Dec. 6, 1966 T. A. KENNARD 3,289,691

VALVE SUB

Filed Nov. 9, 1964 3 Sheets-Sheet 1

Fig. 1

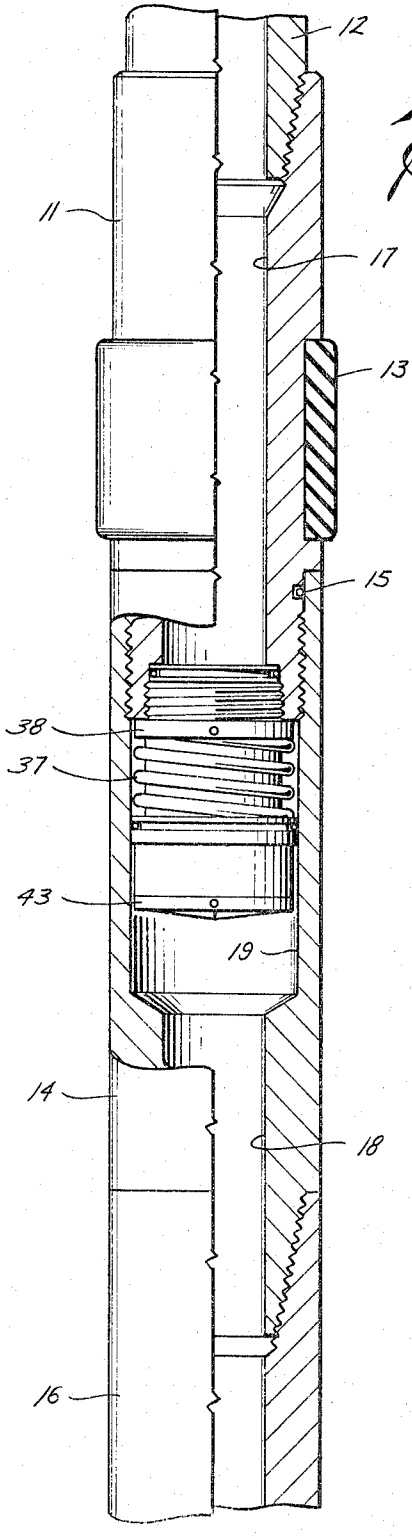
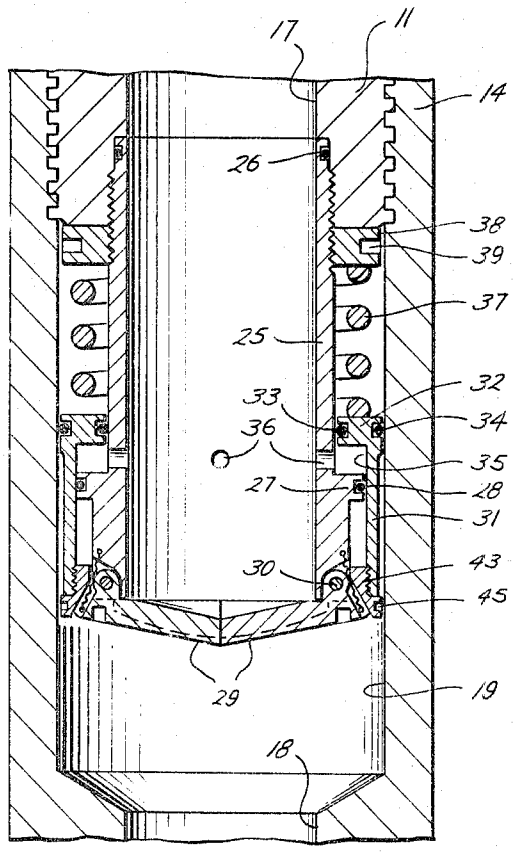


Fig. 2



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Dec. 6, 1966 T. A. KENNARD 3,289,691

VALVE SUB

Filed Nov. 9, 1964 3 Sheets-Sheet 2

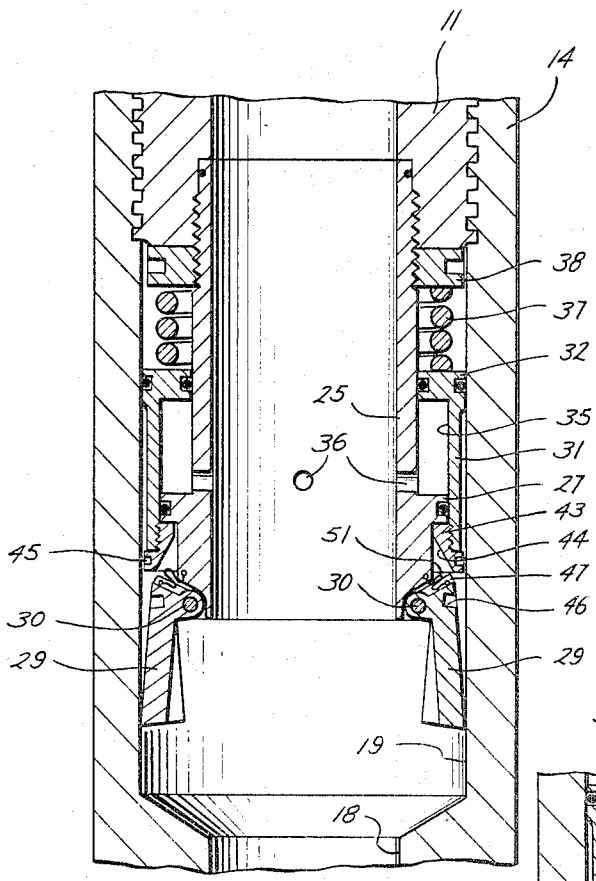


Fig. 3

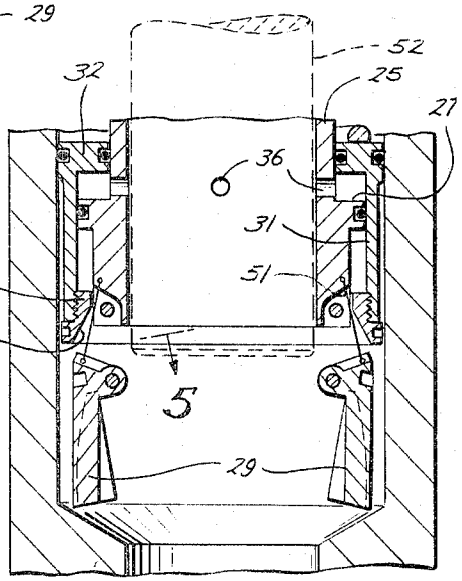


Fig. 4

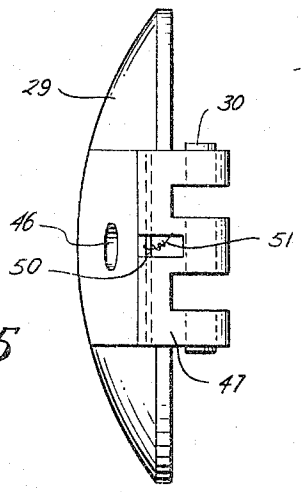


Fig. 5

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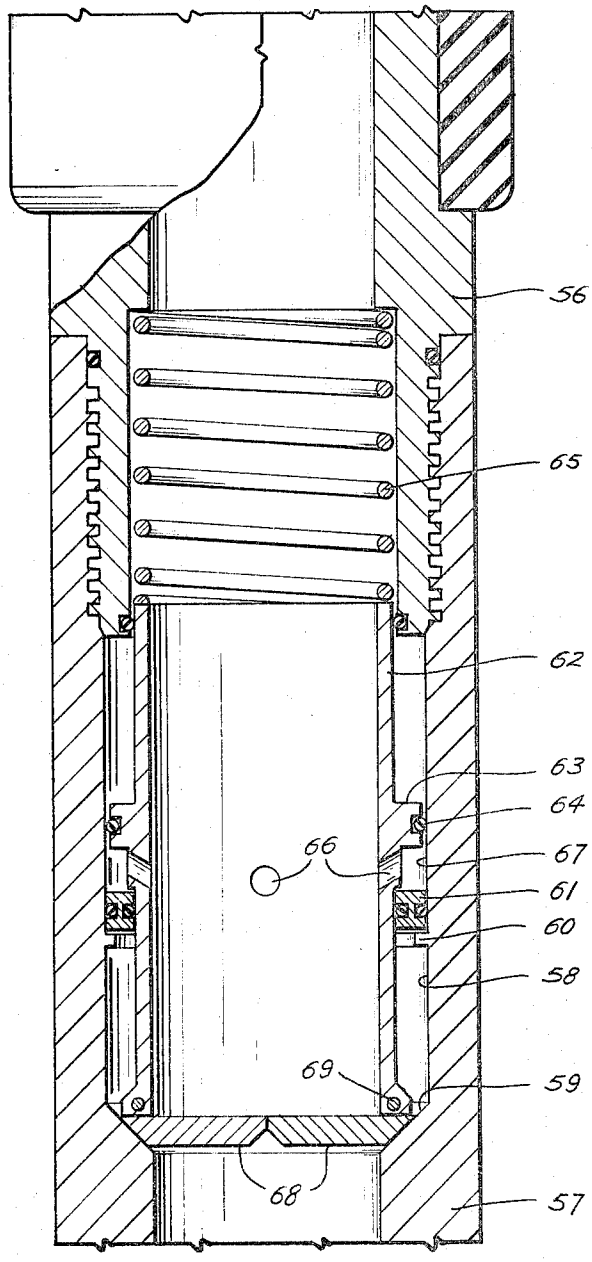
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Dec. 6, 1966 T. A. KENNARD 3,289,691

VALVE SUB

Filed Nov. 9, 1964 3 Sheets-Sheet 3

Fig. 6



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3,289,691
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3,289,691

VALVE SUB

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12 Claims. (Cl. 137—496)

This invention relates to a valve sub for including in a drill string to prevent loss of drilling fluid while making connections during down hole bore drilling. More particularly, the invention relates to an automatically operating valve sub for including in a drill string generally just below the kelly to prevent loss of drilling fluid when a joint of pipe is added to the drill string.

During down hole drilling operations, when it becomes desirable to add another joint of drill pipe to the drill string, the kelly is normally unthreaded from the top of the drill string and a new length of drill pipe is threaded therein and added to the drill string. Quite often a sub is attached to the lower end of the kelly which sub is sometimes referred to as the kelly saver sub, which protects the kelly from wear occasioned by the multiplicity of make ups during such drilling operations. However, when the kelly or the kelly saver sub is unthreaded from the balance of the drill string, the drilling fluid contained in the kelly and the kelly saver sub, spills out on the drilling floor or platform. This spillage of the drilling fluid causes it to be spread over the equipment causing hazardous working conditions. It then becomes necessary for the crew to wash the platform down to remove the drilling fluid therefrom. Not only does this take a considerable amount of operating time to perform the wash-down, but constitutes a great economic loss as to the drilling fluid so lost. For example, as much as 300 barrels of drilling fluid may be lost by such spillage in drilling a 10,000 foot deep hole. With the cost of such drilling fluid being several dollars per barrel, the economic loss is obviously great.

Various prior art devices have been utilized in attempts to solve the foregoing problems. For example, a manually operated valve has been included in the drill string below the kelly for the purpose of preventing the aforesaid spillage of drilling fluid. However, a manually operated valve has many disadvantages. For example, it must be operated by a wrench prior to disconnecting the kelly from the drilling string which requires much operator time and involves the risk of losing the wrench down the well bore. Moreover, when it is desirable to open the valve after the new length of drill pipe has been added to the string, the valve is then at a location up in the derrick where it is very difficult to reach and manipulate at such a remote position. Moreover, if the operator forgets to open the valve, and the fluid pressure pump is started to thereby resume circulation of the drilling fluid, breakage of the pump or other equipment will result.

It is, therefore, an object of this invention to provide an automatic pressure-sensitive valve sub for including in a drill string to overcome the aforesaid problems and prevent loss of drilling fluid while making connections during down hole drilling.

Briefly stated, the valve sub of this invention comprises a body member which may be generally tubular in shape having an axial bore therethrough. The body member is provided with piston means mounted therein and adapted for movement therein. This piston means is biased in a first direction by resilient biasing means. The sub is provided with bore closing means operably connected to the piston means, which bore closing means are adapted to be placed in the closed position by movement of the piston means in the first direction. Means are also provided for applying a pressurized fluid to the

piston means to thereby drive the piston means in a direction counter to the biasing means to thereby move the bore closing means to the open position. Hence, upon completing the connection, the valve automatically opens upon resumption of the drilling operation since pressure is applied to the piston means contemporaneously with the application of pressure to cause circulation of the drilling fluid.

While the bore closing means have been described as being operably connected to the piston means and adapted to be placed in the closed position by movement of the piston means in a first direction, it is to be understood that the bore closing means may be either attached directly to the piston means or to the housing, but in either event, they are so arranged and designed that they are moved to the closed position upon movement of the piston means in the first direction. Hence, the closing means have been described as being operably connected to the piston means.

Reference to the drawings will further explain the invention wherein:

FIG. 1 is a side elevation view partially in central vertical section showing one embodiment of the instant invention.

FIG. 2 is an enlarged fragmentary view of the valve shown in FIG. 1.

FIG. 3 is a view similar to FIG. 2, but showing the bore closure means in the open position.

FIG. 4 is a fragmentary view of FIG. 3, but showing the bore closure means severed from the body member.

FIG. 5 is a sectional view taken along line 5—5 of FIG. 4 showing the details of one of the closure gates.

FIG. 6 is a side elevation view, partially in central section showing another embodiment of the instant invention.

Referring now to FIG. 1, one embodiment of the instant invention will be described in detail. The valve sub is generally tubular in shape and formed with an axial bore therethrough and comprises top sub connector **11**, having a box end which threadably connects with the pin end of kelly **12**. Top sub connector **11** is shown having protector **13** positioned thereabout. The lower end of top sub connector **11** is threadably connected with the upper or box end of lower sub **14**, having O-ring seal **15** therebetween. The lower end of lower sub **14** is provided with pin threads which threadably engage with the box end of drill pipe **16** therebelow.

It will be observed that top sub connector **11** is provided with an axial bore **17** therethrough, which is of the same general diameter as the bore of kelly **12** and drill pipe **16**. In addition, the lower portion of lower sub **14** is provided with another axial bore **18**, which is of the same general size as axial bore **17**. However, the upper portion of lower sub **14** is provided with an enlarged axial bore **19** for the accommodation of valve means which will now be explained by reference to FIG. 2.

There it will be observed that a generally tubular shaped fixed sleeve **25** is threadably connected to the lower internal end of top sub connector **11**, with O-ring seal **26** therebetween. It will be observed that the axial bore of fixed sleeve **25** is of the same general size as axial bore **17** of top sub connector **11**.

Toward the lower portion of fixed sleeve **25**, there is provided thereabout an enlarged annular portion forming piston stop **27**, having an annular O-ring seal **28** thereabout. The lower end of fixed sleeve **25** has attached thereto a pair of flapper gates **29** by means of pivot pins **30**, such that flapper gates **29** may pivot to an open and closed position, with the closed position being shown in FIGS. 1 and 2. Hence, it may be stated that the flapper

gates 29, which form the bore closure means, are attached to the body of the valve sub.

In the annular space between fixed sleeve 25 and lower sub 14, there is mounted an annular or tubular shaped piston which is mounted for axial movement therein and is comprised of piston sleeve 31, having attached to the upper end thereof, an enlarged internally extending annular flange forming piston head 32, which is provided with appropriate O-ring seals 33 and 34 on the inside and outside thereof. Hence, piston chamber 35 is formed in the area below piston head 32 and on the outside of fixed sleeve 25 and the inside of piston sleeve 31.

Means are provided for supplying a pressurized fluid to piston chamber 35 which means conveniently takes the form of a plurality of transverse openings 36 through the wall of fixed sleeve 25. Hence, when fluid pressure is supplied downwardly through bore 17, pressure is exerted in piston chamber 35 with the piston head 32 being forced upwardly.

In the annular space between fixed sleeve 25 and lower sub 14 and above piston head 32, there is provided resilient biasing means in the form of compression spring 37, with the lower end thereof exerting a downwardly extending force on piston head 32, and with the upper end thereof being supported by stop nut 38, which is threaded onto fixed sleeve 25 and abutts the lower end of top sub connector 11 and has a plurality of wrench holes 39 thereabout.

The lower end of piston sleeve 31 has attached thereto, annular ring seal nut 43, having a frusto conical shaped inner camming surface 44 thereabout and a plurality of wrench holes 45 spaced circumferentially around the outside thereof as best seen in FIG. 3.

As indicated above, the closure means in the form of flapper gates 29 are attached to the body member by pivot pins 30. The details of one of the flapper gates 29 is best shown in FIG. 5. There it will be observed that each of flapper gates 29 has a wrench hole 46 therein to facilitate make up of the tool. In addition, each of the flapper gates 29 is provided with camming means to facilitate movement of the flapper gates 29 to the closed position, which camming means takes the form of cam surface 47, which is formed on the face of each of the flapper gates 29.

It will be observed that the hinge end or cam end of each of the flapper gates 29 has a safety pin 50 passing therethrough to which is secured a small flexible cable 51, the opposite end of which is secured to a portion of fixed sleeve 25 as by means of welling or the like. Cable 51 serves as a safety means to prevent gates 29 from falling down through the bore of the tool if they should become severed from the tool, as for example, when a drive bar such as drive bar 52, shown in FIG. 4, is driven down through the tool for the purpose of passing string shot equipment therethrough, in which event, pins 30 holding gates 29 may be severed.

Flapper gates 29 together operate as the closure means for completely closing off the bore thereabove. In other words, they are so designed and constructed that the two together, when placed in a closed position, constitute a barrier to the passage of fluid thereby.

In operation and during drilling, a circulating fluid will be passed downwardly through axial bore 17 under pressure, causing the passage of pressurized fluid through transverse openings 36 to piston chamber 35, thereby forcing piston head 32 upwardly, thereby compressing spring 37. Spring 37 is selected such that it may be compressed only when the pressure of the drilling fluid exceeds a pre-determined level, which level is usually the minimum pressure which will insure proper circulation of the drill fluid through the drill string during drilling operations. When the drilling fluid is not pressurized, spring 37 will move to an expanded condition, which normally results when pressure on the drilling fluid is terminated when the operator desires to make a connection.

With the fluid pressure in piston chamber 35 reduced or terminated, piston head 32 and piston sleeve 31 are forced downwardly such that camming surface 44 of ring seal nut 43 engages cam surface 47 of the flapper gates 29 and cams them to the closed position, as shown in FIG. 2. Hence, it is desirable that the spring 37 be of sufficient strength to force gates 29 to the closed position to thereby support the column of drilling fluid thereabove, which drilling fluid would then not have any pressure applied thereto. Stated another way, spring 37 must have sufficient force to urge the piston means downwardly only when pressure on the drilling fluid is below a predetermined amount, which amount would be below the pressure to circulate fluid through the drill pipe.

With the valve in the closed position as thus described, the sub of the instant invention could then be disconnected from drill pipe 16, and another length of drill pipe added therebelow without the loss of the drilling fluid thereabove.

After the length of pipe is added to the drill string, pressure on the drilling fluid in bore 17 may then be increased to normal operating levels, which would thereby cause piston head 32 to move upwardly, permitting the flapper gates 29 to move to the open position as shown in FIG. 3.

It will be observed that the industry has been provided with an automatic valve which will effect the saving of drilling fluid. At the same time it will speed drilling operations by eliminating the necessity to wash down the drilling floor and thereby providing cleaner and safer working conditions as well. One further advantage of the instant invention is that it acts as a blow out preventer when the pump pressurizing the drilling fluid is off and flapper gates 29 are closed.

There are many alternatives with the foregoing embodiment. For example, while the apparatus has been described as hydraulically operated by use of the pressurized drilling fluid acting on piston head 32, it is to be understood that piston head 32 could be moved upwardly by any other source of pressurized fluid, as for example, a pressurized fluid from an external source.

Reference to FIG. 6 will show another embodiment of the instant invention wherein the bore closing means are not only operably connected to the piston means but in which the bore closure means are actually attached to the piston means. This embodiment of the invention is provided with top sub connector 56 which corresponds with top sub connector 11 of the apparatus shown in FIGS. 1–5. Attached to the lower end of top sub connector 56 is lower sub 57, which corresponds with lower sub 14 of the apparatus shown in FIGS. 1–5. Lower sub 57 has an enlarged axial bore 58 having a frusto conical shaped camming surface 59 at the lower end thereof. Spaced above camming surface 59 is a radially inwardly extending enlarged portion forming butt ring 60 above which is seated packing ring 61 having appropriate O-ring seals on the inside and the outside thereof.

A generally tubular shaped piston formed by piston sleeve 62 having an enlarged annular portion thereabout forming piston head 63, provided with O-ring seal 64 thereabout, is positioned in the axial bore and inside of packaging ring 61 for axial movement therein.

The lower internal bore of top sub connector 56 is provided with an enlarged bore in which is seated compression spring 65, the lower end of which abuts against and resiliently biases downwardly the top end of piston sleeve 62.

Sleeve 62 also has passing transversely therethrough a plurality of transverse openings 66 which communicate with piston chamber 67 formed in the space between piston sleeve 62 and lower sub 57 and below piston head 63 and above packing ring 61.

Bore closing means in the form of a pair of flapper gates 68 are attached to the lower end of piston sleeve 62 by appropriate pivot pins 69 for pivotal movement therewith. The rear or outside edges of flapper gates 68 are

provided with camming means in the form of cam surfaces which engage cam surface **59** of lower sub **57**. Hence, when spring **65** forces piston sleeve **62** downwardly to the position shown in FIG. 6, flapper gates **68** are cammed to the closed position by cam surface **59**. This is the condition which will obtain when no pressure is applied to the drilling fluid supported thereabove.

Upon application of pressure to the drilling fluid supported above flapper gates **68**, drilling fluid passes through transverse openings **66** to piston chamber **67** to thereby drive piston sleeve **62** upwardly overcoming the bias exerted by spring **65**. When this occurs, flapper gates **68** are removed from contact with camming surface **69** such that flapper gates **68** fall or pivot to the open position, thus permitting the flow of drilling fluid therepast.

Thus, the operation of the valve taught in FIG. 6 is similar to that taught in FIGS. 1–5. The apparatus shown in FIG. 6 is likewise adapted to move to the open position upon application of pressure to the drilling fluid which normally occurs after make up has been completed during down hole drilling operations. Similarly the valve is adapted to move to the closed position upon termination of pressure on the drilling fluid which occurs prior to break out or the addition of another length of drill pipe to the drill string. It may also be said that the bore closing means are attached to the piston means and adapted to be placed in the closed position when the piston is moved in a downward direction and in the open position when the piston is moved in an upward direction.

The foregoing invention teaches a valve sub which not only has unique design features but solves many of the prior art problems. Not only does it save the waste of drilling fluid which is normally encountered during drilling operations, but it prevents the drilling fluid or mud from splashing over the workmen, thereby creating better working conditions. It also saves time and expense normally incurred in washing down the drilling floor. It provides safer working conditions and there is less likelihood of losing tools down the well bore because of the automatic operation of the device. The apparatus also works as a blowout preventer when the drilling fluid pump is off and the flapper gates are closed. Moreover, there is provided safety means whereby the flapper gates are secured from falling into the bore of the drill pipe in case they should become dislodged from their pivoted position.

Because of the simplicity of design and operation of the valve, it requires very little maintenance and is subject to little or no malfunctioning.

Further modifications may be made in the invention as particularly described without departing from the scope of the invention. Accordingly, the foregoing description is to be construed illustratively only and is not to be construed as limitation upon the invention as defined in the following claims.

What is claimed is:

1. A valve sub for including in a drill string below the kelly to prevent loss of drilling fluid while making connections during down hole drilling comprising:

a body member having means for attaching in said drill string and having an axial bore therethrough,

piston means mounted for axial movement in said body member, said piston means including a tubular member having an axial bore therethrough of a diameter substantially as large as the diameter of the bore through the drill string,

resilient biasing means for urging said piston means downwardly,

full opening bore closing means operably connected to the lower end of said piston means and adapted to be placed in the closed position by movement of said piston means downwardly, and

means for applying a pressurized fluid to said piston means to thereby drive said piston means upwardly

and to move said bore closing means to an open position.

2. An hydraulically operated valve sub for including in a drill string below the kelly to prevent loss of drilling fluid while making connections during down hole drilling, comprising:

a body member having upper and lower threads for threadably attaching in a drill string and having an axial bore therethrough for passage of drilling fluid downwardly therethrough,

a generally tubular piston having an axial bore therethrough of a diameter substantially as large as the diameter of the bore through said drill string and mounted for axial movement in said body member,

resilient biasing means for urging said piston downwardly,

full opening bore closing means operably connected to said piston and adapted to be placed in the closed position by the downward movement of said piston for supporting a column of drilling fluid thereabove in the closed position,

camming means cooperative with said piston for camming said bore closing means to the closed position when said piston is biased downwardly by said biasing means, and

means for applying said drilling fluid under pressure to said piston to overcome said biasing means and drive said piston upward to thereby open said bore closing means.

3. An hydraulically operated valve sub for including in a drill string to prevent loss of drilling fluid while making connections during down hole drilling, comprising:

a generally tubular body member having an axial bore therethrough,

a generally tubular piston having an axial bore therethrough which is generally concentric with the axial bore of said body member and mounted for axial movement therein and forming a piston chamber therewith,

bore closing means mounted in said body member near the lower end of said piston for closing the bore of said drill string and supporting a column of drilling fluid thereabove in the closed position,

means communicating with said piston chamber and the bore of said drill string above said closing means for applying said drilling fluid under pressure to said chamber to drive said piston upwardly,

resilient biasing means having sufficient force to urge said piston downwardly only when pressure on said drilling fluid is below a predetermined amount, and

camming means cooperative with said piston for camming said bore closing means to the closed position when said piston is moved downwardly by said biasing means.

4. The sub as claimed in claim **3**, wherein:

said bore closing means includes a pair of gate flaps which are cammed to a closed position when said biasing means moves said piston downward, and are adapted to move to the open position when said piston moves upward in response to drilling fluid pressure above said predetermined amount.

5. A valve sub for including in a drill string to prevent loss of drilling fluid while making connections during down hole drilling, comprising:

a body member having an axial bore therethrough for passage of drilling fluid downwardly therethrough;

piston means mounted for axial movement in said body member, said piston means including a tubular member forming an enclosed piston chamber with said body member and having an axial bore therethrough of a diameter substantially as large as the diameter of the bore through said drill string,

resilient biasing means for urging said tubular member downwardly,

full opening bore closing means attached to said body member and adapted to be placed in the closed position when said tubular member is moved downwardly, for supporting a column of drilling fluid thereabove in the closed position, and

means communicating with said piston chamber and the bore of said drill string above said closing means for applying a drilling fluid to drive said tubular member upwardly whereby said bore closing means are permitted to move to the open position.

6. A valve sub for including in a drill string to prevent loss of drilling fluid while making connections during down hole drilling, comprising:

a body member having an axial bore therethrough for passage of drilling fluid downwardly therethrough,

piston means including a tubular member having an axial bore therethrough mounted for axial movement in said body member and having a cam portion attached near the lower end thereof,

full opening bore closing means attached to said body member for engagement by said cam portion of said piston means for supporting a column of drilling fluid thereabove in the closed position,

resilient biasing means for urging said camming portion of said piston means downward into engagement with the camming surface of said bore closing means, whereby said bore closing means are moved to the closed position, and

means communicating with the bore of said drill string above said closing means for applying pressurized drilling fluid to said piston means to thereby drive said piston means upwardly whereby said bore closing means are removed from engagement with said camming portion and are thereby permitted to move to the open position.

7. An hydraulically operated valve sub for including in a drill string below the kelly to prevent loss of drilling fluid while making connections during down hole drilling, comprising:

a generally tubular body member having an axial bore therethrough for passage of drilling fluid downwardly therethrough,

a generally tubular piston having an axial bore therethrough of a diameter substantially as large as the bore through said drill string and mounted for axial movement in said body member and having a cam portion attached near the lower end thereof and having an annular flange portion forming a piston head,

bore closing means attached to said body member for engagement by said cam portion of said piston upon downward movement of said piston for supporting a column of drilling fluid thereabove in the closed position,

resilient biasing means for urging said piston downwardly whereby said bore closing means are cammed to the closed position by said cam portion, and

means communicating with the bore of said drill string above said closing means for applying pressurized drilling fluid to said piston head to drive said piston upward to thereby disengage said cam portion from said bore closing means which are thereby permitted to move to the open position.

8. An hydraulically operated valve sub for including in a drill string below the kelly to prevent loss of drilling fluid while making connections during down hole drilling, comprising:

a generally tubular body member having an axial bore therethrough for passage of drilling fluid downwardly therethrough,

a generally tubular piston having an axial bore therethrough of a diameter substantially as large as the bore through said drill string and mounted for axial movement in said body member and forming piston chamber therewith, and having

a cam portion attached near the lower end thereof,

means communicating with said piston chamber and the bore of said drill string for applying pressurized drilling fluid to drive said piston upwardly,

resilient biasing means having sufficient force to urge said piston downwardly only when the pressure of said drilling fluid is below a predetermined level, and

a pair of gate flaps attached to said body member and adapted to be placed in the closed position upon downward movement of said piston and engagement by said cam portion for supporting a column of drilling fluid thereabove in the closed position.

9. A valve sub for including in a drill string to prevent loss of drilling fluid while making connections during down hole drilling, comprising:

a body member having an axial bore therethrough for passage of drilling fluid downwardly therethrough,

piston means mounted for axial movement in said body member, and forming an enclosed piston chamber therewith, said piston means including a tubular member having an axial bore therethrough of a diameter substantially as large as the diameter of the bore of said drill string,

resilient biasing means for urging said tubular member downwardly,

full opening bore closing means attached to said piston means and adapted to be placed in the closed position when said piston means is moved downwardly, for supporting a column of drilling fluid thereabove in the closed position,

means communicating with the bore of said drill string above said closing means for applying a pressurized fluid to said piston chamber to thereby drive said piston means upwardly to thereby permit said bore closing means to move to the open position.

10. A valve sub for including in a drill string to prevent loss of drilling fluid while making connections during down hole drilling, comprising:

a body member having an axial bore therethrough for passage of drilling fluid downwardly therethrough,

piston means including a tubular member having an axial bore therethrough mounted for axial movement in said body member,

resilient biasing means for urging said piston means downwardly,

full opening bore closing means attached to said piston means near the lower end thereof and adapted to be placed in the closed position upon movement of said piston downwardly for supporting a column of drilling fluid thereabove in the closed position,

camming means provided in said body member and cooperative with said tubular member for camming said bore closing means to the closed position in response to downward movement of said tubular member, and

means for applying a pressurized fluid to said piston means to thereby drive said tubular member upward to thereby disengage said camming means and permit said bore closing means to move to the open position.

11. An hydraulically operated valve sub for including in a drill string below the kelly to prevent loss of drilling fluid while making connections during down hole drilling, comprising:

a generally tubular body member having an axial bore therethrough for passage of drilling fluid downwardly therethrough,

a generally tubular piston mounted for axial movement in said body member and having an axial bore therethrough which is substantially as large as the bore of said drill string and having an annular flange portion forming a piston head,

resilient biasing means for urging said piston downwardly, a pair of gate flaps attached to said piston

near the lower end thereof and having camming surfaces for engagement with said body member, whereby said flaps are placed in the closed position upon downward movement of said piston, for supporting a column of drilling fluid thereabove in the closed position, and

means for applying pressurized drilling fluid to said piston head to drive said piston upward to thereby disengage said flaps from engagement with said body member whereby said flaps are free to move to the open position.

12. An hydraulically operated valve sub for including in a drill string below the kelly to prevent loss of drilling fluid while making connections during down hole drilling, comprising:

a generally tubular member having an axial bore therethrough for passage of drilling fluid downwardly therethrough and an annular shoulder forming a camming surface near the lower end thereof,

a generally tubular piston having an axial bore therethrough and mounted for axial movement in said body member and forming a piston chamber therewith, and having at least one transverse opening

through the wall thereof for passage of drilling fluid from said axial bore to said piston chamber, with said piston adapted to move upwardly upon application of fluid pressure to said chamber,

resilient biasing means having sufficient force to urge said piston downward only when the pressure of said drilling fluid is below a predetermined level, and

a pair of gate flaps attached to said piston near the lower end thereof and adapted to be cammed to the closed position by said camming surfaces upon downward movement of said piston for supporting a column of drilling fluid thereabove in the closed position.

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