March 1, 1960 R. L. CLINKENBEARD 2,926,884

VALVE

Filed May 28, 1958

Fig. 1.

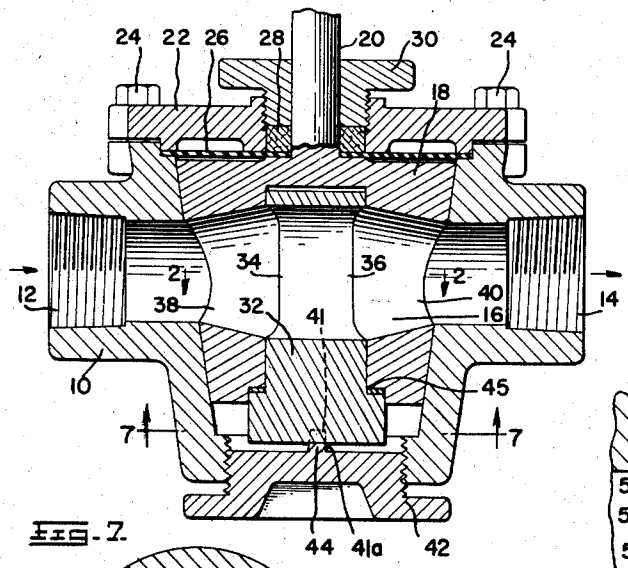


Fig. 2.

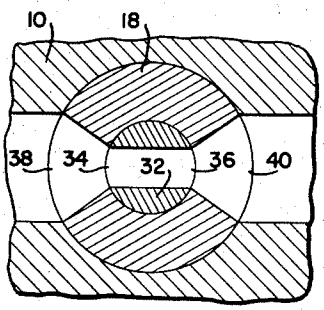


Fig. 3.

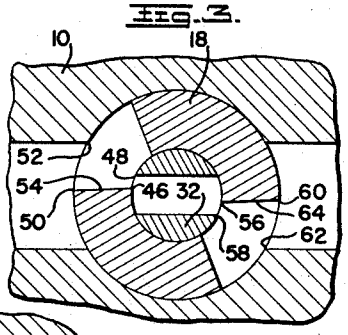
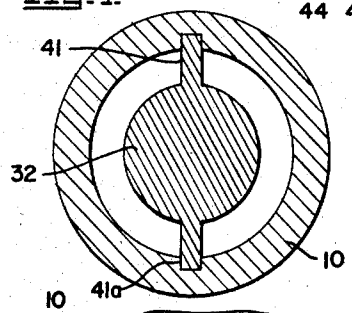


Fig. 7.



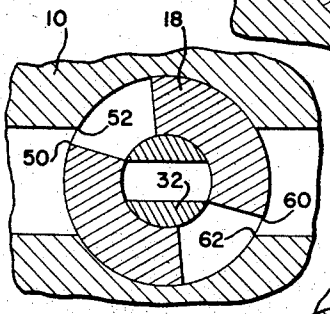
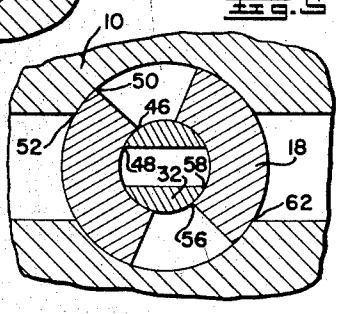


Fig. 4.

Fig. 5.



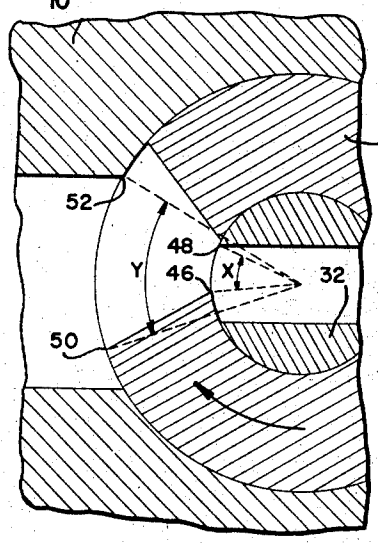


Fig. 6.

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VALVE

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3 Claims. (Cl. 251—210)

The present invention relates to valves and more particularly to valves for handling fluids having abrasive materials entrained therein.

When a valve is used in the handling of a fluid having abrasive particles such as sand or scale entrained therein, it is inevitable that the particles should to some extent cause scoring, erosion or abrasion of the valve parts. The wear to which a valve is thus subjected is primarily of three types: first, there is the ordinary wear to which the valves and conduits alike are subjected simply by the passage therethrough of the abrasive fluid at ordinary line velocities. This wear is quite gradual and does not ordinarily necessitate replacement of the conduit system except after a number of years, nor does this first type of wear damage the valves more rapidly than it damages the remainder of the system. The second type of wear to which a valve in contact with abrasive fluids is subjected is the scoring which results from the entrapment of abrasive particles between the relatively moving parts of the valve. This second type of wear, however, can be kept to a minimum by careful valve design and close manufacturing tolerances so that the actual damage from this type of wear is not as great as might otherwise appear. Moreover, the first and second types of wear affect different valve surfaces and are not cumulative.

But the third type of wear to which a valve is subjected in connection with the handling of abrasive fluids is much more serious than the other two and is the principal factor necessitating frequent replacement of valves used in connection with erosive fluids. This third type of wear is that which occurs during valve opening and closing movements and results from the opening or closing of a movable valve member against a rapidly flowing abrasive fluid under pressure. As is well known, the velocity of a fluid flowing through a valve under pressure between two opposed valve surfaces varies roughly inversely as the distance between those opposed surfaces, so that as opposed valve portions for example close together to stop fluid flow through the valve, the fluid velocity between the closing surfaces increases very abruptly and reaches a maximum just prior to closing. Moreover, the impact of abrasive particles upon the valve parts varies roughly as the square of the fluid velocity, so that the impact of the abrasive particles and hence their erosive action increases even more abruptly than the velocity of the fluid upon valve closing movement. Of course, the same relationships obtain and the same problems are encountered during valve opening movement, the only difference being that the parts are moving relatively in the other direction. Furthermore, although valve parts are customarily designed so that the surfaces exposed to the flowing fluid are substantially in line with the direction of fluid flow in the open valve position, it is inevitable that during valve opening or closing movement at least one portion of the valve be displaced from this in-line relationship and assume a position more nearly perpendicular to the direction of fluid flow. The impact of the abrasive particles on the valve parts varies roughly as the tangent of the

angle by which those parts are displaced from in-line relationship to the fluid flow. Accordingly, considering these factors together, it will be clear that valve opening or closing movement during the handling of abrasive fluids can be extremely destructive to valve parts; and in fact, this source of valve wear comprising the third of the three types recited above presents the principal obstacle to keeping valves in operation over long periods when abrasive fluids are handled.

A number of efforts have been made to overcome the above and other difficulties and disadvantages of the prior art in this connection, but none, as far as is known, has been entirely successful when practiced commercially on an industrial scale.

Accordingly, it is an object of the present invention to provide a valve in which the fluid sealing surfaces and adjacent parts will be subject to a minimum of wear by abrasion, erosion or scoring.

Another object of the present invention is the provision of a plug valve having a rotatable valve member which will be subject to the least possible wear during valve opening or closing movement against abrasive fluids.

Still another object of the present invention is the provision of a valve in which such wear as occurs may be rapidly, easily and inexpensively repaired without removal of the valve from its associated system.

Finally, it is an object of the present invention to provide a valve which will be simple and inexpensive to manufacture, easy to install, maintain and repair, and rugged and durable in use.

Other objects and advantages of the present invention will become apparent from a consideration of the following description, taken in connection with the accompanying drawings, in which:

Figure 1 is a cross-sectional view of a valve according to the present invention;

Figure 2 is a fragmentary cross-sectional view taken on the line 2—2 of Figure 1 and showing the valve parts in open position;

Figure 3 is a view similar to Figure 2 but showing the valve parts approaching closed position;

Figure 4 is a view similar to Figures 2 and 3 but showing the valve parts as they just attain a preliminary closed position in which fluid flow has effectively ceased;

Figure 5 is a view similar to Figures 2, 3 and 4 but showing the valve parts in fully closed position;

Figure 6 is an enlarged fragmentary view similar to the preceding four views, showing the valve parts in partly closed position and illustrating diagrammatically certain essential operative relationships of the present invention; and

Figure 7 is a partial sectional view taken on the line 7—7 of Figure 1.

Broadly, the present invention comprises a valve having a rotatable valve member in the form of an annular sleeve within a valve casing and a fixed but replaceable plug at least partly within the sleeve. The fluid path includes the casing, sleeve and plug, but the sleeve closes with the plug before it closes with the casing. Thus the plug takes the wear and protects the seal between the casing and the sleeve.

Referring now to the drawings in greater detail, there is shown in Figure 1 a valve having a valve casing **10** provided with an inlet port **12** and an outlet port **14** interconnected by a valve chamber **16**. The valve is of the rotatable plug type and has an annular valve member comprising a sleeve **18** disposed within chamber **16** and rotatable about its axis with its outer periphery in sliding fluid sealing contact with the complementary inner periphery of that portion of casing **10** which defines chamber **16**. The outer periphery of sleeve **18** has a truncated conical configuration, and a circular cross-sectional con-

figuration in any plane perpendicular to its axis. It should be noted that the axis of sleeve **18** is perpendicular to and intersects the axes both of inlet port **12** and of outlet port **14**.

Rotation of sleeve **18** is effected by means of a coaxial valve stem **20** which extends outside casing **10** and is rotatable under the influence of a valve actuator (not shown). A cover plate **22** surrounds valve stem **20** and is secured to the remainder of casing **10** by means of screws **24**. A flexible diaphragm **26** of rubber or the like also surrounds stem **20** and is held in place by cover plate **22** and by packing **28** which in turn is compressed by a gland nut **30** surrounding and coaxial with valve stem **20** and screw-threadedly received within a central aperture through cover plate **22**.

Disposed at least partly within the inner periphery of sleeve **18** is a plug **32** having a cylindrical outer periphery complementary to the inner periphery of sleeve **18** and fitting that inner periphery slightly more loosely than the outer periphery of sleeve **18** seals with casing **10**. Plug **32** has a fluid passageway therethrough having an inlet opening **34** and an outlet opening **36**. Sleeve **18**, in turn, has an opening **38** therethrough extending between the inner and outer peripheries thereof and communicating between inlet port **12** of casing **10** and inlet opening **34** of plug **32**. Sleeve **18** also has a similar but diametrically opposed opening **40** therethrough communicating between outlet opening **36** of plug **32** and outlet port **14** of casing **10**. The opening through plug **32** is substantially taller, as seen in Figure 1, than the least height of the inlet and outlet ports **12** and **14** of casing **10**. It is also of substantially less width, as seen in Figure 2, than those inlet and outlet ports. The side walls of openings **38** and **40** through sleeve **18** taper to provide a smooth fluid passageway through the valve in open position, as seen in Figures 1 and 2.

Thus, sleeve **18** is rotatable between open and closed valve positions, the open position being as shown in Figure 2 in which the openings of the sleeve are lined up with those of the casing and plug and the closed position being that of Figure 5 in which the openings of the sleeve are entirely out of line with the openings of the casing and plug. Of course, it is immaterial which way the sleeve is turned to open or close the valve, as the valve is bisymmetric on opposite sides of the plane including the axes of ports **12** and **14** and sleeve **18**.

The opening through plug **32** is at all times in line with ports **12** and **14** of casing **10**. To maintain plug **32** thus fixed with regard to casing **10**, the lower end of plug **32** as in Figure 1 is provided with diametrically opposed keys **41** receivable in corresponding slots **41***a* of casing **10** as seen in Figure 7. Plug **32** is retained in casing **10** and at least partly within sleeve **18** by means of a screw-threaded closure plate **42** which closes the bottom of casing **10** as seen in Figure 1 and has a central boss **44** integral therewith for easy turning movement of plate **42** relative to plug **32** and for positioning a portion of plug **32** within the inner periphery of sleeve **18**. Plug **32** is fitted with an annular sealing gasket **45** of rubber or other elastic deformable material which is held in position axially by an annular external shoulder on plug **32** and an opposed annular internal shoulder on sleeve **18**.

The successive positions of sleeve **18** during valve closing movement in one direction are shown in Figures 2 through 5. Upon clockwise rotation of sleeve **18** as viewed in those figures, a first edge **46** of opening **38** at the inner periphery of sleeve **18** approaches an edge **48** of inlet opening **34** of plug **32**. At the same time, a second edge **50** of opening **38** at the outer periphery of sleeve **18** approaches an edge **52** of inlet port of casing **10**. However, as seen in Figure 4, edge **46** comes into closing proximity with edge **48** before edge **50** closes with edge **52**. In this way, the contiguity of edges **46** and **48** effects a preliminary closing of the valve to the extent that fluid flow therethrough substantially stops; and hence, edges **50** and **52**, which effect the true valve sealing action, close in what is essentially a static fluid system. Thus, the wear which would ordinarily result immediately prior to the closing of edges **50** and **52** is borne by edges **46** and **48** instead. It is not necessary that plug **32** fit exactly snugly within the inner periphery of sleeve **18**, as the closing of edges **46** and **48** need only substantially stop fluid flow so as to protect edges **50** and **52**. There can be quite a bit of leakage between edges **46** and **48** without spoiling this result.

The wear on edge **48** of plug **32** is compensated by replacing plug **32** from time to time. To do this, it is necessary only to place the valve in the fully closed position of Figure 5, remove closure plate **42** and the worn plug **32**, insert a new plug **32** and replace closure plate **42**. Thus, plug **32** is a sacrificial plug and can be manufactured quite cheaply as it need not have close tolerances for the reasons explained above.

What would otherwise be the wear on edge **46** is substantially prevented by the shape of that portion of sleeve **18** which terminates radially inwardly in edge **46**. Specifically, a portion of opening **38** is defined by an inclined face **54** between edges **46** and **50** of sleeve **18**. It will be seen from Figures 3 and 4 that just prior to the closing of edges **46** and **48** face **54** is disposed substantially in line with the direction of fluid flow through the closing valve. In order that this be so, it is necessary that face **54**, which bounds that side of opening **38** which trails during valve closing movement, be inclined radially outwardly away from the principal path of fluid flow in the open valve position of Figure 2. In this way, face **54** is brought more nearly in line with the path of fluid flow upon rotation of sleeve **18** toward the closed valve position. Of course, the inclination of face **54**, and the closing of edges **46** and **48** before edges **50** and **52**, is achieved at the expense of disposing that portion of plug **32** adjacent edge **48** almost perpendicular to the direction of fluid flow just prior to closing of the valve, as seen by a comparison of Figures 3 and 4; but as was pointed out above, plug **32** is sacrificial and it is intended that it be replaced. In short, edges **46** and **48** are sacrificial as compared to edges **50** and **52**, but as between edges **46** and **48**, edge **48** is sacrificial by virtue of the orientation of face **54**. Moreover, it will be appreciated that even if some wear of edge **46** nevertheless does take place, this wear does not necessitate replacement of sleeve **18** since the seal between edges **46** and **48** can be quite imperfect and at the same time quite effective, as was pointed out above.

Thus, there are two important relationships of the present invention. The first is that edges **46** and **48** close before and open after edges **50** and **52**; and the second is that the surface of sleeve **18** on the upstream side of edge **46** at the time of valve closing or opening be disposed more nearly in line with the direction of fluid flow than the corresponding surface of plug **32**. The essential operative relationships by which the first of these features is achieved are illustrated somewhat diagrammatically in Figure 6. As there shown, an imaginary line is drawn from edge **46** to the common axis of sleeve **18** and plug **32**, and another imaginary line is drawn from edge **48** to that common axis. The angle between these two lines is designated "*x*," and for convenience will be referred to as the angle between edges **46** and **48** measured from the axis. Similarly, the angle between edges **50** and **52** measured from the axis is designated "*y*." It is essential to the first feature of this invention that angle *x* be less than angle *y*. In this way, upon closing rotative movement of sleeve **18**, it is assured that edges **46** and **48** will close together before edges **50** and **52** close. In Figure 6 these relationships are somewhat exaggerated for purposes of clear illustration.

Some but not all of the same considerations apply to the outlet side of the valve. In the illustrated embodiment, the parts are bisymmetric, and hence a first edge **56** of opening **40** at the inner periphery of sleeve **18** closes

with an edge 58 of outlet opening 36 of plug 32 before a second edge 60 of opening 40 at the outer periphery of sleeve 18 closes with an edge 62 of outlet port 14 of casing 10, and the face 64 of sleeve 18 between edges 56 and 60 has an inclination corresponding to that of face 54 on the inlet side. This symmetry permits inlet and outlet ports 12 and 14 to be reversed with no need for a change of valves or valve parts. Admittedly, face 64 when disposed on the outlet side does not provide the same protection for edge 56 that face 54 provides for edge 46 on the inlet side; but this does not adversely affect the operation of the valve since if the inlet side is protected it makes little or no difference whether the outlet side is protected.

The necessity for protecting only one side of the valve makes it obvious that the valve of the present invention is susceptible of embodiment in forms other than that shown. Instead of a straight-through plug valve, the invention could obviously be embodied in an elbow plug valve having the same illustrated relationships on the inlet side thereof but having an axial outlet. From this, it follows that the interengaging surfaces between casing 10, sleeve 18 and plug 32 need not be fully circular in their cross-sectional configuration but need be circular only adjacent the inlet. It will also be obvious that a valve according to the present invention could be an elbow plug valve having an axial inlet and a lateral outlet as shown with regard to either side of the illustrated embodiment; but this latter embodiment would be less preferred as the protection afforded edge 46 by the orientation of planar face 54 would be lost.

It will therefore be apparent that the third type of valve wear initially recited, the wear resulting from the impact of abrasive particles immediately after opening and immediately prior to closing, is successfully combatted by the present invention.

But it should also be noted that the present invention, as a secondary feature thereof, makes provision for reducing the second type of valve wear initially recited, that resulting from the scoring due to entrapment of abrasive particles between the relatively moving valve surfaces. As was pointed out above, sleeve 18 and casing 10 are in closely fitting relationship; and thanks to the protection afforded by sacrificial plug 32 they tend to remain so. There is little opportunity for abrasive particles to be caught between them. However, sleeve 18 and plug 32 are either initially in loosely fitting relationship or else they quickly become so due to sacrificial wear of plug 32. Thus, there is an opportunity for abrasive particles to infiltrate between sleeve 18 and plug 32 and score the opposed surfaces thereof. In order to assure that this scoring take place preferentially on sacrificial plug 32, plug 32 is made of a material softer than sleeve 18. Sleeve 18 is substantially harder than plug 32 at least adjacent the surfaces thereof contiguous to plug 32. For example, sleeve 18 may be cast steel having the exposed surfaces thereof coated with a 0.05-inch coating of a hard surfacing alloy of chromium, boron and nickel imparting to the surfaces a Rockwell "C" hardness of about 60 and sold commercially by the Wall Colmonoy Corporation under the trademark "Colmonoy No. 6"; while plug 32 may for example be machined from a substantially softer material such as a cold rolled pearlitic chromium-containing molybdenum steel, SAE 4140. It It should be particularly noted that the provision of a softer plug 32 has special relationship to and utility in the present invention inasmuch as the plug sacrificially suffers such severe wear by preferentially absorbing the impact abrasive wear that would otherwise be borne by the sleeve that it is worn down to the extent that a problem might otherwise arise from the scoring action of abrasive particles caught between the sleeve 18 and the worn plug 32.

From a consideration of the foregoing, it will be obvious that all of the initially recited objects of the present invention have been achieved.

Although the present invention has been described and illustrated in connection with preferred embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit of the invention, as those skilled in this art will readily understand. Such modifications and variations are considered to be within the purview and scope of the present invention as defined by the appended claims.

What is claimed is:

1. A valve comprising a valve casing, a valve member comprising an annular sleeve mounted in the casing for rotation about its axis between an open valve position and a closed valve position, and a replaceable plug detachably fixed relative to the casing and disposed at least partly within the sleeve, the valve having a fluid passageway therethrough in the open valve position, the passageway including an opening through each of the casing and the sleeve and the plug, a first edge of the sleeve opening approaching an edge of the plug opening upon valve closing movement to close the plug opening from communication with the sleeve opening, a second edge of the sleeve opening approaching an edge of the casing opening upon valve closing movement to close the sleeve opening from communication with the casing opening, the angle between said first sleeve edge and said plug edge measured from said axis in the open valve position being less than the angle between said second sleeve edge and said casing edge measured from said axis in the same open valve position, so that upon valve closing movement said first sleeve edge and said plug edge close before said second sleeve edge and said casing edge close.

2. A valve as claimed in claim 1, in which the surface of the sleeve between said first and second sleeve edges is inclined radially outwardly away from the principal path of fluid flow in the open valve position.

3. A valve as claimed in claim 1, in which said first sleeve edge is substantially harder than said plug edge.

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