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 [33] **Great Britain**
 [31] **31606/68**

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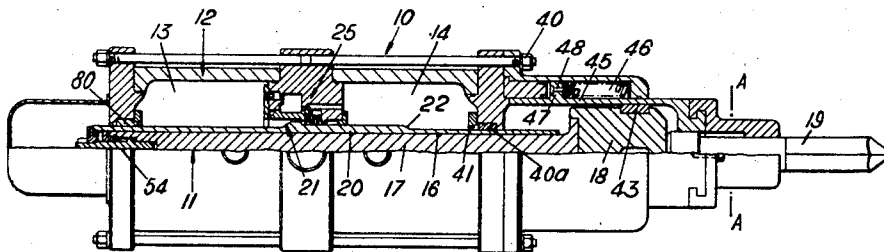
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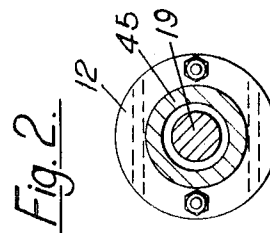
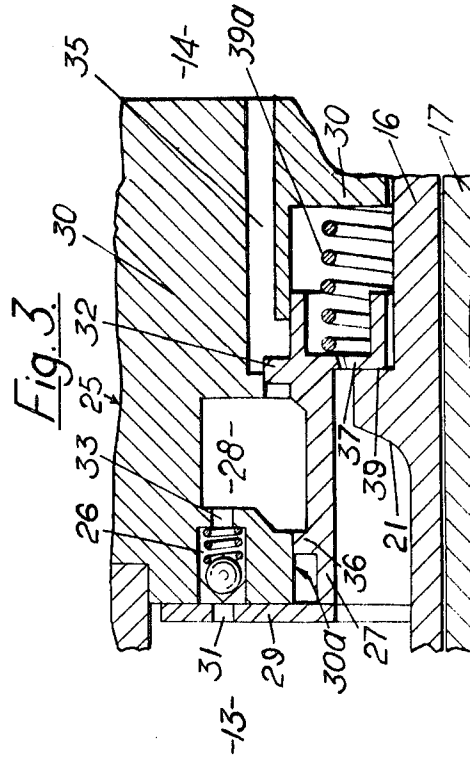
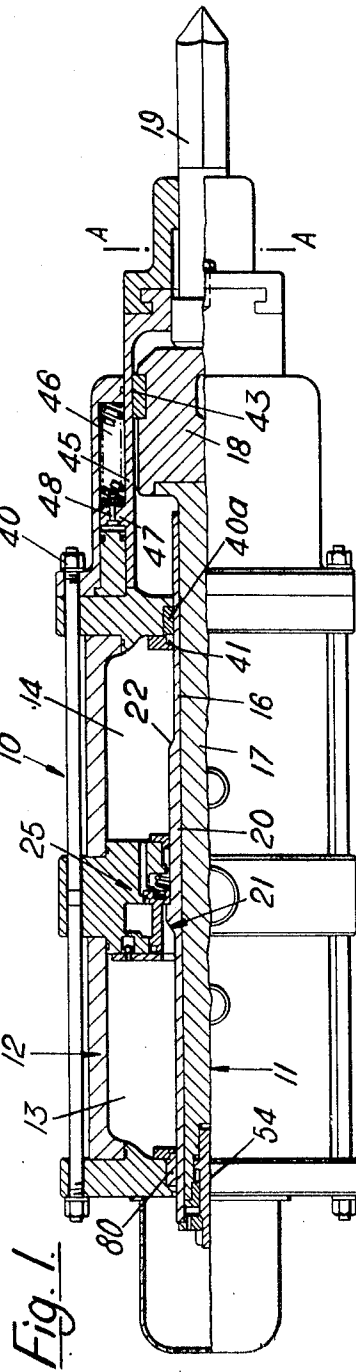
[54] **TRANSDUCER FOR PRODUCING MECHANICAL OSCILLATIONS**

16 Claims, 8 Drawing Figs.

[52] U.S. Cl. **91/390,**
 92/10, 92/84, 92/85
 [51] Int. Cl. **F15b 15/22**
 [50] Field of Search **91/390;**
 92/8, 9, 10

ABSTRACT: A transducer for converting fluid pressure oscillations into mechanical oscillations usable as a rock breaking tool comprises a differential area piston sliding in a cylinder having two chambers therein. One chamber is connected to the oscillating pressure fluid source, and a valve arrangement including a fluid storage space ensures that the pressure in the storage space is greater than the algebraic mean pressure in the first chamber. A position control valve prevents slow drift or rapid excessive movements of the piston.





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Fig. 4.

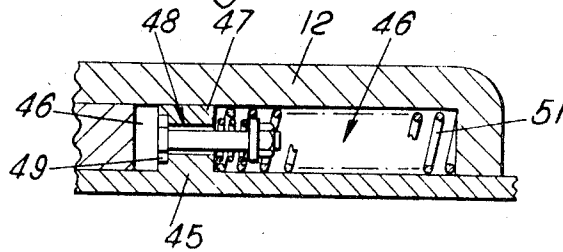


Fig. 5.

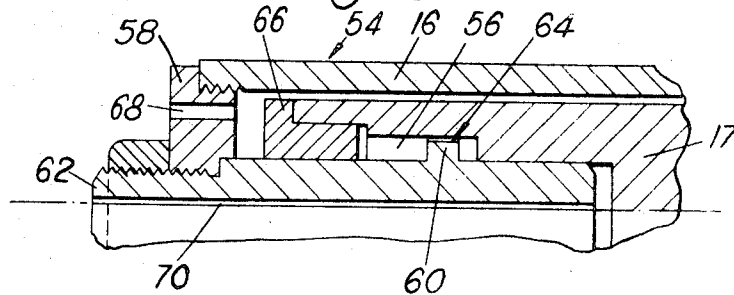
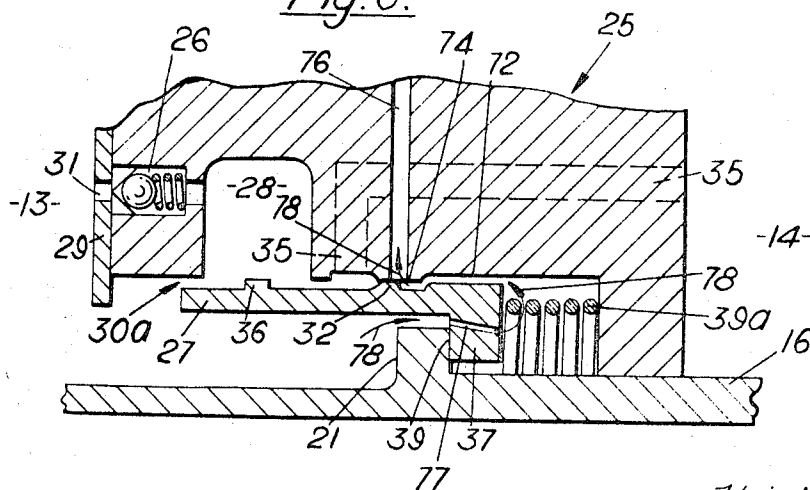


Fig. 6.



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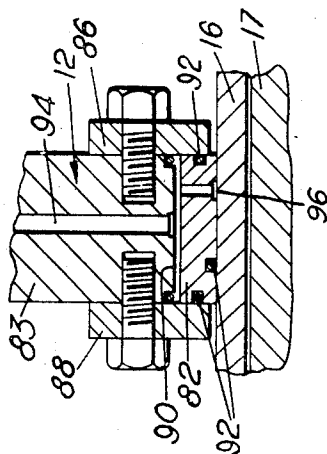


Fig. 7.

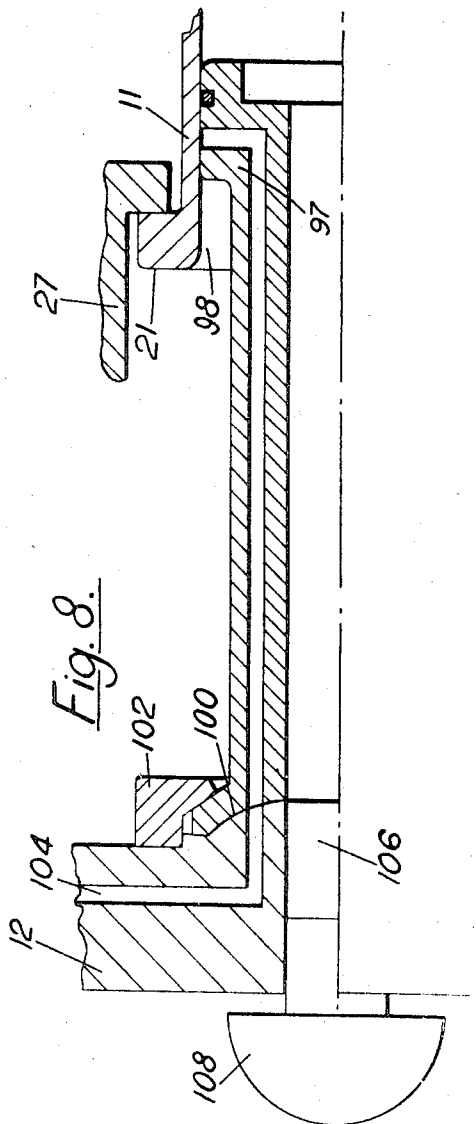


Fig. 8.

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TRANSDUCER FOR PRODUCING MECHANICAL OSCILLATIONS

This invention relates to a transducer for producing mechanical oscillations.

The present invention provides a transducer for converting fluid pressure oscillations into mechanical oscillations comprising a piston member and a cylinder member mounted for relative oscillatory movement, first and second opposing faces of the piston member respectively bounding first and second chambers in the cylinder member, means to connect at least the first chamber to a respective source of oscillating pressure fluid to cause said relative oscillatory movement, a valve assembly within the cylinder member, the valve assembly comprising a storage space, a flow regulator valve connecting the first chamber to the storage space and biased to maintain the fluid pressure in the storage space greater than the algebraic mean pressure in the first chamber, and a position control valve within the cylinder member and engageable by the piston member, the position control valve being adapted upon relative movement in one sense in excess of a predetermined amount, to cause the storage space to be connected to the second chamber, to oppose the said relative movement in excess of a predetermined amount.

Preferably, the position control valve is adapted upon further relative movement in said one sense to connect the second chamber to the first chamber.

The position control valve may be adapted to connect the second chamber to the first chamber via the storage space, bypassing the flow regulator valve.

The position control valve may be adapted to be moved axially when engaged by the piston member, and has an axially extending surface provided with two axially spaced lands, a first land cooperating with a first port to connect the storage space to the second chamber upon said relative movement in excess of a predetermined amount, a second land cooperating with a second port to connect the storage chamber to the first chamber upon said further relative movement, whilst the second chamber is connected to the storage chamber.

The surface of the position control valve may bound the storage chamber.

A spring may be provided to oppose said axial movement of the position control valve.

The position control valve may be adapted, upon said further relative movement, to connect the first chamber to a relatively low pressure port.

Thus, the position control valve may have a third land which cooperates with the relatively low pressure port.

The piston member may be slidably supported in the cylinder member in at least two axially spaced-apart bearings, a said bearing permitting the piston member freedom of movement to accommodate malalignment between said bearings.

Said bearing may comprise an annular bearing pad in which the piston member is supported, and which has limited freedom of movement radially of the axis of the piston member.

Said bearing may support one end of the piston member, the piston member being hollow at said end, the said bearing comprising a spigot which slidably engages said hollow end, the spigot being universally mounted from the cylinder member.

The piston member may consist of at least two portions connected together by a shock absorbing device.

The shock absorbing device may comprise a dashpot.

The piston member may comprise two relatively moveable coaxial elements, one inside the other, connected together by the shock absorbing device.

The dashpot may comprise an axially extending cavity in the inner piston element which is adapted to contain pressure fluid, the outer piston element carrying a plunger which is disposed in said cavity for damped axial movement therein.

An end of the piston member may be slidably supported in a portion of the cylinder member which is connected to the

remainder of the cylinder member via a vibration damping device.

In another aspect, although not so restricted, the invention provides a rock breaking tool comprising a transducer as set forth above and a rock breaking bit arranged to receive impact blows from the piston member.

The rock breaking bit may be slidably mounted in said portion of the cylinder member.

The invention will be described, merely by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is a part-sectional, part-elevational view of a transducer in accordance with the present invention,

FIG. 2 is a sectional view taken along the line A-A of FIG. 1,

FIGS. 3, 4 and 5 are sectional views showing details of FIG. 1 on an enlarged scale,

FIG. 6 shows in section an alternative form of the structure of FIG. 3, and

FIGS. 7 and 8 show sectional views of alternative forms of part of the structure of FIG. 1.

The terms "left" and "right" as used hereinafter refer to directions as seen in the drawings.

Referring to the drawings, there is shown a transducer 10 adapted to be driven by fluid pressure oscillations to produce mechanical oscillations in accordance with the present invention, embodied in a rock breaking tool. The transducer 10 includes a double-acting piston member generally indicated at 11 mounted in a cylinder member generally indicated at 12 for relative sliding movement therewith.

Within the cylinder member 12 are first and second chambers 13 and 14, each of which is adapted to contain pressure fluid. The chambers 13 and 14 are each adapted to be connected to a source of pressure fluid of cyclically varying pressure to cause relative oscillatory motion between the piston member 11 and the cylinder member 12, the pressure variations in the two chambers being arranged to be 180° out of phase.

The piston member 11 comprises an outer hollow annular working piston element 16 and an inner element or rod 17 which is a coaxial sliding fit inside the piston element 16. A large mass 18 is connected to the rod 17, and is arranged to apply impact blows to a rock breaking bit 19. The piston element 17 and the piston element 16 are connected at their respective left-hand ends by a small movement shock absorbing dashpot device 54, described hereafter. This manner of connecting together the two elements of the piston member 11 is designed to reduce the Euler load imposed on a long piston at impact, such as would occur when the transducer of the present invention is incorporated into a 1,000 ft.-lb. hammer to be mounted on a digger to give blows at a rate of approximately 10 blows per second, with a mass of 200 lbs.

The left-hand end of the piston member 11 is supported in a bearing 80 which may be an annular sintered bronze bearing pad, or which may be as described hereafter with reference to FIG. 7.

The piston element 16 is provided with a raised land 20 having two oppositely tapering working surfaces 21, 22. The surface 21 bounds the chamber 13 and is subjected to the cyclically varying pressures therein in operation, while the surface 22, which has a smaller area than the surface 21, bounds the chamber 14.

The chambers 13 and 14 are axially separated by a valve assembly generally indicated at 25 and located internally of the cylinder member 12. The valve assembly 25 includes a flow regulator valve 26 of the nonreturn type, an axially moveable position control valve 27 (see FIG. 3), as well as a storage space 28. In addition to these elements, the valve assembly 25 includes a wall member 29 and a fixed structural body 30.

The nonreturn valve 26 communicates with the chamber 13 via a bore 31 in the wall 29, and it communicates with a storage space 28 via a bore 33 in the body 30. The storage space 28 may be placed into communication with the right-hand chamber 14 via a port 35 in the body 30.

The position control valve 27 is generally cylindrical in shape, with its left-hand end abutting the wall 29. The valve 27 has an axially extending surface which bounds the storage chamber 28 and is provided, adjacent its right-hand end, with a first land 32 which is in sliding engagement with the port 35 in the body 30, which constitutes a first port. The left-hand end of the axially extending surface of the valve 27 is provided with a second land 36 which cooperates with a second port 30a in the structural member 30. It will be noted that the lands 32, 36 are axially spaced. The right-hand end of the valve 27 is provided with a radially inwardly extending flange 37 which is engageable with the hollow piston element 16. In fact, as can be seen in FIG. 3, the piston element 16 is provided with a shoulder 39 to abut the flange 37 so as to axially move the valve 27 when the piston member 12 moves rightward in excess of a predetermined amount. A spring 39a urges the valve 27 leftward towards the wall 29.

The right-hand end of the chamber 14 is bounded by an inwardly extending flange 40 of the cylinder member 12, and a bearing pad 40a in the flange 40 through which the piston member passes is sealed by way of sealing elements 41.

To the right of the flange 40 the cylinder member 12 has a portion 45 of reduced radial cross section within which slides the mass 18, with an annular sintered bronze bearing pad 43 therebetween. The portion 45 is itself slidably mounted in the remainder of the cylinder member 12 and is radially spaced therefrom to provide an annular space 46 wherein a shock absorbing, vibration damping device is provided. Said annular space 46 is filled with oil and the vibration damping device (FIG. 4) comprises a radially outwardly extending flange 47 on the cylinder portion 45 which is provided with a bore 48.

A spring loaded valve 49 seats against the left-hand end of the bore 48 and is provided with one or more small orifices to permit restricted flow through the valve 49. A spring 51 urges the cylinder portion leftward relative to the remainder of the piston portion. In operation, should the piston member move excessively far to the right, e.g. due to the tool 19 breaking through into relatively soft material, the mass 18 will strike the right-hand end of the portion 45, forcing it rightward against the spring 51. The valve 49 lifts under the action of the increased oil pressure in the space 46 to allow oil to flow through the bore 48 to permit this movement. When the piston member 11 retracts, the valve 49 closes and the portion 45 moves leftward under the action of the spring 51 in a heavily damped manner, due to the dashpot effect of the small orifices on the return flow of the oil in the space 46.

The small movement dashpot device 54 (FIG. 5) consists of an axially extending cavity 56 in the inner piston element 17 which contains oil, the outer piston element 16 carrying by means of a threaded bush 58 a plunger 60, which has a threaded spigot 62 engaging the threaded bush 58 and secured thereto by a locknut. The plunger 60 is disposed in the cavity 56 and has at intervals around its periphery axially extending grooves 64 which permit a restricted flow of oil from one side of the plunger 60 to the other. A plug 66 closes the left-hand end of the cavity 56. The grooves 64 permit a small degree of heavily damped relative axial movement between the piston elements 16, 17. Only a small degree of relative movement may be required to sufficiently reduce the Euler load on the relatively long piston elements 16, 17 to a satisfactory figure. The elasticity of the oil in the cavity 56 assists in this respect. Vents 68, 70 prevent air compression in enclosed spaces in the dashpot device 54.

In operation, the chambers 13, 14 are each connected to a respective source of oscillating pressure fluid causing the piston member 11 to perform oscillatory sliding motion relative to the cylinder member 12, the pressure variations in said chambers being arranged to be 180° out of phase with each other. However, owing to the unequal areas of the surfaces 21 and 22 of the hollow outer piston element 16, the piston will normally drift to the right and makeup fluid will be introduced only into the left-hand chamber 13. Excessive drift to the right is, however, prevented by the provision of the shoulder 39 on

the element 16. When the piston member 11 moves in excess of a predetermined amount, the shoulder 39 will engage the flange 37 of the position control valve 27, thereby causing the land 32 of the valve to be displaced relative to the port 35 to permit communication between the storage space 28 and the right-hand chamber 14 via the bore 35. During this time, however, the land 36 of the valve 27 still closes the port 30a. The nonreturn valve 26 is biased in such a way that it will only open at the peaks of the pressure oscillations in the chamber 13 and thus only this peak pressure will pass from the chamber 13 to the storage space 28 via the bores 31, the valve 26 and the bore 33. In this way, the storage space 28 will be charged up with high pressure fluid and this high pressure fluid will pass to the right-hand chamber 14 when the land 32 opens the port 35. When this happens, the pressure level in the chamber 14 will be raised quickly and will oppose the rightward drift of the piston member.

It will be appreciated that the function of the flow regulator nonreturn valve 26 is to maintain the pressure in the storage space 28 above the algebraic mean pressure in the left-hand chamber 13. Consequently, the flow regulator valve 26 need not be a true nonreturn valve; some reverse flow from the storage chamber 28 to the left-hand chamber is permissible provided the pressure in the chamber 28 is suitably maintained.

If there should be further rightward movement of the piston member 11, e.g. a too sudden and extreme drift to the right, as may occur when the tool 19 "breaks through," the position control valve 27 will open fully, that is to say, the land 36 will open the port 30a and direct communication will be established between the chamber 13 and the chamber 14, via the space 28, bypassing the nonreturn valve 26. Thus, the oscillating pressure difference between the two chambers is greatly reduced and the reciprocating motion of the piston member 11 will come to a rapid stop. The difference in the areas of the faces 21, 22 promotes the cessation of the reciprocating motion because, once the pressure difference between the chambers 13, 14 is reduced, the piston member tends to drift further to the right. Restarting of the transducer may be effected by forcing the piston member mechanically leftward until the ports 30a, 35 are closed, whereafter reciprocating motion will recommence.

FIG. 6 shows an alternative form of the valve assembly 25. Corresponding parts in FIGS. 3 and 6 carry the same reference numerals, and will not be described again.

In FIG. 6 the position control valve 27 is provided with a third land 72 which cooperates with a port 74 which is connected via a low pressure return line 76 to the source of pressure fluid oscillations which is connected to the chamber 13. The spacing of the lands 36, 32, 72 is such that upon the aforementioned further relative rightward movement, the land 72 uncovers the port 74 and connects the chamber 13 to the low pressure return line 74 via a vent 77 and the space in which the spring 39a is located. The flow of pressure fluid from the first chamber 13 to the return line, indicated by the arrows 78, permits the pressure difference between the chambers 13, 14 to be more quickly reduced upon the further relative movement, whereby to more quickly stop the oscillatory movement of the piston member 11. The flow of fluid via the land 72 and port 74 also has a cooling effect, since relatively hot fluid leaves the transducer via the return line.

The axial spacing of the lands 36, 32, 72 and their respective ports is preferably such that the port 35 is opened at an earlier stage of the further rightward movement than is the port 74. It will be appreciated that the port 35 is shown ghosted in FIG. 6 so as to indicate that it does not connect with the return line 76. A vent similar to that at 77 is provided in the FIG. 3 embodiment to avoid unwanted fluid compression in the space containing the spring 39a.

It will be appreciated that the transducer need not be double acting; the chamber 14 may be a closed chamber constituting a fluid spring. Also leftward drift of the piston member 11 may be controlled by a dump port which is uncovered by the

piston member upon excessive leftward movement to vent the chamber 14 to a return line such as 76.

An alternative form of the bearing 80 is shown in FIG. 7. Again, previously referenced parts carry the same numerals. The bearing comprises an annular sintered bronze bearing pad 82 supported in a radial wall 83 of the cylinder member 12 and axially located by two keep plates 86, 88. A bore 90 in the wall 83 in which the pad 82 is disposed is of larger diameter than the pad 82, to permit it limited radial freedom of movement. O-rings 92 seal the pad 82 against fluid leakage from the chamber 13. A return line 94 which may be branched off the line 76 of FIG. 6 connects via the radial clearance between the pad 82 and the bore 90 with a leakage collecting groove 96 in the bearing pad 82. Since the return line 94, although at a low pressure compared to that in the chamber 13, may still carry a pressure of (say) 100 ft.-lb./in.², the pressure in the said radial clearance imparts a degree of resilience to the bearing. The radial freedom of movement of the pad 82 permits any malalignment between this pad and the pads 40a, 43 to be accommodated.

A further alternative form of the bearing is shown in FIG. 8. In this embodiment, the piston member 11, instead of being in two pieces, joined by a shock absorber, is in one piece.

The working face 21 of the piston member is formed by the annular end face of the left-hand end of the piston member 11, which is hollow. A spigot 97 slidably engages the hollow left-hand end 98, and this spigot is universally mounted from the cylinder member 12 via a spherical seat 100 and a split clamp ring 102. The seat 100 and clamp ring 102 permits the spigot 97 freedom to pivot slightly during movement of the piston member 11 to accommodate malalignment between the spigot 97 and the bearing pads 40a, 43. A return line 104 collects leakage, and a vent 106 provided with a filter 108 prevents undesirable air compression in the interior of the hollow end 98 of the piston member 11.

I claim:

1. A transducer for converting fluid pressure oscillations into mechanical oscillations comprising a piston member having first and second opposing faces and a cylinder member mounted for relative oscillatory movement, the said first and second opposing faces of the piston member respectively bounding first and second chambers in the cylinder member, means to connect at least the first chamber to a respective source of oscillating pressure fluid to cause said relative oscillatory movement, a valve assembly within the cylinder member, the valve assembly comprising a storage space, a flow regulator valve connecting the first chamber to the storage space, means to bias the regulator valve to maintain the fluid pressure in the storage space greater than the algebraic mean pressure in the first chamber, and a position control valve within the cylinder member and engageable by the piston member, the position control valve being adapted upon relative movement in one sense in excess of a predetermined amount, to cause the storage space to be connected to the second chamber, to oppose the said relative movement in excess of a predetermined amount.

2. A transducer as claimed in claim 1 wherein the position control valve is adapted upon further relative movement in said one sense to connect the second chamber to the first chamber.

3. A transducer as claimed in claim 2 wherein the position control valve is adapted to connect the second chamber to the first chamber via the storage space, bypassing the flow regulator valve.

4. A transducer as claimed in claim 3 wherein there are two ports, and the position control valve is adapted to be moved axially when engaged by the piston member, and has an axially extending surface provided with two axially spaced lands including a first land cooperating with a first port to connect the storage chamber to the second chamber upon said relative movement in excess of a predetermined amount, a second land cooperating with a second port to connect the storage space to the first chamber upon said further relative movement, whilst the second chamber is connected to the storage space.

5. A transducer as claimed in claim 4 wherein the said surface of the position control valve bounds the storage space.

6. A transducer as claimed in claim 4 wherein a spring is provided to oppose said axial movement of the position control valve.

7. A transducer as claimed in claim 2 wherein the position control valve is adapted, upon said further relative movement, to connect the first chamber to a relatively low pressure port.

8. A transducer as claimed in claim 4 wherein the position control valve has a third land which cooperates with the relatively low pressure port.

9. A transducer as claimed in claim 1 wherein at least two axially spaced-apart bearings are provided slidably to support the piston member in the cylinder member, a said bearing permitting the piston member freedom of movement to accommodate malalignment between said bearings.

10. A transducer as claimed in claim 9 wherein said bearing comprises an annular bearing pad in which the piston member is supported, and which has limited freedom of movement radially of the axis of the piston member.

11. A transducer as claimed in claim 9 wherein the said bearing supports one end of the piston member, the piston member being hollow at said end, the said bearing comprising a spigot which slidably engages said hollow end, the spigot being universally mounted from the cylinder member.

12. A transducer as claimed in claim 1 wherein there is provided a shock absorber device, the piston member consisting of at least two portions connected together by said shock absorbing device.

13. A transducer as claimed in claim 12 wherein the shock absorbing device comprises a dashpot.

14. A transducer as claimed in claim 12 wherein the piston member comprises two relatively movable coaxial elements, one inside the other, connected together by the shock absorbing device.

15. A transducer as claimed in claim 13 wherein the dashpot is defined by an axially extending cavity formed in the inner piston element which is adapted to contain pressure fluid, there being a plunger carried by the outer piston element which plunger is disposed in said cavity for damped axial movement therein.

16. A transducer as claimed in claim 1 wherein a vibration damping device connects a portion of the cylinder member with the remainder thereof, the said portion slidably supporting an end of the piston member.