United States Patent [19]

Persson

[11] **3,889,959**

[45] **June 17, 1975**

[54] **EARTH DRILLING APPARATUS**

[75] Inventor: **Jan Edvard Persson,** Nacka, Sweden

[73] Assignee: **Atlas Copco Aktiebolag,** Nacka, Sweden

[22] Filed: **Aug. 2, 1973**

[21] Appl. No.: **384,953**

[30] **Foreign Application Priority Data**

Aug. 7, 1972 Sweden 10239/72

[52] **U.S. Cl.** **277/27;** 166/315; 173/74; 175/25; 175/64; 175/212; 175/218; 251/1

[51] **Int. Cl.** **E21b 33/06**

[58] **Field of Search** 251/1, 5; 166/53, 82, 84; 175/25; 277/3, 31, 34, 28, 27

[56] **References Cited**

UNITED STATES PATENTS

2,192,805	3/1940	Seamark	277/31
2,590,215	3/1952	Sausa	251/5 X
3,145,995	8/1964	Adamson et al.	166/53 X
3,492,007	1/1970	Jones	166/84 X
3,614,111	10/1971	Regan	251/1 X

Primary Examiner—Martin P. Schwadron
Assistant Examiner—Richard Gerard
Attorney, Agent, or Firm—Flynn & Frishauf

[57] **ABSTRACT**

A drilling apparatus for pressure drilling through the earth, comprising a drill string, a casing tube assembly, a rotary drilling machine with mechanized drill string handling and a liquid handling system. The liquid handling system comprises means for controlling the casing tube pressure and the liquid level within the drill string during withdrawal and disconnection of the drill string. At disconnecting a drill string section, a pressure air impulse is introduced into the flushing channel thereof so as to lower the liquid level and thereby avoid liquid over-flow at the top of the casing tube. A back-flow restricting valve prevents rapid rising of the liquid level within the drill string. A preventer unit having a pressure balanced packing sleeve seals off the upper end of the casing tube; the contact pressure of said packing sleeve is automatically and continuously adapted to the actual casing tube pressure by means of a pressure responsive control valve which is arranged to release the packing sleeve from pressure in response to decreasing casing tube pressure.

12 Claims, 4 Drawing Figures

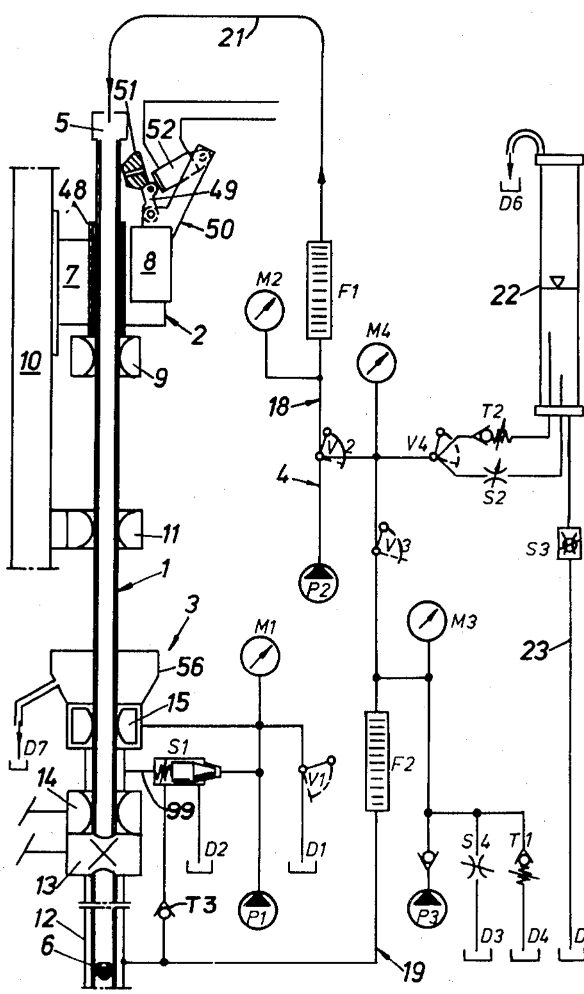
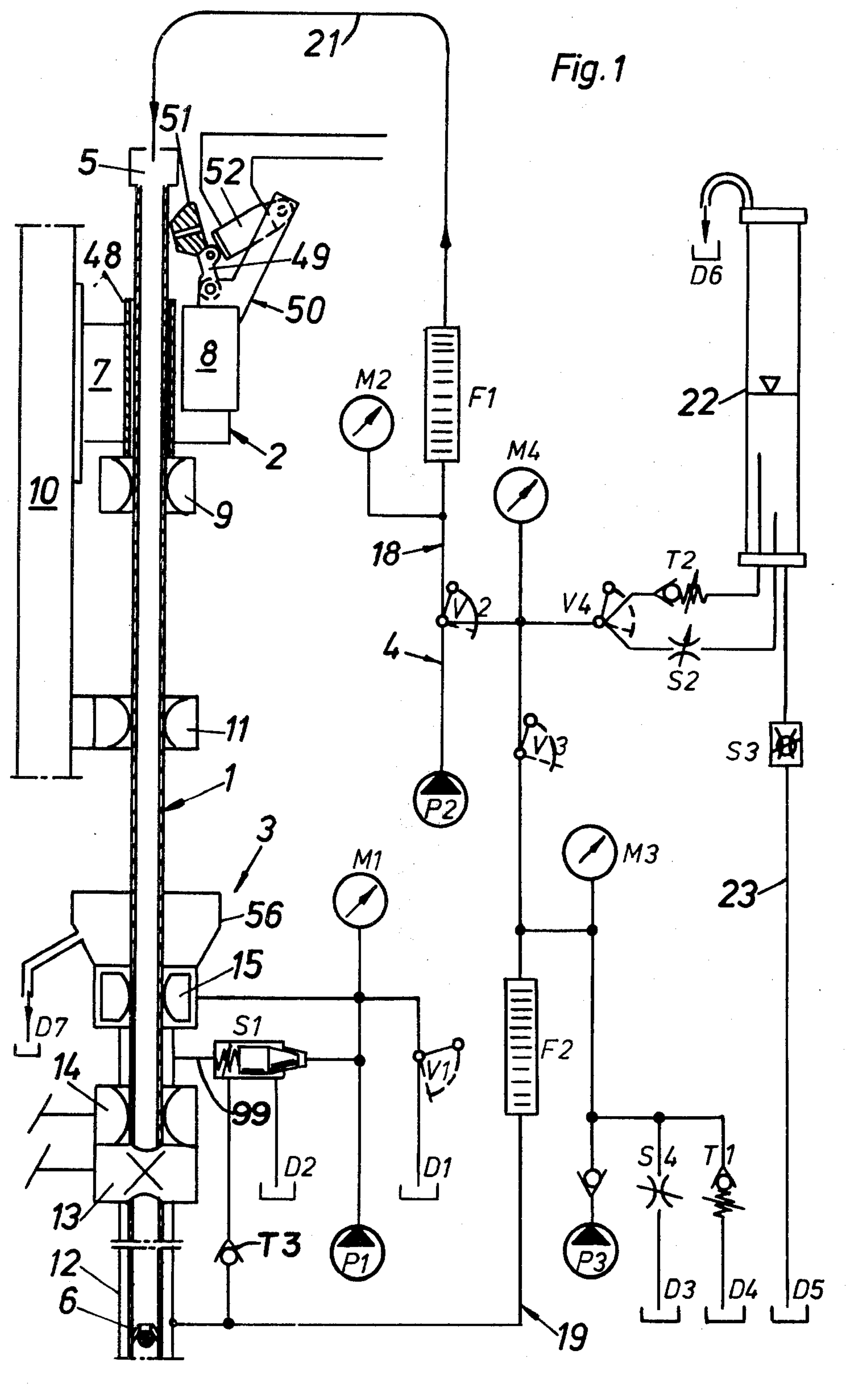


Fig. 1


21
51
5
52
48
49
50
7
8
2
10
9
M2
F1
M4
22
D6
18
T2
V2
V4
4
S2
11
V3
S3
1
P2
3
M1
M3
56
23
15
D7
S1
V1
F2
14
99
D2
D1
S4
T1
13
T3
P1
P3
12
D3
D4
D5
6
19

PATENTED JUN 17 1975

3,889,959

SHEET 2

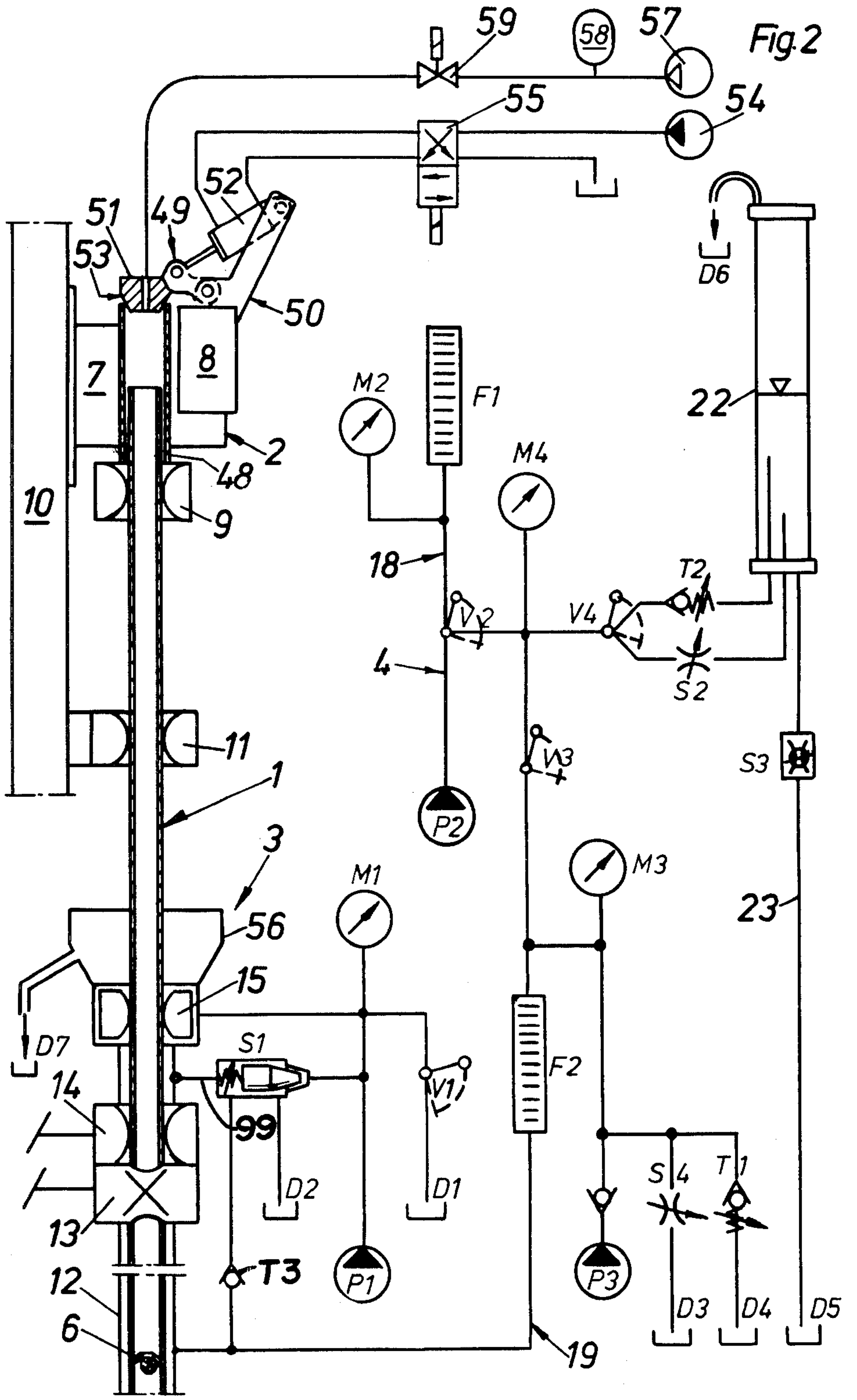


Fig. 3

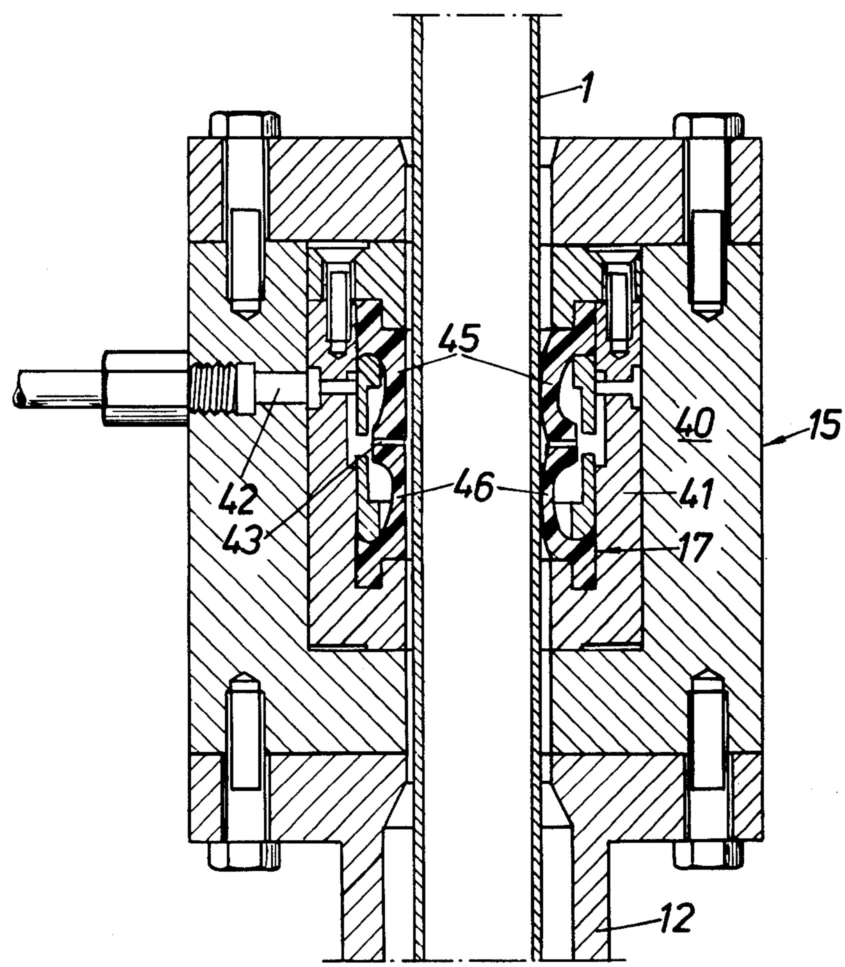
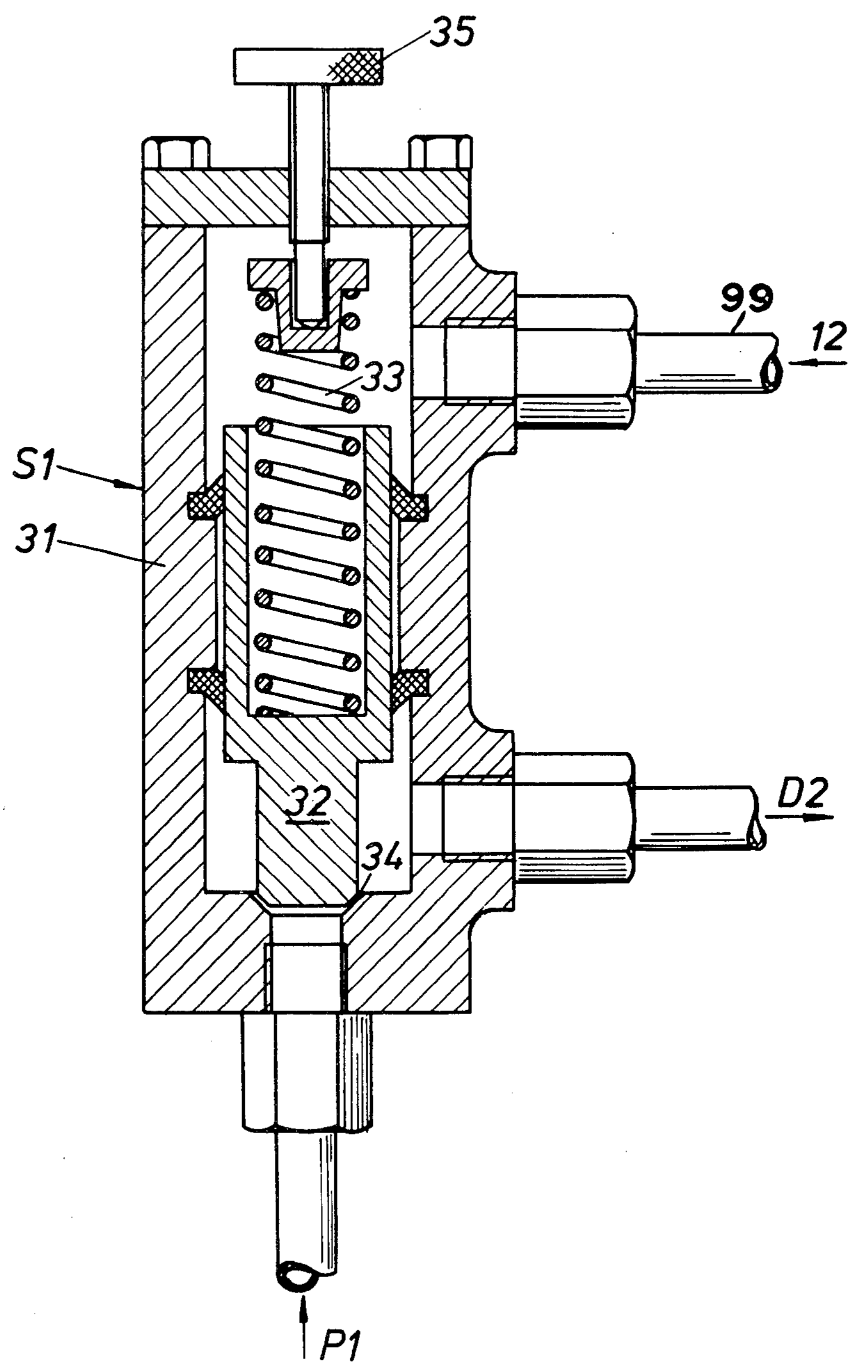


Fig. 4



EARTH DRILLING APPARATUS

This invention relates to a drilling apparatus for pressure drilling through the earth, and more particularly to a device for maintaining the drill hole pressure during withdrawal and disconnection of the drill string.

An object of the invention is to provide a preventer unit for sealing off the casing tube during drilling and vertical travel of the drill string, the preventer being provided with a long-life packing sleeve.

A further object of the invention is to provide a means for controlling the contact pressure of the preventer unit packing sleeve with respect to the casing tube pressure.

Further objects and advantages of the invention will be apparent from the detailed description and the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1** and **2** schematically show a drilling apparatus according to the invention, FIG. **1** showing the drilling apparatus in its drilling position, and FIG. **2** showing the drill string withdrawing position and also showing a pressure air injection device;

FIG. **3** is a longitudinal section through a preventer unit according to the invention, the preventer unit being shown in its active, as well as in its non-active position; and

FIG. **4** shows a longitudinal section through a pressure control valve intended for adapting the contact pressure of the preventer unit in correspondence to the actual pressure in the casing tube.

DETAILED DESCRIPTION

The drilling apparatus shown in FIG. **1** comprises mainly a drill string **1,** a drilling machine **2** for rotating the drill string **1,** a casing tube assembly **3** and a liquid handling system **4.**

The drill string **1** is constituted by a number of conventional drill tube sections and is terminated at its forward or lower end by a core tube provided with an annular diamond bit. (Not shown). At its rear or upper end, the drill string **1** is provided with a water swivel **5** and adjacent its forward end, the drill string is provided with a backflow restricting valve **6.** The valve **6** has to be located above the core tube.

The backflow restricting valve **6** is in fact a check valve provided with a restricted by-pass opening through which the drill string is slowly filled up when it is lowered down into a water containing hole. The by-pass opening should be of such a size that the drill string is filled up with water as it has reached the bottom of the hole. Thereby, the drilling operation can be started immediately.

The drilling machine **2** comprises a housing **7,** a motor **8,** a rotating chuck **9,** a feeding device **10** for accomplishing longitudinal movements of the drilling machine and a stationary chuck **11.** The drilling machine **2** is intended for positive feeding, retracting and disconnecting the drill string. Such a drilling machine is shown in Swedish patent No. 324,747, corresponding to U.S. Pat. No. 3,613,804.

The casing tube assembly **3** comprises a casing tube **12,** a gate valve **13** located at the upper end of the casing tube and intended for closing the casing tube when the drill string is withdrawn. The casing tube assembly also comprises an emergency preventer **14** of a conventional type for sealing off the casing tube **12** when the drill string **1** is present therein but stationary. Finally, the casing tube assembly comprises a preventer unit **15** according to the invention, the object of which is to seal off the casing tube **12** during drilling and withdrawal of the drill string. The main component of the preventer unit **15** is an annular pressure fluid actuated packing sleeve **17** (see FIG. **3**). The preventer unit **15** is herebelow described in detail.

The liquid handling system **4** is intended for providing the drill hole with flushing medium through the drill string **1.** The liquid handling system **4** comprises means for restricting the return flow in order to establish an over-atmospheric pressure in the drill hole. For that purpose the liquid handling system **4** is split up into two main branches, namely one feed branch **18** and one return branch **19.** The feed branch **18** comprises a pump **P2,** a manometer **M2** and a flow meter **F1** and is connected to the water swivel **5** through a conduit **21.**

The return branch **19** of the liquid handling system **4** is connected to the casing tube **12** through a conduit and comprises a flow meter **F2,** a manometer **M3** and a variable restricting device **S2.** Moreover, the return branch **19** contains a more sensitive flow meter **22** which is connected downstream of the restricting means **S2.** Flow meter **22** is provided with an outlet conduit **23** containing a variable restricting means **S3.** Further, the sensitive flow meter **22** includes a vessel having one of its walls made of a transparent material. Through this wall, the liquid level within the vessel is observable from the outside. Rising or sinking of the liquid level indicates variations in the return flow. The vessel is also provided with an overflow outlet **D6** through which drill hole gas is exhausted. Owing to the fact that the return flow branch **19** of the liquid handling system is closed up to the flow meter **22,** it is possible to control the gas outlet. Such a gas is very often unhealthy.

The return flow branch **19** also contains a constant pressure valve **T2** which is arranged in parallel with the flow restricting means **S2** and connected to the three-position valve **V4.** During intermittent flow in the system the valve **T2** is put into action by shifting the valve **V4.**

The return flow branch **19** of the liquid handling system **4** also contains a variable displacement pump **P3** and two additional outlets **D3** and **D4.** The outlet **D3** contains a flow restricting means **S4** and the outlet **D4** contains a safety valve **T1** the opening pressure of which is adjustable and normally set on the top pressure limit of the casing tube. This part of the system, together with the flow meter **F2** and the manometer **M3,** is suspendable from the rest of the system by means of a valve **V3.**

The pump **P3** is driven by a pressure compensated hydraulic motor (not shown) and is intended to be put into work in order to maintain the drill hole pressure and thereby avoid collapsing of the drill hole wall if the regularly working pump **P2** is stopped or if the liquid loss in the hole rapidly increases. In the latter case, the pump **P3** can be supplied with a thicker flushing liquid in order to obtain a choking up of the high-porous formations.

The feed and return flow branches **18** and **19,** respectively, are interconnected by a conduit comprising a three-position valve **V2** and a manometer **M4** which is intended for calibration purposes.

Furthermore, the drilling apparatus comprises a pressure fluid system for actuating the preventer unit **15.** This pressure fluid system comprises a pump P1 and is connected to the casing tube **12** via a pressure control valve S1.

The pressure control valve S1 comprises a housing **31** and a spring biased valve piston **32** (see FIG. 4). The valve piston **32** is biased in one direction partly by means of a pressure spring **33** and partly by the casing tube pressure through a pressure sensing conduit **99.** The biasing force of the spring **33** is adjustable by a screw **35.** The valve piston **32** is also exposed to a counter-directed force constituted by the pressure from the pump P1. The pump pressure actuated end of the valve piston **32** is of a smaller diameter than the opposite end and is provided with a valve seat portion for cooperation with an annular seat **34** in the housing. The housing **31** is provided with an outlet D2 which is so located that, when the piston **32** is pushed away from the seat **34** by the pump pressure, the pump is drained through the outlet D2.

As the pump P1 has a determined flow capacity, the pressure in the system which is the pressure acting upon the packing sleeve **17** of the preventer unit **15** is dependent on the size of the drainage opening. The drainage opening is defined by the seat **34** and the valve piston **32.** Oppositely, the opening force acting upon the valve piston is dependent on the pressure in the system. The size of the drainage opening is also dependent on the counter directed force of the spring **33** and the casing tube pressure which act upon the opposite end of the valve piston. Thus, the latter is acted upon by two oppositely directed fluid pressures and gives at a certain setting of the spring force a greater drainage opening when the pressure in the casing tube decreases. The result of that is that the pressure in the system as well as the pressure acting upon the packing sleeve **17** decreases. The relationship between the pressure in the casing tube and the pressure in the liquid system can be adjusted by means of the screw **35.** The pressure fluid system can be drained to an outlet D1 by means of a valve V1.

Moreover, the pressure fluid system contains a manometer M1 and a conduit for connection with the return flow branch **19** of the liquid handling system, which conduit contains a check valve T3.

Referring to FIG. **3,** the preventer unit **15** comprises a housing **40** which is provided with a central opening for the drill string **1.** Within the housing **40** there is rotatably mounted a retainer ring **41** which is connected to the pressure fluid system through an opening **42** in the housing **40.**

The packing sleeve **17** is rigidly secured in the retainer ring **41** in such a way that pressure fluid from the pump P1 has access to its outside for applying a radial contact force and make it engage the drill string with its inside. To the left in FIG. **3,** the packing sleeve **17** is shown in its pressure released rest position and to the right in the same figure the packing sleeve **17** is shown in its active position.

As seen in FIG. **3,** the packing sleeve **17** is provided with two axially spaced contact portions **45** and **46** which are intended to cooperate with the drill string when the packing sleeve is pressurized.

During axial movement of the drill string **1,** the packing sleeve **17** slides along the drill string. In order to limit the friction force arising upon the packing sleeve **17,** the latter is provided with a number of small diameter leakage openings **43** which are located intermediate the contact portions **45** and **46.** Through these leakage openings **43,** pressure fluid is able to leak out between the packing sleeve **17** and the drill string **1.** Thereby, a pressure balancing of the packing sleeve is accomplished. By this arrangement not only a limitation of the contact pressure between the packing sleeve and the drill string is obtained but also a lubrication of the contact surfaces.

As the difference between the actuating pressure of the packing sleeve **17** and the drill hole pressure is less than the difference between the actuating pressure and the atmosphere, the sleeve **17** may very well be non-symmetric, which means that it is thicker at its upper end than at its lower end. In order to obtain an equal pressure balancing and lubrication of the packing sleeve **17** throughout its length, the leakage openings may be placed somewhat closer to that end of the packing sleeve which is closest to the drill hole. The packing sleeve **17** may very well be made of rubber or plastic. As water is used as pressure fluid in the system, it is very easy to obtain lubrication of the retainer ring **41** by using bearing surfaces made of rubber, plastic and the like. By this arrangement the bearing surfaces of the retainer ring do not have to be packed in.

FIG. **2** shows the same drill equipment as FIG. **1** but in FIG. **2** it is shown in position "withdrawal of the drill string". In this position, the water swivel **5** is disconnected from the rear end of the drill string and a hydraulically operated air injection device **50** is fitted. The object of this device is to connect the drill string **1** to a pressure air source. To obtain a proper connection between the air injection device and the drill string, the drilling machine **2** is provided with a coupling sleeve **48** which extends rearwardly from the rotatable chuck **9.**

The air injection device **50** comprises a swing arm **49** upon which is mounted a tapered connecting member **51.** The connecting member **51** is movable by means of the swing arm between an active position (as in FIG. **2**) and a non-active position (as in FIG. **1**) and is provided with a conical outer surface **53** for cooperation with the rear end of the coupling sleeve **48.** The swinging arm **49** is actuated by means of a hydraulic cylinder **52** which is connected to a pump **54** via a control valve **55.**

The pressure air system which communicates with the connecting member **51** comprises a compressor **57,** a pressure air tank **58** and a control valve **59.**

The operation order of the above described drilling equipment is the following.

At the start of the drilling operation, the lower part of the drill string **1** containing the drill bit, the core tube and the backflow restricting valve **6** is introduced through the drilling machine **2** and the casing tube assembly **3.** Thereafter, the drilling operation is carried out in a conventional manner in that the chuck **9** rotates the drill string **1** at the same time as the feeding device **10** forces the drill string **1** downwards. The feed branch **18** of the liquid handling system **4** is connected to the drill string by means of the water swivel **5.** During drilling, the safety preventer **14** and the gate valve **13** are fully opened, while the preventer unit **15** is activated by the pressure fluid system pump P1. The drill hole is continuously flushed by a liquid delivered by the pump P2, the feed pressure being indicated at the manometer M2 and the fluid flow being indicated at the flow meter F1. The flushing liquid is pumped down the hole through the interior of the drill string 1 and returns to the surface at the outside of the drill string. As the drill hole is closed by means of the preventer unit 15, the flushing liquid is forced out into the return flow branch 19 of the liquid handling system 4. Because of porosity in the penetrated formations, losses of flushing liquid always occur, which means that the return flow is less than the feed flow. The actual return flow is indicated on the flow meter F2.

During drilling, the valve V3 is open, the valve V2 is closed between the feed branch 18 and the return flow branch 19 and the valve V4 is open toward the flow restricting means S2. The pressure in the return flow branch 19 is indicated on the manometers M4 and M3.

At the beginning of the drilling operation, the flow restricting means S2 and S3 is set so as to match an estimated return flow or so as to match a certain loss of liquid in the drill hole. The restriction means S2 gives a desirable return flow pressure. The restriction means S3 should be set so that the liquid level within the vessel 22 remains stationary at a certain level. If a considerable increase or decrease in the flush liquid losses occurs, it could be observed upon the flow meter F2. On the other hand, if the liquid losses in the drill hole are diminutive, it could be observed upon the flow meter 22. The flow meter 22 is very sensitive because of the fact that even a very little change in return flow is indicated as a successive rising or sinking of the liquid level. This high sensitivity makes it possible to discover gas inflow into the drill hole at an early stage which is very important from the safety point of view, because the operators get more time for taking precautionary measurements in order to avoid blow-outs.

In order to maintain the liquid pressure in the drill hole, when the water swivel 5 and the feed branch 18 of the liquid handling system is disconnected from the drill string 1, the valve V2 is closed toward the water swivel and the valve T2 is activated by shifting the valve V4. By this arrangement the liquid pressure in the drill hole is maintained.

Owing to the fact that the hydrostatic pressure within the drill hole increases as the depth of the drill hole increases, the pressure of the flushing liquid has to be adapted thereto in order to control occurring gas inflow into the drill hole. For making the preventer unit 15 seal off the drill hole around the drill string at increasing pressure, a higher contact pressure has to be applied upon the packing sleeve 17. This pressure adaptation is accomplished by the pressure control valve S1 which communicates with the casing tube 12 through the pressure sensing conduit 99. As the casing tube pressure increases, the pressure required to obtain drainage of the pump P1 also increases. This means that the drainage of the pump P1 decreases and the pressure in the pressure fluid system as well as the contact pressure of the preventer unit packing sleeve 17 increases. The actual pressure in the pressure fluid system can be observed on the manometer M1 and could be adapted manually by setting of the screw 35 of the pressure control valve S1.

At withdrawal and disconnection of the drill string 1, which is carried out in a common way by cooperation between the chucks 9 and 11 of the drilling machine and the feeding device 10, the water swivel 5 is disconnected, whereby the liquid pressure within the drill string ceases. In order to prevent the liquid within the drill string from rising and overflowing the drilling machine above the preventer unit 15, the connecting member 51 is swung into engagement with the coupling sleeve 48. Pressure air is introduced into the drill string in the form of a pressure air impulse. The purpose of the pressure air impulse is to press down the liquid level within the drill string a certain distance below the uppermost drill string joint. Then, the air injection device 50 is disconnected by shifting of the valve 55 and the uppermost drill string section is disconnected. As soon as the disconnected drill string section has been removed, the pressure air system is reconnected to the drill string.

The liquid level within the drill string has to be lowered to such a low level that a pressure that may remain in the drill string, is not able to raise the liquid level up to the section joint that has just been broken during the time interval when the air injection device is removed. The liquid level rising speed depends on the size of the by-pass opening of the backflow restricting valve 6. If the by-pass opening through this valve 6 has a proper size the liquid level does not reach the upper end of the drill string and any liquid overflow does not occur. At the top of the casing tube assembly 3, there is mounted a funnel 56, the object of which is to collect overflowing liquid in the case the liquid level rises too fast in the drill string. The funnel is provided with an outlet D7 through which liquid is drained to the tank.

As previously mentioned, an annular diamond bit is used and a core is formed throughout the hole. For that purpose, a single-walled core tube is used in order to obtain greatest possible core diameter. This means that the drill string has to be withdrawn from the drill hole every time the core tube has to be emptied. However, the drilling machine of the above described type, is especially well fitted for that purpose in that handling of the drill string sections is fully mechanized, and connection and disconnection of the drill string section is carried out very fast.

On the other hand, the single-walled core tube makes it possible to use a thin-walled drill bit which requires quite a little power with regard to rotation as well as feeding movements. Furthermore, this method makes it possible to continuously obtain information about the penetrated formations.

With the shown drilling apparatus a light and low-viscous flushing liquid is used, the density of which substantially corresponds to that of water. However, the flushing liquid contains some additives for instance for transportation of drill cuttings and for stabilizing the drilled hole. For the stabilizing purpose, the cuttings produced are used as reinforcement in the drill hole walls. The invention is not limited to the shown and described embodiment but can be freely varied within the scope of the claims.

What I claim is:

1. Preventer unit for establishing a seal between a casing tube and a drill stem during pressure drilling through the earth, comprising an elastic packing sleeve rotatably mounted on the casing tube, the outside of said packing sleeve communicating with a pressure fluid source for applying a contact pressure upon the drill string, said preventer unit further comprising a pressure control valve which is connected to said fluid pressure source as well as to the casing tube pressure and which is arranged to automatically adapt the packing sleeve contact pressure in response to the casing

tube pressure by controlling a pressure fluid source drainage.

2. Preventer unit according to claim 1, wherein the pressure control valve comprises a housing containing a slidable valve piston, a valve seat and a drain outlet, said valve piston being provided with a valve seat matching surface at its one end which communicates with said pressure fluid source, while its other end communicates with the casing tube pressure, said drain outlet being connected to said pressure fluid source via the valve seat.

3. Preventer unit according to claim 2 wherein the packing sleeve is provided with at least one leakage opening through which pressure fluid has access to the inner surface of the packing sleeve.

4. Preventer unit according to claim 1, wherein the packing sleeve is provided with at least one leakage opening through which pressure fluid has access to the inner surface of the packing sleeve.

5. Preventer unit according to claim 4, wherein the packing sleeve has two axially spaced contact portions between which said leakage opening is located.

6. Preventer unit according to claim 4 wherein said at least one leakage opening extends from a radially outer surface of the packing sleeve to the inner surface of the packing sleeve.

7. Preventer unit according to claim 4 wherein said

packing sleeve is thicker at its upper end than at its lower end and wherein said at least one leakage opening is located closer to the lower end of said packing sleeve than to the upper end thereof.

8. Preventer unit according to claim 1 wherein said packing sleeve is thicker at its upper end than at its lower end.

9. Preventer unit according to claim 1 wherein said pressure control valve controls said pressure fluid source drainage so as to cause the packing sleeve contact pressure to increase in response to increasing casing tube pressure.

10. Preventer unit according to claim 9 wherein said pressure control valve decreases the pressure fluid source drainage in response to increasing casing tube pressure.

11. Preventer unit according to claim 1 wherein said pressure control valve controls said pressure fluid source drainage so as to cause the packing sleeve contact pressure to decrease in response to decreasing casing tube pressure.

12. Preventer unit according to claim 11 wherein said pressure control valve increases the pressure fluid source drainage in response to decreasing casing tube pressure.

* * * * *