Sept. 14, 1965 F. WHITTLE 3,205,955

DRILL STRING VALVE

Filed Jan. 21, 1963 3 Sheets-Sheet 1

Fig. 1.

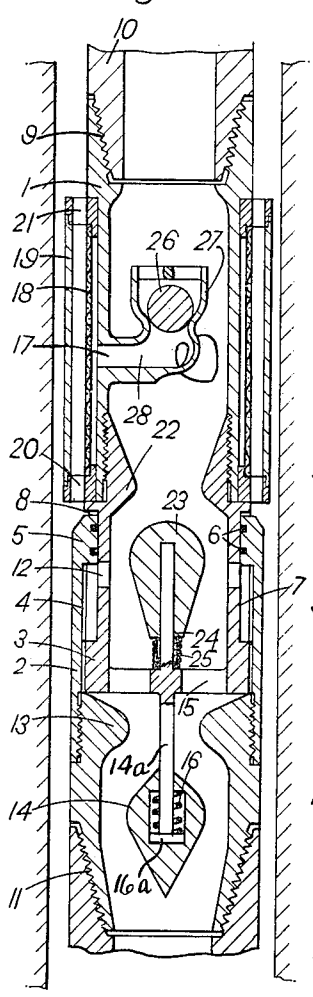

Fig. 2

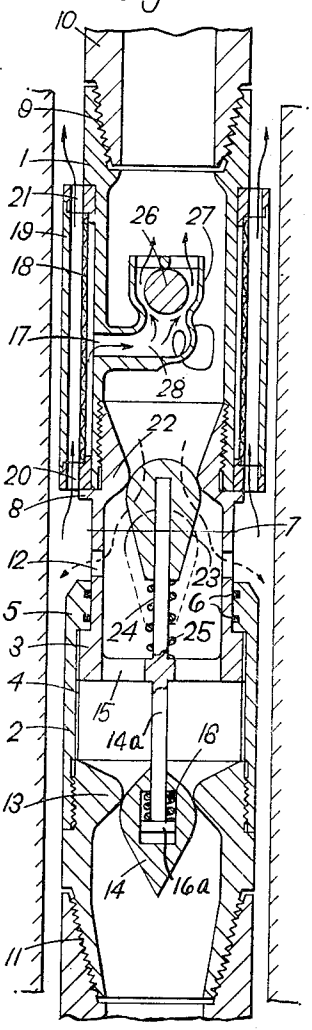

Fig. 3

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Sept. 14, 1965 F. WHITTLE 3,205,955

DRILL STRING VALVE

Filed Jan. 21, 1963 3 Sheets-Sheet 2

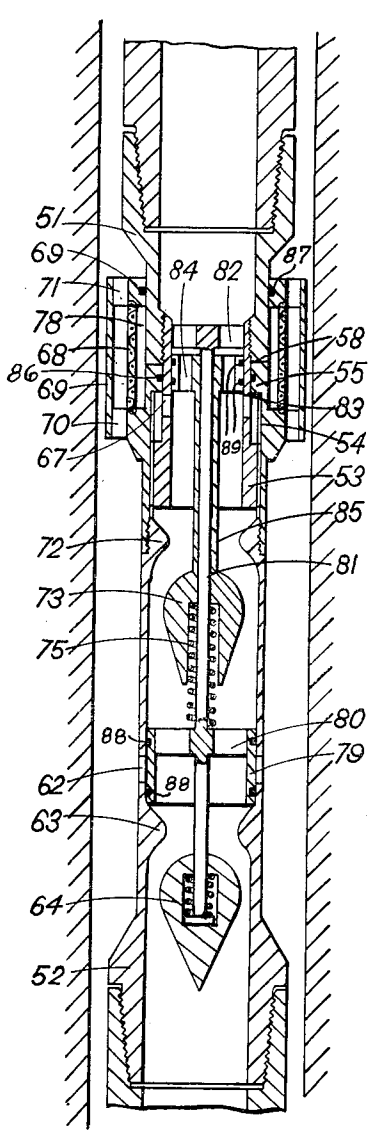

Fig. 4.

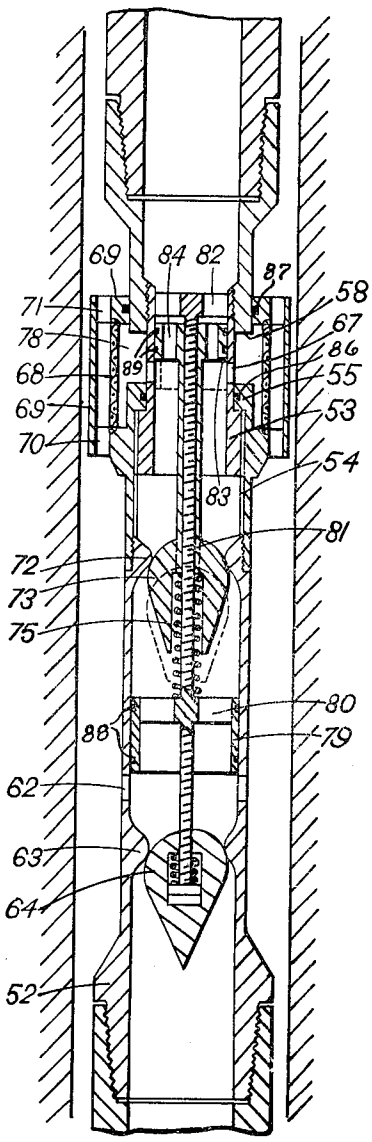

Fig. 5.

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Sept. 14, 1965 F. WHITTLE 3,205,955

DRILL STRING VALVE

Filed Jan. 21, 1963 3 Sheets-Sheet 3

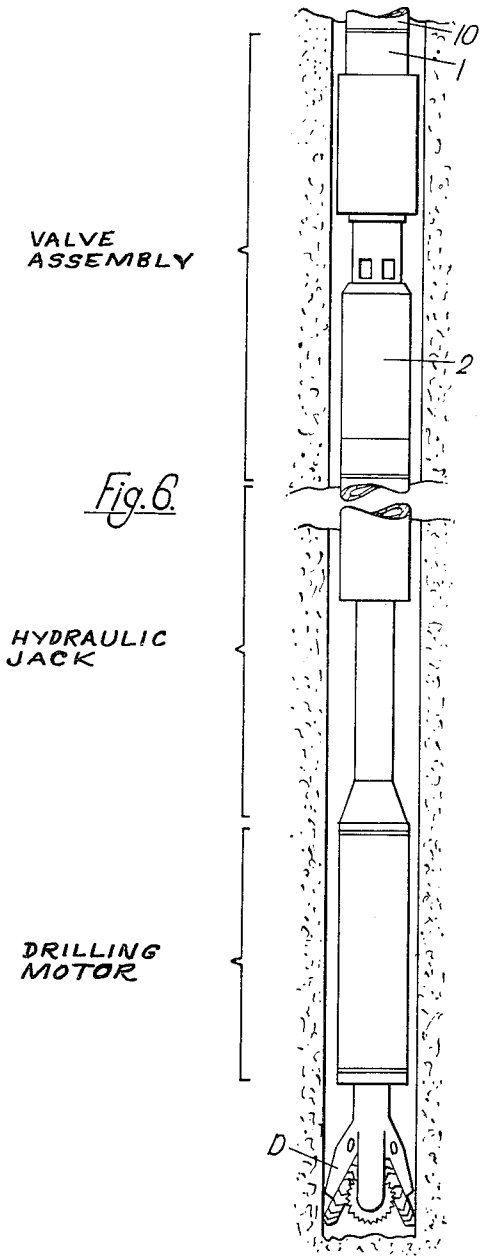

Fig. 6.

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3,205,955

DRILL STRING VALVE

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Claims priority, application Great Britain, Jan. 22, 1962, 2,280/62
9 Claims. (Cl. 175—235)

The invention relates to equipment for drilling oil well bore holes, and in particular to a valve assembly for insertion between a bore hole drilling bit and a drill string to enable liquid to pass from the drill string to the bore hole and vice versa without passing through the bit. A "drill string" is a series of lengths of pipe, which are connected together and which extend from equipment at ground level down to a drilling bit in the bore hole. The valve assembly with which the present invention is concerned serves, firstly to permit entry of liquid from the bore hole into the drill string when the drill string is being returned into the bore hole after withdrawal, for example for replacement of the drilling bit; and secondly, to permit liquid loaded with plugging material to be pumped into the bore hole without passing through the drilling bit and/or adjacent mechanism.

In normal operation, so-called "drilling mud" is pumped down through the drill string and issues through jets in the drilling bit, to cool the latter and convey the rock debris up through the bore hole around the drill string to the surface for disposal. The drilling mud is a liquid which contains sufficient finely divided matter in suspension to form a filter cake on the wall of the bore hole where the latter traverses porous strata and thus seal the pores and prevent excessive loss of liquid. The drilling bit may be rotated either through the drill string by a motor located at the surface, or by a motor located adjacent the drilling bit and operated, for example, by the drilling mud.

When the drill string is withdrawn from the bore hole, the latter remains filled with drilling mud loaded with rock debris, and this material will re-enter the string as it is returned into the bore hole, since it is not practicable to maintain a flow of drilling mud down through the string during this operation. When pumping is re-started, this material will be ejected through the bit driving motor (if of a mud-operated type) and through the bit, and is liable to cause damage by erosion or excessive wear. One object of the present invention is to provide means for separating rock debris from liquid entering the drill string from the bore hole.

Occasionally, when strata having fissures or cavities are encountered, the action of the drilling mud in forming a filter cake on the bore hole surface is not sufficient to prevent a serious loss of liquid. This condition is referred to as "lost circulation" and is costly and can be dangerous. A common form of remedial action consists in feeding plugging materials into the drilling mud. The variety of materials used for this purpose is quite astonishing—nut shells, any kind of fibrous material lying to hand, flakes of cellulose wrapping film etc.—and it is obvious that such materials could easily block the orifices of the jet bit and create a hazard if allowed to pass through a mud operated drilling motor. A second object of the invention is accordingly to provide means allowing passage of plugging material into the bore hole without passing through the bit, or through the bit driving motor if of a mud-operated type.

According to this invention a valve assembly for the purpose described comprises:

(a) A tubular casing having one or more ports for passage of plugging material and, axially spaced therefrom in the upstream direction (i.e. the direction from which the drilling mud will be pumped), one or more ports for flow of liquid into the casing to fill the drill string, the casing being composed of two parts connected for transmission of torque, but with freedom to move telescopically relatively to one another to a limited extent;

(b) first means in flow relationship with the pump and operatively associated with the two casing parts and including a member subjected to the pressure within the casing, this first means being effective to stop flow through the plugging material port whenever the casing parts are telescopically contracted and to stop flow through the plugging material port whenever there is no pumping pressure within the casing, but to permit flow through the plugging material port from within the casing whenever simultaneously the casing parts are telescopically extended and there is pumping pressure within the casing;

(c) second valve means carried by the casing in flow relationship with the string-filling port to stop flow out through the string-filling port during mud pumping;

(d) means carried by the casing in flow relationship with the string-filling port to separate rock debris from liquid flowing into the string-filling port;

(e) a third valve means in flow relationship with the bore of the casing downstream of the plugging-material port and operatively associated with the two casing parts to close the bore of the casing downstream of the plugging-material port on telescopic extension of the casing.

The second valve means of sub paragraph (c) preferably comprises a non-return valve openable by excess pressure in the bore hole over that in the casing.

The separating means of sub paragraph (d) preferably comprises a tubular filter screen surrounding the casing in the vicinity of the string-filling porting. The filter screen may be protected by an outer tubular shield open at both ends to form with the screen an annular passage through which there is a flow of liquid as the drill string is lowered into the bore hole. Preferably, swirl vanes are provided at one or both ends of the annular passage to cause rotary swirl of the liquid flowing through the passage and thus assist separation of rock debris by centrifugal action and reduce the tendency for filter cake to build up on the filter screen.

The first means of subparagraph (b) may include a non-return valve closing the casing bore between the plugging-material porting and the string-filling porting, and openable by pumping pressure on its upstream side. As the drill string is lowered into a bore hole containing drilling mud and rock debris, the casing space between the last-mentioned non-return valve and the valve of subparagraph (e), closing the bore of the casing downstream of the plugging-material porting, will fill with liquid from near the surface, which is relatively free from rock debris; consequently there will be little tendency for liquid to enter through the plugging-material porting, as the casing passes through lower parts of the bore hole where there is a greater concentration of large particle size rock debris.

During normal operation, the valve assembly acts merely as a through passage for the drilling mud, and it is therefore important to design all components so as to keep pressure drops as low as possible.

Two embodiments of the invention are shown by way of example in the accompanying drawings.

FIGURES 1 and 2 show in longitudinal section a first embodiment, in the contracted and extended positions of the casing parts respectively, while

FIGURE 3 illustrates a detail of construction,

FIGURES 4 and 5 are views similar to FIGURES 1 and 2, of the second embodiment; and

FIGURE 6 shows the relationship between the valve assembly and other components of the well drilling equipment, the valve assembly being that shown in FIGURES 1 to 3, in the extended position as in FIGURE 2.

The valve assembly shown in FIGURES 1 to 3 comprises a tubular casing composed of an upper part **1** and a lower part **2**. The upper part **1** has, at its lower end, an outwardly-projecting flange **3** formed with splines to engage corresponding splines **4** on a portion of the internal wall of the lower part **2**, axial movement in the extending direction being limited by engagement of the flange **3** with an inwardly-projecting flange **5** at the upper end of the lower part **2**. The flange **5** carries two sealing rings **6** working on a cylindrical surface **7** on the upper part **1**. Axial movement in the contracting direction is limited by contact of the flange **5** with a shoulder **8** on the upper part.

At its upper end, the casing part **1** is provided with a taper screw thread **9** for attachment to the bottom end of a drill string. Such a string is normally composed of a succession of pipe sections, followed by a sufficient number of heavy "drill collars" to apply the required weight to the drilling bit while maintaining the pipe sections in tension. The bottom end of the lowermost drill collar is shown at **10**.

At its lower end, the casing part **2** is provided with a taper screw thread **11**, which may engage a drilling bit directly, in the case in which the drill string is rotated by a motor at the surface for driving the bit. In the example shown in FIGURE 6, the drilling bit D is rotated by a drilling motor operated by drilling mud pumped down through the drill string. If desired, a hydraulic jack for controlling the weight on the bit may, as shown, be interposed between the valve assembly and the drilling motor. In any case it will be understood that, during drilling, the splines **4** transmit either the drill torque or the equal and opposite reaction of the drilling motor, and that when, on lowering the equipment into a bore hole, the bit D reaches the bottom of the hole, further paying off of the drill string will cause relative contraction of the two parts of the casing of the valve assembly, until the flange **5** abuts the shoulder **8** and weight is applied to the bit.

In the region traversed by the flange **5**, the casing part **1** is provided with a ring of ports **12** which, in the extended condition of the casing (shown in FIGURE 2), produced by raising the drill string sufficiently to lift the drilling bit off the bottom of the bore hole, provide for passage of drilling mud loaded with plugging material from the bore of the casing out into the bore hole without passing through the bit or an interposed drilling motor. To prevent any of this material continuing downwardly through the casing, a valve is provided consisting of a throat **13** carried by the casing part **2** and a plug **14** carried by rod **14***a* extending from a spider **15** at the lower end of the casing part **1**, the plug closing the throat in the extended condition of the casing as shown in FIGURE 2. A spring **16** between the plug and a shoulder **16***a* on the rod **14***a* ensures proper closing of the plug against the throat and is sufficiently strong to prevent the plug being opened by the upstream circulation pressure.

Axially spaced upstream from the ports **12**, the casing part **1** is provided with three ports **17** for entry of liquid when the drill string is being returned into a bore hole containing drilling mud and rock debris. To prevent entry of rock debris of such particle size as to create a hazard to the equipment when drilling is re-started, a filter screen **18** is provided, surrounding and spaced from the casing in the region of the ports **17**. The screen may, for example, be an agglomerate of sintered particles of a corrosion resisting metal. The screen is surrounded and protected by a tubular shield **19**, spaced from the screen by lower and upper rings of swirl vanes **20** and **21**. As may be seen from FIGURE 3, which is a view looking radially at the ends of some of the vanes, the lower vanes **20** are shaped to receive axially moving liquid, during lowering of the drill string, and to impart circumferential swirl to it as it enters the space between

the filter screen **18** and the shield **19**. The upper vanes **21** are shaped to re-direct the liquid axially as it leaves the said space, and it will be understood that these effects are reversed during "haul-out" of the drill string. This action has two effects, firstly the larger particles of rock debris tend to be centrifuged away from the filter screen, and secondly the velocity of flow over the filter screen is increased, with consequent reduction in the formation of filter cake upon it.

During lifting and lowering of the drill string, the casing parts **1** and **2** are of course telescopically extended, so that the plugging material ports **12** are open, and it is necessary to prevent flow of liquid and rock debris into the drill string from these ports. Since this phase of operation is distinguished by absence of pumping pressure, it is convenient to use for this purpose a valve which opens automatically when pumping is resumed. This valve comprises a throat **22** carried by the upper casing part at a position between the ports **12** and **17** and a plug **23** sliding on an axially directed rod **24** carried by the spider **15**. A spring **25** keeps the plug pressed against the throat, except when it is opened by pumping pressure on its upstream side (as shown in FIGURE 1 for the drilling condition). When the casing is extended (as shown in FIGURE 2) the plug **23** is in the closed position shown in full lines, except when plugging material is being pumped through the drill string, when it opens to the position shown in dotted lines. The plugging material must be prevented from flowing out through the string-filling ports **17**, and for this purpose a non-return valve **26** is provided, comprising a spherical valve member **26** operating in a throated casing **27** connected to the ports **17** by hollow spider arms **28**.

The second embodiment shown in FIGURES 4 and 5 comprises a tubular casing composed of an upper part **51** and a lower part **52**. As in the first embodiment, the upper part has, at its lower end, an outwardly projecting flange **53** formed with splines to engage corresponding splines **54** on a portion of the internal wall of the lower part **52**, axial movement in the extending direction being limited by engagement of the flange **53** with an inwardly projecting flange **55** at the upper end of the lower part **52**. Axial movement in the contracting direction is limited by contact of the flange **55** with a shoulder **58** on the upper part. The flange **55** carries a sealing ring **86** sliding on the upper part **53**.

In the region traversed by the flange **55**, the casing part **51** is provided with a ring of ports **67** which, in the extended condition of the casing shown in FIGURE 5, provide for passage into the drill string of filtrate from a chamber **78**. This chamber **78** is formed between the casing and a surrounding filter screen **68**, which is attached at its lower end to the casing part **52** and at its upper end to a collar **69** which carries a sealing ring **87** sliding on a cylindrical surface on the casing part **51**. The screen **68** is surrounded and protected, as in the first embodiment, by a tubular shield **69**, spaced from the screen by lower and upper rings of swirl vanes **70** and **71**.

Axially spaced downstream from the ports **67** is a ring of ports **62**, for passage of drilling mud loaded with plugging material out into the bore hole. Under drilling conditions, when the casing is contracted as shown in FIGURE 4, these ports are closed by a valve sleeve **79** connected by a spider **80** to an axially extending rod **81** attached to the upper casing part **51**, at a position upstream of the string-filling ports **67**, by a further spider **82**. The sleeve **79** carries two sealing rings **88** sliding on the inner surface of the lower part **52**. When the casing is extended by lifting the drill string, upward movement of the sleeve **79** uncovers the ports **62** as shown in FIGURE 5, and pumping of plugging material can proceed. Passage of the plugging material down into the drilling bit and/or drilling motor is prevented by a valve comprising a throat **63** and a plug **64** similar to the corresponding parts in the first embodiment, the plug in this

case being carried by an extension of the rod **81** which moves with the upper casing part **51**.

As in the first embodiment, passage of mud and rock debris into the drill string through the ports **62** is prevented by a valve automatically opened by pumping pressure, this valve comprising a throat **72** carried by the casing part **52** and a plug **73**, which slides on the rod **81** and is urged upwards towards the throat by a spring **75**.

With the arrangement as so far described, the string-filling ports **67** would be open whenever the casing is extended, and therefore during pumping of plugging material, which is not permissible. A sleeve **83** operated by pumping pressure is therefore provided for closing these ports. Conveniently, the sleeve **83** is connected by a spider **84** and a tube **85** to the plug **73**, which is also operated in the same direction by pumping pressure. This sleeve **83** carries two sealing rings **89** sliding on the inner surface of the upper part **51**.

I claim:

1. A valve assembly for insertion between a bore hole drilling bit and a drill-string to enable plugging fluid to pass under the action of a pump from the drill-string to the bore hole and to allow liquid to pass from the bore hole to the drill string without passing through the bit, comprising:

(a) a tubular casing composed of upper and lower parts connected for transmission of torque, but with freedom to move telescopically to a limited extent, said parts having at least one port for passage of the plugging fluid, and, axially spaced therefrom in the upstream direction, at least one port for flow of liquid from the outside to fill the drill string:

(b) first means operatively connected with said casing parts for closing said plugging fluid port when said casing parts are telescopically contracted, and means to stop flow through the plugging fluid port whenever there is no pumping pressure within the casing, to permit flow through said last means being responsive to the pressure of fluid pumped into said casing from above the plugging fluid port from within the casing whenever simultaneously the casing parts are telescopically extended and there is pumping pressure within the casing;

(c) second valve means carried by the casing in flow relationship with the string-filling port to stop flow out through the string-filling port during mud pumping;

(d) means carried by the casing in flow relationship with the string-filling port to separate rock debris from liquid flowing into the string-filling port;

(e) a third valve means in flow relationship with the bore of the casing downstream of the plugging fluid port and operatively associated with the two casing parts to close the bore of the casing downstream of the plugging fluid port on telescopic extension of the casing.

2. An assembly according to claim **1** in which the second valve means comprises a one-way valve openable by excess pressure in the bore hole over that in the casing.

3. An assembly according to claim **1** in which the pressure fluid responsive means comprises a one-way valve closing the casing bore between the plugging fluid port and the string-filling port, and openable by pumping pressure on its upstream side.

4. An assembly according to claim **1** in which the first means comprises an externally directed flange on the lower casing part traversing an external surface on the upper casing part, the plugging fluid port being in this external surface.

5. An assembly according to claim **1** in which the first means comprises a sleeve connected to the upper casing part and sliding within a portion of the downstream casing part, the plugging fluid port being in this portion.

6. An assembly according to claim **1** in which the third valve means is loaded towards closed position by a spring coacting with the upper casing part and the third valve means, said spring being strong enough to resist pumping pressure during pumping of the plugging fluid.

7. An assembly according to claim **1** in which the separating means comprises a tubular filter screen surrounding the casing in the vicinity of the string-filling port.

8. An assembly according to claim **7** having an outer tubular shield open at both ends and means holding the shield in position around the filter screen to form with the screen an annular passage through which there is a flow of liquid as the drill string is lowered into the bore hole.

9. An assembly according to claim **8** having swirl vanes provided at at least one end of the annular passage to cause rotary swirl of the liquid flowing through the passage and thus assist separation of rock debris by centrifugal action and reduce the tendency for filter cake to build up on the filter screen.

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