AUTOMATIC DRILLER

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Fig. 1

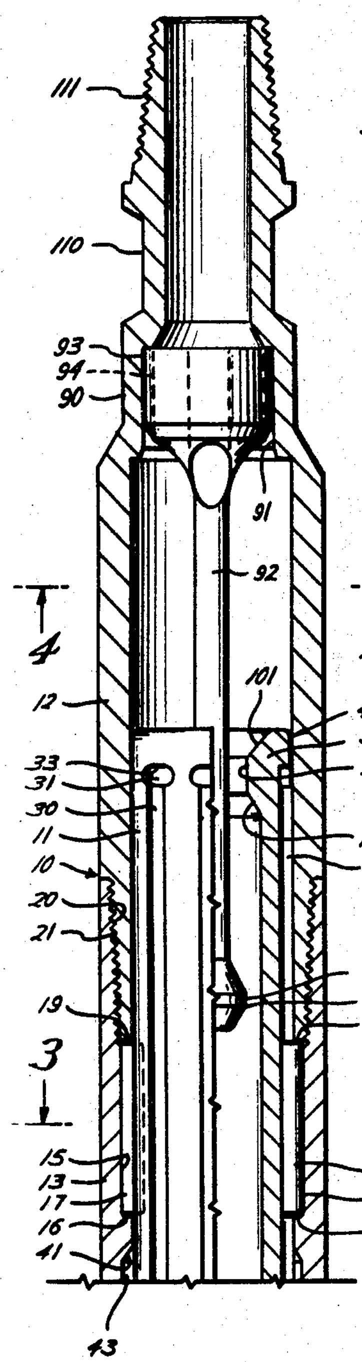


Fig. 2

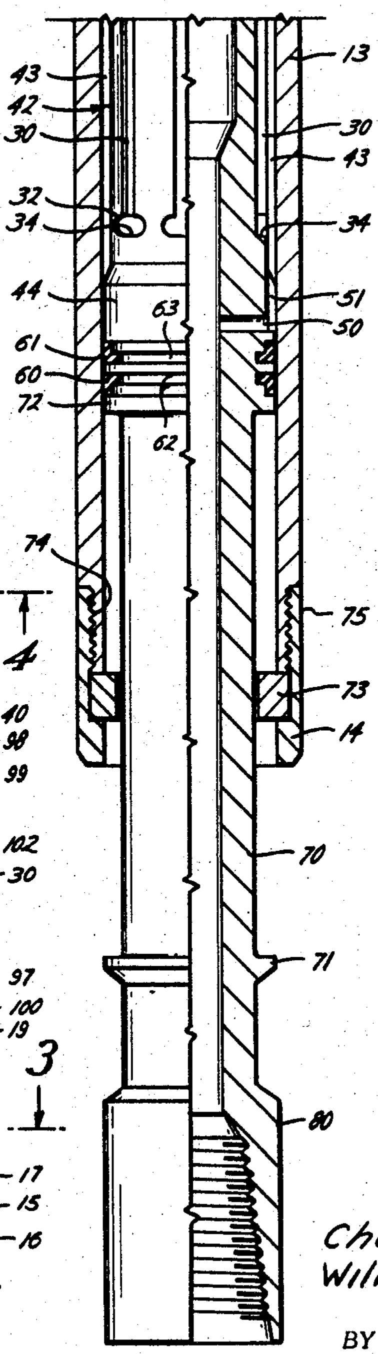


Fig. 3

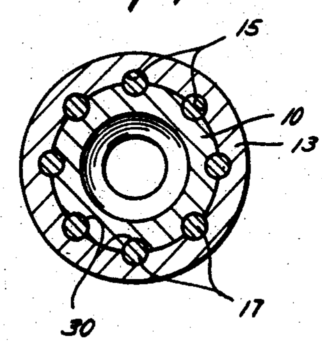
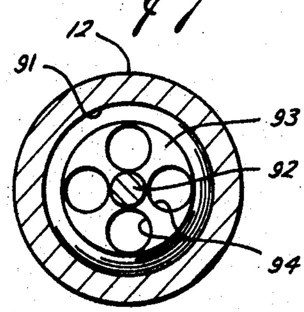


Fig. 4



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Aug. 26, 1969 C. E. MILLER ET AL 3,463,252

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Fig. 5

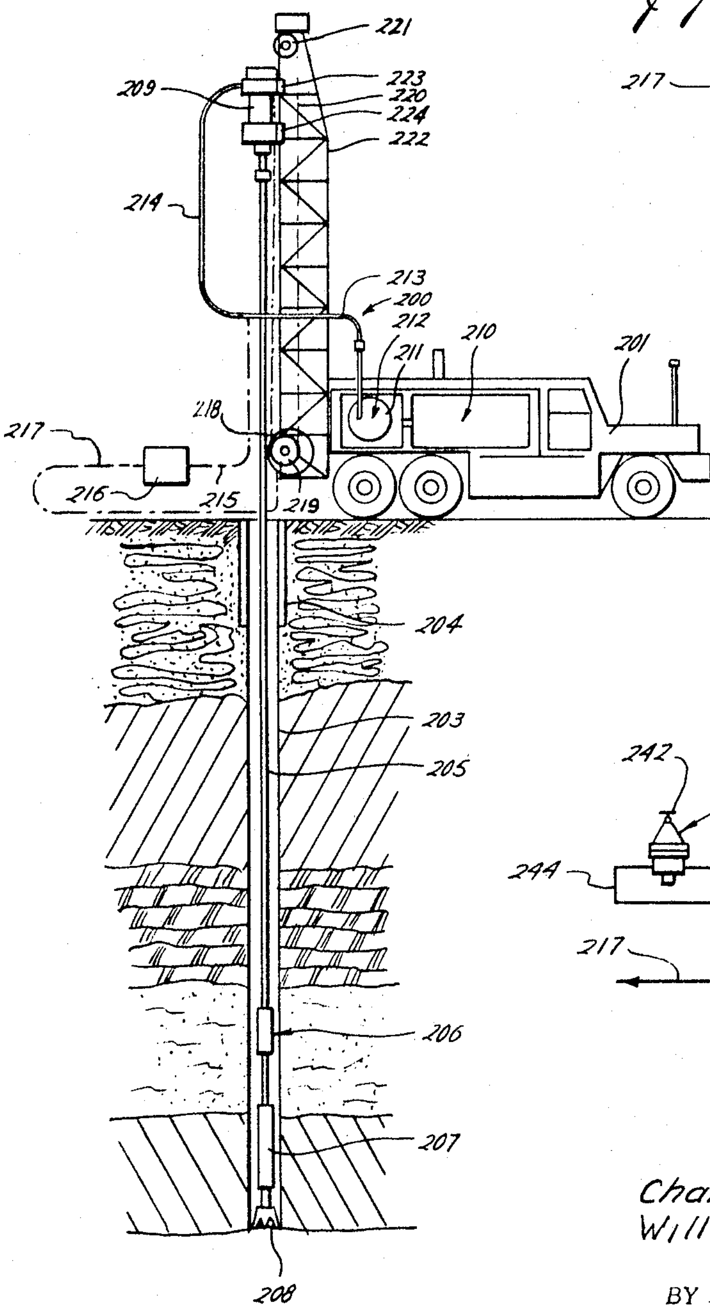


Fig. 6

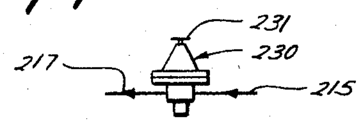
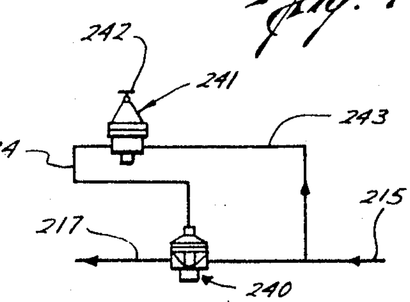


Fig. 7



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AUTOMATIC DRILLER

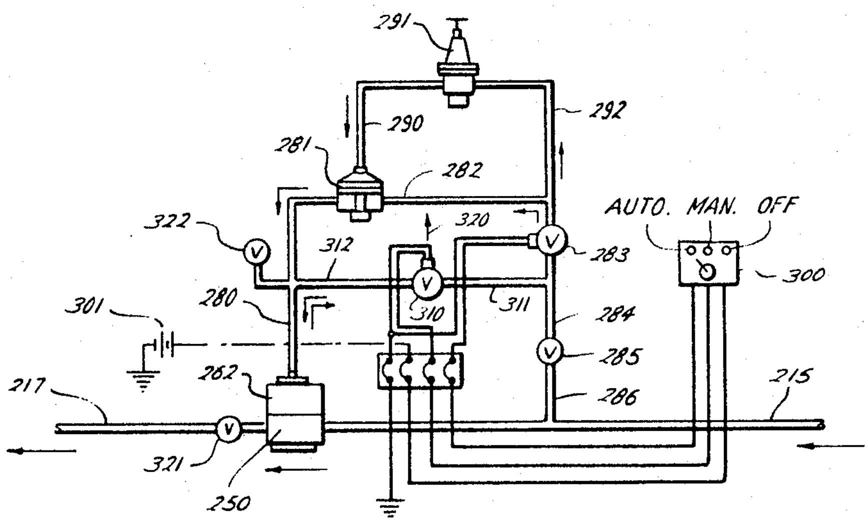

Fig. 8

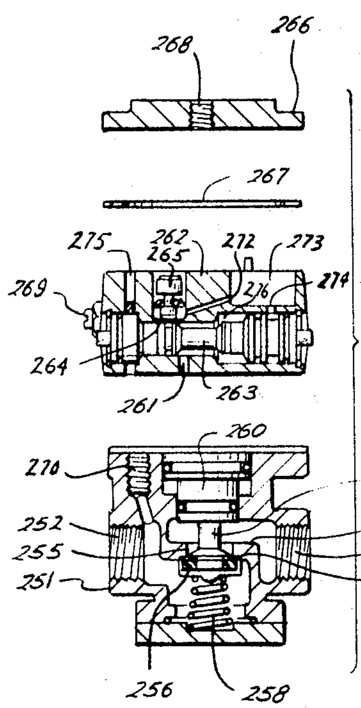

Fig. 9

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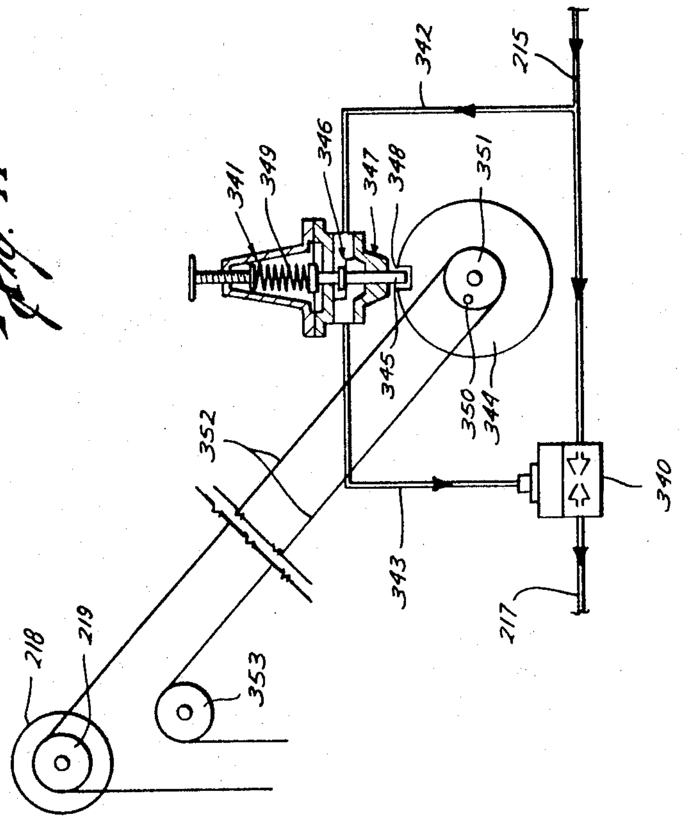

Fig. 11

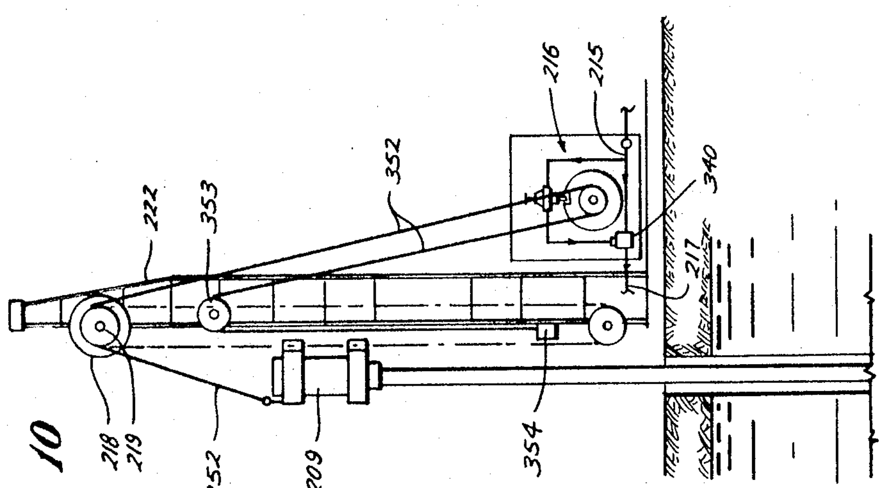

Fig. 10

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Fig. 12

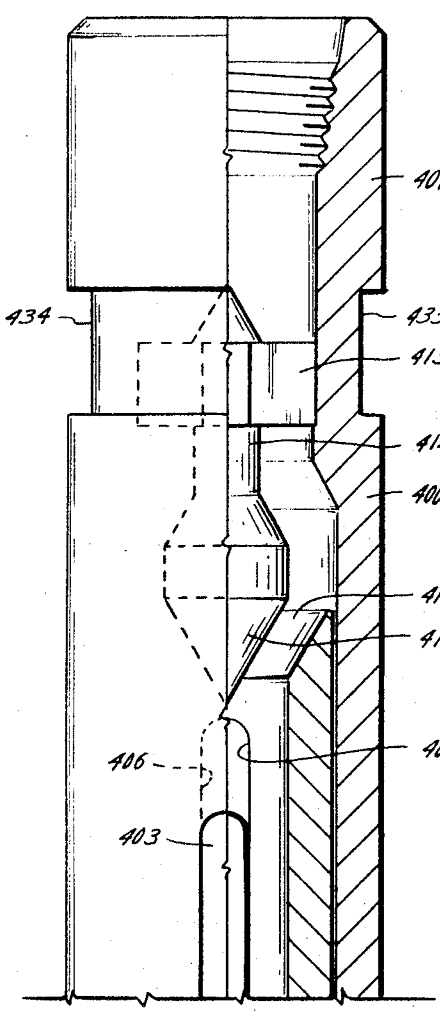
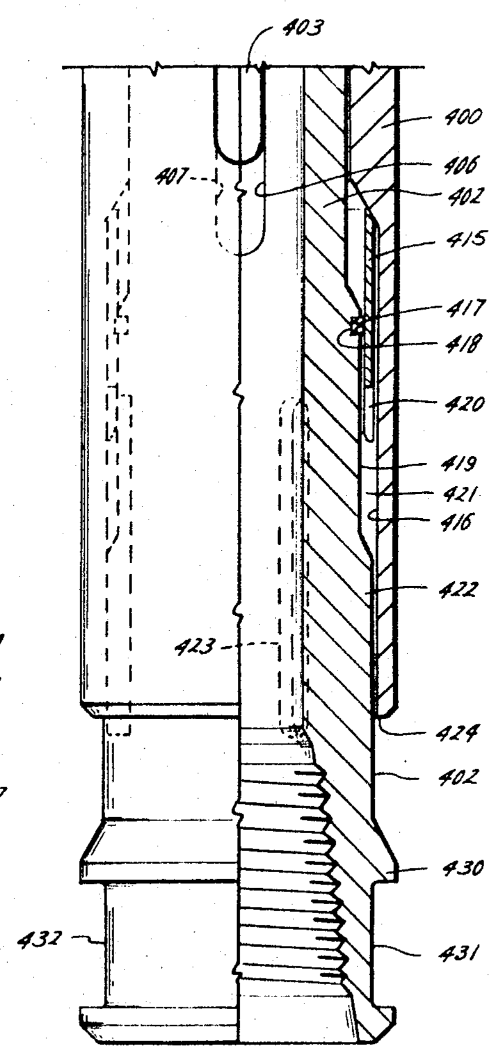


Fig. 13



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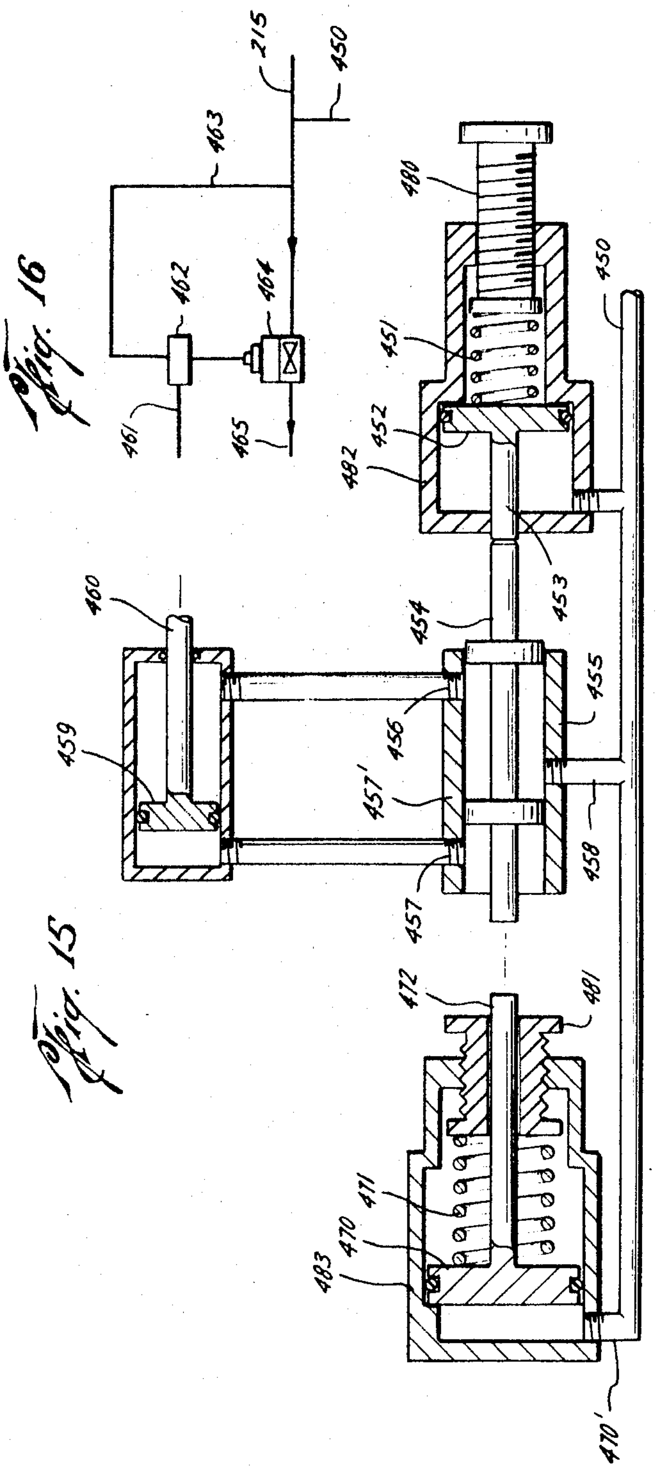

Fig. 16

Fig. 15

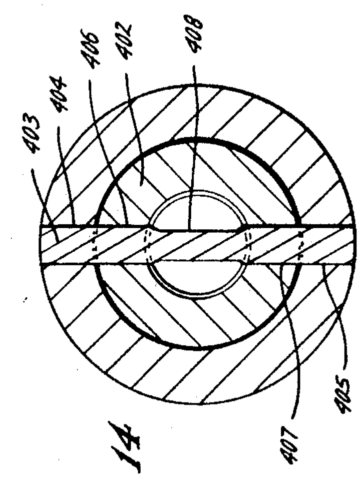

Fig. 14

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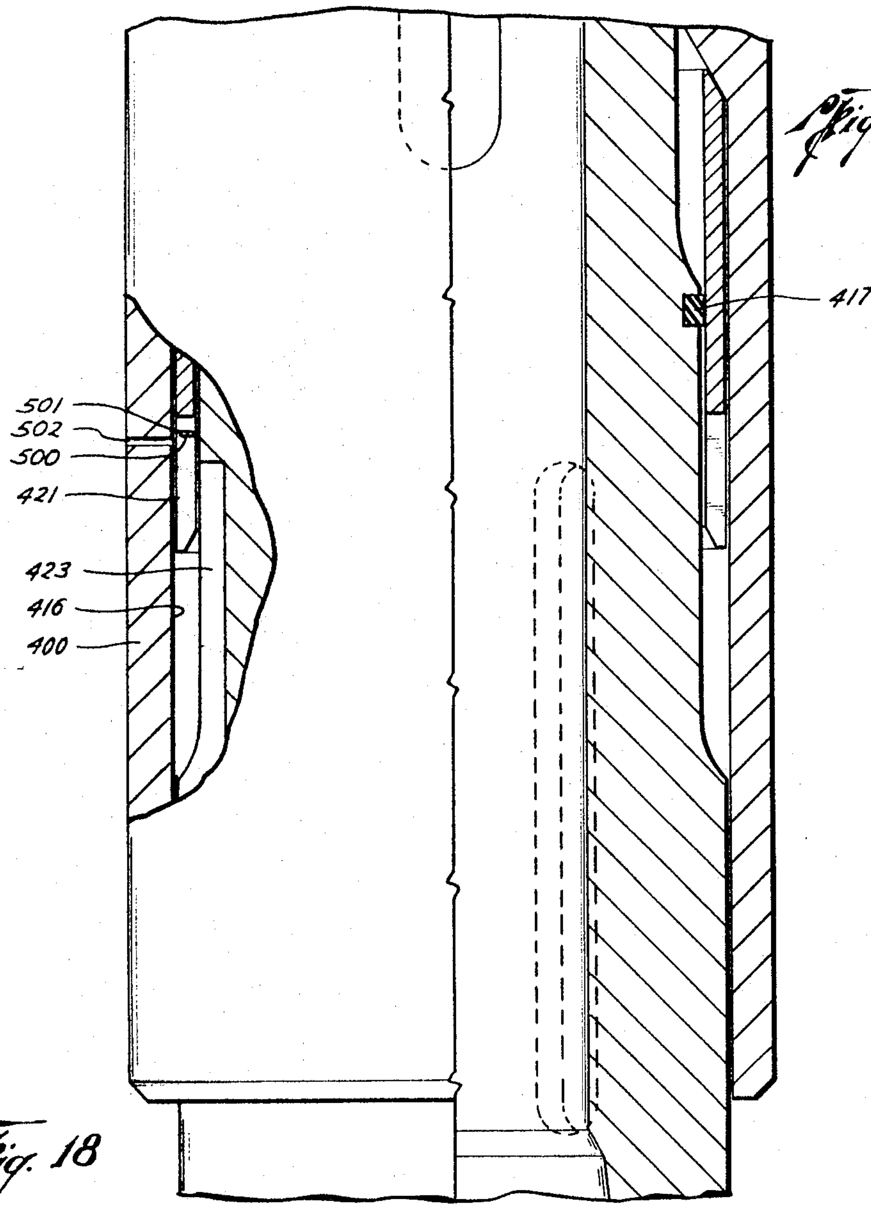
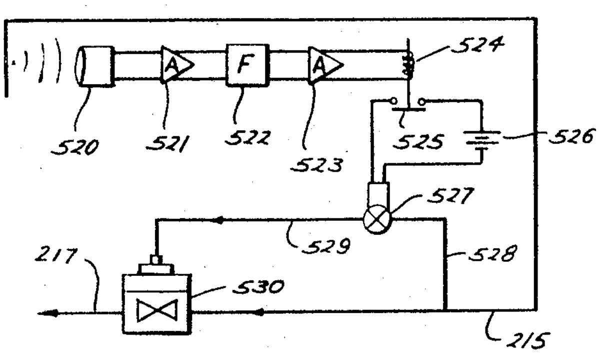


Fig. 17

Fig. 18



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3,463,252
Patented Aug. 26, 1969

3,463,252

AUTOMATIC DRILLER

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Int. Cl. E21b *17/04;* E21c *15/00*
U.S. Cl. 175—27 24 Claims

ABSTRACT OF THE DISCLOSURE

Contraction and extension of a telescopic joint just above a down hole percussor and drill bit in a drill string generate signals to which responds mechanism for lowering drill string thereby to maintain constant the weight on down hole percussor. Signals may be air pressure changes, vibrations, or other types. On receipt of initiating signal the lowering mechanism may be operated for a predetermined distance or a predetermined time or so long as there is predetermined pressure rise or until a second predetermined signal to stop is received.

This invention relates to earth drilling and more particularly to apparatus for automatically lowering a drill string as the drill bit progresses down the earth bore. Although especially suited for use in drilling apparatus employing air or other gas as a medium to cool the bit and bring the cuttings to the surface, it may also be used in connection with other drilling apparatus, e.g. a system employing circulating mud to cool the bit and bring the cuttings to the surface. The apparatus preferably is constructed to operate in response to pressure changes in the drilling fluid, air, gas, water, oil, mud, or other, created as the bit advances in the hole. In particular the apparatus is designed to respond to pressure changes created by the extension and contraction of a telescopic joint incorporating a choke, which joint is placed in the drill string close below the neutral point. In the case of air or gas drilling the joint is placed just above or close to the down hole percussor used to drive the impact type drill bit. A telescopic joint of this type is disclosed in U.S. patent application Ser. No. 569,727, filed Aug. 2, 1966, by William R. Garrett, entitled "Telescopic Joint," now Patent No. 3,410,355 to which reference may be made for a detailed description thereof.

As disclosed in said Garrett application, the telescopic joint may comprise a lower inner and an upper outer tube splined together so as to transmit torque while allowing limited relative axial motion, cooperating stops being provided to limit the extent of contraction and extension. Sliding seal means between the tubes provides for fluid tight transmission of fluid through the joint. Near its upper end the outer tube carries a spider on which is mounted a stinger extending down into the inner tube. The stinger carries a plug at its lower end adapted to cooperate with a constriction in the inner tube. When the joint approaches full extension the plug enters the constriction to signal such position by causing an increase of presence in the drill string that is observable at the surface.

In the case of air as a drilling fluid the rise in pressure occurs because within the limits of its capacity the motor driven air compressor unit forming part of the drilling apparatus is regulated automatically to maintain a constant rate of flow of drilling fluid. When the plug of the telescopic joint approaches the constriction thereof, there is created a choke which impedes flow of drilling fluid. In order to maintain a constant rate of flow the pressure in the drill string above the choke must be increased.

The regulator or governor on the compressor unit is set to maintain constant speed, which corresponds to constant rate of flow, and this means that when the telescopic joint moves to choking position the motor of the compressor unit must supply more power. In this case of a gasoline engine driving the compressor, the governor opens the throttle to the engine; when the engine loads up the driller can hear it and will know it is time to lower the drill string to contract the telescopic joint a prescribed amount, something less than the full range of travel of the joint.

In the foregoing manner drilling can proceed with the intermittent downward progress of the drill string keeping up with the fairly steady downward travel of the drill bit. At the same time, the downward force on the drill bit will remain substantially constant, consisting of the weight of the drill string below the telescopic joint plus the weight of the lower half of the telescopic joint plus the force of the drilling fluid acting to extend the telescopic joint. Maintenance of proper downward force or "weight" on the drill bit is very important in order that drilling proceed rapidly but with a minimum bit wear.

According to the present invention, control apparatus is provided responsive to pressure rise in the drilling fluid to automatically lower the drill string, thereby relieving the driller of this job. Briefly, means is provided responsive to the drilling fluid pressure to control means for vertically positioning the drill string. In accordance with one embodiment of the invention, whenever there is a sufficient pressure rise the drill string vertical positioning means is actuated to lower the drill string a predetermined distance. In accordance with another embodiment of the invention whenever there is a sufficient pressure rise the drill string vertical positioning means is actuated to lower the drill string for a predetermined time. In a third embodiment of the invention the drill string vertical positioning means is actuated to lower the drill string whenever and for so long as there is a sufficient pressure rise.

In a fourth embodiment of the invention the drill string vertical positioning means is lowered until the telescopic joint reaches a predetermined position of contraction at which the joint creates a further signal, e.g. a pressure drop to which the pressure responsive means at the surface is responsive to deactivate the vertical positioning means.

In accordance with a fifth embodiment of the invention instead of using a means at the surface responsive to pressure of the drilling fluid to control the vertical positioning means, the surface means is a vibratory signal responsive means and the telescopic joint includes a vibratory signal generator which is actuated whenever the joint nears full extension. The surface means responds to the vibratory signal to actuate the vertical positioning means.

Generally speaking, the invention encompasses the use of any signal generating means responsive to the position of the telescopic joint in combination with a surface means responsive to such signal to activate the vertical positioning means, either until the signal ceases, or for a predetermined time thereafter, or until the pipe has been lowered a predetermined amount, or until a further signal is received from the telescopic joint, or in other predetermined manner. The signal may be an air pressure rise or fall, a sound signal, an electric, magnetic, electromagnetic signal, a mechanical vibration, or any other desired type of signal. Broadly the characteristic features of the invention are the generation of the signal in response to the relative positions of the parts of the telescopic joint and the reception of the signal at the surface and use thereof to vertically position the drill string. In this regard the term telescopic joint is to be considered in its broadest sense, namely, a lost motion connection between the upper and lower portions of a drill string.

It is to be noted that when air or other gas (e.g. natural gas) is used as the drilling fluid there is normally an air storage chamber between the air compressor unit and the drill string. In addition, there may be several hundred or even thousands of feet of drill string between the telescopic choke or other pressure signaling means and the pressure responsive means at the surface. Depending on the depth of the hole there may be as much as a second or so time lag between the restriction of flow at the telescopic choke and an increase of pressure in the drilling fluid at the surface (upper part of the drill string) sufficient to be readily distinguishable from minor pressure fluctuations due to operation of ancillary equipment powered from the same air source. During the interim the compressor continues to operate at the same speed but with gradually opening throttle while the storage tank and drill string fill up with air causing the pressure to rise. During this same period the drill bit continues to advance and the telescopic joint further contracts. With a drilling rate of 10 to 30 feet per hour the joint would contract only about 0.03 to 0.1 inch. The telescopic joint disclosed in the aforementioned Garrett application has a travel of about three inches from initial throttling to maximum throttling position plus an additional two inches of travel from maximum throttling position to the limit of contraction. Therefore, there is no difficulty with the joint reaching its limit of travel before the pressure builds up enough to operate the pressure responsive means at the surface.

After pressure of the drilling fluid, e.g. air, has risen enough to initiate operation of the surface controls there will be a further time lag due to the time required for the controls to actuate the drill string positioning means. This time lag should also be kept short. At the maximum the time should be short enough so that the telescopic joint will not reach the limit of its extension before the drill string is lowered. At a drilling rate of 30 feet per hour and a five inch travel of the telescopic joint, this means that the controls must operate to start downward motion of the drill string within fifty seconds.

It is furthermore desirable that the surface controls act quickly enough so that the telescopic choke does not move to maximum throttling position, for the greater the throttling or choking the more the pressure of the drilling fluid must rise and the greater the load and strain on the motor-compressor unit. Ultimately, if the load reaches the capacity of the unit, either the throttle will be full open or the governor will not open the throttle further and the unit will slow down, thereby slowing down the percussor motor at the bottom of the hole. Assuming that a one-tenth inch extension of the telescopic joint is permissible after throttling sufficient to initiate actuation of the surface controls and prior to beginning of downward motion of the vertical positioning means, and assuming as before a 30 feet per hour drilling rate, a one second response time lag at the surface is the limit.

It is also desirable that the surface controls actuate the vertical positioning means for the drill string quickly in order to minimize the length of time the telescopic joint is in the throttling position, for during throttling the air velocity through the choke is high, tending to cause rapid erosion. Also the clearances are reduced during throttling so that foreign matter tends to collect in the choke to interfere with its operation.

The apparatus of the invention may be classified as of the intermittent type since the vertical positioning means is actuated only periodically. It would be possible to provide a continuously operating vertical positioning means for the drill string and control its rate of downward travel continuously as a function of the pressure in the drill string. Not only would this require reduction or elimination of pressure variations due to factors other than downward progress of the bit but also it would be necessary for the telescopic choke in the drill string and also the surface controls to operate at all times in a throttling condition. This would be particularly detrimental to the life of the surface controls because of the more rapid erosion caused by the high velocity air and the clogging of the controls with dirt particles. An intermittently actuating system is preferred since opportunity is given for operation with valves wide open to purge the system and the time of throttling and rapid wear is reduced. It is to be observed however that in the third embodiment of the invention the telescopic joint or subsurface part of the system may be operating in a throttling condition all or most of the time and the surface control, though intermittent, may be operating one or more times per second with the result that downward travel of the drill string is substantially continuous.

A further desirable feature of the invention is the provision of means by which the automatic surface control apparatus can be overridden with a manual control so that the driller can operate the vertical positioning means manually. This is desirable for at times other apparatus such as hoists, grinders, sprayers, or cleaners may divert enough air from the compressed air supply system to interfere with proper automatic operation, e.g. by so loading the system as to prevent pressure build up sufficient to actuate the surface controls.

For a detailed description of preferred embodiments of the invention reference will now be made to the accompanying drawings wherein:

FIGURES 1 and 2 together form a vertical section through the telescopic choke disclosed previously in the aforementioned Garrett application, that is assigned to the same assignee as the present invention;

FIGURES 3 and 4 are sections taken at planes **3—3** and **4—4** of FIGURE 1;

FIGURE 5 is a schematic drawing, partly in section, showing an air drill embodying the invention, the down hole signalling means or telescopic choke and the surface control means being shown only as boxes;

FIGURE 6 is a schematic view of a simple form of surface control means that could be used in the apparatus of FIGURE 5;

FIGURE 7 is a schematic view illustrating an improvement on the control means illustrated in FIGURE 6;

FIGURE 8 is a schematic view illustrating a further improvement on the control means illustrated in FIGURES 6 and 7;

FIGURE 9 is an exploded sectional view of a valve used in the FIGURE 8 construction;

FIGURE 10 is a schematic view similar to the upper portion of FIGURE 5 and showing generally a further modified form of surface control means; and

FIGURE 11 is a schematic view showing details of the surface control means of FIGURE 10;

FIGURES 12 and 13 together form an elevation, partly in section, through a modified form of telescopic joint that may be used in conjunction with the invention;

FIGURE 14 is a section taken at **14—14** of FIGURE 12;

FIGURE 15 is a section through part of a modified surface control means to be used in conjunction with the downhole signalling means of FIGURES 12–14;

FIGURE 16 is a schematic view of other parts of the modified surface control means of which part is shown in FIGURE 15;

FIGURE 17 is a view similar to FIGURE 13 showing a modification incorporating a sonic signalling means; and

FIGURE 18 is a schematic view of a modified surface control means to be used in conjunction with the downhole signalling means of FIGURE 17.

Referring now to FIGURES 1 and 2 there is shown a telescopic joint including an outer tube **10** and inner tube **11**. The other tube includes an upper pipe **12**, a lower pipe **13**, and a nut **14**, all screwed together. There are a plurality of semi-cylindrical grooves **15** (see FIGURE 3) inside pipe **15** terminating at their lower ends **16**. Within grooves **15** are received cylindrical steel bars **17** bearing against the lower ends **16** of the grooves and retained against axial motion by the lower end **19** of pipe **12**. When the threaded pin **20** of pipe **12** is screwed into threaded box **21** of pipe **13**, the bars **17** are securely held against axial motion.

The inner portions of bars **17** are slidably received in longitudinal semi-cylindrical grooves **30** (see FIGURE 3) in the outer periphery of the inner tube **11**. At the ends of grooves **30** there are holes **31**, **32** extending radially into the inner tube. Holes **31**, **32** are provided to facilitate machining. They also provide flat surfaces **33**, **34** against which the ends of bars **17** abut at the maximum contraction and extension of the joint.

Except for the grooves **30**, the inner tube makes a fairly close sliding fit with the inner surface of pipe **12**, as shown at **40**. Pipe **13**, however, below shoulder **41** near the lower end of the bars **17**, has a larger inner diameter than the outer diameter of tube **11**, as shown at **42**, leaving an annular space **43** therebetween. There is an enlargement or hub **44** on inner tube **11**, below the lower ends of grooves **30**. Hub **44** makes a fairly close sliding fit with the inner surface of pipe **13**, thus providing guide means to keep the tubes concentric during contraction and extension of the telescopic joint. The guide means also takes some of the load when bending moment is applied to the joint.

One or more radial ports **50** in hub **44** connect with one or more longitudinal ports **51** which in turn communicate at their upper ends with annulus **43**. With this arrangement fluid leaking between tube **11** and pipe **12** at **40** will travel down through annulus **43** and ports **51**, **50** back into inner tube **11**, thereby flushing out grooves **30**.

Seal means comprising oppositely facing annular packing cups **60**, **61** are received in grooves **62**, **63** formed in the outer periphery of hub **44**, making a sliding seal between inner tube **11** and pipe **13** of the outer tube. This prevents fluid in the casing annulus, the fluid returning the cuttings to the surface, from contacting the bars **17** and grooves **30** forming the spline means.

Below hub **44** of the inner tube **11** is of smaller outer diameter than at **40** forming an elongated neck **70**. Near the lower end of the neck is an enlarged diameter portion **71** forming a stop means. The lower end **72** of hub **44** also forms a stop means. A ring **73** is held between the lower end of threaded pin **74** on pipe **13** and the bottom of threaded box **75** of nut **14**. The ring **73** is initially split in two halves, then assembled on neck **70** and the two halves welded together. Then nut **14** is screwed onto pipe **13**, the ring **73** being held therebetween. Ring **73** forms stop means on the outer tube engageable with the stop means **71**, **72** on the inner tube to limit the extension and contraction of the joint.

The distance between stop means **71** and **72** minus the thickness of ring **73** is less than the distance between the surfaces **33**, **34** minus the length of bars **17**. Ring **73** is so positioned relative to stop means **73**, **74** as to normally prevent the bars **17** from contacting surfaces **33**, **34**. However, if nut **14** should accidentally become unscrewed from pipe **13**, the bars **17** and surfaces **33**, **34** would then be engageable to hold the joint together and prevent a fishing job.

Whenever it is desired to replace seal means **60**, **61**, it is only necessary to unscrew nut **14** from tube **13**, thereby allowing the fuller extension of the joint permitted by bars **17** and surfaces **33**, **34**. This exposes the seal means below the lower end of the pipe **13** so that the seal means can be replaced.

Below stop means **71** the inner tube **11** is provided with a threaded box **80** for connection to a percussor, drill collar or other lower part of the drill string.

Referring now particularly to FIGURES 1 and 4, the pipe **12** has a portion **90** of reduced outer and inner diameter forming a socket **91**. A stinger **92** has a spider **93** at its upper end received in socket **91** and suitably secured in place, e.g. by a press fit, shrink fit, cement, or other means. Ports **94** provide longitudinal fluid passages through the spider.

The lower end of the stinger carries a plug **97** of fusiform cross section. A constriction **98** near the upper end of tube **11** has an inner peripheral cylindrical surface **99** of slightly larger diameter than the outer peripheral cylindrical surface **100** of the plug. Guide tapers **101**, **102** are formed at the upper and lower ends of constriction **98**. Plug **97** and constriction **98** form choke means presenting an increased resistance to fluid flow through the telescopic joint when the joint is near to full extended position wherein plug **97** is inside constriction **98**. The choke means does not, however, prevent fluid flow; it merely requires an increase in pressure in the upper part of the drill string to maintain any given flow rate. This signals the operator that it is time to lower the drill string.

When the telescopic joint is fully extended the plug **97** moves up past and out of constriction **98** to enable maximum flow to be achieved, as may be desirable to clean the well, e.g. before lowering the drill string, after drilling the full extent permitted by extension of the telescopic joint. No signal means is needed to tell the operator how far to lower the drill string since the telescopic joint has a known travel between full extended and full contracted positions. The operator merely lowers the drill string a lesser distance.

The upper end of pipe **12** is provided with a fishing neck **110** and a threaded pin **111** for making connection with the drill pipe or other drill string members thereabove.

Referring now to FIGURE 5 there is shown an air drill **200** including a truck **201** disposed on the surface of the earth **202** adjacent an earth bore or well **203**. A casing **204** extends part way the well to exclude near surface waters from the well. Extending from the surface through casing **204** down to adjacent the bottom of the well is a drill string **205**. The drill string comprises a plurality of tubular drill pipe members known as drill rods or drill steels, screwed together end to end. In the lower part of the drill string is incorporated the subsurface signalling means to telescopic choke **206** described in detail in connection with FIGURES 1–4. Below the choke **206** is connected an air hammer **207** driving a chisel like percussion bit **208**. Air is supplied to the air hammer through the drill string. Rotary drives means **209** adjacent the upper end of the drill string rotates the drill string slowly to change the position of the bit.

The air hammer will usually be immediately above the percussion bit. The telescopic joint will usually be immediately above the air hammer but if desired there may be one or more joints of drill steel between the hammer and telescopic joint. The hammer is known in the mining and oil well drilling industry as a "Down Hole percussor" to distinguish it from arrangements in which the hammer is above ground and there is a long pipe or bar (anvil) extending down the hole from the hammer to the bit. The hammer is usually a free piston air motor in which the piston, reciprocating for example at several hundred to several thousand (e.g. 1500) strokes per minute, functions as a hammer to strike an anvil connected to the bit. Usually the anvil and bit are integral because threaded connections will fail.

It is desirable to control the weight on the bit very closely in order to avoid rapid deterioration of the bit. In fact, it is found that some percussion bits usually work best with substantially zero or very little weight thereon. It is difficult to control bit weight from the surface. The telescopic choke **206** is inserted above the hammer and whatever joints of drill steel collars, if any, are desired, and below the lower end of the drill pipe, so that none of the weight of the drill pipe is imposed on the bit, thereby automatically achieving the desired result.

Periodically when the joint approaches or reaches the limit of its extension as the bit drills deeper into the hole the operator may lower the drill string to contract the telescopic joint so as to allow the bit to continue its downward travel in the bottom of the hole. In accordance with the present invention the lowering of the drill string when the telescopic joint approaches or reaches the limit of its extension is accomplished automatically.

Referring still to FIGURE 5, on the truck is mounted a power source such as a gasoline engine **210** driving an air compressor **211**. The compressed air, e.g. at pressure in the range of 50 to 300 p.s.i., is delivered from the compressor to storage tank **212**. The tank may, for example, have a capacity of the order of several hundred gallons. A fluid conduit **213** connects through hose **214** from the storage tank to the top of the drill string **205** and the rotary drive means **209**. A branch pipe **215** conducts air through surface control means **216** to pipe **217** leading to air motor **218**. Motor **218** rotates lower sprocket wheel **219** over which passes one bend of continuous **220**. The other bend of the cable passes around upper sprocket wheel **221**. The sprocket wheels **219**, **221** are rotatably mounted on tower **222** carried by the truck. The rotary drive means **209** in which the upper end of the drill string is suspended is slidably mounted at **223**, **224** on tracks carried by the tower and is attached to cable **220**. As the motor **218** drives the cable **220**, the rotary drive means **209** is moved up or down raising or lowering the drill string. There is thus provided a vertical positioning means for the drill string.

The combination of the rotary drive means **209** and the drive motor **218** with associated sprocket wheels and chain is known as a top head drive, to be distinguished from other conventional drilling arrangements which could be used with this invention such as the combination used in drilling oil wells comprising a rotary table and a hoist. The present invention is especially well suited for use with a top head drive.

Since the air supply for motor **218** passes through surface control means **216**, the vertical position means for the drill string is under the control of surface control means **216**. In perhaps its simplest form, as shown in FIGURE 6, control means **216** may comprise simply a normally closed spring loaded relief valve **230** disposed between air pipes **215**, **217** and set by means of adjustment **231** to open at a pressure somewhat higher, e.g. 2 p.s.i., than the normal operating pressure in drill string **205**. Whenever the telescopic choke **206** extends so far as to cause a pressure increase of 2 p.s.i., the relief valve **230** opens and actuates the vertical positioning means to lower the drill string.

An objection that may be made to the surface control means of FIGURE 6 is that most relief valves open rather gradually so that initially only a low volume of air would be fed to the sheave drive motor or top head feed **218**, insufficient to operate the motor which may for example have a rating of 15 horsepower. To operate such a motor a large pressure increase, e.g. 8 to 12 p.s.i., might be required to open most relief valves sufficiently. Such a large pressure increase would load the compressor unduly. Also, if the relief valve operates only after a large pressure rise, the slow response gives time for the telescopic choke to throttle down more which is also undesirable as previously explained. Therefore, a specially designed relief valve, e.g. a two-way snap acting valve, is required.

FIGURE 7 illustrates a modified surface control means that may be constructed with more conventional valving. In place of the simple spring loaded relief valve **230** of the FIGURE 6 construction, a pilot operated diaphragm relief valve **240** such as a Norgren A–1014B–04–A1 type valve manufactured by C. A. Norgren Co., 3400 S. Elati St., Englewood, Colo., may be employed. In connection with valve **240** is used a pressure regulator **241** such as a Norgren 11–002–019 pressure regulator. The regulator **241** is set by means of adjustment **242** to maintain a constant pressure slightly, e.g. 2 p.s.i., above the normal operating pressure of the drill string. The regulator **241**, fed from pipe **215** through pipe **243** discharges through pipe **244** to the top of valve **240** and normally maintains the valve **240** closed. If pressure in the drill string rises 2 p.s.i. above normal, relief valve **240** opens quickly and fully, thereby causing prompt operation of the vertical positioning means to lower the drill string.

The FIGURE 7 construction illustrates a surface control means which will be operating on-off at relative high frequency, e.g. once every second, and in conjunction with which the subsurface signal means or telescopic choke will be continuously maintained in a throttling position or close thereto. Operation of the vertical positioning means will be nearly continuous. A construction better suited for use in conjunction with a 12 inch stroke telescopic joint such as shown in FIGURES 1–4 is shown in FIGURE 8.

Referring now to FIGURE 8 there is shown normally closed, time delay on closing, main valve **250** taking the place of valve **230** or **240** in the control means of FIGURE 6 or 7. Valve **250** may, for example, be a Norgren A–1014B–04–A1, 2-Way In Line 0–60 second TDR (Delayed on release) Normally Closed Air Operated ½" Valve.

As shown in FIGURE 9, valve **250** includes a hollow body **251** having inlet port **252** and outlet port **253** separated by partition **254**. In partition **254** is a flow passage **255** over which is normally positioned valve disc **256**. The valve disc is urged against its seat **257**, formed by the periphery of flow passage **255**, by a helical spring **258**. Valve disc **256** is connected by valve stem **259** to actuating piston **260**. Piston **260** receives air through passage **261** of the time delay head **262**. Over the top of time delay head **262** is a cover **266** seated and slightly spaced from head **262** by a gasket **267**. A port **268** in cover **266** is adapted to connect to a source of actuating air.

Flow of air to passage **261** is controlled by spool valve **263** which in turn is connected to passage **264** through check valve **265** to port **268**. Spool valve **263** is shown in position to block flow of air to passage **261** so that valve **250** is closed: Air from the upstream inlet **252** is conducted through ports **270** and **271** to the left side of the core of the spool valve, always urging it to the left. However when actuating air is applied to port **268**, some of the air after going through check valve **265** enters passage **272** leading to air chamber **273**. The latter is connected by port **274** to the right end of the core of the spool valve. Since this end is larger than the other, the core moves to the left, opening port **264** and admitting air to actuating piston **260**, thereby opening the valve **250**. When the air supply port **268** is cut off, valve **250** stays open until the pressure in chamber **273** drops. Chamber **273** is vented to port **268** through a needle valve controlled by adjustment screw **269** and through passage **274**. When the core of the spool valve moves to the right, not only is port **264** cut off but port **276** is opened venting the space above actuating piston **260** to insure the opening of valve **250**. Since this is a commercially available valve, further detail of description is unnecessary. Furthermore, it is to be understood that other known time delay on reclosing valves may be used in place of the one described.

Referring again to FIGURE 8, to the port **268** in valve **250** is connected pipe **280** which in turn is connected to the outlet of a pilot operated diaphragm relief valve

281 which may in all respects be the same as valve 240 of the FIGURE 7 construction. Valve 281 receives air through pipe 282, solenoid valve 283, pipe 284, handgate valve 285, and pipe 286 from pipe 215. As in the FIGURE 7 construction, valve 281 is connected by a pipe 290 to a pressure regulator 291 which receives air through pipe 292 and pipe 282. Therefore, when solenoid valve 283 is closed both regulator 291 and pilot actuated valve 281 are shut off from air with the result that main valve 250 is closed This is the condition when the three-way switch 300 is in the off position.

When switch 300 is moved to the automatic position, current from battery 301 energizes the solenoid of valve 283 and opens the valve. If the pressure in line 215 rises above the normal operating pressure of the air in the drill string to the pressure at which regulator 291 is set, e.g., 2 p.s.i. above said normal operating pressure, the relief valve 281 opens quickly and fully and causes main valve 250 to open. This is quite similar to the operation of the control means of the FIGURE 7 construction. However, upon drop in pressure in pipe 215, the main valve 250 remains open for whatever period (0 to 60 seconds) it is set. The vertical positioning means continues to lower the drill string. The time of reclosing of valve 250 is set so that the drill string will be lowered enough to bring the telescopic joint to a position of near to full contraction well away from the throttling position thereof. Ultimately valve 250 recloses and the drive motor 218 of the vertical positioning means stops. The time delay (t) in the closing of valve 250 is related to the velocity (v) of down travel of the vertical positioning means and the distance (d) when it is desired to lower the drill string by the usual law

$$t=d/v$$

and in an actual case may be of the order of several seconds more or less, e.g. 3 seconds.

In case the normal pressure in pipe 215 should drop so as to render the automatic control system relatively unresponsive or if for any other reason it is desired to operate the vertical positioning means manually, switch 300 may be moved to the manual position. In that position solenoid valve 283 is closed but another solenoid valve 310 is opened. Valve 310 is connected by pipes 311, 312 between pipes 284 and 280 so that when valve 310 is open air is supplied to main valve 250 to open same and actuate the vertical positioning means to lower the drill string. When it is desired to discontinue lowering the drill string, switch 300 is moved to the off position and after the predetermined time delay valve 350 will close. Because of this time lag it will be understood that the driller desiring to operate the system manually would move switch 300 to the manual position only long enough to open valve 310 and would immediately thereafter move switch 300 to the off position, thus allowing the preset time delay of reclosing of main valve 250 to determine the time of down travel of the vertical positioning means.

In order to relieve the pressure in pipe 280 upon closing of overriding solenoid valve 310, a vent is provided through the valve stem to exhaust at 320. This exhaust is open only to the downstream side of valve 310 when the valve is closed. This vent also functions to relieve the pressure in pipe 280 upon closing of valve 281 during automatic operation of the system.

If it is desired to shut off both the automatic and manual (semi-automatic) controls and utilize the regular pure manual control provided on the drill, master gate valve 285 may be closed. Under such circumstances it may also be desirable to completely isolate the subject control system and to that end downstream gate valve 321 may be closed. Whenever it is desired to blow out any water or other foreign matter collected in the air pipes, exhaust gate valve 322 may be opened.

The switch 300 may be moved about to any place convenient to the driller. If electrical remote control is

considered undesirable for any reason, a three-way air valve may be used controlling air to air actuated valves substituted for solenoid valves 283, 310.

Although air operated valves have been shown in the control system, electric operated pressure sensing valves and operators can be substituted throughout the system. Also, the functions of the several physically separate components of the system can be combined into fewer components if desired. The disclosed consrtuction, however, does have the advantage of being capable of assembly out of presently commercially available components.

Referring now to FIGURES 10 and 11 there is shown another form the control means 216 can take. A pilot controlled relief valve 340, which may be the same as valve 240 of the FIGURE 7 construction, is placed between pipes 215 and 217. A pilot valve 341 is connected by pipe 342 to air supply pipe 215 and the outlet of valve 341 is connected through pipe 343 to relief valve 340. Whenever the pressure in pipe 215 rises a preset amount, pilot valve 341 opens and this in turn opens relief valve 340. Howver, when the pressure in pipe 215 drops due to actuation of the vertical positioning means by the opening of valve 340, pilot valve 341 is prevented from reclosing by mechanical locking means including a circular cam 344 and a cam follower 345. The cam follower is connected to the closure disc 346 of valve 341 through seal 347. The follower 345 holds the valve open except when the cam is positioned so that its notch 348 will receive follower 345 and allow valve spring 349 to close the valve.

Cam 344 is releasably connected by retractable pin 350 to one end of spool 351 on which are wound several turns of a wire 352. One end of wire 352 (see especially FIGURE 10) passes over sheave 219 and is anchored to the rotary drive means 209. The other end of wire 352 passes over a special sheave 353 rotatably mounted on tower 222 and is connected at its end to a weight 354 which either hangs freely as shown or is vertically slidable in guide means provided on the tower. The wire 352 and its associated sheaves and spool 251 and pin 350 thus provide drive means releasably interconnecting the drill string and cam 344 to cause the cam to rotate in proportion to the vertical travel of the drill string. This drive means is constructed so that one revolution of the cam corresponds to the desired downward travel of the drill string after the telescopic choke has signaled that it is time to lower the drill string. Whenever the pressure in pipe 215 rises to the value at which relief valve 341 is set, e.g. one or two percent above normal pressure in the drill string, valve 341 opens causing valve 340 to open to actuate motor 218 of the vertical positioning means. The latter then lowers the drill string and cam 344 rotates, the follower 345 being elevated out of notch 348 by the opening of valve 341. The valves 341 and 340 stay open and the motor 218 continues to operate until the cam has made one revolution positioning notch 348 under follower 345 and allowing valve 341 to close.

It will be readily apparent that valve 341 could itself be pilot operated the same as valve 240 is pilot operated by regulator 241 in the FIGURE 7 construction.

Instead of providing surface control means activating the vertical positioning means to lower the drill string a predetermined distance as shown in FIGURES 10 and 11, the surface means can be constructed to continue the actuation of the vertical positioning means until a further signal is received from the down hole signalling means. For example the telescopic joint may include a vent opened when the joint is near full extended to signal the surface by a drop in pressure and a choke that is actuated to raise the pressure when the joint is near full contraction. Such joint is shown in FIGURES 12, 13, and 14 and a suitable surface control means cooperable therewith is shown in FIGURE 15.

Referring now to FIGURES 12–14, the telescopic joint there shown includes an upper outer tubular member **400** having a threaded box **401** at its upper end adapted for connection in a drill string. The joint further includes a lower inner tubular member **402** axially slidably disposed in member **400**. As shown best in FIGURE 14, a bar **403** is mounted in holes **404**, **405** in member **400**, being welded in place. The bar **403** extends through slots **406**, **407** in member **402**, thereby providing means to transmit torque between the outer member **400** and inner member **402** while allowing relative axial motion therebetween. Bar **403** is of reduced transverse dimension at its mid-portion **408** to provide a maximum fluid passage through the joint.

Above bar **403** there is a choke means including a tapered throat **410** formed at the upper end of inner member **402**, and a tapered plug **411** carried at the lower end of stringer **412**. Stinger **412** is mounted in a spider **413** secured in outer member **400**, there being fluid passages between the webs of the spider. When the joint approaches full contraction, as limited by bar **403** engaging the lower ends of slots **406**, **407**, the plug **411** approaches seat **410** closely enough to provide a flow construction but not enough to block fluid flow.

Referring now particularly to FIGURE 13 below bar **403** the outer member carries a liner sleeve **415** pressed or shring fitted or otherwise secured in enlarged bore **416** in the lower end thereof. Sleeve **415** cooperates with split metal (steel) seal ring **417** snapped into groove **418** on the enlarged diameter position **419** at the lower end of inner member **402**. The telescopic joint is thus sealed against escape of air or other drilling fluid passing therethrough, but only so long as seal **417** is above longitudinal slots **420** in the lower end of sleeve **415**.

When the joint approaches full extension, as limited by engagement of bar **403** with the upper ends of slots **406**, **407**, the ring **417** passes below the upper ends of slots **420** allowing fluid inside the joint to escape. The escaping fluid, e.g. air, will pass through the clearance annulus between the inner member **402** and outer member **407** beginning at the upper end of the inner member adjacent throat **410** and thence down past liner sleeve **415**, through slots **420**, and the annular space **421** between enlarged portion **419** of the inner member and enlarged bore **416** in the outer member, and finally emerge through the clearance between guide hub **422** at the lower end of the inner member and bore **416** in the outer member.

Circumferentially spaced slots **423** extend longitudinally from adjacent annular space **421** to below the lower end **424** of the outer member when the joint is in near full extended position. Slots **423** thus provide fluid by pass means over the surface of hub **422**. Hub **422** can therefore be dimensioned to make a close sliding fit with the bore **416** as is desirable to enable the joint to transmit bending moments and to prevent wobble.

Inner member **402** has a further enlarged portion **430** below hub **422**. Wrench receiving flats **431**, **432** are formed in portion **430**. Similar flats **433**, **434** are formed at the upper end of the inner member as shown in FIGURE 12.

The telescopic joint shown in FIGURES 12–14 is similar to that shown in FIGURES 1–4 but differs in that it provides a fluid exhaust rather than a flow constriction when the joint approaches full extension. It thus signals the surface that the joint is near full extension by causing a drop rather than a rise in fluid pressure. When the driller notes the drop in pressure he can activate the vertical positioning means to lower the drill string. He can either lower the drill string a predetermined amount as in the use of the joint of FIGURES 1–4 or he can rely on the rise in pressure due to the floor construction as the joint approaches full contraction as a signal that the drill string has been lowered sufficiently. According to the present invention surface control means responsive to the pressure signals received from the joint are provided to automatically activate the vertical positioning means. This is shown in FIGURES 15 and 16 to which reference will now be made.

Referring also to FIGURE 5, pipe **450** of the FIGURE 15 surface control means is to be connected to pipe **215** which is connected to pipe **213** coming from the air storage tank **212** shown in FIGURE 5. It will be recalled that pipe **213** supplies air (or other drilling fluid) to drill string **205**. Therefore the pressure in pipes **213** and **215** and in pipe **450** connected thereto is subject to the pressure variations caused by the telescopic joint of FIGURES 12–14 which is to be used as the joint **206** shown in FIGURE 5.

When the pressure in pipe **450** drops, e.g. a few p.s.i., spring **451** overcomes the pressure acting on piston **452** and the latter moves to the left. As piston **452** moves to the left, piston rod **453** pushes stem **454** of spool valve **455** to the left. This opens port **456** to atmosphere and communicative port **457** with the interior of the body **457′** of the spool valve. As a result, fluid from pipe **458** passes through spool valve **455** to the left side of piston **459** forcing piston rod **460** to the right. Rod **460** is connected to stem **461** (FIGURE 16) of gate valve **462**, which is thereby opened. When valve **462** opens, air feeding from pipe **215** through pipe **463** is supplied to valve **464** which is similar to valve **340** shown in FIGURE 11. When valve **464** opens, air is fed through pipe **465** to top head drive motor **218** (FIGURE 5). This lowers the drill string **205**.

When the drill string lowers enough to close the vent passage means of the telescopic joint, the line pressure of the drilling fluid returns to normal and piston **452** (FIGURE 15) moves to the right, overcoming compression spring **451**. Stem **454** of spool valve **455** remains in the same position however and the vertical positioning means continues to lower the drill string.

When the drill string is lowered enough so that the telescopic joint approaches full contraction, the flow constriction means of the joint becomes active and causes a rise in pressure of the drilling fluid. When the line pressure thus rises, e.g. a few p.s.i., the pressure at the left of piston **470**, fed through pipe **470′** overcomes compression spring **471** and moves piston rod **472** to the right. This moves spool valve stem **454** to the right, as shown, opening port **457** to atmosphere and communicating port **456** with line pressure. Piston **459** is thus caused to move to the left, carrying with it stem **461** of gate valve **467**, thereby closing valve **462**. When pilot valve **462** closes, valve **464** closes and deactivates the vertical positioning means.

The operating pressures for pistons **452** and **470** can be adjusted by varying the prestress in springs **451** and **471**. This can be done by varying the position of screws **480** and **481** screwed into the ends of cylinders **482**, **483** respectively.

Referring now to FIGURE 17 there is shown a modification of the lower part of the telescopic joint of FIGURES 12–14. In this modification a sharp lipped bridge **500** is incorporated in one of the slots **421** leaving a narrow flow passage **501** between the lip of the bridge and bore **416**. Just below bridge **500** there is a vent port **502** extending through outer member **400**. When the joint approaches full extension and ring **417** passes below the upper ends of slots **421**, the air escaping past bridge **500** will create a sonic vibration, e.g. a whistle, whose pitch will depend on the length of the resonating air columns available, e.g. in slots **423**. Such sonic vibration means can be provided in each of the slots **421** if desired. Except as noted, the remainder of the lower part of the telescopic joint shown in FIGURE 17 is the same as that shown in FIGURE 13. The upper part of the telescopic joint will be the same as that shown in FIGURE 12, except that the flow construction means including stinger **412** and plug **411** may be omitted.

With a telescopic joint as described with reference to FIGURE 17 incorporated in the drill string at **206** (FIGURE 5), whenever the joint approaches full extension a sonic vibration is created which is detectable at the surface and can be used to actuate the vertical positioning means. FIGURE 18 shows a suitable surface control means to be used at **216** (FIGURE 5) in conjunction with the telescopic joint of FIGURE 17.

Referring to FIGURE 18, a michophone **520** placed in position to pick up acoustic vibrations in the drill string or drilling fluid, e.g. near or in contact with pipe **215**, generates an electric signal which is amplified by electric amplifier **521**. The signal passes through filter **522** which is tuned to pass only the band of frequencies of vibrations generated by the sonic signal of the telescopic joint, thereby to eliminate spurious signals. After passing through filter **522** the signal is transmitted to power amplifier **523** which is connected to relay **524**. When the relay is actuated by the signal to close switch **525**, battery **526** supplies current to open solenoid pilot valve **527**. When valve **527** opens, air is fed through pipes **528**, **529**, to time delay on closing valve **530**. The latter valve is similar to that shown in FIGURE 9. Valve **530** is thus opened and activates the vertical positioning means by supplying air through pipe **217** to motor **218** of the top head drive (FIGURE 5).

When the vertical positioning means has been actuated long enough to contract the telescopic joint to the point where its vent means is closed, the sonic signal is discontinued. However the vertical positioning means continues to operate during the time which valve **530** requires for closing. In this respect the operation is similar to that of the FIGURE 8 construction.

From the foregoing description it is to be understood that the invention includes down hole signalling means and surface control means responsive to signals from the down hole signalling means to control the vertical positioning means for the drill string. In one aspect the invention is characterized by signalling means operating by variations in the pressure of the drilling fluid, regardless of how such pressure variations are generated. In another aspect, the invention is characterized by signalling means dependent upon the relative positions of the parts of a telescopic joint, regardless of the nature of the signals generated, e.g. pressure rise, pressure fall, sonic vibrations, electric, magnetic, electromagnetic, or other form of signal. Furthermore, the features and the variations of the elements of each of the several constructions may be employed with any and all of the constructions described. For example, the override and remote control means of the FIGURE 8 construction could readily be added to the construction of FIGURES 10 and 11 or to the constructions of FIGURES 6, 7, 16, or 18. Likewise, electrically powered pressure sensitive valves and operators can be used with any of the several constructions in place of the air powered equipment shown in the drawings.

It is also to be understood that the drive motor **218** could easily be a hydraulic or an electric motor and that the main air control valves **215**, **240**, **250**, **340** of the several constructions of surface control means illustrated could in such case be replaced by hydraulic control valves or electric switches.

Finally, it is to be recalled that although the invention is especially adapted for use in air drilling, similar subsurface and surface controls can be used in drilling with other fluids such as gas, water, oil or mud.

In conclusion, although preferred embodiments of the invention have been shown and described, many modifications thereof can be made by one skilled in the art without departing from the spirit of the invention.

We claim:

1. An automatic drilling apparatus for making a hole in the earth, said apparatus comprising

a drill string including an upper portion and a lower portion,

a drill bit connected to the lower portion of said drill string,

positioning means at the upper portion of said drill string for raising and lowering same,

down hole signalling means responsive to the position of the drill bit, and

surface control means responsive to signals from the down hole positioning means to control said positioning means,

said signalling means signalling by generation of oscillating vibrations, and

said surface control means including means responsive to oscillating vibratory signals transmitted from said signalling means.

2. An automatic drilling apparatus for making a hole in the earth, said apparatus comprising

a tubular string including an upper portion and lower portion,

a drill bit connected to the lower portion of said drill string,

positioning means at the upper portion of said drill string for raising and lowering same,

down hole signalling means responsive to the position of the drill bit,

surface control means responsive to signals from the down hole positioning means to control said positioning means, and

means to cause flow of fluid under pressure through said drill string,

said signalling means signalling said surface control means by acting on said pressure fluid,

said signalling means including a whistle and said surface control means including a microphone.

3. An automatic drilling apparatus for making a hole in the earth, said apparatus comprising

a tubular string including an upper portion and a lower portion,

a drill bit connected to the lower portion of said drill string,

positioning means at the upper portion of said drill string for raising and lowering same,

down hole signalling means responsive to the position of the drill bit,

surface control means responsive to signals from the down hole positioning means to control said positioning means, and

means to cause flow of fluid under pressure through said drill string,

said signalling means signalling said surface control means by acting on said pressure fluid.

said signalling means acting on said pressure fluid to cause a change of pressure therein, and

said surface control means including means responsive to change of pressure of said fluid.

4. Combination of claim **3** wherein said signalling means causes a rise in pressure of said fluid to signal said surface control means to lower the drill string.

5. Combination of claim **3** wherein said signalling means causes a fall in pressure of said fluid to signal and surface control means to lower the drill string.

6. Combination according to claim **5** wherein said signalling means causes a rise in pressure of said fluid to signal said control means to discontinue lowering of said drill string.

7. Combination of claim **3** wherein said surface control means includes means responsive to receipt of a pressure change signal from said signalling means to cause lowering of said drill string.

8. Combination of claim **7** wherein said surface control means further includes means responsive to the passage of a predetermined time after receipt of said pressure change signal to cause discontinuance of lowering of said drill string.

9. Combination according to claim 7 wherein said surface control means includes means responsive to lowering of the drill string a predetermined distance to cause discontinuance of the lowering of the drill string.

10. Combination according to claim 7 wherein said surface control means includes

a fluid conduit communicating at one end with said pressure fluid adjacent the upper portion of said drill string and at another end with said vertical positioning means, and

valve means in said fluid conduit responsive to pressure of said fluid to open and close.

11. Combination according to claim 10 wherein said valve means includes

a pilot controlled valve having a through flow passage connected in said conduit and a control chamber connected through a line to said conduit upstream from said pilot controlled valve, and

a pilot valve means in said line responsive to pressure in said line upstream from said pilot valve means to open and close said pilot valve means.

12. Combination according to claim 11 wherein said pilot controlled valve includes time delay means to delay return to normal position until a predetermined time after actuation by said pilot valve means.

13. Combination of claim 12 wherein said pilot valve means includes cam means driven in response to the motion of said drill string to prevent return of said pilot valve means to normal following actuation thereof until said drill string has been lowered a predetermined amount.

14. Combination according to claim 12 wherein said pilot valve means includes

an auxiliary pilot controlled valve having a flow passage connected in said line and a control chamber connected to said line by a pipe, and

a pilot valve in said pipe responsive to pressure in said pipe upstream from said pilot valve to open and close said pilot valve.

15. Combination according to claim 14 including

a remote controlled solenoid valve means controlling fluid flow to said pipe and said line to deactivate said control means when desired,

a bypass connecting said control chamber of the first said pilot controlled valve to said fluid conduit independently of said line, and

a second remote controlled solenoid valve means controlling flow of fluid through said bypass to actuate said control means in response to the position of said second remote controlled solenoid valve means.

16. An automatic drilling apparatus for making a hole in the earth, said apparatus comprising

a drill string including an upper portion and a lower portion,

a drill bit connected to the lower portion of said drill string,

positioning means at the upper portion of said drill string for raising and lowering same,

down hole signalling means responsive to the position of the drill bit, and

surface control means responsive to signals from the down hole positioning means to control said positioning means,

said drill string including a telescopic joint,

said joint having a first part connected to said upper portion of the drill string and a second part connected to said lower portion of the drill string to which the drill bit is connected,

said signalling means responding to predetermined positioning of said second part relative to said first part to signal to the surface control means to actuate the positioning means to lower the upper portion of the drill string,

said surface control means including means responsive to the passage of a predetermined time after initiation of the actuation of said positioning means to cause discontinuance of the operation of said positioning means.

17. An automatic drilling apparatus for making a hole in the earth, said apparatus comprising

a drill string including an upper portion and a lower portion,

a drill bit connected to the lower portion of said drill string,

positioning means at the upper portion of said drill string for raising and lowering same,

down hole signalling means responsive to the position of the drill bit,

surface control means responsive to signals from the down hole positioning means to control said positioning means,

said drill string including a telescopic joint,

said joint having a first part connected to said upper portion of the drill string and a second part connected to said lower portion of the drill string to which the drill bit is connected,

said signalling means responding to predetermined positioning of said second part relative to said first part to signal to the surface control means to actuate the positioning means to lower the upper portion of the drill string,

said surface control means including means responsive to the lowering of said upper portion of the drill string a predetermined distance after initiation of the lowering of the upper portion of the drill string to cause discontinuance of the operation of said positioning means.

18. An automatic drilling apparatus for making a hole in the earth, said apparatus comprising

a drill string including an upper portion and a lower portion,

a drill bit connected to the lower portion of said drill string,

positioning means at the upper portion of said drill string for raising and lowering same,

down hole signalling means responsive to the position of the drill bit,

surface control means responsive to signals from the down hole positioning means to control said positioning means,

said drill string including a telescopic joint,

said joint having a first part connected to said upper portion of the drill string and a second part connected to said lower portion of the drill string to which the drill bit is connected,

said signalling means responding to predetermined positioning of said second part relative to said first part to signal to the surface control means to actuate the positioning means to lower the upper portion of the drill string,

said signalling means responding in a second predetermined position of the second part of the telescopic joint relative to the first part to signal to the surface control means to discontinue actuation of the positioning means.

19. An automatic drilling apparatus for making a hole in the earth, said apparatus comprising

a drill string including an upper portion and a lower portion,

a drill bit connected to the lower portion of said drill string,

positioning means at the upper portion of said drill string for raising and lowering same,

down hole signalling means responsive to the position of the drill bit,

surface control means responsive to signals from the down hole positioning means to control said positioning means,

said drill string including a telescopic joint,

said joint having a first part connected to said upper portion of the drill string and a second part connected to said lower portion of the drill string to which the drill bit is connected,

said signalling means responding to predetermined positioning of said second part relative to said first part to signal to the surface control means to actuate the positioning means to lower the upper portion of the drill string,

said fluid driving means including regulator means tending to maintain a constant rate of flow of fluid down through said upper part of the drill string, and

said signalling means including flow resistance varying means to vary the resistance to fluid flow downstream from the upper portion of said drill string.

20. Combination of claim **19** wherein said flow resistance varying means comprises flow constriction means in said telescopic joint to restrict flow when said second part of the telescopic joint is in said predetermined position relative to said first part of the telescopic joint.

21. Combination of claim **19** wherein said flow resistance varying means comprises vent means to vent fluid from said telescopic joint when said second part of the telescopic joint is in said predetermined position relative to said first part of the telescopic joint.

22. Combination according to claim **19** wherein said signalling means responds in a second predetermined position of the second part of the telescopic joint relative to the first part to signal to the surface control means to discontinue actuation of the positioning means, and

said flow resistance varying means comprises vent means to vent fluid from said telescopic joint when said second part of the telescopic joint is in the first said predetermined position relative to said first part of the telescopic joint and flow constriction means in said telescopic joint to restrict flow when said second part of the telescopic joint is in said second predetermined position relative to said first part of the telescopic joint.

23. An automatic drilling apparatus for making a hole in the earth, said apparatus comprising

a tubular drill string including an upper portion and a lower portion,

a drill bit connected to the lower portion of said drill string,

positioning means at the upper portion of said drill string for raising and lowering same,

down hole signalling means responsive to the position of the drill bit,

surface control means responsive to signals from the down hole positioning means to control said positioning means,

said drill string including a telescopic joint,

said joint having a first part connected to said upper portion of the drill string and a second part connected to said lower portion of the drill string to which the drill bit is connected,

said signalling means responding to predetermined positioning of said second part relative to said first part to signal to the surface control means to actuate the positioning means to lower the upper portion of the drill string,

fluid driving means to transfer fluid under pressure through said drill string,

said signalling means signalling said surface control means by acting on said pressure fluid, and

down hole percussor means in said drill string between said drill bit and telescopic joint,

said predetermined position of said second part of the telescopic joint relative to said first part corresponding to near full extension of said joint.

24. Combination according to claim **23** wherein said vertical positioning means forms part of a top head drive for said drill string.

References Cited

UNITED STATES PATENTS

1,891,062	12/1932	Sager	175—26
1,891,329	12/1932	Le Compte et al.	175—317 X
3,039,543	6/1962	Loocke	175—26
3,223,183	12/1965	Varney	175—27

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175—321

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,463,252 August 26, 1969

Charles E. Miller et al.

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 7, line 27, before "220" insert -- cable --. Column 14, lines 10, 28 and 47, Column 15, line 61, Column 16, lines 13, 43 and 71, and Column 18, lines 1 and 6, "positioning", first occurrence, each occurrence, should read -- signalling -- Column 14, lines 19 and 38, after "tubular", each occurrence, insert -- drill --; line 61, "and" should read -- said --. Column 15, line 9, cancel "vertical". Column 17, line 7, "said" should read -- and --; line 9, cancel "and". Column 18, line 28 cancel "vertical".

Signed and sealed this 29th day of June 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
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Commissioner of Patents