Aug. 27, 1963 E. E. DAVIDSON 3,101,784

ROTARY WASH SCREEN SETTING COMBINATION AND ROTARY WASHING TOOL THEREFOR

Filed Oct. 16, 1961 2 Sheets-Sheet 1

Fig. 1

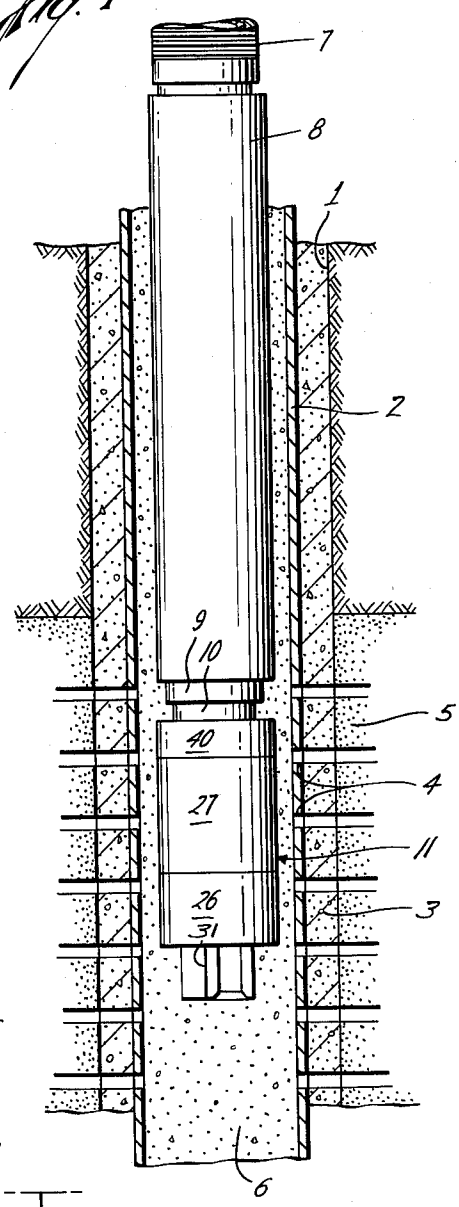

Fig. 2

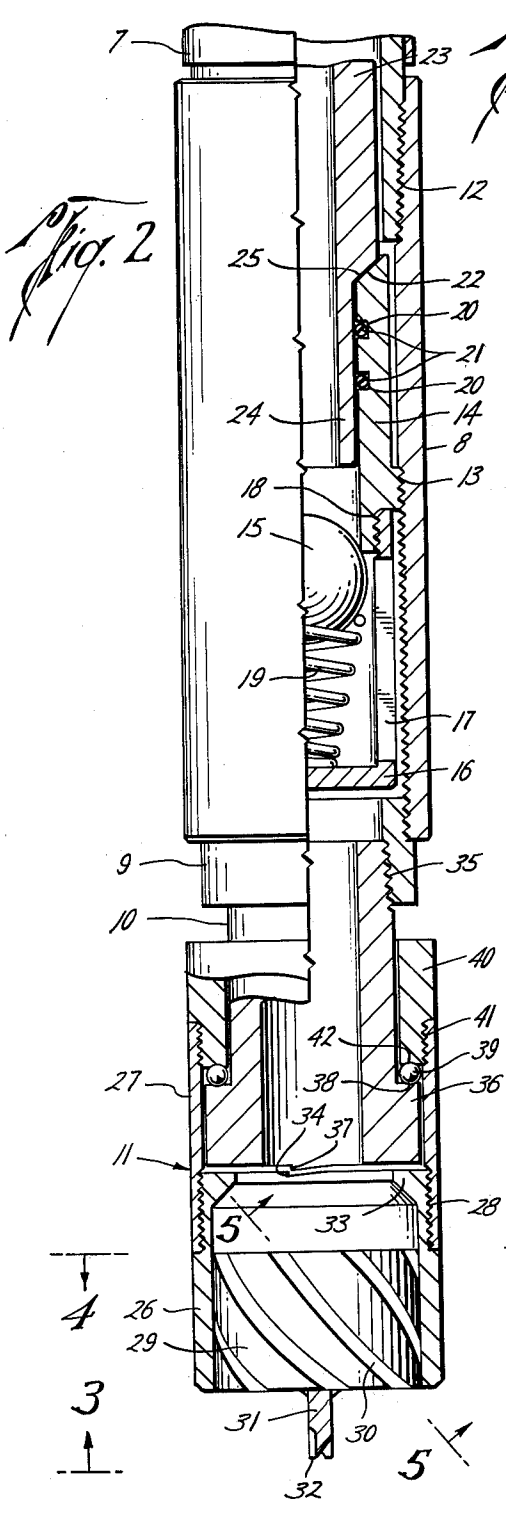

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Fig. 3

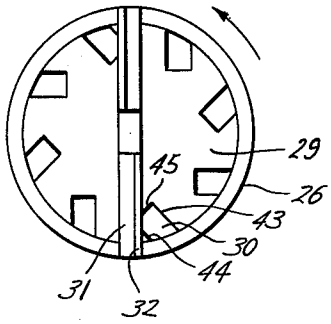


Fig. 4

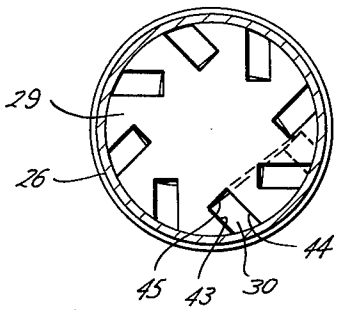


Fig. 5

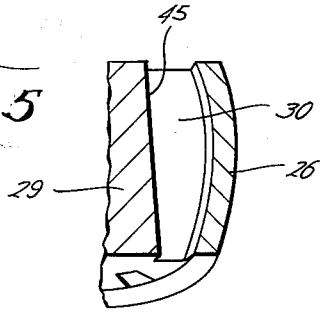
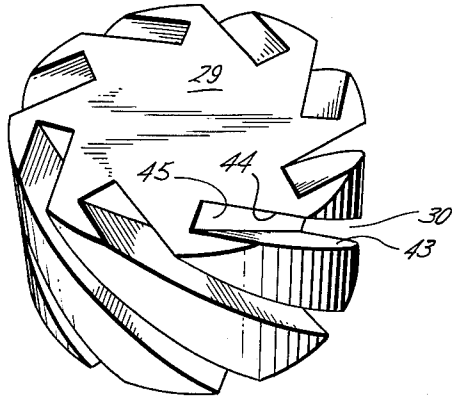


Fig. 6



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ROTARY WASH SCREEN SETTING COMBINATION AND ROTARY WASHING TOOL THEREFOR

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5 Claims. (Cl. 166—158)

This invention relates to the combination with a well screen of means for setting the same in a loosely compacted body of aggregate and to a rotary washing tool forming part of such combination.

One of the methods employed in completing a well and preparing it for flow after the well has been drilled through a formation believed to be suitable for production of the desired product from the earth is to set a large pipe or casing in the well extending down past such formation and cement the same in place by pumping cement down through the casing and up around the outside thereof preferably to a point above the producing formation so as to seal it off from other formations which might produce other contaminating substances. Then such casing and the cement surrounding the same are perforated by shooting through them from inside the casing either with a so-called gun which fires bullets laterally through the casing and cement into the formation or by a so-called shaped charge gun which directs an explosive jet through the casing and cement into the formation. The formation may then produce either liquid or gas through the openings provided by such shooting and into the interior of the casing from which the production may be withdrawn through a tubing or the like.

It frequently occurs that the fluid being produced carries sand or other particles which not only cause the well to become partly filled at its lower end with such sand or the like, but also tend to erode the pipe and tubing and other equipment used in the well. One way of preventing such sand or the like from being carried up with the production from the well is to employ a screen pipe or strainer which is lowered into the casing and through which the production is forced to flow in order to reach the tubing. However, the erosion from such sand content or the like is very frequently so great as to destroy the screen. In order to deal with this situation, the space within the casing is first filled with gravel or aggregate so as to break up the high velocity of streams of production flowing through the shot holes into the well, and the screen is then set inside of this body of aggregate so that the annular wall of aggregate between the screen and the casing protects the screen against erosion.

In many instances great difficulty has been encountered in setting screen through such a body of aggregate after the aggregate has been put in place in the well because of the fact that the aggregate becomes somewhat compacted and it is difficult with the usual washing devices to wash the aggregate away sufficiently to lower the screen therethrough.

It is therefore an object of this invention to provide a screen and screen setting and washing combination by which a screen may be readily set in a body of sand or aggregate which has become somewhat compacted.

Another object is to provide an inexpensive rotary washing tool capable of high speed agitation of loosely compacted aggregate for a short time such as required for lowering a well screen into a gravel packed zone of a well.

Another object is to provide a simple, inexpensive rotary washing tool for use on the lower end of a tubular member in lowering it through a bed of material such as sand or gravel.

Another object is to provide a rotary tool of the nature last mentioned which is of such simplicity and low cost

that it may be used as a guide for a back pressure valve on the lower end of a well screen or in such other uses as may require it to be left in a well.

Another object is to provide in combination with a well screen or the like a back pressure valve on the lower end of a fluid pressure operated device which will disperse a body of sand, gravel or the like and permit the expeditious lowering of such screen and valve therethrough, even if such bed be well compacted.

Another object is to provide such a rotary washing tool which will provide an optimum of simplicity and low cost with the greatest rotary power from a given size and pressure of fluid stream.

Another object is to provide a high speed, simple, inexpensive fluid-driven drilling mechanism.

One other object is to provide a rotary washing shoe with an agitating and drilling blade thereon which may be driven in one direction by pumping fluid therethrough but which may serve as an anchor for a tubular member to which it is secured and with respect to which it normally rotates, so as to permit the tubular member to be unscrewed therefrom and removed.

Other objects and advantages of this invention will become apparent from the following description taken in connection with the accompanying drawings, wherein is set forth by way of illustration and example one embodiment of this invention.

In the drawings:

FIG. 1 is a longitudinal cross section through a portion of a graveled producing zone of a well through which a screen and washing mechanism constructed and assembled in accordance with this invention is being lowered;

FIG. 2 is a view partly in longitudinal cross section and partly in elevation of the rotary washing tool and back pressure valve employed at the lower end of the screen of FIG. 1;

FIG. 3 is a bottom plan view of the rotary washing tool taken along the line 3—3 of FIG. 2;

FIG. 4 is a transverse cross section through the rotary washing tool taken along the line 4—4 of FIG. 2;

FIG. 5 is a fragmentary cross section taken along a center line of one of the grooves providing passageways for the flow of fluid through the rotary washing tool taken along the inclined line 5—5 of FIG. 2;

FIG. 6 is a perspective view on an enlarged scale showing the plug-type inner portion of the rotary washing tool of FIGS. 1–5 and illustrating more in detail the grooves providing the fluid flow passageways therein.

As illustrated in the drawings above mentioned, the present invention accomplishes the objects hereinbefore set out by providing the combination with a well screen or strainer to be set in the well and the more or less conventional wash pipe extending down through the same for conducting fluid to the bottom thereof during the setting operation and back pressure valve for preventing backflow up through the wash pipe, of a rotary washing tool rotated by the flow of fluid therethrough during the washing and having an agitating blade thereon so as to agitate and displace gravel or aggregate and permit expeditious lowering of the strainer.

The rotary washing tool shown for use in connection with the above-mentioned combination is actually a simple drill bit with cutting and agitating blades welded to its lower end and mounted for rotation with respect to the check valve or other tubular member on which it is carried. The rotation is accomplished by means of forcing the fluid which passes through the bit to pass through passageways which are inclined with respect to and spaced laterally from the bit axis and arranged in balanced relationship about the axis so that they direct the emerging fluid in a downward and more or less tangential direction from each passageway. The reaction from this arrange-

ment causes the drill bit to rotate and it has been found that the rotation will be at very high speed.

The construction for providing these downwardly and inclined passageways for fluid is made extremely simple so as to be very inexpensive and permit the device to be left in a well after the setting of the screen. This simplified construction is achieved by providing a composite body made up of a tubular member with a plug tightly fitted into the tubular member and integrally secured therein and with the drilling and agitating blades welded across the bottom of this plug. The passageways are formed by making substantially straight line cuts by a suitable tool such as a milling tool along the outer surface of this plug at an angle to the axis thereof. Not only is the cut made straight, but it is made with a straight line bottom so that the work piece may be chucked up on a milling machine and held stationarily thereon while the cut is made by a straight line pass of the cutter with respect to the work, resulting in a very inexpensive fabrication.

Additionally, the efficiency of the jets emerging from such passageways may be increased by making the cut deeper at the upper end of the plug than at the lower end thereof so as to provide a nozzle-type action in the passageway increasing the velocity of fluid emerging therefrom.

The rotary washing tool is also mounted in a novel manner with a thrust bearing that operates as such only when the tool is urged by fluid pressure therein downwardly and away from the tubular member on which it is mounted, and is provided with a clutch which will engage when the tool is moved upwardly toward the tubular member on which it is mounted so as to prohibit rotation of the tool with respect to the tubular member and permit the tubular member to be rotated from above to unscrew it and disconnect it from the tool.

Referring more in detail to the drawings, there is shown in FIG. 1 a well hole 1 having a casing 2 therein which has been cemented into place by pumping cement 3 around the outside of the casing within the well hole in the customary fashion. Thereafter provision is made for producing the well by shooting holes 4 through the casing and through the surrounding body of cement into the producing formation 5, a procedure likewise conventional. The cement outside the casing not only fixes the casing in place, but provides a means for isolating unwanted production from zones other than that which is to be produced.

The well may then be completed in any conventional manner unless a situation is known to exist which would require the use of what is known as a gravel pack to prevent erosion of tubing, screen or the like used in producing the well.

In the event of the erosion problem being present at the time the well is completed or becoming apparent later, the tubing, screen or the like would be removed from the well if any had been set therein and a quantity of gravel or aggregate of suitable size for the particular erosion problem involved would be dumped into the well providing within the perforated section of the casing opposite the producing formation what is customarily termed a gravel pack. Then the screen would be run in again, usually with a back pressure or check valve on its lower end and a wash pipe extending down through the screen to pump wash water or other fluid to the lower end of the screen, and while pumping takes place to agitate the gravel pack and loosen it, the screen would be worked down in the gravel pack to the desired depth.

The matter of washing and working the screen down into the gravel pack is frequently troublesome and time consuming and the present invention is chiefly involved in dealing with this problem, although it might well be found suitable for dealing with other similar problems.

The gravel pack having been established in the well as indicated at 6, a conventional well screen or strainer 7 would be lowered into the well with a back pressure or check valve contained within a housing 8 secured to its lower end. In accordance with this invention, the check valve would have an adapter 9 threadedly engaged in its lower end for the purpose of receiving a stem or upper portion 10 of a rotatable connection for a rotary washing tool 11. The washing tool 11 is in the form of a rotary drill bit adapted to rotate under the influence of fluid flowing downwardly therethrough so as to agitate the gravel pack both by the impingement of fluid thereon in a more effective manner than with the usual washing equipment, and by the mechanical agitation of the rotating washing tool.

The check valve housing 8 is secured to the screen 7 by any suitable means such as the threaded connection 12, and has an elongated threaded section 13 therein to threadedly receive a valve seat element 14. The valve seat element 14 has a seat formed on its lower end to receive a valve such as the ball valve 15 which when seated against the valve seat will prevent upward flow therethrough.

Secured to the lower end of the seat element 14 is a valve cage 16 having slots 17 therein through which flow may take place and threadedly secured at 18 to the valve seat element 14. Interposed between the lower end of this cage 16 and the ball valve 15 is a spring 19 constantly urging the ball valve 15 against the seat, yet yieldable to move downwardly and permit downward flow past the ball valve.

Above the seat on its lower end the seat element 14 is provided with internal grooves 20 adapted to receive suitable packing such as the O-rings 21, and on its upper end it is provided with a beveled seat 22.

Extending downwardly through the screen 7 is a wash pipe 23 adapted to convey washing fluid downwardly through the interior of the screen. On its lower end this wash pipe 23 is provided with a reduced portion 24 adapted to fit within the upper portion of the valve seat element 14 and be sealed thereto by the O-rings 21. The downward movement of this wash pipe is limited by engagement of an externally tapered shoulder 25 thereon with the upwardly facing beveled surface 22 on the valve seat element 14.

Thus it may be seen that washing fluid may be forced downwardly through the wash pipe 23, passing through the screen 7 and being forced downwardly past the check valve 15 and out the lower end of the check valve housing 8, passing through the slots 17 in the cage 16 in the process.

The rotary washing tool comprising a rotary drill bit is shown as composed of several parts including a lower tubular body part 26, an upper tubular body part 27 secured thereto by means of threads 28, and a slotted plug or rotary bit body 29 tightly fitted into the lower tubular part 26. The tubular parts 26 and 27 are formed in two parts for convenience in manufacture but might otherwise be formed into the integral member which they constitute in operation.

The plug 29 has slots 30 formed at spaced intervals around its exterior for the purpose of providing fluid passageways so that when this plug is fixed within the lower tubular member 26 as illustrated in FIG. 2 and fluid is forced downwardly therethrough, the fluid passing through the slots 30 will be directed downwardly at intervals around but spaced from the axis of rotation of the plug and within a plane on an angle to a radial plane which intersects the slot. Thereby the reaction of fluid passing through the slots 30 will tend to cause rotation of the rotary washing tool.

Fixed across the lower surface of the plug 29 as by welding or the like is an agitating and drilling blade 31 preferably having a cutting edge 32 on its lower extremity after the manner of drilling tools customarily known as fishtail bits.

On its upper end the lower tubular member 26 is provided with an inwardly extending flange 33 having clutch

teeth **34** on its upper surface forming one of two relatively rotatable members of a clutch for a purpose presently to be described.

The stem **10** which is secured to the adapter **9** by means of threads **35** or other suitable means has on its lower end an outwardly extending flange **36** the lower end surface of which is provided with clutch teeth **37** forming the other of two relatively rotatable members of a clutch adapted to interengage with the clutch members formed by clutch teeth **34** when the stem **10** is moved downwardly with respect to the rotary washing tool **11**. When in such position it will readily be seen that these interengaging clutch teeth will prevent rotation of the rotary washing tool **11** with respect to the stem **10** and the tubular member thereabove in the direction that such rotary washing tool tends to rotate under the influence of the reaction of fluid passing through the slots **30**.

On its upper surface the flange **36** is provided with an upwardly facing shoulder having a ball race **38** therein for receiving balls or other suitable antifriction members **39** and forming one part of a thrust bearing. The upper end of the upper tubular member **27** extends up around such antifriction members **39** and is internally threaded at **41** to receive the ball race member **40** which has a ball race **42** on its lower end engaging the upper surfaces of the balls **39** and forming another thrust bearing part. Thus it will be seen that when the rotary washing tool is in its lowermost position with respect to the stem **10** as illustrated in FIG. 2, it will be free to rotate and the balls **39** will provide a thrust bearing restricting the movement of the rotary washing tool in a direction away from the tubular member or members to which it may be connected and from which it may be suspended.

It will thus be apparent that when fluid is forced under pressure down through the wash pipe **23** past the valve **15** and into the rotary washing tool its pressure exerted against the upper surface of the plug **29** and the adjacent surfaces of the body of the rotary washing tool will force such tool to its lowermost position with respect to the stem **10** in which position the thrust bearing provided by the balls **39** and their associated races will permit rotation of the rotary washing tool under the influence of the reaction of fluid passing downwardly through the slots **30**. On the other hand, when the weight of the equipment above the rotary washing tool is placed thereon with the rotary washing tool against the gravel pack or other obstruction and without the pressure of fluid thereabove, it will serve to hold the lower end of the equipment thereabove against rotating so that such equipment may be unthreaded or otherwise disconnected if desired.

On reference to FIGS. 3–6, more detail of the slots **30** and the plug **29** may be observed. It will be seen by comparison of these figures that each of the slots **30** is a rectilinear cut of a character which may be made, for example, by a milling machine. In the form illustrated, the side walls of each slot **30** are plane surfaces as illustrated at **43** and **44**. See particularly FIGS. 4 and 6 in which the hidden portions of one of the slots are shown in dotted lines. Likewise, in the form illustrated, the bottom **45** of each slot **30** in a plane surface. It will be understood that the sides and bottom of the slots **30** are not necessarily plane surfaces as illustrated, but that it is preferable that they have straight line elements from end to end of each slot in order that they might be formed with a straight line pass of a cutting tool as this greatly reduces the cost of manufacture as compared with previous types of fluid driven rotary bits and the like, in which the fluid passageways have customarily been formed along curved lines or made of expensive vanes or fins. It will be seen that the only machining required to provide the fluid passageways in the present invention consists of a series of straight line passes of a machining cutter to form the slots **30**. It is further to be noted that by merely inclining the bottoms of the slots slightly it is possible to make the outlet ends of the fluid passageways resulting therefrom of smaller cross-sectional area than the inlet ends thereof. By this means the longitudinal cross section through a slot appears as shown in FIG. 5 and provides a nozzle effect at the outlet end increasing the velocity of fluid emerging therefrom and thereby increasing the jetting effect of such fluid. This provides not only a more efficient rotative tendency for the rotary washing tool, but also a more efficient agitation of the aggregate body or the like into which the screen or other tubular member is to be lowered.

From the foregoing, the operation of the present invention will be apparent. A forcing of fluid under pressure downwardly through the wash pipe **23** past the valve **15** into the rotary washing tool will apply pressure to such tool and force the drill bit which makes up a part of the tool downwardly to engage the thrust bearings **39** in which position the clutch teeth **34** and **37** will be disengaged and the tool may rotate. Lowering of the tool into an aggregate bed will be so governed as not to place such weight on the tool as will move it upwardly with respect to the screen and wash pipe but instead will allow it to remain in position with the thrust bearing **39** engaged and the clutch teeth **34** and **37** disengaged.

After operation of the device in the fashion just described until lowering of the screen into the aggregate bed has been completed, the flow may be stopped whereupon the check valve **15** will close and prevent backflow upwardly into the wash pipe or into the screen **7**. The wash pipe may then be withdrawn, leaving the screen **7** open for fluid to flow laterally inward therethrough and up in the usual manner of production. The gravel pack around the screen **7** will protect the screen **7** from erosion due to the jetting action inwardly through the perforations **4** in the casing.

It being customary to lower such an assemblage on a suitable string of pipe or the like which is then disconnected by reversely rotating the same at the surface with respect to the screen, this may be accomplished in the present invention by lowering the weight of the equipment thereabove onto the rotary washing tool causing the clutch teeth **34** and **37** to engage. This action will also cause the blade **31** to engage in the bed of aggregate and hinder reverse rotation of the rotary washing tool so that the entire assemblage including the screen **7** would be prevented from rotating in a reverse direction when a torque is placed on the suspending pipe at the surface to rotate and disconnect it so that it may be withdrawn.

From the foregoing it will be seen that a means has been provided for carrying out all of the objects and advantages of this invention.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the structure.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

The invention having been described what is claimed is:

1. In combination, a well screen, a wash pipe extending through said screen for conducting washing fluid through said screen from one end to the other thereof, a check valve closing one end of said screen and releasably and sealingly engaging one end of said wash pipe to receive washing fluid therefrom, and arranged to permit flow from said wash pipe through said check valve and prevent flow in the opposite direction, and a rotary washing tool comprising a rotary bit and means rotatably connecting said bit to the check valve to receive fluid there-

from, said bit having fluid passageways longitudinally therethrough with a tangential component whereby flow of fluid therethrough will urge said bit to rotate in one direction with respect to said screen and check valve.

2. The combination set forth in claim 1 in which said means rotatably connecting said bit to the check valve includes a thrust bearing permitting said rotation while restricting longitudinal movement of the bit in a direction away from the check valve, and a clutch having two coengageable and disengageable members relatively rotatable when not engaged with one another secured respectively to said bit and check valve, said members being engageable with one another upon movement of said bit toward said check valve to prevent relative rotation of said members and said bit and valve in one direction, said bit having an area subject to the pressure of fluid entering said bit from said check valve and urging said bit upon application of said washing fluid thereto into a position to permit said relative rotation of the bit and check valve.

3. The combination set forth in claim 2 in which said clutch members have mutually engageable parts positioned to prevent said relative rotation in the direction in which said bit tends to rotate relative to the valve under the influence of fluid flowing therethrough.

4. A rotary washing tool for use on an end of a tubular member to agitate a body of aggregate or the like into which the tubular member is to be passed comprising a rotary drill bit body having fluid passages therethrough spaced about the axis of said body and each inclined in the same angular direction relative to a radial plane of said body which intersects said passageway, and each lying in a plane at an angle to said radial plane and having a portion equidistant throughout its length from the axis of the body, a blade on said body projecting from one end thereof, and means including a thrust bearing on the other end of said body comprising two relatively rotatable parts, one rigidly mounted on said body and the other rotatably secured thereto and having securing means thereon adapted for securing to a tubular member, whereby when fluid is forced from said tubular member through said passageways its reaction will tend to rotate said body in one direction relative to such tubular member, the parts of said bearing being secured to each other with a lost motion connection to permit them to move with restricted longitudinal movement relative to each other, and a clutch having two engageable and disengageable members relatively rotatable when not engaged with one another secured respectively to the parts of said bearing, said members being engageable with one another upon movement of the parts of said bearing toward one another to prevent relative rotation of the said clutch members and parts of said bearing in one direction.

5. A rotary washing tool for use on an end of a tubular member to agitate a body of aggregate or the like into which the tubular member is to be passed comprising a rotary drill bit body having fluid passages therethrough spaced about the axis of the body and each inclined in the same angular direction relative to a radial plane of said body which intersects said passageway, and each lying in a plane at an angle to said radial plane and having a portion equidistant throughout its length from the axis of the body, a blade on said body projecting from one end thereof, and means including a thrust bearing having relatively rotatable parts, one of which is secured to the other end of said body and the other of which is rotatably connected to the first part and has a connection thereon adapted to receive a tubular member, whereby when fluid is forced from such tubular member through said passageways its reaction will tend to rotate said body in one direction relative to such tubular member, said body being made up of an outer tubular member and a plug fitting and fixed therein and said passageways are provided by slots in the radially outer surface of said plug, the sides and bottoms of said slots being surfaces with straight line elements from end to end of the slots.

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