Aug. 9, 1966 J E BOWDEN 3,265,359

AUTOMATIC TENSION CONTROL SYSTEMS FOR OIL WELL DRILL LINES

Filed June 7, 1962 6 Sheets-Sheet 1

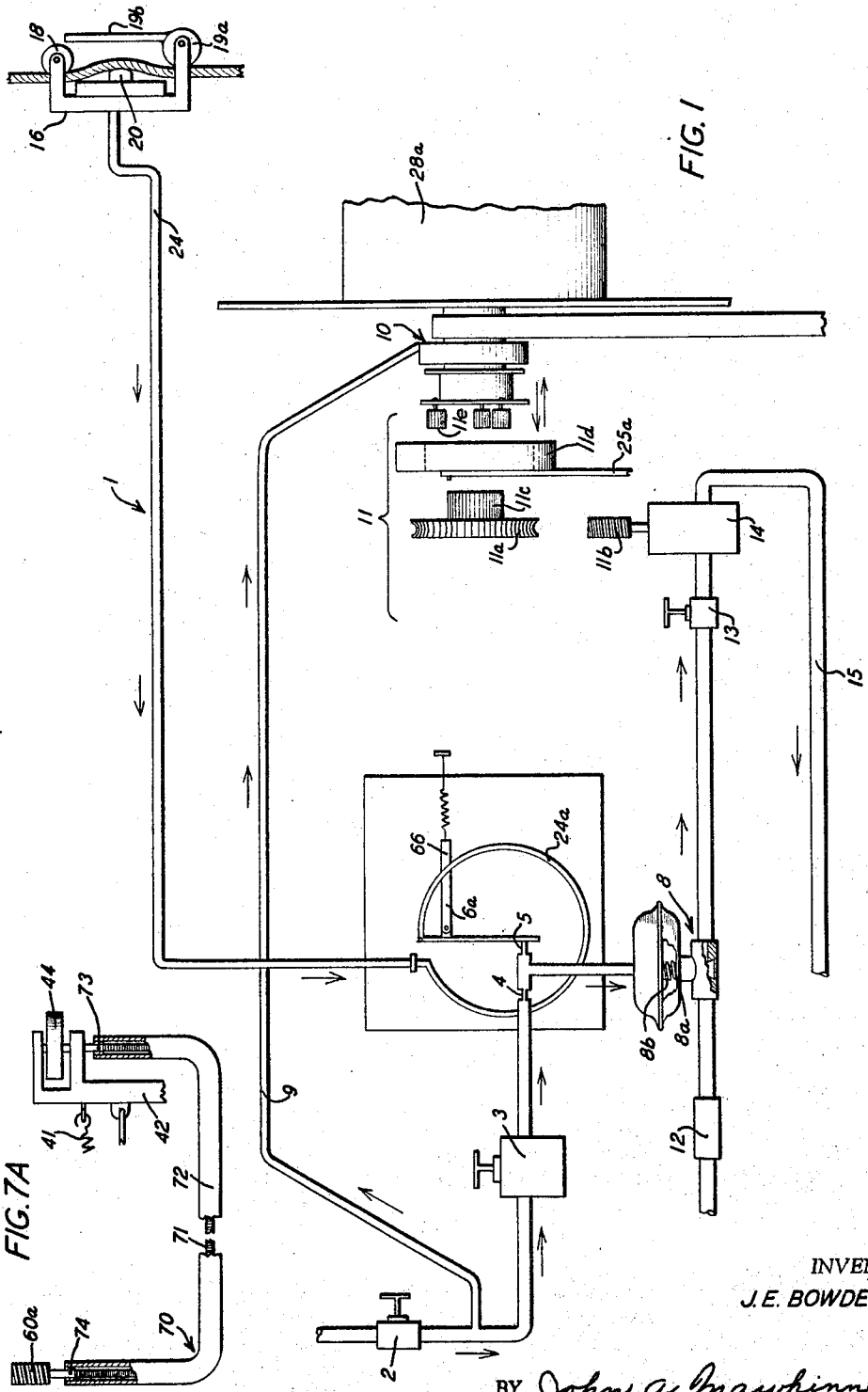


FIG. 1

FIG. 7A

INVENTOR
J.E. BOWDEN

BY John a. Mawhinney
ATTORNEY

Aug. 9, 1966 J E BOWDEN 3,265,359

AUTOMATIC TENSION CONTROL SYSTEMS FOR OIL WELL DRILL LINES

Filed June 7, 1962 6 Sheets-Sheet 2

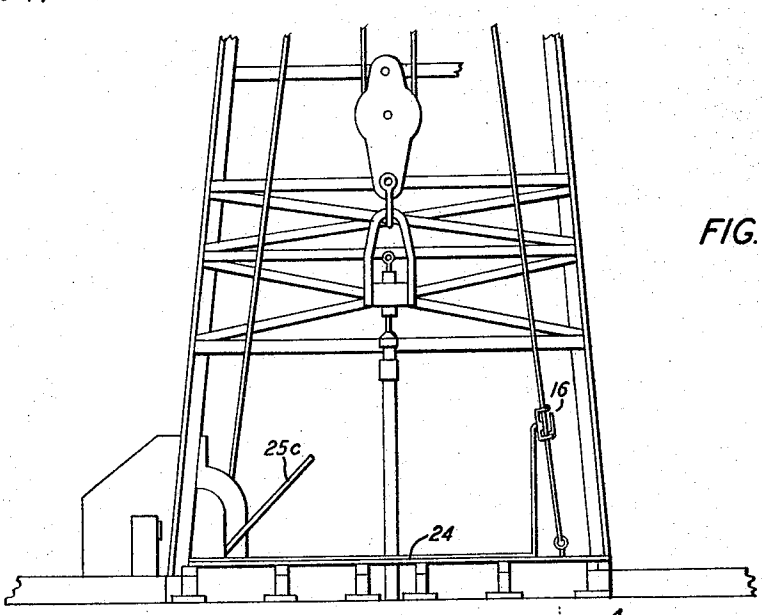


FIG. 2

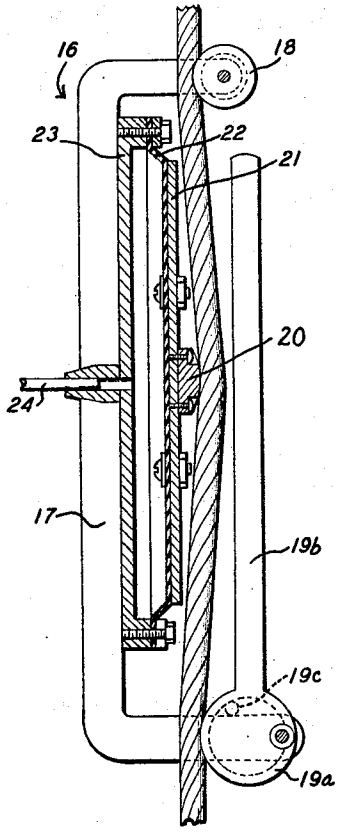


FIG. 4

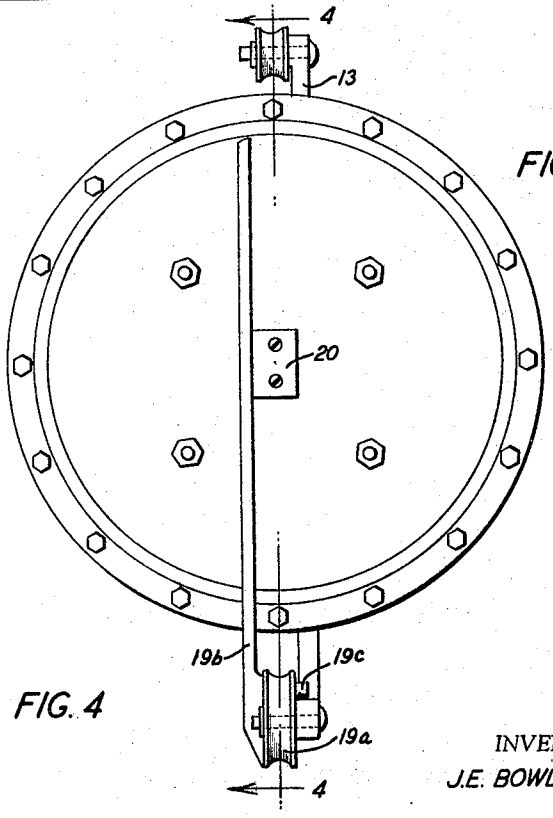


FIG. 3

INVENTOR
J.E. BOWDEN

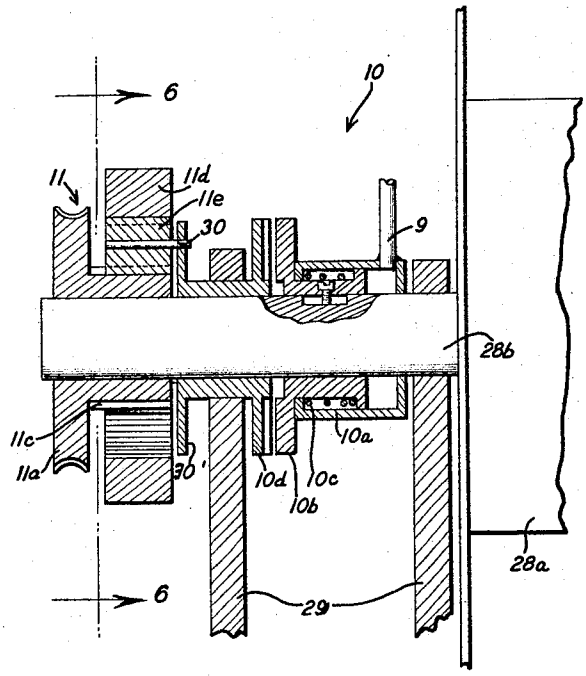
BY John a. Mawhinney

ATTORNEY

AUTOMATIC TENSION CONTROL SYSTEMS FOR OIL WELL DRILL LINES

Filed June 7, 1962 6 Sheets-Sheet 3

FIG. 5



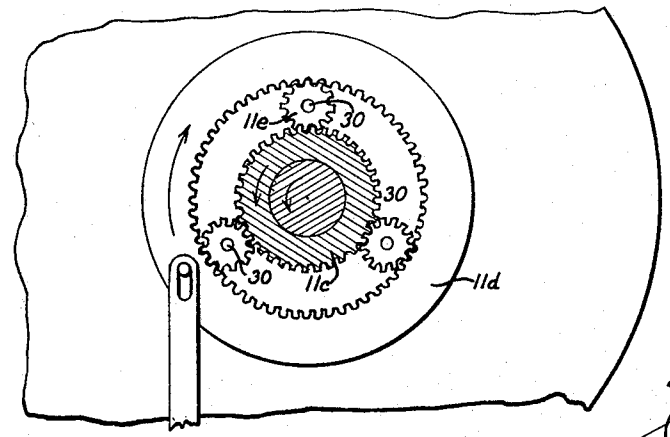
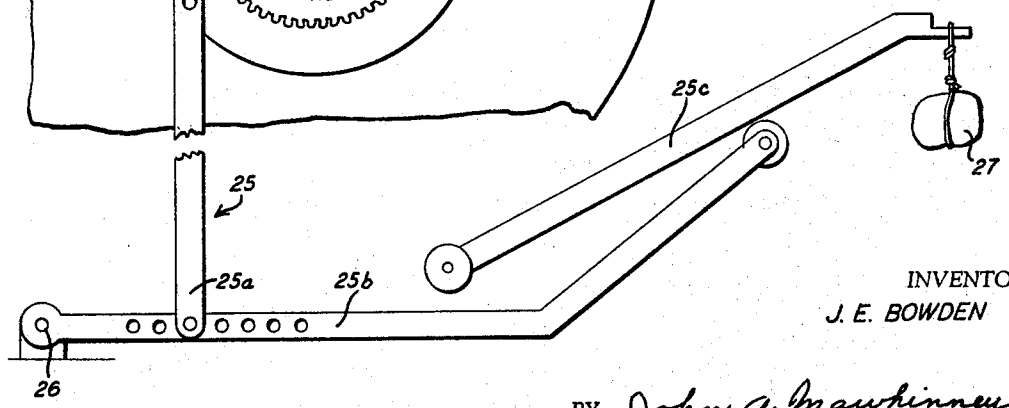


FIG. 6



INVENTOR
J. E. BOWDEN

BY John A. Mawhinney

ATTORNEY

Aug. 9, 1966 J E BOWDEN 3,265,359

AUTOMATIC TENSION CONTROL SYSTEMS FOR OIL WELL DRILL LINES

Filed June 7, 1962 6 Sheets-Sheet 4

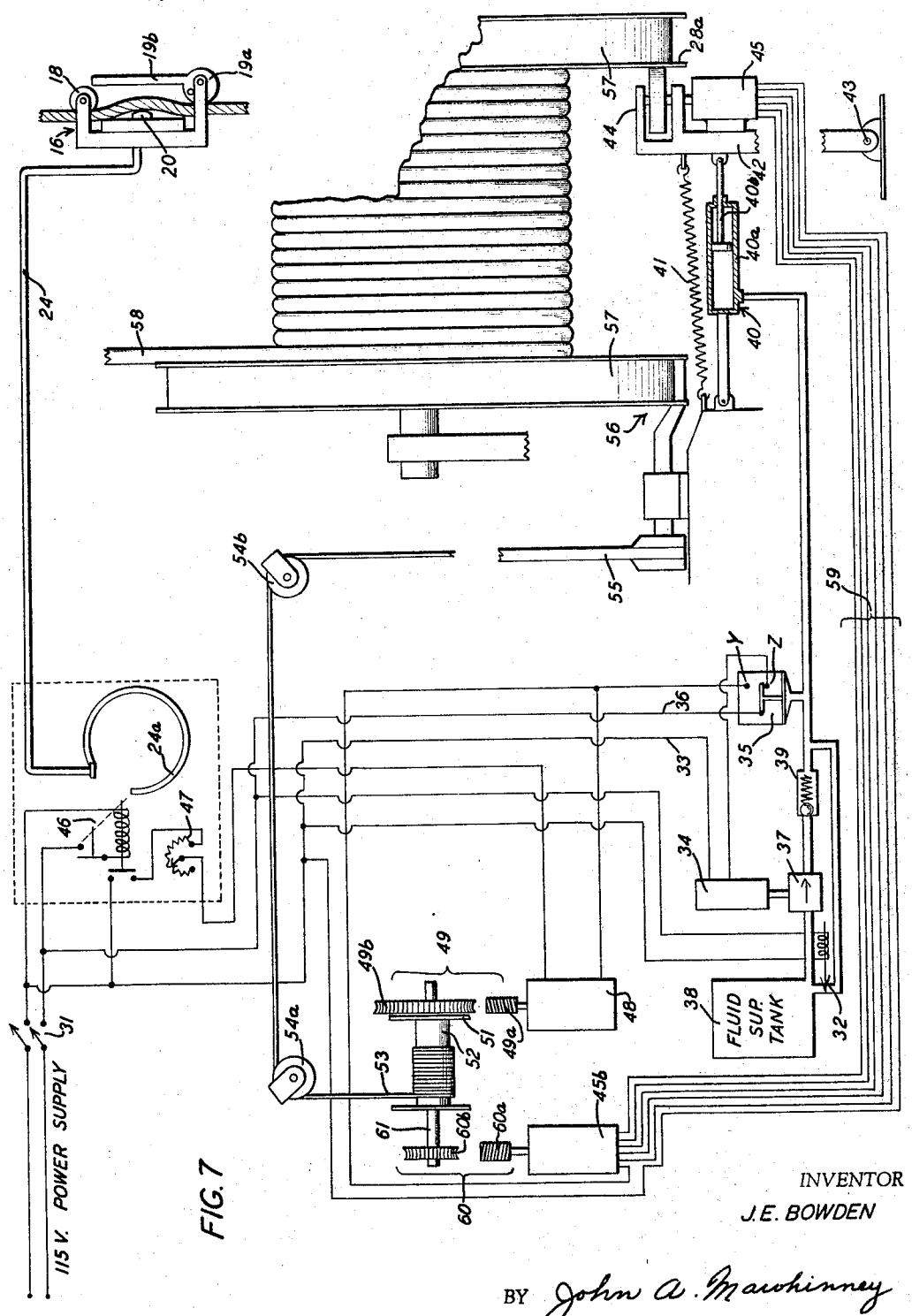


FIG. 7

INVENTOR
J.E. BOWDEN

BY John A. Marchinney

ATTORNEY

Aug. 9, 1966 J E BOWDEN 3,265,359

AUTOMATIC TENSION CONTROL SYSTEMS FOR OIL WELL DRILL LINES

Filed June 7, 1962 6 Sheets-Sheet 5

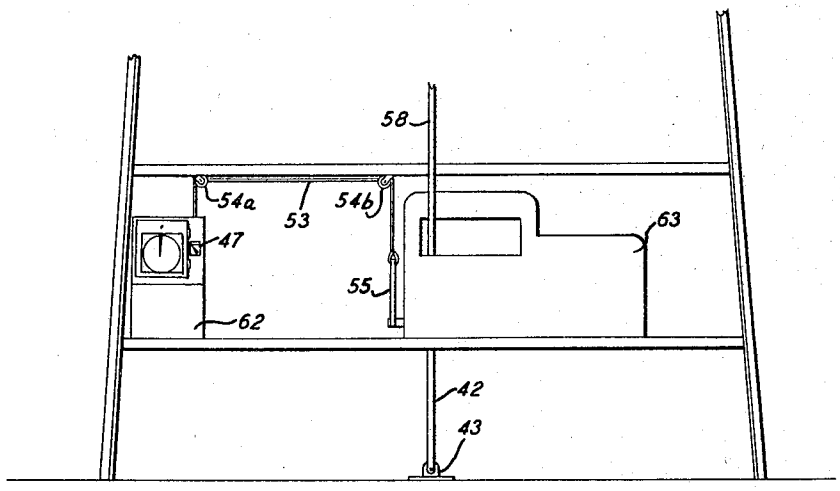


FIG. 10

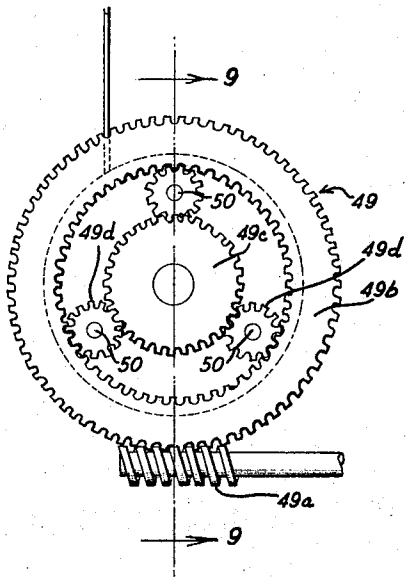
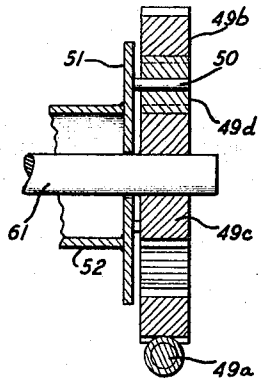


FIG. 8

FIG. 9



INVENTOR
J. E. BOWDEN

BY John A. Mawhinney
ATTORNEY

Aug. 9, 1966 J E BOWDEN 3,265,359

AUTOMATIC TENSION CONTROL SYSTEMS FOR OIL WELL DRILL LINES

Filed June 7, 1962 6 Sheets-Sheet 6

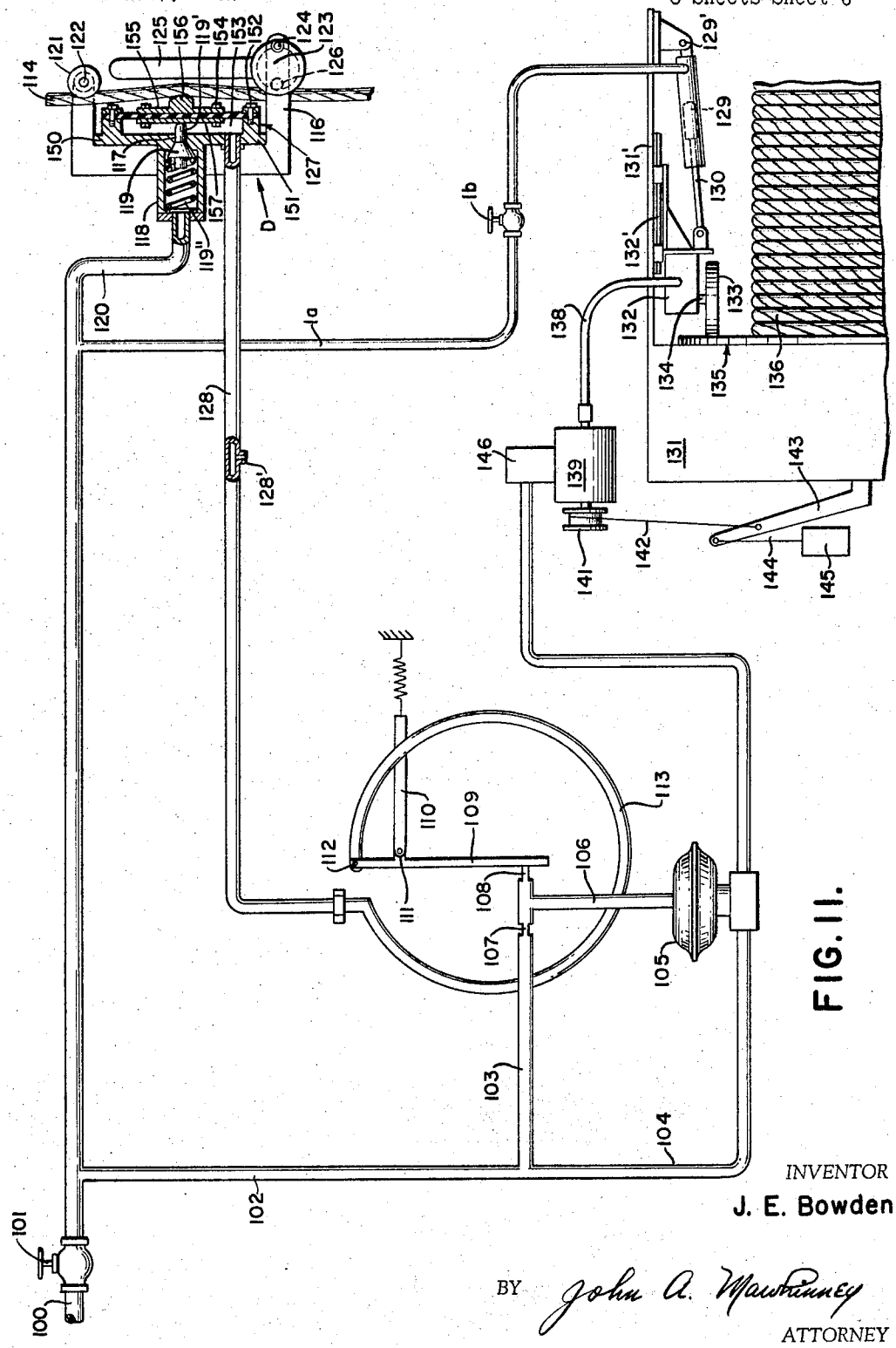


FIG. 11.

INVENTOR
J. E. Bowden

BY John A. MacKinney
ATTORNEY

United States Patent Office 3,265,359 Patented August 9, 1966

3,265,359

AUTOMATIC TENSION CONTROL SYSTEMS FOR OIL WELL DRILL LINES

J. E. Bowden, 503 Mesa Drive, Hobbs, N. Mex.

Filed June 7, 1962, Ser. No. 203,684
11 Claims. (Cl. 254—173)

This application is a continuation-in-part of my application, Serial No. 668,230, filed June 26, 1957, now abandoned.

The invention relates particularly to automatic well drilling control systems for regulating tension in a drill line as successively deeper subsurface formations are penetrated.

Accordingly, therefore, among my objects, I aim to teach an ingenious automatic control system for continuously controlling the tension in a drill line.

Another object of this invention is to disclose a means for automatically maintaining constant drilling weight on a drilling bit in order to enhance the bit efficiency as well as the efficiency of the entire drilling operation.

Another object of the invention is to disclose a method of oil well drilling in which the location of oil, gas, mineral and water formations may be more accurately determined by virtue of the constant drilling pressure which is maintained on the drill bit.

Another object of this invention is to provide a compact portable drilling control system which may be easily attached to any conventional rotary oil rig.

Another object of this invention is to disclose a new functional relationship between the hoist drum or spool, and the friction brake mechanism of the oil well drilling apparatus.

Another object of the invention is to each a method of accurately sensing the amount of rotation of the hoist drum which occurs when the top end of a drill string is lowered.

Still further objects of this invention are to disclose means for generating a mechanical signal proportional to the hoist drum shaft movement, and effecting a resetting of friction brake bands or mechanism in response thereto; to provide a novel construction wherein the said new functional relationship between the hoist drum or spool is accomplished at minimum expense both with respect to initial and operational costs and which may be carried out very simply and advantageously through the coaction of a pulley device or equivalent and with minimum power as from a side or end wall of the hoist drum or spool; to effect this last-mentioned object by the said coacting pulley device and drum wall in association with gearing having planetary or differential action; to carry out the invention either by way of novel pneumatic, hydraulic, mechanical or electrical apparatus or with parts composed of any combination of pneumatic, hydraulic, mechanical or electrical apparatus or otherwise, and particularly with respect to controlling the tension on the friction brake mechanism of a conventional hoist drum, and to disclose a novel system including planetary type gearing or differential coacting with a control and well drilling friction brake system.

With the foregoing and other objects in view, the invention will be more fully described hereinafter, and will be more particularly pointed out in the claims appended hereto:

FIGURE 1 illustrates a preferred embodiment of the invention in which compressed air or gas is used in conjunction with a pressurized fluid and a diaphragm tension sensor to regulate the drill line tension;

FIGURE 2 shows a view of a typical installation using the system of FIGURE 1, and indicates the method of connecting the diaphragm tension sensor to the dead line;

FIGURE 3 shows a front view of a diaphragm tension sensor;

FIGURE 4 shows a sectional view of the sensor of FIGURE 3, taken along the lines 4—4;

FIGURE 5 shows a view in section of the normally open spring biased clutch used in practising the invention;

FIGURE 6 comprises a partial section view of the clutch shown in FIGURE 5 taken along the line 6—6;

FIGURE 7 shows a preferred embodiment of the invention in which pressurized fluid is used in conjunction with dynamo electric equipment and a diaphragm tension sensor to regulate the drill line tension;

FIGURE 7A is a diagrammatic view illustrating a flexible shaft drive between the friction wheel and its worm in lieu of the selsyn arrangement of FIGURE 7;

FIGURE 8 is a plan view of the planetary gear assembly depicted in FIGURE 7;

FIGURE 9 is a sectional view taken along the line 9—9 of FIGURE 8;

FIGURE 10 shows a view of a typical installation employing the embodiment of the invention illustrated in FIGURE 7 to FIGURE 9; and

FIGURE 11 illustrates a further installation according to the invention which is primarily operable by compressed air or other pressure fluid.

Turning now to the drawings, and more particularly to FIGURE 1, the numeral 1 indicates generally one of the preferred embodiments of the invention in which compressed air or gas is used in conjunction with a pressurized fluid to regulate the tension in the drilling line. More particularly, compressed air or gas from a conventional supply tank is supplied to the system, via the control valve 2 shown in the left-hand portion of the drawing. The valve 2 may comprise any suitable manually operable ON-OFF type valve of conventional design.

A portion of the gas flowing through the valve 2 is forced to traverse a combined filter-regulator unit 3, which effectively eliminates any foreign particles or impurities entrained within the moving gas, and reduces the pressure to any predetermined value. The unit 3 is of conventional design, and the details thereof form no part of the present invention.

The filtered gas emerging from the unit 3 passes through a constricted portion or orifice 4 located in the output conduit leading from the regulator, and is throttled to the atmosphere through the nozzle 5. The rate at which the pressurized gas is allowed to escape to the atmosphere is controlled by a pivotally mounted flapper 6*a* which accurately reflects variations in the drilling line tension, in a manner to be explained more fully later in this specification. The flapper 6*a* exhibits a degree of sensitivity which is controlled by means of a manually operable calibrating element 66.

The incident pressure existing between the orifice 4 and the nozzle 5 is applied to a spring biased diaphragm valve which is indicated generally by the numeral 8. The valve 8 includes a valve stem 8*a* which is secured to and directly energized by the fluctuations of a pressure sensitive diaphragm disc located within the valve 8. The valve also includes a spring 8*b* which normally biases the valve 8 to closed position, and prevents any flow therethrough. It will now be evident that when the pressure between the orifice 4 and nozzle 5 is sufficiently high, the diaphragm within valve 8 is able to overcome the force of spring 8*b* and depress the valve stem 8 in order to unseat the head of the valve from its normally closed position.

Returning momentarily to the disposition of the remainder of the input air or gas which traverses the control valve 2, it will be observed that a conduit 9 is connected downstream from the valve 2 to divert a portion of the compressed medium supplied therethrough. The

conduit 9 conveys this portion of the compressed gas to an air-actuated spring biased normally open clutch indicated generally by the reference numeral 10. The structural configuration of the air actuated clutch 10 is illustrated most clearly in the sectional view which is provided in FIGURE 5.

For present purposes in describing the system shown in FIGURE 1, it is sufficient to point out that the clutch 10 acts to selectively engage a hoist drum to the planetary gear assembly 11 which is shown diagrammatically in an exploded view to the left of the clutch and further in FIGURES 5 and 6.

This planetary gear assembly includes a gear 11*a* which receives torque from a worm 11*b*. A pinion gear 11*c* is keyed or otherwise securely affixed to the gear 11*a* for concentric rotation therewith. An internal sun gear 11*d* is shown slightly to the right of the combined gear and pinion structure, along with a plurality of small planetary gears 11*e* which mesh simultaneously with the outer periphery of the pinion 11*c* as well as the inner periphery of the sun gear 11*d*. The plan view of the planetary gear assembly 11 and its associated lever system is shown most clearly in FIGURE 6, and will be referred to again in connection with the detailed description of structure illustrated therein.

Turning now to the method by which torque is supplied to planetary gear assembly 11, pressurized fluid, such as oil or conventional hydraulic fluid enters the system through a conventional check valve 12 shown in the left-hand portion of the drawing. When the normally closed diaphragm valve 8 is forced to open by the pressure which is sampled between the orifice 4 and the nozzle, 5 the pressurized input fluid passes through the valve 8 to the downstream conduit, and traverses a conventional speed control valve 13. The fluid emerging from valve 13 is applied directly to a fluid motor 14 which supplies the input torque for the planetary gear assembly to the worm 11*b*. The motor 14 may comprise any suitable type of commercially available fluid driven device, and does not form a part of the present invention. The fluid emerging from the motor 14 is conveyed back to a sump or reservoir, via fluid return conduit 15, in the conventional manner.

Turning now to the description of the manner in which the pressure of the compressed air or gas in the system is modulated by the drill line tension, the reference numeral 16 is used in the upper right hand corner of FIGURE 1 to designate generally a diaphargm tension sensor. The sensor 16 is illustrated in detail in the sectional view provided in FIGURE 4 of the drawings. Essentially, the sensor comprises a fluid-filled flexible walled container adapted to supply a value of pressure which is governed by the relative tautness of a cable or drill line stretched therethrough.

Thus, in FIGURE 4, the sensor includes a frame 17 provided with a pivotally mounted upper spool 18 on the upper portion thereof. On the lower portion, a lower spool cam 19*a* is pivotally secured. An elongated operating handle 19*b* is integrally secured to the spool cam 19*a*, and extends longitudinally upward therefrom. A dowel 19*c* is removably positioned within a mating axial recess within the cam 19*a*, to assist in maintaining the handle and cam in the desired position.

The portion of the drill line which passes between the upper spool and the lower spool cam engages a contact point center 20 which is secured directly to a pressure plate 21 and associated flexible diaphragm disc 22. The outer periphery of the diaphragm disc 22 is tightly secured to the back plate 23 by means of suitable bolts in order to form a fluid-tight chamber. It will be evident that any increase in the tautness in the drill line located between the upper and lower spools must necessarily cause the diaphragm disc to deflect inwardly, and increase the pressure of the fluid entrapped within the diaphragm chamber and conduit 24.

Continuing with the detailed description of FIGURE 1, the application of the modulated pressure output of the diaphragm sensor unit will now be explained. In FIGURE 1, it will be observed that the conduit 24 which emerges from the tension sensor is connected directly to the fixed end of a conventional Bourdon pressure tube 24*a*. The tube 24*a* may comprise a component of a commercially available unit such as Fisher Wizard, or similar device, which is used as a controller sensitive to variation in drill line tension. Increases in the pressure of the fluid within the tube 24*a* effect a discernible straightening therein, and displaces the pivoted flapper 6*a* with respect to the nozzle 5. From this discussion it will be appreciated that the air escape through nozzle 5, and the position of the diaphragm valve 8 are both controlled and influenced by the tension in the drill line which is measured by the sensor 16. This, in turn, controls the periods during which fluid motor 14 is actuated by the compressed fluid which is allowed to enter the system through the check valve 12.

The effect of driving the fluid motor 14, and hence the planetary gear assembly 11, is appreciated most readily by inspection of the structure depicted in FIGURE 6 of the drawings. Specifically, the numeral 25 has been used in FIGURE 6 to indicate generally a braking means or mechanism for drum 28*b* and particularly its lever system which is actuated by means of the planetary gear assembly 11. A slotted lever 25*a* is pivotally secured at one end to the radial end surface of the internal sun gear 11*d*. The opposite end of the lever 25*a* is pivotally secured to a lever 25*b* which is adapted to oscillate about a fixed pivot pin 26.

The lever 25*b* is mounted to actuate a hoist drum brake lever 25*c* provided with a suitable counterweight 27 suspended from the outermost extremity thereof. The counterweight 27 assists the brake system in restraining the hoist drum from the tendency to rotate which is caused by the pull of the drill line.

Turning momentarily to FIGURE 5, to complete the necessary description of the individual components employed in FIGURE 1, the numeral 10 indicates generally a sectional view of a normally open spring-biased clutch which is operated by the compressed air conveyed through conduit 9. To the left in FIGURE 1, the component elements of the planetary gear assembly 11 are clearly illustrated. Thus, the gear 11*a* with associated integral pinion 11*c* is shown mounted for concentric rotation with the drumspool 28*a* and drum shaft 28*b*. It will be appreciated that the drum shaft 28*b* is journaled between suitable support members 29. The sun gear 11*d* and the internally disposed planetary gears 11*e* are shown in operative relationship. It will be observed that each of the planetary gears is rotatably journaled upon a spindle 30. Clutch 10 has a plate 10*d* mounted to rotate in its support 29 and on drum shaft 28*b*. The spindle 30, in each case, is properly secured at one end to a flange 30′ of the clutch plate 10*d*, for reasons which will be apparent as the specification proceeds.

The clutch 10 includes an airtight casing 10*a* disposed to permit rotation of the drumshaft 28*b* therein. Within the casing 10*a*, there is provided an axially movable clutch plate 10*b*. The plate 10*b* is biased to its indicated position by means of the coiled compression spring 10*c*.

The plate 10*b* is keyed to shaft 28*b* for concentric rotation therewith. Somewhat to the left of the clutch plate 10*b*, and normally separated by a discernible air gap therefrom, there is provided a second clutch plate 10*d*. The clutch plates 10*b* and 10*d* are each provided with suitable serrations or the like to provide a positive locking engagement therebetween. In operation, the application of compressed air to the clutch through conduit 9 causes the spring biased clutch plate 10*b* to move axially into engagement with the clutch plate 10*d*.

Turning to the sequence of operations accomplished by the system of FIGURE 1, as the drill bit penetrates

successively deeper formations, the tension on the drilling line increases. It will be appreciated that air pressure supplied via control valve 2 and conduit 9 has engaged the normally open clutch 10. The diaphragm sensor 16 samples the increasing tension in the dead line, and produces a higher fluid pressure within the conduit 24 in response thereto. This increased pressure deflects the Bourdon tube 24*a* which, in turn, actuates the pivoted flapper 6*a* and halts the air escape through the nozzle 5. The resulting increase in the pressure supplied the diaphragm valve 8 provides sufficient force to overcome the biasing spring 8*b*. This causes the valve to unseat and permit flow. At this point, the pressurized fluid which enters the system at check valve 12 is permitted to energize the fluid motor 14 and supply torque to the planetary gear assembly 11.

The application of torque to the gear 11*a* and pinion 11*c* causes them to turn freely on the drum shaft 28*b*. Thus, in turn, causes the associated planetary gears each to revolve about its individual spindle 30, as seen most clearly in FIGURE 5. However, since the planetary spindles 30 are held almost motionless by the engagement of the clutch 10, the rotation of the planetaries on such relatively stationary spindles causes the internally toothed ring gear 11*d* to rotate slightly in the clockwise direction, as indicated by the arrow in FIGURE 6.

As a result of this clockwise deflection, the lever 25*a* is raised slightly, effecting a corresponding elevation in the hoist drum brake lever 25*c*. The elevation thus effected reduces or partially releases the tension in the hoist drum friction brake bands, and allows the hoist drum to rotate slightly. The inherent tension in the drilling cable then turns the hoist drum through a given arc, and pulls a quantity of line from the drum spool causing rotation of the spool to allow the drill pipe string to lower, and transfers some of the suspended weight supported by the derrick to the drill bit.

When the drum rotates in this manner, the planetary spindles 30 are each caused to rotate counterclockwise. During this interval, the pinion gear 11*c* is either practically stationary or moving much more slowly than the individual planetary gears. This causes the ring gear 11*d* to rotate counterclockwise, and relieves the upward force previously exerted upon the lever 25*a*. The release of lever 25*a* then causes the friction brake bands to re-engage. Thus, by using compressed fluid as well as compressed gas equipment in combination with a diaphragm sensor unit, the tension of the drilling line is automatically adjusted during continuous drilling operations.

Continuing now with the detailed description of the remainder of the invention, and turning to FIGURE 7 for the combined electrohydraulic embodiment thereof, the numeral 31, in the upper left-hand corner of the drawing, is used to designate a conventional ON-OFF control switch. Closure of the switch 31 permits input electrical power to energize solenoid valve 32. In addition, current flows through conductor 33 to electric motor 34, and returns to the mains via contact "Z," the movable pole in pressure sensitive switch 35, and conductor 36, as shown.

The electric motor 34 provides driving torque to a conventional fluid pump 37 shown directly therebeneath. The pumping action of the unit 37 draws hydraulic fluid from a fluid supply tank 38, and causes it to unseat and flow through a conventional check valve 39. From valve 39 the pressurized fluid is applied to the interior of a spring biased cylinder assembly 40. The assembly 40 includes a fixed cylinder casing 40*a*, an axially movable piston 40*b*, and tensile biasing spring 41.

The piston 40*b* is connected to actuate a lever 42 which is pivotally mounted by means of a suitable pivot base 43. The lever 42 supports a friction wheel 44 at the upper extremity thereof. Rotation of the friction wheel 44 causes simultaneous rotation of the rotor of a directly coupled selsyn unit 45. Thus, when the pump 37 is energized by motor 34, pressurized fluid from tank 38 enters the cylinder casing 40*a*, displaces the piston 40*b* to the right, and causes the friction wheel 44 to engage the hoist drum spool 28*a*. Upon the attainment of a predetermined pressure value, the movable pole in the pressure sensitive switch 35 is caused to disengage contact "Z" and touch the contact "Y" shown immediately thereabove.

As successive layers of formation are penetrated by the drill, and the tension of the drill line sampled by the sensor 16 increases, the pressure of fluid entrapped within the unit 16 and conduit 24 experiences a corresponding increase.

This increased value in the pressure tends to straighten and deflect the Bourdon tube 24*a*. The resulting deflection of tube 24*a* closes the contacts of a conventional solenoid switch 46. The Bourdon tube 24*a* and switch 46 may comprise components of any suitable commercially available unit, which graphically records the variation in drill line tension, as time elapses. The closure of switch 46 permits electric current to traverse the switch, flow through the control rheostat 47 and enter the hoist drum brake lifting motor 48. From the motor 48 the current completes the circuit by traversing contact "Y" and the associated movable pole in switch 35 back to the mains.

The application of power to the motor 48 causes it to deliver torque to the planetary gear assembly 49, shown in semi-exploded view to the left of the drawing. The assembly is perhaps shown most clearly in the plan view provided in FIGURE 8. The gear system is there seen to include a worm 49*a* which mates with an annular external gear 49*b*. The gear 49*b* is provided with teeth on both the inner and outer peripheral surfaces thereof. A pinion gear 49*c* is concentrically journaled within the external gear 49*b*, and is maintained in gearing engagement therewith by means of a plurality of planetary gears 49*d*. Each of the individual planetary gears 49*d* is journaled upon a suitable spindle 50. The ends of the respective spindles are secured in an annular flange 51 which is secured to and rotates concentrically with the brake lever lifting spool 52.

Rotation of the worm 49*a* by motor 48 causes the external gear 49*b* to drive the plural planetary gears 49*d*, and causes them to roll over the periphery of the pinion 49*c*. This, of course, causes the spindles 50 and associated flange 51 to rotate correspondingly about the axis of the pinion 49*c*. The rotational movement of the spool 52 thus effected forces it to wind up a quantity of the wire line 53 which is wound thereupon. The wire line shown in FIGURE 7 and FIGURE 10 will be seen to pass over sheaves 54*a* and 54*b* and terminate in the upper portion of a hoist drum brake lever 55 which is used to control the degree of engagement of the friction brake assembly 56.

When the wire line 53 is rewound upon the spool 52, the hoist drum brake lever 55 is actuated to lessen the degree of restraint imposed by the friction bands 57. As a result, the inherent tension in the drill line causes the drum to rotate slightly. This rotation in turn rotates the friction wheel 44, and causes the selsyn unit 45 to produce an output electrical signal. The signal thus generated is transmitted over the conductors 59 to the selsyn unit 45*b*. Rotation of the selsyn unit 45*b* provides input torque to a worm and gear assembly 60. The torque received from unit 45*b* is transferred via worm 60*a* and gear 60*b* to a shaft 61 which is keyed to gear 60*b*. Rotation of the shaft 61 effects a corresponding rotation of the pinion 49*c* which is affixed to the opposite end of the shaft. This causes the individual planetary gears 49*d* to rotate and walk around the gear 49*b*, and causes the spindles 50 and flange 51 to move through the corresponding arc. During this interval, flange 51 similarly

displaces the spool **52** and causes the wire line **53** to unwind from the periphery of the spool. The resulting decrease in the relative tautness in the wire line permits brake lever **55** to re-engage the friction bands **57** and halt rotation of drum **28***a*.

The appearance of a typical installation using the present embodiment of the invention is illustrated in FIGURE 10 of the drawings. There, the console **62**, which is positioned on the floor of a conventional derrick, may enclose the brake lifting spool unit, and the hydraulic system for energizing the cylinder assembly **40**. The console **62** is fabricated of metal in order to provide an enclosure which is both explosion-proof and gas-proof. It will be appreciated, in this connection, that the console **62** is portable in order to permit the use of the invention at any of several drilling installations.

The console unit houses a conventional recorder, such as the Bristol Free Vane Recorder, which provides a graphical record of the variations in drill line tension. The appearance of the circular-typemoving chart within such a recorder is clearly illustrated in the drawing. The portable console **62** also houses the control rheostat **47**, which is used to control the rotational speed of the hoist drum brake lifting unit, as explained in detail in connection with the electrohydraulic embodiment shown in FIGURE 7 of the drawings. The rheostat **47** may include a suitable selector switch provided with convenient graduation for expediting the selection of different speeds.

In FIGURE 10 the housing **63** in the center of the derrick encloses the hoisting unit, and the drilling line **58** is seen extending upwardly therefrom. The pivoted lever **42**, which supports the friction wheel **44**, is shown directly below the floor of the derrick.

It will be appreciated that the complete cycle for periodically effecting a controlled diminution in the braking effort exerted on the hoist drum has now been described. By using a combined electrohydraulic system in conjunction with a diaphragm sensor unit, the automatic tensioning of the drill line during penetration of successively deeper strata is efficiently and economically accomplished.

In FIGURE 7A is illustrated a flexible drive shaft connection, generally indicated at **70**, between the friction wheel **44** and the worm **60***a* which may be used in lieu of the selsyn units **45** and **45***b* and the conductors **59** of FIGURE 7. This flexible shaft connection **70** may be of the conventional speedometer shaft type used on automobiles and comprises a flexible shaft **71** housed in a close fitting flexible housing **72**. One end of the shaft **71** is connected in the conventional manner to the shaft of the friction wheel **44**, as indicated at **73**, and the other end of the shaft **71** is connected in a conventional manner to the shaft of the worm **60***a*, as indicated at **74**.

The rotation of the friction wheel **44**, caused by the rotation of the drum **28***a*, is imparted to the shaft **71** which, in turn, rotates the worm **60***a*.

The shaft **71** and housing **72** could be of any desired diameter, for example, the shaft **71** could have an outside diameter of three-eighths inch and the housing **72** an inside diameter of seven-sixteenths inch, and an outside circumference of three-fourths inch. The length of the shaft and housing will vary according to the need of its application at the specific drilling rig. Some rigs would require a very long shaft and others only a very short one, so that, for example, the length could vary from six feet to fifteen feet.

Referring now to the form of the invention disclosed in FIGURE 11, **100** designates a conduit through which a fluid, for example, air or other gas, is supplied under appropriate pressure from any suitable source regulated by a cut-off valve **101**, a portion of which enters communicating branch conduits **102**, **103**, and **104**. The latter conduit **104** leads to a normally closed main valve assembly **105** adapted for automatic alternate opening and closing, as required by drilling operations. Conduit **103** communicates with a conduit **106** which directs fluid to said valve assembly **105**, which may be a duplicate of the parts **8**, **8***a* and **8***b* of FIGURE 1, to open the latter at predetermined pressure. Conduit **103** upstream of its junction with conduit **106** is constricted or reduced at portion **107**, and downstream of that junction has a nozzle **108**, throttling release of pressure fluid into the atmosphere.

The rate at which the pressurized fluid is allowed to escape to atmosphere is controlled by a valve in the form of a flapper **109** whose position accurately reflects variations in drilling line tension. Said flapper **109** exhibits a degree of sensitivity which is controlled by means of a manually operable calibrating mechanism **110** which is pivoted thereto at **111**.

Said flapper **109** is also pivoted at **112** to a conventional Bourdon pressure tube **113**.

At this point is to be noted that the parts so far described with respect to FIGURE 11 correspond generally in structure and operation to those designated **2** through **12**, **66** and **24***a* of the form of FIGURE 1.

The conventional rotatable drum **135** for the drill line here designated **136** is mounted within a housing **131**. Drilling operation is regulated by the tension of the dead end **114** of the said drilling line or cable **136** at a sensor unit D which is structurally the same as that disclosed in my pending application, Serial No. 836,027, now abandoned, though somewhat differently connected.

More in detail, sensor unit D includes a conventional mounting frame **116** which has an upper spool **121** pivotally mounted at its top at **122** and a spool cam **123** pivotally mounted at **124** adjacent its lower end. An elongated handle **125** extends upwardly from spool cam **123** and the latter, in combination with a dowel means **126** removably positioned within a mating axial recess or recesses of the cam, assists in maintaining the handle **125** and cam **123** in the desired position with the said dead end portion **114** bowed or deflected out of vertical.

Said frame **116** carries a chamber or casing **127** havin, for example, a base wall **150** and an annular marginal wall **151**, against the outer free edge of which a flexible diaphragm **117** is suitably fastened as at **152**, in spaced parallelism to wall **150** to enclose a space **153**. Bolted or otherwise fastened to the diaphragm at **154**, and movable therewith, is a plate **155** having a central stud or projection **156** in contact with the bow or deflection of said dead end portion **114**. If desired, a plate **157** may also be fastened against the diaphragm by said bolts **154** for further reinforcement.

Projecting centrally from wall **150** is a small housing **118** for a valve **119** slidably mounted in a port **117'** in wall **150** which is urged by an expansive coil spring **119''** against its seat at said port. A section of the supply conduit **100** at **120** leads to housing **118**. A conduit **128** establishes communication between sensor space **153** and the Bourdon tube **113** for expansion and contraction thereof to actual flapper **109** on pivot **111**. A continuously open nozzle or drain opening **128'** is provided in conduit **128**.

A branch conduit **1***a* supplies power fluid from conduit **1**, under control of a valve **1***b* to a power cylinder **129** pivoted at **129'** to wall **131'** of the drum housing **131**. A piston **130** operates in cylinder **129** to move an alternately applied and retracted power take-off unit **132** which is suitably slidably mounted on wall **131'** at **132'** to regulate peripheral contact of a pulley wheel **133** with the inner side surface of one flange **136** of the line spool **135**. During the periods of such contact pulley **133** will be rotated and drive a shaft **134** which, through appropriate reduction gearing in the unit **132**, drives a flexible or other shafting **138** leading to a planetary gear unit or assembly **139** and connected spool or drum **141** on which is wound a wire or other string or cable **142** attached to the brake-applying lever **143** of drill line drum **135**, the lever **143** being urged toward applied position by a weight **145** and suspending cable **144**.

Said spool 141, for example, may be attached coaxial with and rigidly to the gear ring 11*d* of a planetary gearing unit or set as in FIGURES 5 and 6 so as to wind and unwind the cable 142 according to the direction of rotation of the drum spool 135.

Said planetary gearing unit is operated by a fluid pressure operated motor 146 when fluid pressure reaches the same through connected branch conduit 104 with the main valve assembly 105 open. The shaft of motor 146 and the gear ring 11*d* may be drivingly interconnected in any suitable manner, as at 49 and 49*a* in FIGURES 8 and 9.

Presuming operation of the mechanism of FIGURE 11, as rock or earth formation is being drilled from under the drilling bit, this causes more weight of the drill pipe to be suspended from the top of the derrick, thus such drilling line cable 136 becomes more taut, therefore increasing pressure at the stud 156 and thus against valve 119, opening it and allowing more pressure fluid to pass spring 119″ into chamber 153 behind diaphragm 117. This pressure increase is transmitted through conduit 128 to Bourdon tube 113 which tends to straighten the same and swing flapper valve 109 at point 112, causing the flapper valve to close nozzle 108. Pressure fluid has also been fed into passage 103 through orifice 107, and when nozzle 108 is closed by the flapper valve, this causes a pressure build up in tube 106 onto the diaphragm of the main valve mechanism 105, opening the latter and allowing pressure fluid to pass the valve 105 to and through tube 104 to pressure fluid operable motor 146 to effect the release of brake band mechanism 143 to allow drum spool 135 to release a supply of drilling line 136 which, in turn, lowers the top end of the drill pipe string, placing more weight on the drill bit. At the same time the drum spool 135 starts rotating, which allows friction wheel 133 to drive shaft 134 through reduction gear unit 132, shafting 138, and planetary gear set 139, causing a reverse rotation of the drill line drum spool 135 and causing it to pay out drill line 136, which, in turn, allows weight 145 to apply brake lever mechanism 143 to cause the brake bands of the brake mechanism 143 to halt rotation of drum spool 135 and thus stop paying out of drill line 136 from drum spool; thus effecting a complete cycle of operations. Thus, through linkage of mechanism 143, rotation of drum spool 135 will be braked. With drum spool 135 released, however, the drill bit of drill line 136 will be subject to the weight of pipe or casing applied to the line, causing the drill line to pay out and rotate the drum or spool 141 in the opposite direction. Thus, the control of the instant invention in operation will automatically brake rotation of the drum spool 135 in one direction, or alternately rotate such drum by the drill line cable 136 in the reverse direction. Also, when sufficient weight has been added to the drill bit, depending upon the setting of controller 110, tension of the drill line 136 will decrease which, in turn, decreases pressure on the pressure diaphragm at the projection 156 and pressure in chamber 150, which will force the diaphragm 117 away from the valve 119. Bleed-hole 126 will leak constantly to enable said excess pressure to lower the pressure at the dead line diaphragm assembly D corresponding to the tension of the drill line 137. Roller 121, as well as cam device 123–125, enables the diaphragm assembly and dead line to be clamped against relative slippage. Branch conduit 1*a*, controlled by valve 1*b*, conducts pressure fluid to the cylinder 129 to cause piston 130 to push reduction gear unit 132 toward the adjacent drum spool flange to cause engagement of friction-wheel 133 with said flange.

Although I have disclosed herein the best form of the invention known to me at this time, I reserve the right to all such modifications and changes as may come within the scope of the following claims:

What is claimed is:

1. In a system for regulating drill line tension as successively deeper formations are penetrated, drum means mounted to support a supply of said drill line and provided with braking means thereon, means including a line and spool for exerting a variable force on said braking means, a planetary gear assembly mounted to rotate simultaneously with said spool, a first electric motor mounted to supply input torque to said planetary gear assembly to rotate said spool in one direction, a pivotally mounted friction wheel assembly adapted to engage said drum means for simultaneous rotation therewith, mechanism including a second electric motor, hydraulic means driven by said second electric motor, said hydraulic means being adapted to generate fluid pressure to actuate said friction wheel assembly into engagement with said drum, a pressure sensitive switch responsive to said fluid pressure to operatively connect said first electric motor to a source of power, means including a diaphragm tension sensor and Bourdon tube responsive to tension in said drill line to initiate flow of electric power to said first motor, a worm and gear in spaced relation to said planetary gear assembly mounted in operative relationship to said spool, and means connected to said friction wheel and said worm for imparting input torque to said gear in order to rotate said spool in the opposite direction to increase the force on said braking means.

2. In a system for regulating drill line tension as successively deeper formations are penetrated, drum means mounted to support a supply of said drill line and provided with breaking means thereon, means including a line and spool for exerting a variable force on said braking means, planetary gear assembly mounted to rotate simultaneously with said spool, a first electric motor mounted to supply input torque to said planetary gear assmbly to rotate said spool in one direction, a pivotally mounted friction wheel assembly adapted to engage said drum means for simultaneous rotation therewith, mechanism including a second electric motor, means driven by said second electric motor, said last mentioned means being adapted to generate fluid pressure to actuate said friction wheel assembly into engagement with said drum, a pressure sensitive switch responsive to said fluid pressure to operatively connect said first electric motor to a source of power, means including a diaphragm tension sensor and Bourbon tube responsive to tension in said drill line to initiate flow of electric power to said first motor, a worm and gear mounted in operative relationship to said spool, and means connected to said friction wheel and said worm for imparting input torque to said gear in order to rotate said spool in the opposite direction to increase the force on said breaking means.

3. In a system for regulating the tension in a drill line according to claim 1, wherein said means connected to said friction wheel and said worm comprises two Selsyn motors electrically interconnected.

4. In a system for regulating the tension in a drill line according to claim 1, in which the means connected to said friction wheel and said worm includes a flexible shaft.

5. In a system for regulating drill line tension as successively deeper formations are penetrated, drum means mounted to support a supply of said drill line and provided with braking means thereon, means including a wire line and spool for exerting a variable force on said braking means, a planetary gear assembly mounted to rotate simultaneously with said spool, a first electric motor mounted to supply input torque to said planetary gear assembly, a pivotally mounted friction wheel assembly adapted to engage said drum means for simultaneous rotation therewith, hydraulic means including a second electric motor and a pump connected to deflect said friction wheel assembly into engagement with said drum, a pressure sensitive switch mounted to sample fluid pressure generated by said hydraulic means, means including a diaphragm tension sensor and Bourdon tube for sampling pressure in said drill line in order to initiate flow of electric power to said first motor responsive thereto

and displace said spool to release said braking means and permit rotation of said drum, a worm and gear assembly mounted in operative relationship to said spool and said planetary gear assembly, and means including Selsyn means mounted to sample rotation of said friction wheel assembly and supply input torque to said worm and gear assembly responsive thereto in order to reset said braking means and halt rotation of said drum.

6. In a system for regulating drill line tension as successively deeper formations are penetrated, drum means mounted to support a supply of said drill line thereon, braking means mounted to control rotation of said drum, actuating means including a wire line for releasing said braking means and a spool for maintaining a controlled degree of tension therein, planetary gear means mounted to rotate with said spool, a hydraulically operable friction wheel assembly adapted to sense rotation of said drum means, hydraulic circuit means including pump means for supplying pressurized hydraulic fluid to displace said assembly into said rotation sensing relationship with said drum, a pressure operated electrical switch mounted to sample said pressurized fluid and actuate in response thereto, means including a diaphragm sensor and Bourdon tube for sampling tension in said drill line, an electric motor connected to receive power responsive to actuation of said electric switch and said tension in said drill line to drive said planetary gears as well as said spool in a first direction in order to release said braking means, and a Selsyn system connected to sense rotation of said drum and provide an electrical signal responsive thereto including gear means mounted to rotate said spool in a direction opposite to said first direction to reset said braking mechanism.

7. In a system for regulating drill line tension as successively deeper formations are penetrated, drum means mounted to support a supply of said drill line and provided with braking means thereon, means including a wire line and spool for exerting a variable force on said braking means, a planetary gear assembly mounted to rotate simultaneously with said spool, a first electric motor mounted to supply input torque to said planetary gear assembly, a pivotally mounted friction wheel assembly adapted to engage said drum means for simultaneous rotation therewith, mechanism including a second electric motor and hydraulic means having a pump connected to deflect said friction wheel assembly into engagement with said drum, a pressure sensitive switch mounted to sample fluid pressure generated by said hydraulic means and upon actuation thereof to operatively connect said first electric motor to a source of power, means including a diaphragm tension sensor and Bourdon tube for measuring tension in said drill line, switch means connected across a source of electrical potential and actuated by said tension sensor in order to insure flow of electric power to said first motor, a worm and gear assembly mounted in operative relationship to said spool and said planetary gear assembly, and means including a Selsyn system having motors connected to said friction wheel and said worm for imparting input torque to said worm and gear assembly responsive thereto in order to reset said braking means and halt rotation of said drum.

8. In a system for regulating drill line tension as successively deeper formations are penetrated, rotatable drum means including a drum spool mounted to support a supply of said drill line and provided with coacting braking means normally urged to applied position, means including a line and a line spool for controlling said braking means, a planetary gear assembly including differentially movable parts, said line spool being movable with one of said parts, a friction wheel assembly for engaging said

drum means for rotation thereby, means for selectively actuating said friction wheel assembly into and out of engagement with said drum means, means including a tension sensor and Bourdon tube responsive to tension in said drill line and another of said parts to rotate the line spool in a direction to decrease the applying force on the braking means, a driving connection for said line spool from still another of said differentially movable parts, said last-named part being operatively connected to said friction wheel assembly to allow said line spool to move in the direction to increase the applying force on said braking means.

9. In a well drilling control system provided with a rotatably mounted drum for supporting a supply of the drill line which supports the drill bit, brake means mounted to halt rotation of said drum, rotation sensing means mounted to detect movement of said drum and provide torque responsive thereto, tension sensing means mounted to measure drill line tension and generate a fluid pressure related thereto, fourth means responsive to the generated fluid pressure for rotation in a first direction, fifth means responsive to the provided torque including means for rotation in a direction opposite to said first direction; and spool and line means responsive to rotation in both directions for applying and releasing said brake means, said fourth, fifth and spool means being interconnected by planetary gearing and including gears rotatable on the same axis as said drum, said gears being on opposite sides of said drum.

10. In a well-logging control system for regulating the tension in a drill line during drilling operation, drum means mounted to support a supply of said drill line and provided with friction braking means movable generally transversely of the axis of the drum means, means selectively movable generally axially of the drum means, means responsive to the tension of said drill line for varying the degree of restraint imposed upon said drum means by said braking means, and mechanism including a spool having a line partially wrapped thereon leading therefrom to said braking means, and said mechanism having cooperating planetary movable parts for rotating said spool controlled by said third and fourth means to wind and/or pay out the last-mentioned line.

11. A well-logging control system according to claim 10 wherein said means movable axially generally of the drum includes a friction element.

References Cited by the Examiner

UNITED STATES PATENTS

1,779,581	10/1930	Behnke.
1,779,656	10/1930	Brauer.
1,926,119	9/1933	Smith.
2,117,078	5/1938	Brauer.
2,455,917	12/1948	Crake.
2,672,222	3/1954	Stevens.
2,759,702	8/1956	Abraham.
2,867,411	1/1959	Simmonds et al.
2,931,628	4/1960	Simmonds et al.
2,944,789	7/1960	Le Gate.
2,950,086	8/1960	Abraham.

FOREIGN PATENTS

776,132	6/1957	Great Britain.

SAMUEL F. COLEMAN, *Primary Examiner.*

HARRISON R. MOSELEY, *Examiner.*

O. M. SIMPSON, *Assistant Examiner.*