Sept. 16, 1958 L. H. REES 2,852,237

APPARATUS FOR PRESSURE HOMOGENIZATION

Filed Jan. 9. 1956 2 Sheets-Sheet 1

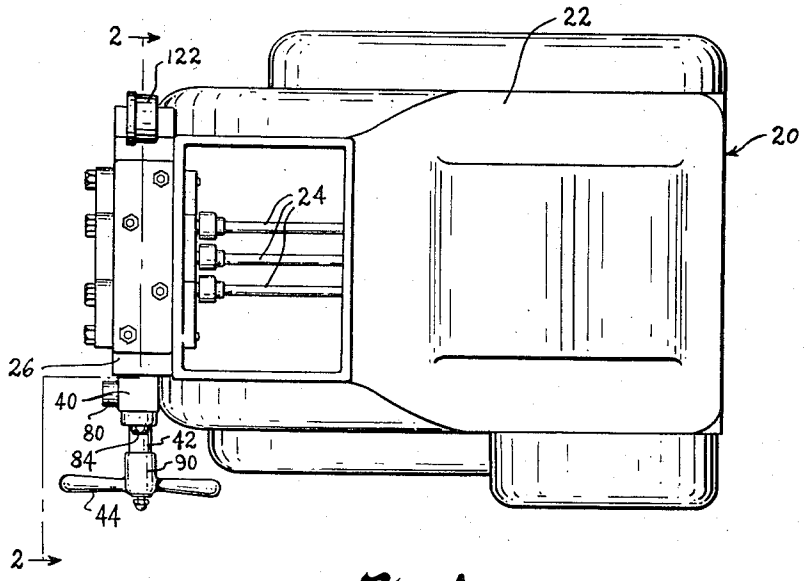


Fig. 1

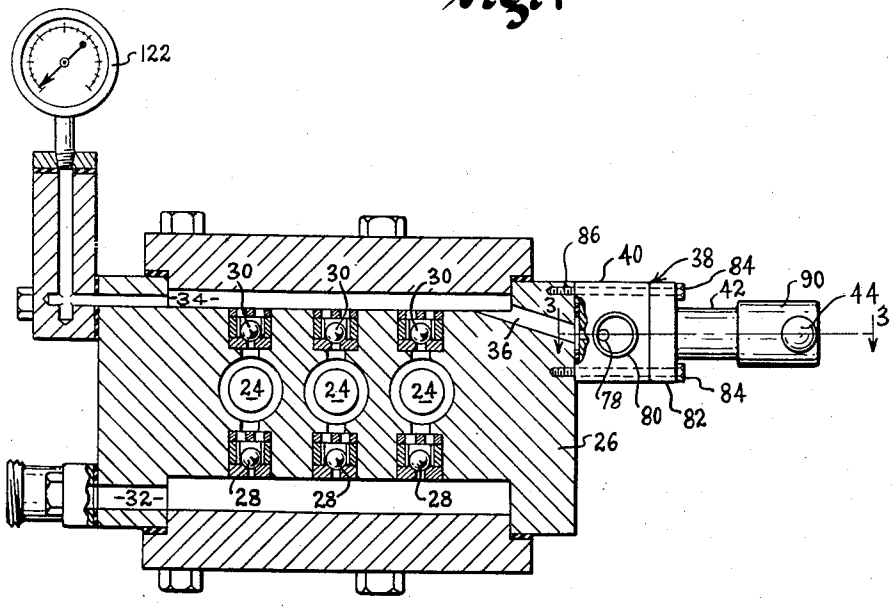


Fig. 2

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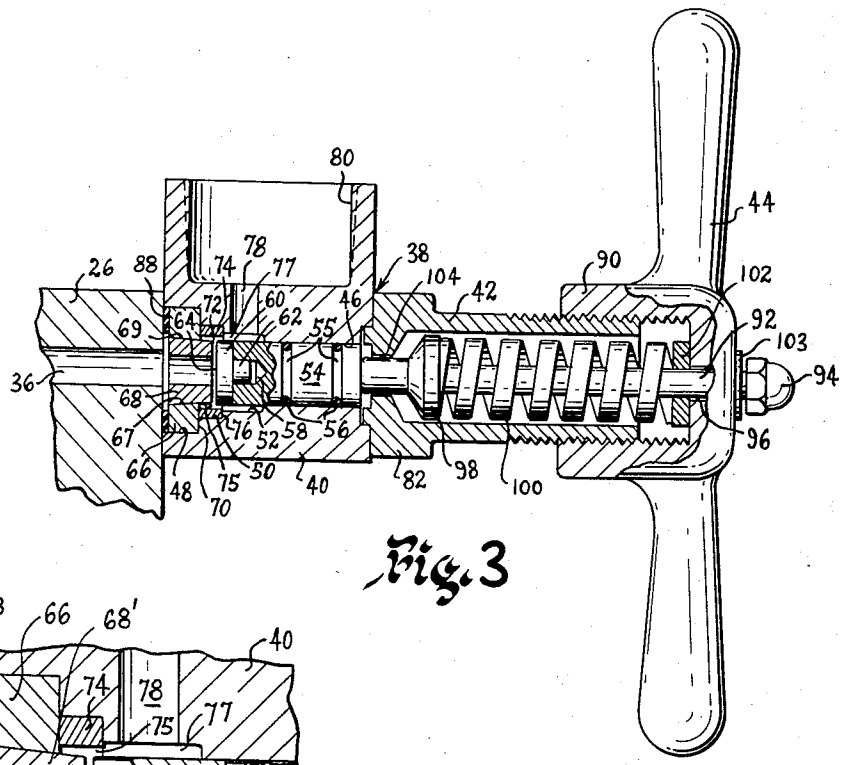


Fig. 3

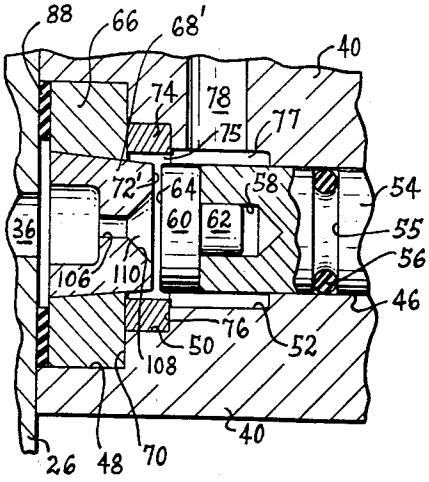


Fig. 4

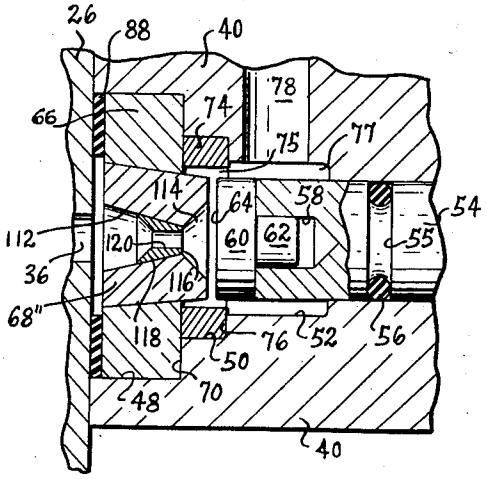


Fig. 5

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APPARATUS FOR PRESSURE HOMOGENIZATION

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7 Claims. (Cl. 259—4)

This invention relates to pressure homogenization of fluid materials and to equipment therefor. More particularly it concerns homogenization of fluid materials by forcing them under positive pressures of a high order through a restricted zone, imparting very high velocities to the material in so doing. Such restricted zone is provided by adjacent surfaces resiliently urged against the fluid pressure by controllable biasing means into abutting relation, and the material is forced between these surfaces whereby it is subjected to drastic shearing action. Commonly also the fluid is caused to strike a surface disposed transversely of the flow as it emerges from between the first set of surfaces, and the change in direction of the material on striking the transverse surface further assists in breakdown of the particle size of the material to enhance the uniformity and stability of suspension.

Pressure homogenization as thus defined is generally accomplished by a homogenizer valve providing the aforesaid resiliently abutting and transversely disposed surfaces in conjunction with a high pressure pump for supplying the fluid under pressure to the valve, and it is an object of the present invention to provide improvements in valve constructions adapted for this purpose. Certain portions of these valves, notably the valve seats and valve plugs or closing members, become rapidly worn, especially when the material being processed is abrasive in nature, as many are, particularly at the pressures involved. The expense of replacing these various valve components therefore becomes a very considerable factor in the operation of the machine, more especially since the parts must of necessity be made of an expensive abrasion resistant material, as for example specially hardened steels or metal carbides. Since these valve parts require accurate sizing and finishing, and since these very hard materials are extremely difficult to shape or machine, the expense is considerable.

One of the principal objects of the present invention, therefore, is to provide a homogenizer valve construction in which those portions of the valve assembly which are most subject to wear are made as removable and replaceable inserts which can be readily removed and replaced when they have become worn, without replacing large and expensive parts of the valve assembly.

The use of replaceable inserts at points of wear in mechanical equipment is, of course, generally known. In the field of pressure homogenization, however, there are special problems arising from several sources which by ordinary standards have rendered this expedient impractical in designs heretofore proposed. For example, since one of the principal uses of pressure homogenizers is in processing food products, the degree of cleanliness, if not complete sterility, required makes it imperative that cracks, threads and similar depressions or crevices be avoided so that there will be a minimum of opportunity for food particles to become lodged in the equipment in places which make it difficult to clean and to maintain in such condition. Similar considerations obtain in the

processing of other materials, such as paint pigments, for example, where it is imperative that complete cleaning of the homogenizer components be readily possible after use so as to avoid contamination of subsequent pigment of a different color processed in the unit. Under the extreme pressures which are employed in pressure homogenization, and generally these run from a minimum of around 1000 pounds per square inch to 10,000 pounds per square inch, or even more, the abrasiveness of the materials being processed becomes of vital significance. Naturally, the use of extremely hard abrasion resistant materials for fabrication of the homogenizer parts suggests itself, but such materials almost invariably are extremely brittle and of low tensile strength so that they present serious problems of design and fabrication in order to meet the high stress load which is placed upon them by reason of the high operating pressures. Prior attempts to provide a homogenizer valve construction employing hard abrasion resistant inserts have been faced with satisfying the conflicting requirements of valve components having excellent tensile strength yet extreme abrasion resistance, simple design of minimum size and ease of machinability, freedom from cracks or crevices where accumulation of processed materials might occur, and ready access of the valve components for thorough cleaning and replacement when excessively worn. The more common highly abrasion resistant materials, such as specially hardened steels or chrome or tungsten carbides, have generally failed in previous attempts, owing to lack of mechanical strength. Cracking and disintegration of the abrasion resistant parts often resulted, therefore, long prior to any appreciable deterioration occasioned by abrasive wear.

It is a further object of the present invention, therefore, to provide in pressure homogenizing valves at the points of maximum wear removable and replaceable inserts of hard, abrasion resistant material which will withstand the severe loads imposed by the homogenizing pressures applied without cracking. At the same time there is provided a valve design which permits the ready assembly of the internal valve components without the use of tools and thereby avoids the liability of marring the parts and rendering them unfit for use.

Maximum wear occurs at the valve seat and cooperating head of the valve plug, and at the point of discharge of fluid from between these cooperating surfaces. Accordingly the present invention provides an insert in the form of a valve seat member which is held in place without reliance upon threads or other special securing means, which are objectionable for many reasons, the insert being so designed and positioned that the fluid pressure itself presses the insert firmly into place in sealing engagement with its support. A removable insert is also provided in the cooperating valve plug or valve closing member. This is so constructed as to avoid problems of concentricity with respect to the valve seat, being designed to position itself and be held in proper location during operation of the valve by the fluid pressure also.

A still further feature of the invention is the provision of a homogenizing valve in which the valve seat or insert is of annular configuration and is provided within its central aperture with a significantly reduced orifice area formed by a constriction positioned intermediate the axial extent of the aperture. The valve seat or insert is further designed to provide a small expansion chamber between this reduced orifice area and the restricted passage defined by the abutting surfaces of the valve seat and plug. By properly proportioning the size of the orifice area to that of the aforesaid restricted passage to obtain a fluid velocity at the entrance to the expansion chamber of a minimum order hereinafter disclosed, a surprisingly great improvement is obtained in

homogenization of compositions containing particles of very small ultimate size.

In general, therefore, the invention provides a pressure homogenizer valve construction primarily of interest for abrasive products where rapid wear of the component parts of the valve may take place. The valve construction affords easy replacement of worn components and this facilitates choice of materials for the replaceable valve components, making it economically practical for the processer to have replaceable components of various materials on hand for use by him, depending upon the nature of the fluid material being treated.

These and other objects and features of the invention will become apparent from the following description of several embodiments of the invention illustrated in the accompanying drawings in which:

Fig. 1 is a plan view from above a complete pressure homogenizer;

Fig. 2 is a view in side elevation, partly in section, on line 2—2 of Fig. 1, showing the pump cylinder and homogenizer valve secured thereto;

Fig. 3 is a detailed view in plan, partly in section, taken on line 3—3 of Fig. 2; and

Figs. 4 and 5 are fragmentary views in section of the valve assembly, showing modifications of the construction in Fig. 3.

Referring to Fig. 1, the pressure homogenizer **20** comprises a housing **22** enclosing an electric motor or other suitable source of driving power, not shown. The motor drives a crank shaft (also not shown) to reciprocate plungers **24** which work into a pump cylinder block **26**. In this instance there are three plungers providing a triplex action pump. As seen more particularly in Fig. 2, suitable intake and outlet check valves **28** and **30**, respectively, are located in the cylinder block **26** in conjunction with each plunger. Fluid is supplied to an intake passage **32** bored in the lower side of the block and is sucked up through the respective intake valve **28** on the intake stroke of each plunger **24**, successively, and then expelled through the respective outlet valve **30** into the high pressure discharge chamber **34** in the top of cylinder block **26**. An outlet passage **36** in the block leads from the high pressure discharge chamber **34** to the inlet port of a homogenizer valve assembly **38** bolted to the side of the cylinder block.

As shown more particularly in Fig. 3, valve assembly **38** includes a main body **40**, a hand wheel support **42**, and an operating hand wheel **44**. Valve body **40** is provided with a through-bore **46**, and is counter-bored at the end adjacent the cylinder block **26** to form a series of inwardly stepped recesses **48**, **50** and **52** concentric on bore **46** and the outlet passage **36** of the cylinder block. A valve plug or valve closing member **54** is disposed in through-bore **46** in snug, sliding engagement therewith and carries in appropriate circumferential grooves **55** a pair of O-rings **56** for effecting a fluid tight seal with the walls of the bore. Plug **54** has a pilot hole **58** at its upstream end, and carries a removable tip **60** having a stud **62** which makes an easy fit in the pilot hole **58**. The plug tip presents a smooth flat surface **64** of substantial cross sectional area transversely of the axis of the through-bore **46**.

Within the recess **48** in valve body **40** as illustrated in Fig. 3, there is positioned a removable composite valve seat comprising an annular holder member **66** of any suitable steel, and a separate annular valve seat portion **68** of hard abrasion resistant material such as a metal carbide. Holder **66** fits snugly at its external periphery within the wall of recess **48**, and bottoms on shoulder **70** lying between recesses **48** and **50** so that its inner face is recessed slightly below the inner face of the body **40**. At its interior wall **67**, holder **66** tapers inwardly in the direction of fluid flow, and the external surface **69** of seat insert **68** is similarly tapered so that when inserted into the holder, a fluid tight seal is effected between the two members. Seat insert **68** is frusto-conical in shape and is somewhat longer, axially, than the axial extent of holder **66** so as to project to a point substantially midway along the axial extent of recess **50**. The annular end wall **72** of insert **68** is thus disposed in abutting relation to the surface **64** of plug tip **60**, the two members coextending radially to provide mating surfaces of substantial area. Surrounding the valve seat insert **68** and plug tip **60** adjacent their abutting faces there is disposed an annular breaker ring **74** which seats in the pocket or recess **50** and bottoms on shoulder **76** disposed between recesses **50** and **52**. The inner diameter of the breaker ring **74** is slightly greater than that of the external diameter of the valve insert and the plug tip at this point so that there is a small peripheral space **75** between that surface and the seat insert and plug providing a passage for the outflow of fluid material. A similar peripheral space **77** is formed between the plug **54** and the wall of recess **52**, and connects with space **75**. A lateral passage **78** in valve body **40** intersects the through-bore **46** within recess **52** to provide communication between space **77** and a discharge port **80** of the valve.

Hand wheel support **42** has a flanged base portion **82** through which holddown bolts **84** pass, as seen best in Fig. 2. These bolts also pass through holes bored through valve body **40**, and threadedly engage tapped holes **86** in the cylinder block **26** to secure the valve assembly to the cylinder block in fluid tight relation. A gasket **88** is positioned between the recessed valve seat holder **66** and the exposed face of the cylinder block **26** to form a pressure seal at this point. Gasket **88** is backed up by the body **40** of the valve which prevents it from being blown out by the high pressures to which it is subjected during operation of the unit.

Control of the pressure which is built up by the pump in order to force fluid from the discharge passage **36** in cylinder block **26** through the valve is determined primarily by the pressure applied to the rear of plug **54**. To permit adjustment of this pressure, hand wheel **44** is provided with an internally threaded central hub **90** which engages external threads on the support **42**. The hand wheel carries a valve rod **92** which passes freely through a bore **96** in the hub **90** and a cap nut **94** is secured to the outer end of the rod. The latter has a skirt or flange **98** spaced somewhat from its inner end, and a helical compression spring **100** is disposed around the rod and confined between the skirt and the underside of hub **90**. A bearing washer **102** is positioned between the hub and the spring to prevent wear on the hub itself, and a second bearing washer **103** is likewise positioned between the outer end of the hub and cap nut **94**. When the hand wheel assembly, including the valve rod, is screwed onto the threaded shank of support **42**, the nose of the valve rod passes freely through an aperture **104** in the base of the support and comes in contact with the rear face of plug **54**, pushing the tip **60** into abutment with surface **72** of insert **68**. As the hand wheel is turned farther in a tightening direction, spring **100** is compressed by the sliding of hub **90** down on rod **92**, and the surfaces **64** and **72** are resiliently compressed together. As the fluid pressure in passage **36** is built up by the pump, it reaches a point at which it is sufficient to displace plug **54** against the urging of spring **100**, whereupon fluid may pass between surfaces **72** and **64**, out through the small peripheral passageways **75** and **77** to outlet passage **78** and port **80**.

The structural simplicity of the foregoing valve arrangement, affording minimum likelihood of accumulation of particles of material being processed owing to the absence of any cracks or crevices is apparent from the illustration in the drawings. Moreover, with respect to valve insert **68** and plug tip **60**, easy replacement of these parts, which are the points most subject to wear, is obtained, as the only holding means for retaining these parts in position is the pressure of the fluid being treated forcing these parts continuously into seating engagement with

their associated supporting members. It will be apparent also that the size of these parts can be kept very small so as to minimize the amount of expensive material from which these parts are fabricated. The simple design of the parts here shown is such that they can be readily fabricated, even from the hardest materials such as the metal carbides mentioned previously, since about the only machining operations necessary in forming them are grinding operations. As has been mentioned hereinbefore, because of the heavy stress applied to the components by the high fluid pressure, valve insert **68** is made separable from its holder **66**, and by so doing the liability of fracture of the valve seat members is substantially eliminated.

A modification of the foregoing valve construction is shown in Fig. 4, in which a valve insert **68'** is provided with an internal constriction forming an orifice **106** of greatly reduced cross sectional area. As will be seen from the drawings, this constriction is disposed intermediate the axial extent of the valve seat insert, and the inner wall of the insert flares outwardly at **108** from constriction **106** to substantially the same diameter as at the upstream or entrance end of the passageway through the insert. This outward flaring forms a small expansion chamber **110** immediately preceding the point at which fluid passes between the surfaces **72'** and **64**. It has been found that providing a severe constriction such as orifice **106** in the valve seat insert, followed by an expansion chamber immediately preceding the shearing action afforded by passage of the fluid material between the closely spaced surfaces, results in tremendously improved product, particularly when handling materials having a small ultimate particle size in the range below one-half micron. The results obtained appear to be especially good where the size of the orifice **106** is so proportioned as to cause the fluid passing through it to have a velocity upon entering the expansion space **110** on the order of at least 100 feet per second.

In Fig. 5 a further modification of the valve seat insert is illustrated. In this instance an insert **68''** has a double conical taper providing inwardly and outwardly flared walls **112, 114**. These flared walls intersect to provide a point of maximum constriction **116** intermediate the axial extent of the insert **68''**. A separable orifice plug **118**, having an external surface shaped to snugly fit within the inwardly tapered surface **112** of the insert is positioned in the latter. Orifice plug **118** is pierced to provide a passage **120** therethrough. Thus in this arrangement the valve seat assembly is composed of a replaceable plug **118** nested within a valve insert **68''**, which latter in turn nests within the holder **66**. In this manner, variations in the size of the passage **120** can be readily obtained very economically by simply replacing insert plug **118** with similar plugs having internal bores of varying diameters.

In the operation of the homogenizer valve, it is customary to start pumping the fluid through the valve with the latter positioned in open condition, that is, with control handle **44** unscrewed to permit plug **54** to be easily pushed back by oncoming fluid so as to offer little or no resistance to the passage of fluid through the valve. Once flow of the fluid has been established the control handle **44** is then turned to compress helical spring **100** which in turn presses against the plug **54** as described above to cause the fluid pressure to be built up to the desired amount for the particular material concerned. The resilience of spring **100** thereafter permits rapid vibrations or axial shifting of the plug **54** and tip **60** to maintain the pressure essentially constant as the material passes through the valve. In so doing it is subjected to severe shearing action by surfaces **64** and **72**, which causes breakdown of the particles suspended in the fluid material. Upon emerging from between the aforesaid surfaces at a high rate of velocity, the fluid is also caused to strike the breaker ring **74** in a substantially perpendicular direction, and this impact and sudden change in flow direction causes further breakdown of the particles, thereby effecting more uniform particle size and better suspension. The fluid then passes out through the outlet passage **78** to port **80** as previously mentioned.

The operation of a homogenizer employing valves such as that shown in Figs. 4 and 5 of the accompanying drawings is essentially the same. However, in this instance, the preliminary constriction or orifice **106** or **120**, as the case may be, effects a resistance to the through-flow of fluid, causing substantial back pressure to be built up in the high pressure chamber **34** of the cylinder block **26** even with no spring pressure or plug **54**. It has been found in practice that in this case it is desirable to provide a restricted orifice so sized that a back pressure of between 3000 and 7000 pounds per square inch is indicated on homogenizing pressure gauge **122** (Figs. 1 and 2) before the valve **38** is closed at all. After the flow of fluid through the valve has then been established, the valve is closed as before to bring the total pressure to some value higher than the initial, valve-open condition. By operating in this manner a surprising improvement in uniformity of dispersion is obtained when handling materials of small ultimate particle size as mentioned hereinabove. No such improvement is obtained where the same type of valve and valve seat, but without the restricting orifice in the latter, is used at corresponding homogenization pressures. In practice it has been found that orifices on the order of 0.020 to 0.030 inch, for example, are especially desirable for obtaining particularly uniform dispersion of particles in a slurry. Such small orifices, however, are of course easily plugged if the slurry contains agglomerates of any substantial size, and consequently careful screening or filtering of the slurry prior to running it through the homogenizer is necessary. As a practical matter, orifices on the order of 1/16 to 1/8 of an inch are found to provide excellent results and to be free of the difficulty arising from the occasional inclusion of agglomerates just mentioned.

Various modifications in the design of the valves illustrated and described herein will be apparent, and all such modifications as come within the scope of the appended claims are accordingly intended to be included therein.

I claim:

1. In a valve for a pressure homogenizer, a valve body having a through-bore stepped progressively inward from the inlet end of the valve and a discharge passage communicating laterally with said bore, valve means in said bore for restricting the flow of fluid there through and resilient control means for positioning said valve means, said valve means including a removable annular valve seat insert disposed in the upstream step of said bore, said insert being frusto-conical with its outer wall tapering inwardly in the direction of fluid flow, and an axially slidable plug disposed in fluid sealing engagement with the wall of a downstream step in the bore of said body, a removable tip carried loosely in the upstream end of said plug and having a surface disposed to abut against and conform with the opposing downstream end face of said annular seat insert, forming with the latter radially coextending surfaces of substantial area between which fluid material entering said valve must pass, said plug being engaged at its downstream end by said control means for resiliently urging said tip into abutting relation with the end face of said annular valve seat insert.

2. A pressure homogenizer valve as defined in claim 1, wherein said removable annular seat insert is provided in its inner wall with a constriction located axially intermediate the ends of the aperture in said seat, said aperture being radially enlarged at the downstream side of said constriction to provide a small expansion chamber immediately adjacent the abutting face of said removable plug tip.

3. A pressure homogenizing valve as defined in claim 1,

which further includes a removable annular breaker ring disposed in a downstream step in said bore in said valve body and in which it is confined by said annular valve seat, said breaker ring surrounding said valve seat insert and plug tip adjacent the abutting faces thereof, the size of the aperture in said breaker ring being sufficiently large to provide peripheral spacing between it and said seat insert and plug tip.

4. A pressure homogenizer valve as defined in claim 3, wherein said valve seat insert, plug tip and breaker ring are formed of extremely hard, abrasion resistant material.

5. A pressure homogenizer valve as defined in claim 4, wherein said abrasion resistant material is a metal carbide.

6. A pressure homogenizer valve as defined in claim 1, wherein said annular valve seat insert has an internal constriction in the aperture thereof located intermediate the axial extent of the aperture, said aperture flaring outwardly from said restriction toward each end of said seat insert.

7. A pressure homogenizer valve as defined in claim 6, which further includes a removable orifice plug seated in fluid tight relation in the tapered aperture of said valve seat insert at the upstream side of said constriction.

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