April 22, 1958 R. H. BLOOD 2,831,439

SAMPLING PUMP FOR USE IN BORE HOLES

Filed Nov. 27, 1953 2 Sheets-Sheet 1

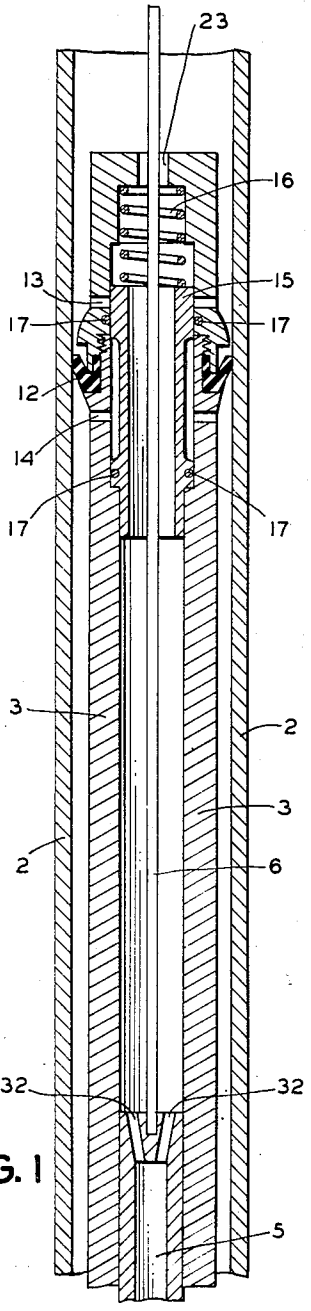


FIG. 1

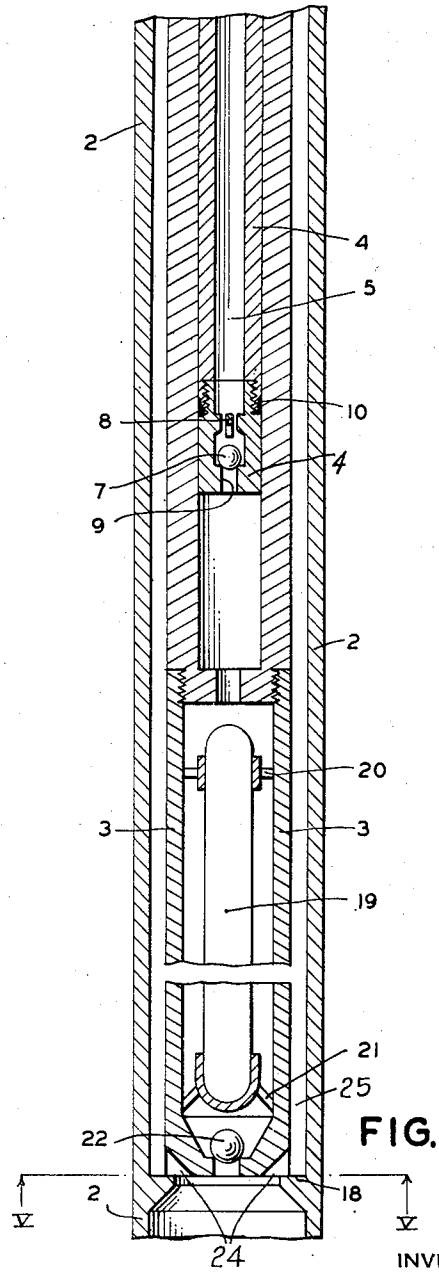


FIG. 2

INVENTOR
ROBERT H. BLOOD
BY W. N. Wright
ATTORNEY

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FIG. 5

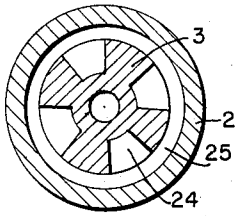
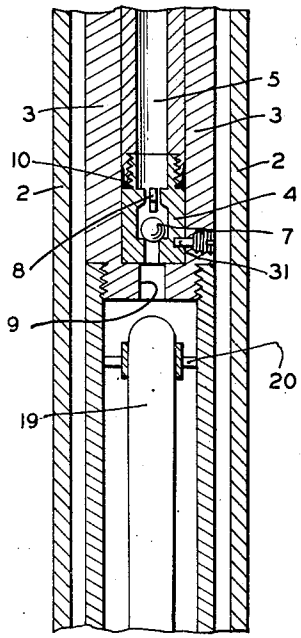


FIG. 4



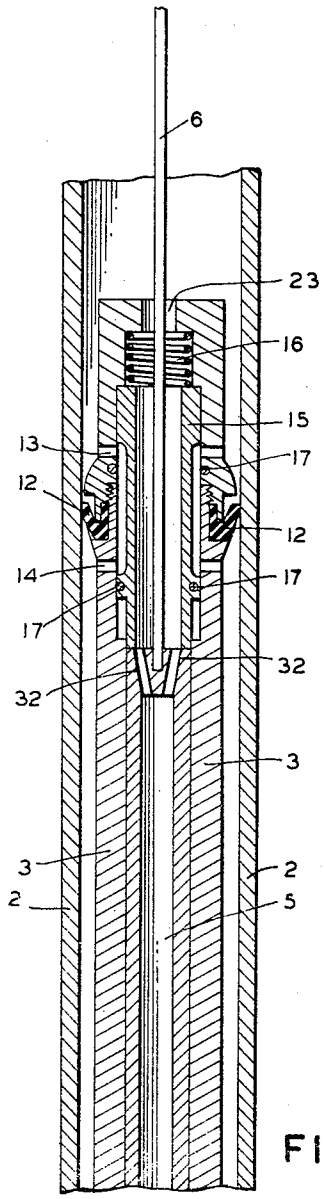


FIG. 3

INVENTOR
ROBERT H. BLOOD
BY W. N. Wright
ATTORNEY

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SAMPLING PUMP FOR USE IN BORE HOLES

Robert H. Blood, Tulsa, Okla., assignor to Esso Research and Engineering Company, a corporation of Delaware

Application November 27, 1953, Serial No. 394,661

5 Claims. (Cl. 103—181)

This invention is primarily concerned with a pump for use in bore holes employed in the exploration for and production of petroleum from the earth. The pump of this invention is operative as a wire line supported pump and may be used in a wide variety of applications for obtaining samples of fluid from a bore hole or from formations adjacent the bore hole. The particular feature of this invention is the provision of a down-the-hole force pump which can effectively be used to force fluids from any depth in a bore hole under virtually any pressure to the surface of the earth. In one embodiment of the invention, use of this pump is particularly attractive with formation testers in order to force fluid from strata adjacent the bore hole to the surface of the earth.

In drilling a bore hole in the attempt to discover oil deposits in the earth, it is important at various stages of the procedure to determine the composition of fluids present in the bore hole. This problem is complicated by the fact that so-called "drilling mud" is ordinarily present in the hole so that it is desirable to isolate fluids produced in the bore hole from the drilling mud which is present. Because of the fact that the drilling mud is used to maintain a high hydrostatic pressure within the bore hole, it also follows that production of fluids for testing purposes from low pressure producing zones adjacent the bore hole is also difficult.

Apparatus known as "formation testers" are employed for the purpose of sampling fluids which may be produced at a bore hole. Formation testers are known and used of many different types. One of the most attractive forms of such testers is the type employing an inflatable elastic packer which can be inflated to seal off a portion of the bore hole. In some cases two such packers are employed so that fluid can be produced between the packers while keeping out drilling mud otherwise present in the hole. In other cases suitable fluid sampling passages may be provided through a portion of the inflatable packer itself. In any case, it is necessary to make some provision for the passage of fluid from strata adjacent the bore hole into a sample chamber or through the drill string so as to maintain this fluid separate from drilling mud in the bore hole to the extent possible.

While fluid may be produced from a formation in this general manner for recovery in a sample chamber associated with the formation tester, this is subject to the real disadvantage that the volume of a sample chamber by its nature is comparatively limited. Again, it is difficult to prevent at least some contamination of the sampled fluid with drilling mud in the filling of a sample chamber. It has also been appreciated that fluid may be sampled from formations by pumping out the drilling mud in the drill string leading to the formation tester so that produced fluid can be brought to the surface of the earth. However, in the case in which a vacuum pump is employed for this purpose at the surface of the earth, the maximum pressure differential which can be developed to produce this fluid is a head of some thirty feet of water.

This limitation makes it impractical to suitably produce fluids from low pressure producing zones adjacent the bore hole. "Swabbing" techniques which are employed are subject to the disadvantage that large quantities of fluid must be removed before production of fluid can begin from low pressure producing strata.

It is the purpose of this invention to provide an apparatus which will satisfy the objectives indicated in the foregoing discussion. Thus, one of the principal objects of this invention is to provide a down-the-hole force pump which can be used to successfully force sampled fluid to the surface of the earth without the limitations of a vacuum pump employed at the surface of the earth. It is another object of this invention to provide a wire line suspended and operated pump which can be used for obtaining a sample of fluid from any level in a bore hole. These and other benefits of this invention will become apparent from the following description of a preferred form of the invention. In this description reference will be made to the accompanying drawings, in which:

Figures 1 and 2 taken together illustrate in cross-sectional, elevational detail the operative features of a basic pump embodying the principles of this invention. In these figures, Figure 1 illustrates the upper section of the pump assembly, while Figure 2 illustrates the lower continuation of the pump;

Figure 3 similarly illustrates in cross-sectional, elevational detail the upper portion of the pump assembly of Figure 1 illustrating the position of the pump elements during suspension on the wire line;

Figure 4 is a fragmental cross-sectional, elevational drawing of the lower portion of the pump showing a variation of the invention in which a shear pin is used to lock the piston of the pump with respect to the pump cylinder;

Figure 5 is a cross-section view of the apparatus of Figure 2 taken along the section lines V—V in Figure 2.

Referring to Figures 1 and 2, the pump of this invention is illustrated in operative pumping position within a casing or a drill string **2** positioned in a bore hole. The pump primarily comprises two major elements; the pump barrel or cylinder **3** and the tubular piston element **4**. The piston **4** may constitute a cylinder as illustrated in order to provide a central passage **5** through which fluid can pass. As shown, the passage **5** terminates at the upper end of the piston in ports **32** adjacent the point of suspension of the piston by the wire line or cable **6**. The lower termination of the passage **5** is provided with a check valve arrangement **7**, which is employed to permit the flow of fluid upwardly through passage **5** but to prevent flow of fluid downwardly through passage **5**. For this purpose the simple ball check valve arrangement shown may be employed, in which a spider **8** or a similar provision is made for retaining the ball of the check valve adjacent the valve orifice **9** without preventing flow of fluid upwardly through the spider **8**. A cup seal **10** may be employed at one or more positions along the piston so as to secured effective fluid displacement as the piston is pulled upwardly within the cylinder **3**, but permitting the piston to move downwardly without undue restriction.

The pump barrel **3** is also provided with a cup packer arrangement **12** at an upper portion thereof so as to prevent the flow of fluid downwardly in the annulus **25** between the drill string **2** and the pump barrel **3**. Packer **12** is of a character permitting the pump cylinder to slide within the drill string **2** and may permit fluid to pass upwardly about the packer, although, as stated, flow of fluid downwardly past the cup packer is prevented. It is an important feature of this invention to provide means to bypass fluid about the cup packer **12**, and for this pur-

pose a number of orifices 13 and 14 are drilled through the pump barrel above and below the cup packer 12. These orifices are arranged to register with a slide valve 15 when the valve 15 is placed in the position illustrated in Figure 3, permitting fluid to bypass the packer 12. During operation of the pump, slide valve 15 is held in a position to prevent fluid flow through orifices 13 and 14 by action of the spring 16, which forces the slide valve 15 into the downward or closed position illustrated in Figure 1. The slide valve 15 may be provided with seals 17 in order to seal the slide valve within the pump cylinder 3.

In the embodiment of the pump illustrated in Figures 1 and 2, it is important to provide some means to limit the downward position of the pump cylinder 3 with respect to the drill string 2. As illustrated in Figure 2, this may be accomplished by providing a shoulder 18 within the drill string 2 on which the lower termination of the pump cylinder may rest. The lower end of the pump cylinder 3 is fluted or otherwise provided with one or more fluid passageways 24 to provide fluid communication between the portion of the drill string 2 below shoulder 18 and the annulus 25 between the drill string and the pump cylinder. It is an optional feature of the invention to employ a pressure recorder 19 which is preferably positioned within the lower portion of the pump cylinder 3 or an extension thereof. A suitable pressure recorder is diagrammatically illustrated including spider arrangements 20 and 21 for positioning the pressure recorder within the pump barrel 3. It is necessary to provide a check valve at a lower portion of the pump cylinder of a nature to permit fluid flow upwardly within the pump cylinder but to prevent fluid flow downwardly out of the pump cylinder. This can be simply achieved by employing a ball type check valve 22 at the lowermost portion of the pump cylinder.

From this description of the essential elements of the pump illustrated in Figures 1, 2 and 3, the operation of this device can now be understood. For the purpose of this description, it can be assumed that the cut-away portion of the drill string 2 at the bottom of Figure 2 is connected with a suitable formation tester. For example, a formation tester of the character disclosed and claimed in U. S. Patent 2,600,173, issued to Ben W. Sewell et al. on June 10, 1952, may be employed. In the event this type of formation tester is employed, the lower termination of the drill string 2 illustrated in Figure 2 of this patent may connect with the drill string 5 illustrated in the drawings of the Sewell et al. patent. It will therefore be understood that fluid which can be obtained from a formation to be tested will have access to the pump cylinder 3 of this invention through the check valve arrangement 22.

After the formation tester identified, or any other desired type of formation tester, is placed in operative position within a bore hole, the wire line pump of this invention is lowered into the drill string by means of the cable 6. During the lowering operation, the piston 4 of the pump will be held upwardly against slide valve 15 so as to hold the slide valve in the position shown in Figure 3. Since the entire weight of the pump will be borne by the piston through the cable suspension, it is apparent that spring 16 can be compressed during the lowering operation to maintain the slide valve 15 in the indicated position. In the position of the slide valve 15 illustrated in Figure 3, fluid can readily pass from the annulus within the drill string 2 so as to bypass the packer 12. The fluid will flow through the orifices 13 through slide valve 15 and through orifices 14. It is also apparent that fluid will have a course of flow upwardly through the check valve 22 through the lower portion of the pump barrel 3, through check valve 7, through the passage 5 of the piston 4, through the central opening of the slide valve 15, and through the upper port 23 of the pump cylinder. Consequently, movement of the entire pump assembly will not be impeded as the pump is lowered into the drilling mud or other fluid present in the drill string.

When the pump has been lowered to contact the shoulder 18 within the drill string 2, the pump cylinder will be locked with respect to the drill string. Thereafter, continued lowering of the cable 6 will permit the piston 4 to slide within the pump cylinder to the downward limit of movement with respect to the pump cylinder. This will permit the spring 16 to force slide valve 15 into the downward and closed position illustrated in Figure 1 so as to close off fluid flow through ports 13 and 14. The pump is then in operative position for use.

Pumping action is achieved by raising and lowering the cable 6 within suitable limits of movement. Thus, for example, suitable means may be used to limit the rotation of the cable winch so that during stroking the piston 4 will not contact or alter the position of slide valve 15. On each upward stroke of the piston, check valve 7 will close so that fluid trapped above the check valve within the passage 5 of the piston and within the pump cylinder will be forced upwardly. During the upward stroke of the piston, fluid will also enter the lower portion of the pump cylinder through the check valve 22 so as to replace that fluid pumped upwardly by the piston. On the downward stroke of the piston, check valve 22 will close preventing escape of fluid downwardly from the pump barrel and permitting this fluid to pass upwardly through check valve 9 into the piston and upper portion of the pump cylinder. In this manner continuous pumping action can be carried out to force any desired quantity of fluid upwardly through the drill string 2.

It will be apparent that the cup packer 12 positioned about the upper portion of the pump cylinder 3 provides an important function during pumping. Initiation of the pumping action reduces the pressure below cup seal 12 with respect to the pressure above the cup seal 12 so that this pressure differential tightly seals the packer against the drill string 2 and serves to hold down the pump cylinder in the operative position shown in Figures 1 and 2.

While operation of the pump has been described in connection with continuous pumping action for displacing considerable volumes of fluid upwardly through the bore hole, if desired, single stroke action of the pump may be employed. In this case the pump itself can be used as a sample chamber for produced fluid. Thus, after the pump has been lowered to the operative position within the drill string 2, an upward stroke of the piston 4 will serve to bring fluid within the pump cylinder. When the pump is then pulled to the surface of the earth, this fluid will be trapped within the pump cylinder by action of the different check valves so that the fluid can be recovered when the pump is retrieved at the surface of the earth.

For removal of the pump from the drill string, the slide valve 15 inherently operates to eliminate the pressure differential across the cup packer 12 so as to permit unrestricted removal of the pump from the drill string. This is accomplished when the cable 6 is reeled in since the piston 4 will be forced upwardly against slide valve 15 to move the valve into the position shown in Figure 3. Fluid can then bypass the cup packer 12 through orifices 13 and 14 so that the entire pump assembly can readily be pulled from the drill string.

The pump described may be employed in widely different manners in order to sample fluid from a bore hole. For example, the pump may be used to sample the fluid present in a bore hole at any given level without necessity for using the shoulder or other supporting means within the drill string. In this case, the arrangement shown in Figure 4 may be used to obviate necessity for including provision for limiting the downward movement of a pump barrel with respect to the drill string. As shown in Figure 4, a shear pin 31 may be passed through the lower portion of the pump barrel 3 into the lower portion of

the piston 4 so as to lock the piston with respect to the pump barrel. Shear pin 31 must be strong enough to support the entire pump barrel assembly. Consequently, during lowering of the pump with the shear pin in place, the pump may be brought to any desired level within the drill string 2 while the piston is maintained in the lowermost position within the pump cylinder. Fluid passes upwardly through check valves 22 and 7 during lowering of the pump. When the pump has been lowered to the selected level in the drill string, an upward pull on cable 6 will serve to break shear pin 31, due to the fact that the weight of the drilling mud acting through the pump seal 12 will provide sufficient shearing stress to break shear pin 31. Therefore, the piston 4 will be moved upwardly with respect to the pump barrel 3 so as to pump fluid within the pump cylinder. As formerly indicated, this fluid will remain trapped within the pump barrel until the pump can be removed at the surface of the earth.

Again, while the invention has been described with reference to the use of a drill string 2 in a bore hole, it is apparent that the pump assembly can be used in an open bore hole if desired. In this use of the invention, the cup packer 12 must be of a nature to effectively seal against the open bore hole. Packers of this nature are known to the art and may include, for example, a plurality of upwardly extending elastic skirt members. Such seals may be successfully employed in an open bore hole provided they are of reasonably regular gauge.

If desired, the pump assembly can also be provided with suitable releasable latching means to lock the pump barrel at any desired level in an open bore hole. Such releasable latching means may be used to replace the function of the shoulder 18 illustrated in Figure 2.

To further indicate the scope of use for this invention, it is apparent that while the invention has been described for use with a formation tester, in some cases the pump assembly by itself can function as a formation tester. Thus, for example, the pump itself can be used as a bottom hole formation tester since the cup packer 12 serves to prevent drilling mud contamination of fluid produced below the packer and since the pump will function to force fluid produced below the pump assembly upwardly to the surface of the earth.

The configuration of the different elements of the pump may be varied as desired for design purposes. However, it is particularly preferred that both the piston 4 and the pump barrel 3 constitute elongated, massive elements. This is desirable so that the mass of the apparatus will permit ready lowering of the apparatus through the drilling mud present in the bore hole. Again, by making the pump of substantial length, the single stroke use of the pump may be used to trap a substantial volume of fluid for sampling purposes.

What is claimed is:

1. A pump apparatus comprising in combination: an elongated pump cylinder, a packing element about the upper periphery of said cylinder, a first and second orifice passing through said cylinder above and below said packing element, a slide valve slidably positioned within the upper portion of the cylinder adapted to move to an open position establishing register with said first and second orifices to permit fluid flow therethrough, means to bias said slide valve to a closed position preventing the said fluid flow, a piston slidably positioned within said cylinder having a channel passing completely through the piston, a check valve positioned in said channel permitting unidirectional flow through the piston, a check valve positioned in said cylinder permitting unidirectional flow into said cylinder from a region exterior of said cylinder.

2. The pump defined by claim 1 wherein said slide valve is engageable by said piston when said piston is moved to the upper portion of said cylinder and wherein an opening is provided through the top of said cylinder to receive a supporting cable attachable to said piston whereby when the weight of the pump is supported by the cable the piston will urge said slide valve to its open position against said bias.

3. A pump for use within a vertically disposed passageway which comprises a vertically disposed pump cylinder lowerable within said passageway and defining an annulus therebetween, check valve means in the lower end of said cylinder to enable fluids to flow selectively into the cylinder, a packer positioned on the exterior surface of said cylinder to block fluid flow along said annulus, orifices extending through the wall of said cylinder above and below said packer, valve means within said cylinder operable with said orifices in a first valve position to establish fluid communication around said packer and in a second valve position to block fluid communication around said packer, a piston element movably disposed within said cylinder, a fluid channel extending vertically through said piston, and second check valve means in said channel operable to enable fluid to flow selectively upwardly through said channel.

4. A wire-line operable, deep-well pump which comprises a pump cylinder adapted to be lowered in a vertical disposition within a well, check valve means in the lower end of said cylinder operable to enable fluid to flow selectively into said cylinder, a packer positioned around and near the upper end of said cylinder and operable to block downward flow of fluid in the annulus between the cylinder and the wall of the well, a first orifice through the cylinder wall above said packer, a second orifice through the cylinder wall below said packer, valve means within said cylinder operable in a first open position to establish fluid communication between said orifices and in a second closed position to block fluid communication therebetween, means biasing said valve means in a normally closed position, a wire-line operable piston within said cylinder, and combination port and check valve means within said piston operable to enable fluid to flow selectively upward through said piston.

5. A pump adapted to be lowered and operated within a well which comprises a pump cylinder which is vertically disposed when within a well, a check valve in the lower end of said cylinder operable to enable fluid to enter the cylinder, a piston within said cylinder, combination port and check valve means within said piston adapted to enable fluid to flow upward through said piston, a wire line attached to the upper end of said piston and extending through the upper end of the cylinder, a packer around the upper periphery of the cylinder of a character to effect a fluid-tight seal against the wall of the well, a first orifice penetrating said cylinder above said packer, a second orifice penetrating said cylinder below said packer, a sleeve valve positioned within said cylinder above said piston, said sleeve valve in an upper vertical position operable to provide fluid communication between said orifices through said valve and in a lower vertical position to block fluid communication between said orifices, spring means above said sleeve valve biasing the valve normally to its lower vertical position, said piston at the upper end of its possible travel within said cylinder being adapted to urge said sleeve valve into its upper vertical operating position against the action of said spring.

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