United States Patent

[11] **3,552,412**

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[45] Patented **Jan. 5, 1971**

[54] **DRILL STRING DUMP VALVE**
6 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **137/70,** 166/194
[51] **Int. Cl.** **F16k 31/00**
[50] **Field of Search** ..... 137/68, 70, 71; 166/154, 194, 224(Inquired); 175/237, 318

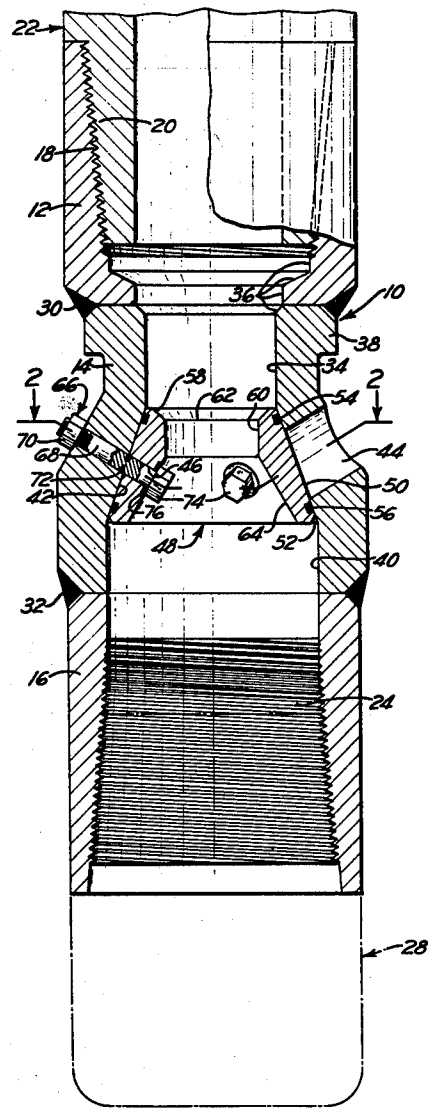
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ABSTRACT: The invention comprises an improved drill string dump valve comprising a moveable member having a downwardly and outwardly sloping sealing surface. The valve comprises structure to permit the moveable member with its operating member thereon to fall free and unrestricted downwardly away from the relief ports.



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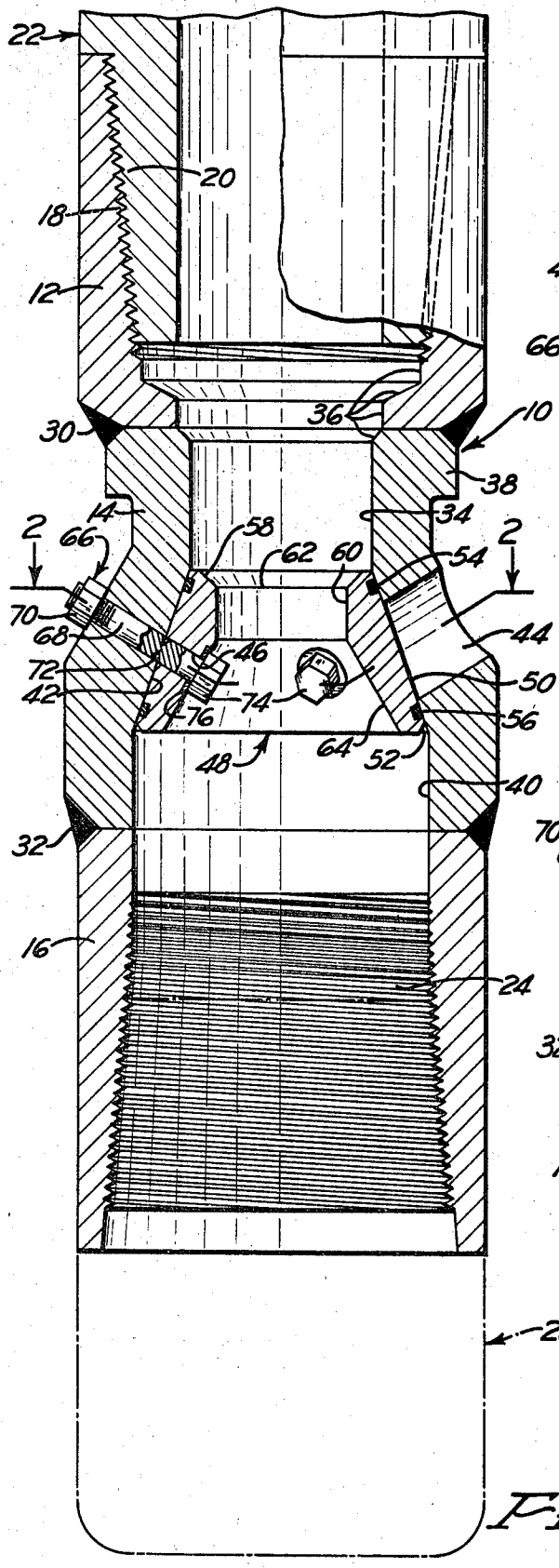


Fig. 1

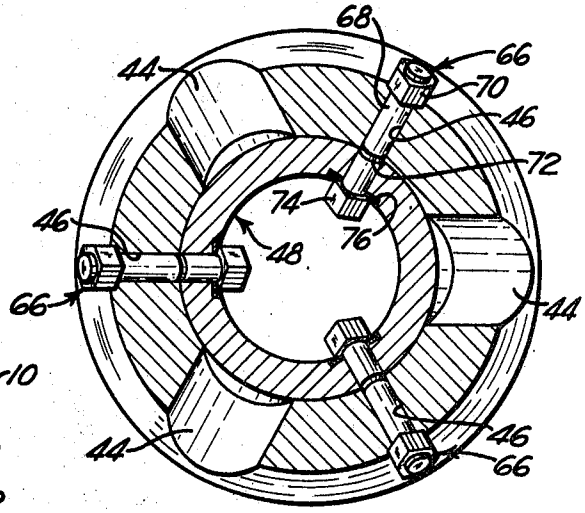


Fig. 2

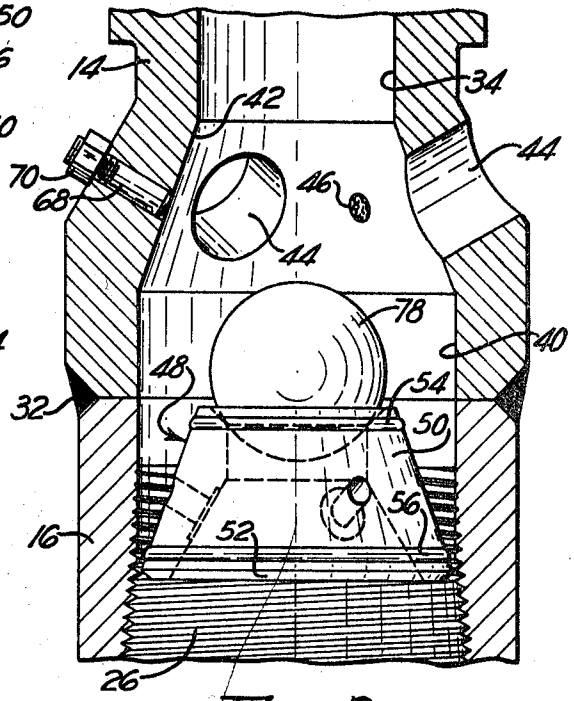


Fig. 3

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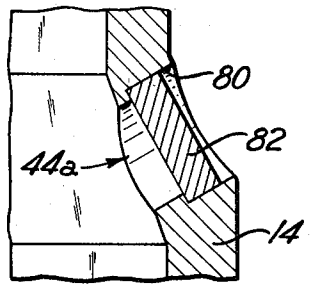


Fig. 4

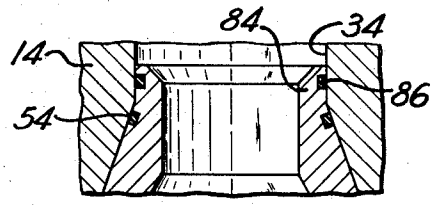


Fig. 5

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DRILL STRING DUMP VALVE

This invention relates to an improved dump valve for use in a long string of substantially vertically disposed fluid-carrying pipe or the like.

More particularly, the invention is directed to a dump valve for use with a string of drill pipe. In drilling wells in the earth by the almost universally used rotary method, a long string of pipe carrying a drill bit at its lower end is utilized. Special fluids, commonly called "drilling mud," are circulated down the drill pipe, through the bit, onto the bottom of the borehole, and up through the annulus between the drill pipe and the borehole. The mud serves as a coolant, as a carrier to carry the chips or cuttings to the surface, as a weight to hold formation fluids in place to prevent a "blowout" of the well, and other purposes well known to those skilled in the art.

The present invention provides a highly reliable dump valve. A dump valve is desirable because for certain purposes the fluid exit passages in the bit do not permit a rapid enough flow of mud therethrough. For example, the problem arises when it is desired to pump certain well treating materials, such as lost circulation materials, into the borehole and the formation at a rate greater than that which can be obtained if these materials were pumped through the openings in the bit. Additionally, some lost circulation materials may be too large to pass through the bit openings.

Another time the problem arises is when a well is or is about to blow out. In such case, it is necessary to increase the hydraulic pressure of the mud in the well as fast as possible. With the relatively small normal openings in the bit, it may not be possible to get a heavier mud in the well fast enough to stop or prevent the "blowout."

Another purpose of a dump valve concerns the normally occurring periods when it is desired to make a "round trip." A "round trip" is a term of the art which means removal of the entire drill string from the well and then replacing it. This is done by taking the drill string apart in joints of one, two, or three sections of drill pipe each, depending on other conditions. A trip must be made many times during the drilling of a normal well for purposes of changing the bit, to set an intermediate string of casing, to run a drill stem test, to run a coring tool to obtain cores, and for other purposes well known to those skilled in the art. As is well understood, the drill string is continuously lengthened as the well is drilled by the periodical addition of single sections of drill pipe at the upper end, as required.

Before making a trip or before treating the well with any of the various well-treating materials, it is highly desirable to provide an enlarged opening or openings at the lower end of the drill string to facilitate rapid removal of the column of mud therein prior to any such operation. In the case of making a trip, it is desirable to provide this enlarged cross-sectional exit area at the lower end of the drill string, particularly when the drilling mud is heavy or viscous, to assure that large quantities of mud will not be wasted since drilling mud is fairly expensive, and will not be splashed around the drill floor forming a severe safety hazard, as a connection is unmade between joints as the drill string is raised out of the well and taken apart.

In prior dump valves, a moveable valve member was provided, usually in the form of a cylindrical member or sleeve, which was moved downwardly to uncover relief openings having various configurations. Such cylindrical or sleeve type dump valves suffer from several disadvantages which are overcome by the present invention. Since the surface of contact between the inside of the valve and the valve member is positioned parallel to the direction of fluid flow through the valve, particulate matter in the mud can wedge in said plane of contact, which results in leakage, and shortening of the life of the valve by wearing of parts. This is a serious problem because drilling mud is inherently abrasive due to fine formation particles therein which are almost impossible to totally remove. The problem is sometimes intentionally increased since various additives and other matter put in the mud are particulate and/or abrasive.

Another disadvantage of these prior sleeve type dump valves is that the shorter the sleeve is, the more it is likely to cock and thereby not move properly, and the longer the sleeve is, the more the surfaces between which particles may wedge are enlarged. Wedged particles can result in the sleeve not moving properly or not moving at all. Another disadvantage of the sleeve type is that a part of each sheared pin or bolt moves with the cylinder and can damage the inside surface of the valve and/or the sealing means, which necessitates rework of the valve. The frequency of malfunctions in sleeve type dump valves is unacceptably high, and the useful life is unacceptably short due to wearing parts, particularly where there is a significant concentration of particulate matter in the mud.

Another prior type of dump valve utilizes pressure differential means. In these valves, the valve is normally open and closes only when the drill string is pressurized. The disadvantages of this type of valve include permitting entry of well fluids and relatively large entrained cuttings into the drill string as it is lowered into the well. These cuttings can clog the fluid exit openings from the inside of the bit when normal operation starts.

The present invention provides an improved, highly reliable dump valve, which overcomes the above and other problems, comprising a valve body having an intermediate position which is formed with a plurality of exit openings or relief ports communicating the flow passageway through the valve with the outside of the valve. A moveable valve member is provided and is held in place by a number of weakened bolts or the like. The valve member normally seals the exit openings shut. The valve is operated by dropping an operating member down through the drill string to seat on a portion of the moveable valve member, and upon application of hydraulic pressure on the operating member by pressurizing the column of mud in the drill string, the weakened bolts break, causing the valve member and the operating member to fall away from the relief ports. The dump valve of the invention provides means to assure highly reliable successful operation of the valve by providing an upwardly and inwardly tapered surface between the valve member and the wall of the valve which is formed with the relief ports. A space below the relief ports into which the movable valve member and the operating member fall is also provided to thereby position them out of the path of the rapid flow of mud and other materials through the relief ports, and to create a relatively large clearance space to prevent any particle wedging anywhere in the valve once it has been operated. The tapered surface assures that the valve member will fall downwardly and way away from the relief ports. Additionally, by providing this downwardly and outwardly tapered surface, the plane of contact between the movable valve member and the wall of the valve body containing the ports is positioned outside of and at an angle to the normal axial flow path of mud. Thus, said plane of contact tends not to have any destructive particles which may be in the mud lodged therein. This is a material advantage for the present invention because of the particulate and abrasive matter always in the mud or added to it. The provision of bolts to hold the valve member in place provides the advantage of ready renewal of the valve of the invention by simple replacement of the bolts while repositioning the valve member over the relief ports. By providing weakened portions in these bolts, a very small amount of elongation and consequent loosening can occur before the valve operates.

Other advantages of the invention will be pointed out or will become evident in the following detailed description and claims, and in the accompanying drawing also forming a part of the disclosure, in which:

FIG. 1 is a longitudinal view of a valve embodying the invention partly in cross section, partly in elevation, and partly diagrammatic;

FIG. 2 is a transverse cross-sectional view taken on line 2–2 of FIG. 1;

FIG. 3 is a view similar to a portion of FIG. 1 showing the condition of the valve after it has been operated;

FIG. 4 is a partial view similar to a portion of FIG. 1 illustrating a modified relief port structure; and

FIG. 5 is a partial view similar to another portion of FIG. 1 showing a modified throat structure for the moveable valve member.

Referring now in detail to the drawing, 10 designates a dump valve embodying the invention. Valve 10 comprises an upper portion 12, an intermediate portion 14, and a bottom portion 16. Upper portion 12 is formed with a "box" or female threaded portion 18 which receives the "pin" or male threaded portion 20 of the bottommost section of drill pipe 22. Bottom portion 16 is formed with a box or threaded portion 24 which receives the pin or upper end 26 of a bit or suitable conversion device 28. Bit 28 is shown diagrammatically only since the dump valve of the invention is adaptable for use with virtually any kind of bit, it being understood that suitable convertors can be added if needed. The top and bottom portions 12 and 16, as shown, are intended for use with conventionally used drill string connections, but it will be understood that any other connection means can be used to accommodate another system.

Top and bottom portions 12 and 16 are joined to intermediate portion 14 by welds 30 and 32 respectively, it being understood that any other connection means could be used, or that the valve 10 could be fabricated in one piece.

The upper end of intermediate portion 14 is formed with an internal throat 34, which serves as a guide for the operating member, as will be explained below. From the upper end of throat 34 to the lower end of threads 18, valve 10 is formed with a series of steps 36 to bring the internal diameter of the valve down to he the diameter of throat 34. The outside surface of intermediate portion 14, at the upper end thereof, is formed with an external shoulder 38 to facilitate welding.

Extending upwardly from the upper end of threads 24 through the upper end of bottom portion 16 and the lower end of intermediate portion 14 is a cylindrical bore 40. Extending between the upper end of cylindrical bore 40 and the lower end of cylindrical throat 34, valve 10 is formed with a downwardly and outwardly sloping inclined surface 42. The wall of intermediate portion 14 at the region of sloped surface 42 is formed with three relatively large equally spaced relief ports 44. Interspaced, at equal distances, between the three ports 44 are three bolt openings 46.

Means are provided to releasably hold relief ports 44 closed against the flow of fluids through the inside of the valve. To this end, a moveable valve member 48 is provided. Referring to FIG. 3, valve member 48 is formed with a downwardly and outwardly sloped surface 50 adapted to fit snugly against sloped surface 42, and having a length less than the length of surface 42, for a reason that will appear below. The lower end of member 48 is clipped by a short downwardly and inwardly sloping surface 52, whereby the largest outside diameter of the member 48, i.e., the junction of surfaces 50 and 52 described a cross-sectional area less than the largest cross-sectional area described by surface 42, i.e., the plane of junction of surface 42 and bore 40.

Valve 10 is essentially cylindrical, and the various cross sections, throat, etc., described are circles or circular. This was done to facilitate manufacture, but these shapes are not to be construed as limiting since oval, prismatic, or other shapes could be substituted in places without departing from the scope of the invention. Similarly, flat areas could be provided around the exit openings to improve sealing if needed.

Surface 50 of member 48 is formed with means to receive an upper O-ring 54 and a lower O-ring 56. As shown in FIG. 1, the O-rings 54 and 56 are positioned above and below the relief ports, to seal off these openings.

Means are provided in member 48 to form a seat for the valve operating member. To this end, the upper inner end of member 48 is formed with a downwardly and inwardly sloping tapered surface 58, the lower end of which joins the upper end of a cylindrical throat 60. The edge 62 at the junction between sloping surface 58 and throat 60 comprises a seat for the operating member as will be described below. Starting from the lower end of throat 60, member 48 is formed with a downwardly and outwardly sloping surface 64 which extends to the bottom of member 48.

Means are provided to releasably hold the moveable member 48 in sealing relation to the relief ports 44, with surface 50 in sealing engagement with surface 42 of the valve by virtue of O-rings 54 and 56. To this end, three shear bolt assemblies 66 are provided. Referring to FIG. 2, each assembly 66 comprises a shank 68 having a threaded outer end on which is mounted a nut 70. A weakened portion, formed by a groove 72 or the like, is cut into shank 68. As shown in FIG. 1, the groove 72 is located at the interface between surfaces 50 and 42 when the valve is assembled. A head 74 is on the inner end of shank 68 and a washer 76 is seated in a suitably formed recess in surface 64 between head 74 and the moveable member 48. Washer 76 is formed of a relatively soft and relatively ductile material, such as copper, so that when the nut 70 is tightened up on its threads, head 74 and washer 76 will form a fluidtight seal on the inside of the moveable member 48 by deformation of the soft washer. Member 48 is formed with suitable bolt openings which align with openings 46 to receive bolt assemblies 66.

In use, an operating member, shown in the form of a sphere 78, is dropped from the surface through the mud down the drill string until it meets the valve member. The ball is guided in its downward motion through valve 10 by cylindrical throat 34, and seats upon edge 62 to close off any further axial passage of fluids through valve 10. Increased pressure on the column of mud above the operating member by pumping equipment at the surface causes bolt assemblies 66 to break at their weakened portions 72, whereupon the moveable member 48 with the operating member 78 seated thereon fall down and away from surface 42 to thereby open the relief ports 44.

The operating member 48 78 is shown in the form of a sphere since this shape is simple and trouble free in operation. However, it is possible to have operating members of other shapes, such as an elongated "torpedo" formed with suitable means at its lower end to seat upon edge 62 or any other suitably formed seat at the upper end of the moveable member. The ball 78 shown may be formed of any suitable material which is hard enough not b to be damaged by its travel down the drill string and has sufficient strength not to be sheared by the pressure on it when elongating and breaking the bolt assemblies 66. Suitable material for ball 78 include tungsten carbide, most ordinary grades of steel, nylon, and other materials well known to those skilled in this art.

The provision of throat 60 as one of the surfaces to form the seating edge 62 imparts the advantage of prolonged useful life to the moveable member 48 of the invention. By providing such a throat, the edge 62 can be worn away by repeated use, and as such wear occurs, a continuous new edge will be presented, moving downwardly along throat 60, to act as a seat for the operating member. In any case, the entire moveable member 48 is easily replaced at any time while the valve is being removed if it should wear or be damaged in handling.

The provision of the groove 72 to act as weakening means provides the advantage that substantially all of the elongation of the bolt will take place in the narrow-necked portion created by the groove, and since a small amount of material is provided at said area, it will be capable of very little elongation before breaking. Thus, opening of the valve is speeded and little leeway is provided for loosening of the moveable member 48 during normal operation. Such loosening would have a deliterious effect firstly because of the leakage of material through the ports 44 and secondly because of possible scoring or other wearing of the sealing surfaces 42 and 50, as well as of the O-rings 54 and 56.

The provision of the soft washers 76 on the inside of the bolt assemblies provides the advantage of a tight seal at this point, as explained above, and additionally, provides the advantage of the ability to easily and inexpensively renew this seal by simply putting in a new washer when the dump valve 10 is renewed after each use.

Tests of a valve embodying the invention showed that after 20 hours of circulation at the rate of 450 g.p.m. at 5,000 p.s.i., the valve opened properly with a pressure of only 1,500 p.s.i. on the operating member.

The improvement of the dump valve of the present invention resides, at least substantially, in the provision of the two downwardly and outwardly sloping surfaces **42** and **50**. This structure assures that the moveable member with the operating member seated thereon will fall downwardly and away from the relief ports **44**. As shown in FIG. **3**, the operating member is finally stopped in its downward free fall by the top end of the threaded pin **26** of the bit **28**, and when so located, is totally out of the flow path of fluid down the drill string and out ports **44**. The moveable member **48** falls freely because of the provision of the clipped lower corner resulting in surface **52** which assures that the largest diameter of member **48** is less than that of bore **40**. The combination of the sloping sealing surfaces and a space below the valve member having a smallest diameter greater than the largest diameter of the moveable member and operating member yields the advantage that once the moveable member begins to move, it is unrestricted in further downward motion and falls freely and unrestricted away from the relief ports. In order to achieve the advantage of having the member **48** fall away, an included angle of 20° between surfaces **42** and **50** and the vertical center line of the valve has been tested, used, and found to be satisfactory. Angles in the range of about 7° to about 25° are deemed usable.

The valve **10** is renewed by taking the valve out from between the drill string and the bit, removing the broken pieces of the bolt assemblies, the washers, and the operating member, repositioning the moveable member against surface **42**, and sealing it in position with new bolt assemblies **66** and washers **76**. The valve **10** is then ready for future service.

Referring now to FIGS. **4** and **5**, there are shown modified structures for two portions of the valve of the invention. Either one or both of these modified structures can be incorporated into valve **10**, as demanded by operating conditions.

Referring to FIG. **4**, there is shown a relief port **44***a* which is similar to relief port **44** shown in FIGS. **1** to **3**, but which has been modified by the addition of a counterbore **80** therein extending inwardly from the outside surface of the valve and terminating at a plane intermediate the thickness of the wall of intermediate portion **14**. Seated in counterbore **80** is a relatively thick plug **82** formed of any suitable material, such as aluminum, that will be easily consumed by the drilling process, i.e., "drilled out." No additional means other than the relatively snug fit between plug **82** and counterbore **80** is used to hold the plug in position. Plug **82** serves to protect the outside surface of the moveable valve member from the hydrostatic pressure of the return fluid in the annulus between the drill string and the wellbore. Particularly in relatively deep wells, the hydrostatic head created by the column of return fluid may be sufficient to loosen the moveable valve member, thus permitting leakage, or even premature operation of the valve. Plug **82** will be easily blown out of its counterbore by the pressurized fluid within the valve after it is operated. Since the plug or disc **82** is relatively thick, and is held by the shoulder created by the the counterbore **80**, it will not be pushed inwardly prior to operation of the valve.

Another problem that may be encountered under certain drilling conditions, particularly where the well fluids are highly abrasive in nature, is that continued normal operation before the valve is used may result in slight elongation of the weakened shanks **68** of the bolt assemblies **66**, but not necessarily any leakage. The same condition exit exists from the time the ball seats until the instant the bolts break, and more serious erosion problems arise during this time of normal elongation of the bolts prior to their breaking. Where the well fluids are not highly abrasive in nature the slight leakage resulting around O-ring **54** may not be serious, but where the well fluids are highly abrasive, this leakage may result in excessive erosion of various parts of the valve. Referring to FIG. **5**, the means to solve this problem comprise an elongated upper end throat portion **84** carrying an O-ring **86** which seals against throat **34** in intermediate portion **14**. Thus, by providing the double seal of O-rings **86** and **54**, a slight downward movement of the moveable valve member during normal usage will not result in leakage between throat **34** and the valve member until the amount of such movement becomes greater than the distance between the level of O-ring **86** in its normal position and the plane of juncture of throat **34** and sloped surface **42**. This distance is made long enough to accommodate the very slight amount of movement normally experienced, yet not so long that any possible sleevelike action in throat **34** will effect normal falling of member **48**.

While the invention has been described in detail above, it is to be understood that this detailed description is by way of example only, and the protection granted is to be limited only within the spirit of the invention and the scope of the following claims.

We claim:

1. A drill string dump valve comprising a valve body formed with a through passageway for the passage of fluids therethrough from an upper end to a lower end when said valve is vertically disposed, said passageway comprising a downwardly expanding section, said body being formed with an opening communicating said section of said passageway with the outside of said body, means to releasably seal said opening at said section against the flow of fluids therethrough, said section of said passageway comprising an upper smallest cross-sectional area and a lower largest cross-sectional area, said releasable sealing means comprising a valve member moveable within said passageway and adapted to close said opening, said valve member comprising an upper smallest cross-sectional area adapted to fit snugly within said upper smallest cross-sectional area of said section and a lower largest cross-sectional area which is a predetermined amount smaller than said lower largest cross-sectional area of said section, whereby said valve member may move freely down and away from said opening to open said opening for fluid flow, said releasable sealing means comprising an operating member adapted to pass down through the inside of the drill string to contact said moveable valve member, said passageway comprising a throat portion extending upwardly from said upper smallest cross-sectional area thereof and adapted to guide said operating member into sealing relation with said valve member, said releasable sealing means comprising a plurality of shear bolts passing through the wall of said valve body and the wall of said valve member to hold said valve member in sealing relation with said opening, said bolts being formed with a bolt head portion positioned on the inside surface of said valve member, and means to form a fluid tight seal at the zone of contact between said bolt head and the inside surface of said valve member.

2. The combination of claim **1**, said last-mentioned sealing means comprising a washer formed of ductile material adapted to be seated in a recess formed on the inside surface of said valve member to receive said washer, whereby tightening of said bolt will cause said head to deform said washer in said recess to form said fluid tight seal.

3. The combination of claim **1**, said opening comprising plug means to protect said releasable sealing means against the flow of well fluids inwardly through said opening.

4. The combination of claim **3**, said plug means comprising an aluminum disc seated in a counterbore extending inwardly from the outside surface of the body of said dump valve.

5. The combination of claim **1**, said releasable sealing means comprising an operating member adapted to pass down through the inside of the drill string to contact said moveable valve member whereby increased pressure on the fluid in said drill string above said operating member will break said shear bolts and permit said moveable valve member with said operating member thereon to move freely downwardly, and said passageway being formed with a space below said opening sufficiently long to receive said moveable valve member and said operating member and to locate said moveable valve member and said operating member below said opening after said moveable valve member has moved down away from said opening.

6. A drill string dump valve comprising a valve body formed with a through passageway for the passage of fluids

therethrough from an upper end to a lower end when said valve is vertically disposed, said passageway comprising a downwardly expanding section, said body being formed with an opening communicating said section of said passageway with the outside of said body, means to releasably seal said opening at said section against the flow of fluids therethrough, said section of said passageway comprising an upper smallest cross-sectional area and a lower largest cross-sectional area, said releasable sealing means comprising a valve member moveable within said passageway and adapted to close said opening, said valve member comprising an upper smallest cross-sectional area adapted to fit snugly within said upper smallest cross-sectional area of said section and a lower largest cross-sectional area which is a predetermined amount smaller than said lower largest cross-sectional area of said section, whereby said valve member may move freely down and away from said opening to open said opening for fluid flow, said passageway comprising a throat portion extending upwardly from said smallest cross-sectional area thereof, said moveable valve member comprising a throat portion extending upwardly from said upper smallest cross-sectional area thereof a predetermined distance into said throat portion of said passageway, and sealing means between said throat portion of said passageway and said throat portion of said valve member.