure in the chamber 61 then builds up to that set by the regulator 55 and applies said pressure to the diaphragm assembly 99 of the relay valve 64 opening the valve assembly 103 whereby air pressure flows from the branch 88 through the relay valve and line 89 to the cylinder 75 to apply pressure to the upper portion of the piston in the cylinder 75 to move the brake lever 80 to apply the brake on the cable drum. Then as drilling operations are continued, the proportion of the weight of the drilling tools supported on the cable 5 tends to increase as the formation is drilled. This applies an increased tension to the cable which reduces the deformation thereof forcing the plunger 45 and diaphragm 43 to increase the pressure on the liquid thereby and accordingly the pressure of the liquid in the Bourdon tube 50. This increase in pressure in the Bourdon tube tends to straighten same, moving the flapper valve 65 away from the nozzle 62 to increase the effective size of the orifice therein until more air can flow through the nozzle 62 than flows through the orifice 60 thereby decreasing the pressure in the line 63 and acting on the diaphragm assembly 99. The decrease in the pressure acting on the diaphragm assembly 99 causes a pro-

portionate decrease in the pressure acting on the upper portion of the cylinder 75. The pressure acting on the lower end of the cylinder remains constant; therefore, as the pressure on the upper end of the cylinder 75 is decreased, the braking action on the cable drum is reduced until it allows the paying out of some cable. As the cable is paid out, the portion of the weight supported by the cable is reduced in reducing the pressure of the liquid acting on the Bourdon tube whereby the flapper valve decreases the size of the orifice in the nozzle 62 causing an increase of pressure acting on the diaphragm assembly 99 and a proportional increase of pressure acting on the upper portion of the cylinder 75 to tighten the brake on the cable drum to stop paying out of cable therefrom. The change of pressure on the liquid in the Bourdon tube in response to change of tension on the cable is such that the apparatus is very sensitive, providing a substantially balanced condition whereby the brake on the cable drum is applied with only sufficient pressure to retard rotation of the drum and maintain a substantially constant portion of the weight of the drill string on the cable, with substantially continual rotation of the drum as the formation is cut away. The use of the orifices in the orifice block controlled by the Bourdon tube is such that the operation of the relay valve is relatively slight, providing a smooth even application and release of the brake, eliminating substantially all hunting for the proper weight and also eliminating substantially all of the jerking of the cable and tools that would result from such hunting.

In the form of the invention illustrated in Fig. 9, a spring 112 is suitably connected in the brake actuating structure, as, for example, from the brake lever 80 to the platform 2, whereby the spring urges the brake lever into brake applying position. A cylinder 113 has a piston plunger 114 extending from the lower end and connected to the brake lever 80 by the bracket 79. The upper end of the cylinder is connected to the bracket 76. The upper portion of the cylinder has a port 115 opening to the atmosphere. The lower end of the cylinder is connected by a line 116 through a valve 117 and line 118 to the relay valve 64. The valve 117 is similar to the valve 90 but operating only on one line whereby when the valve is closed no air flow will occur through the line 118, and the line 116 will be opened to the atmosphere for manual operation of the brake lever 80, and when the valve 117 is open, the flow of air is from the line 118 through the valve 117 and through the line 116 to the lower end of the cylinder 113. The orifice body 58 of the pressure responsive mechanism is arranged on the opposite side of the flapper valve as in the form shown in Fig. 2, whereby, in the modified form, increased pressure in the Bourdon tube moves the flapper valve to decrease the size of the orifice of the nozzle and increase the pressure applied through the line 63 to the relay valve 64. In this form of the invention, lessening or reduced weight on the cable 5 reduces the pressure acting in the Bourdon tube 50 whereby the flapper valve 65 is moved to increase the effective orifice of the nozzle 62, reducing the pressure in the chamber 61 and correspondingly reducing the pressure applied to the diaphragm assembly 99 in the relay valve 64. This effects a reduction in pressure applied to the lower portion of the cylinder 113 whereby the spring 112 tends to overcome said pressure and apply the brake to stop or slow down the paying out of cable from the cable drum. As the tension on the cable increases, due to increased portion of the weight being supported thereby, the pressure in the Bourdon tube increases, reducing the effective size of the orifice in the nozzle 62 to cause a build-up of the pressure in the chamber 61 and a corresponding build-up of the pressure acting on the diaphragm assembly 99 of the relay valve 64 and a proportional increase in the air pressure flowing through the relay valve and line 116 to the cylinder 113 to overcome the spring 112 and reduce the pres-

sure of the brake on the cable drum thereby paying out more of the cable therefrom.

It will be obvious from the foregoing that we have provided an improved apparatus for controlling the paying out of drilling cable in a drilling rig for automatic operation, substantially maintaining a constant pressure of the drill bit on the formation being drilled.

It is to be understood that while we have illustrated and described certain forms of our invention, it is not to be limited to the specific forms or arrangement of parts herein described and shown except insofar as such limitations are included in the claim.

What we claim and desire to secure by Letters Patent is:

A control unit for automatically varying the paying out of cable from a brake restrained cable drum in response to variation in tension of the cable due to the proportion of the weight of well drilling tools supported by the cable tending to unspool the cable from the cable drum comprising, a brake lever connected with the cable drum brake for moving said brake from cable drum holding position to cable drum releasing position, a fluid pressure responsive brake actuator connected with the brake lever, a fluid pressure supply of greater pressure than is required for the fluid pressure responsive brake actuator, means connected with the brake lever to urge the brake into cable drum holding position, a fluid conducting means connecting the fluid pressure supply with the fluid pressure responsive brake actuator to move the brake lever and actuate the brake into drum releasing position, control valve means in said fluid conducting means and operable to selectively shut off the fluid pressure supply to said pressure responsive brake actuator and release pressure from said actuator whereby the brake is urged to cable drum holding position, a relay valve in said fluid conducting means upstream from said control valve for regulating the pressure delivered thereby to said fluid pressure responsive brake actuator, a second fluid conducting means connecting the fluid pressure supply with the relay valve for providing an operating pressure therefor, a pressure regulator in the second fluid conducting means for regulating the maximum operating pressure delivered to the relay valve, orifice means in

the second fluid conducting means downstream from the pressure regulator for limiting flow through said second fluid conducting means, a second orifice of larger capacity than the first-named orifice and communicating the second fluid conducting means between the first-named orifice and the relay valve with the atmosphere, a valve member movable toward and away from the second-named orifice to vary the discharge therefrom, a Bourdon tube having one end fixed relative to said second fluid conducting means and a free end connected with the valve member, a frame having spaced portions one of which is fixed to the cable remote from the cable drum and the other portion movably connected to said cable whereby said cable is movable relative to the frame in response to change of tension of said cable, a cylinder on the frame, means in the cylinder defining a liquid containing chamber, means communicating the liquid containing chamber with a fixed end of the Bourdon tube, and means extending from the cylinder and engaging the cable whereby change of tension in the cable changes the capacity of the liquid containing chamber and effects movement of the free end of the Bourdon tube and the valve member to vary the operating pressure delivered by the second fluid conducting means to the relay valve whereby increase in tension of the cable results in partial release of the cable drum brake and increased paying out of cable from said drum.

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