Feb. 21, 1967 M. P. LEBOURG 3,305,020

WELL PACKING APPARATUS

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Fig. 1

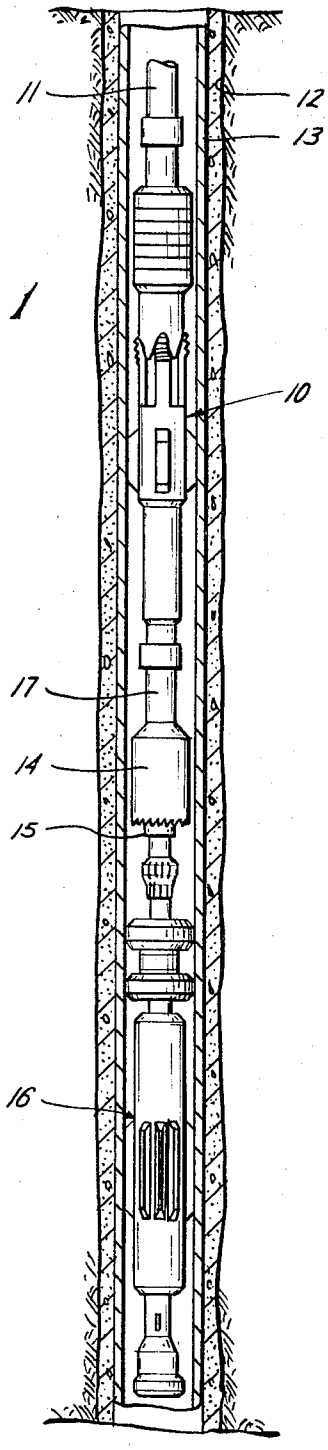


Fig. 3

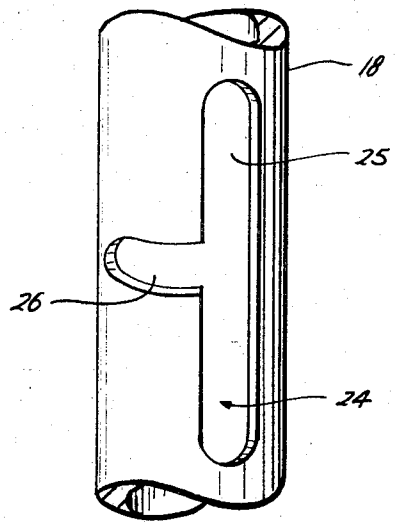
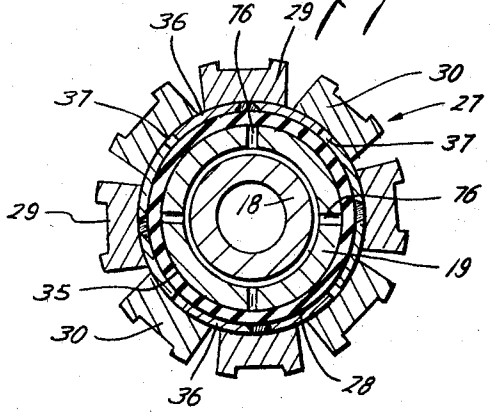


Fig. 4



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WELL PACKING APPARATUS

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Fig. 2A

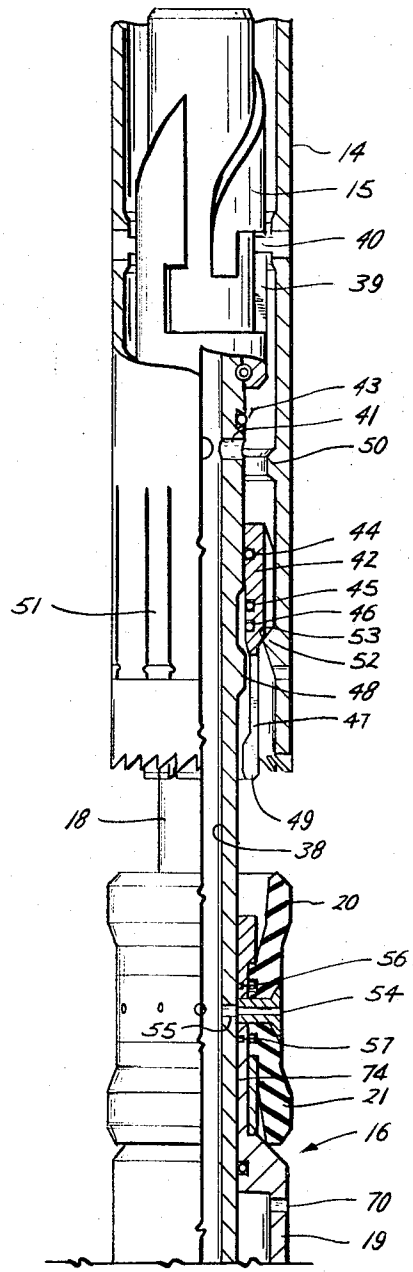
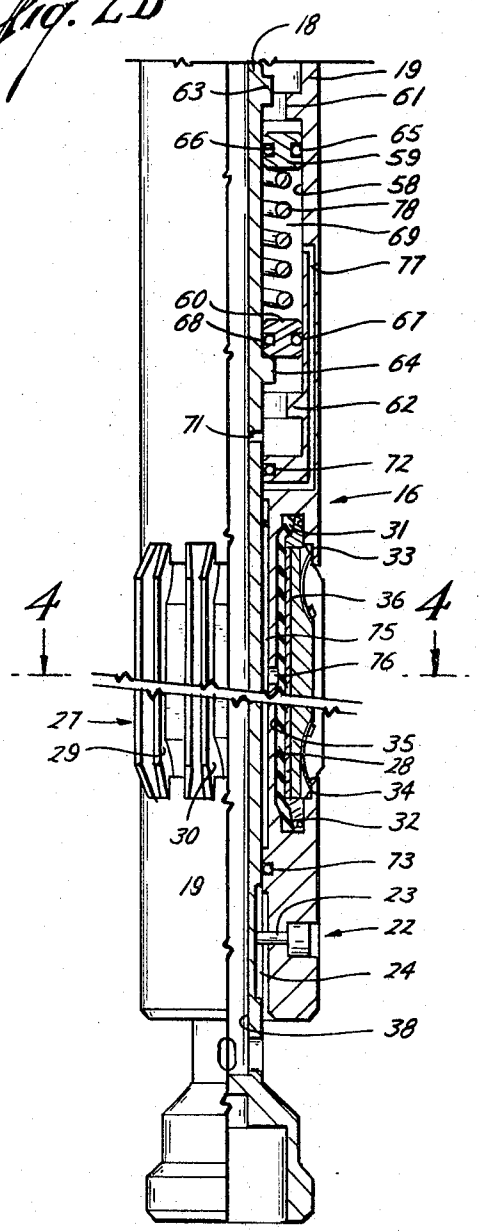


Fig. 2B



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United States Patent Office

3,305,020

Patented Feb. 21, 1967

3,305,020

WELL PACKING APPARATUS

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Filed June 11, 1964, Ser. No. 374,489
3 Claims. (Cl. 166—121)

This invention relates to packers or plugs for packing off a well bore; and, more particularly, to packers or plugs which, when set in place, will be anchored in the well against hydraulic pressures acting from either direction on the packers or plugs by an anchoring force proportionately related to the acting pressure.

In conducting such well-completion operations as acidizing, cementing, or fracturing, a full-opening well packer dependently coupled from a tubing string is positioned at a particular depth in a cased well and the packer set to isolate the formation interval to be treated from the remainder of the well bore thereabove. Treating fluids are then pumped downwardly at high pressure through the tubing into the packer and introduced into the formation being treated through perforations appropriately located in the casing. In those instances where a well having several producing formations is being completed, a selectively operable bridge plug can be dependently coupled beneath the full-opening packer. Such a bridge plug permits formation zones of selected length to be packed-off for selective treatment of different formation intervals with only a single trip into the well.

It will be appreciated that such packers and bridge plugs must be capable of withstanding high fluid pressures acting on them from either direction. Furthermore, during the course of typical completion operations, such apparatus are usually subjected to high fluid pressures acting alternately from both above and below them. Thus, it is necessary that the packers and bridge plugs be securely anchored against movement in either longitudinal direction.

Heretofore, extendible slip members have typically been employed to anchor packing apparatus from movement in at least one direction. Extendible anchoring members have also been developed which are hydraulically actuated by the fluid being pumped through the tubing for securing the apparatus against shifting.

Accordingly, it is an object of the present invention to provide new and improved packing apparatus having hydraulically actuated wall-engaging members which are pressed into anchoring engagement with a force proportionately related to the pressure of fluids in the well.

It is a further object of the present invention to provide new and improved well-packing apparatus capable of being releasably anchored in a packed-off condition to resist extreme pressure differentials acting from either direction.

FIGS. 2A and 2B are successive cross-sectional views of an embodiment of a bridge plug;

FIG. 3 is an isometric view showing particular details of a locking groove employed with the bridge plug of FIG. 2; and

FIG. 4 is a cross-sectional view taken along the lines 4—4 of FIG. 2.

As seen in FIG. 1, a typical full-bore packer **10** is dependently connected from a tubing string **11** and positioned within a well bore **12** having a casing **13** set therein. An overshot **14** dependently connected beneath the well packer **10** is releasably coupled over a fishing neck **15** on the upper end of a retrievable bridge plug **16**. This releasable coupling allows the bridge plug **16** to be set at the lower limit of a particular formation interval and the packer **10** subsequently set at any point thereabove irrespective of the length of the tubing sub **17** connecting the packer to the bridge plug.

Turning now to FIG. 2, the retrievable bridge plug **16** depicted in FIG. 1 includes a rotatable actuating body member or index mandrel **18** telescopically arranged within and slidably engaged with a tubular housing member **19**. Oppositely directed elastomeric packing cups **20, 21** are secured around the upper end of the housing **19** in such a manner that one or the other of them will expand outwardly into sealing engagement whenever there is a pressure differential across the cups.

Normally engaged latch means **22** releasably secure the mandrel **18** to the housing **19** and prevent the relative longitudinally therein until it first been rotated a predetermined amount. The latch drel **18** from shifting longitudinally comprised of a lug means able latching means **22** are comprised of a lug mounted in and groove **24** normally holding the index mandrel fixed against longitudinal movement with respect to the housing **19**, but arranged to release the mandrel limited longitudinal shifting whenever it is torqued in clockwise direction. This lug **23** projects inwardly from a central portion of the housing **19** with its inner end being engaged within the T-shaped groove **24** in the periphery of the mandrel **18**. As shown in FIG. 3, the flat-bottomed T-shaped groove **24** includes an elongated portion **25** extending longitudinally of the mandrel **18** and a branch portion **26** extending circumferentially left and perpendicularly away from the elongated portion **25**.

Thus, so long as the inner end of the lug **23** is engaged within the longitudinal groove portion **25**, the mandrel **18** cannot shift longitudinally in either direction relative to the housing **19**. Thus, so long as the inner end of the lug **23** is engaged within the branch portion **26** of the groove **24**, the mandrel **18**, therefore, cannot shift longitudinally in either direction relative to the housing **19**. The mandrel **18** is torqued to the right to move the lug end from the longitudinal groove portion **25**. Once the lug has been moved from the longitudinal groove portion **25** into the branch portion **26** of the T-groove **24**, the mandrel **18** is of course free to shift longitudinally relative to the housing **19**.

A hydraulically actuated radially expansible slip or anchor **27** mounted around the housing **19** is arranged to be pressed against the casing to initially anchor the bridge plug relatively fixed against rotation of the mandrel **18** so as to subsequently anchor the bridge plug against pressure differentials acting from either direction. The slip **27** includes an elastomeric packing element **28** and a plurality of circumferentially spaced slip members **29** mounted

...tively thin, elongated, arcuate backing mem-
36. These mounted members 29 are arranged uni-
formly around the periphery of the elastomeric sleeve 28
so that the backing members 36 substantially encompass
the sleeve. The unmounted casing-engaging members 30
are alternately disposed between the mounted casing-en-
gaging members 29 in such a manner that the unmounted
members 30 straddle adjacent backing members 36 and
cover the gap 37 therebetween. The beveled ends of the
casing-engaging members 29, 30 are loosely disposed
within the opposed annular recesses 33, 34 around the
housing 19 at opposite ends of the members.

A central axial bore 38 extends the full length of the
mandrel 18 and is capped at its upper end by the conven-
tional fishing neck 15. The fishing neck 15 is arranged
for cooperatively receiving the conventional tubular over-
shot 14 which may be dependently coupled from either
the full-bore packer 10 or by itself from the tubing string
11. Matched J-slots 39 on opposite sides of the fishing
neck 15 are arranged to receive cooperatively arranged J-
pins 40 projecting radially inwardly from the overshot 14
whenever the overshot is lowered over the fishing neck.
After the J-pins 40 enter the open upper end of the long
portion of the slots 39, the pins are lockingly engaged in
the closed short portion of the slots by a concerted ap-
lication of left-hand torque and a slight upward pull on
tubing 11. Conversely, the overshot 14 is selectively
engaged from the fishing neck 15 by lowering the tub-
ing 11 slightly, torquing the tubing to the right, and then
ng upwardly.

dial equalizing ports 41 in the upper end of the
rel 18 allow fluid to flow through the axial bore 38
pass the bridge plug 16 as it is being shifted within
-filled well bore. Fluid communication through
alizing ports 41 is selectively controlled by an an-
lve member 42 which is slidably disposed around
l 18 immediately below the ports. O-rings 43–
the inner surface of the valve member 42 and
ace of the mandrel 18 fluidly seal the ports 41
he equalizing valve member 42 is shifted up-
ts closed position.

ble valve member 42 is cooperatively arranged
dinally shifted by the running overshot 14 so
lizing ports 41 are uncovered whenever the
gaged over the fishing neck 15 and covered
overshot is removed.

e valve member 42 is pulled upwardly, de-
t fingers 47 around the lower end of the
re cammed outwardly as they pass over
der 48 around the index mandrel 18 and
ter clearing this shoulder. The lower
ngers 47 will then engage the upwardly
he annular shoulder 48 and hold the
ber 42 in its uppermost or port-closed
ershot 14 has been removed.

ojecting inwardly from the central
ot 14 is arranged to engage the up-
per 42 and shift it downwardly to its
overshot is being coupled over the
never the overshot 14 is removed
ht and picking up, a group of re-
around the lower portion of the
rojecting shoulders 52 arranged
on the sliding valve member 42
se the equalizing ports 41.

. and re...

...g 16, the
...aged with the fish-
...shot 14 reaches its engaging
...er the open upper end of the
15. As the overshot 14 is
neck 15, the slidable valve
shifted downwardly to re-

the bridge plug 16 is be-
mple, in a fluid-filled well, 22, longitudinal movement of the mandrel in either di-

fluids trapped within the concavity of the lower packing
cup 21 will tend to expand the cup against the casing.
This action naturally further restricts the upward flow of
fluids around the periphery of the cup 21 and creates a
pressure differential across that cup. As a result, the
speed at which the bridge plug 16 can be lowered is lim-
ited. Furthermore, such "swabbing action" can damage
the packing cups 20, 21. The upper packing cup 20 is of
course similarly affected whenever the bridge plug 16 is
being shifted upwardly in a fluid-filled well.

Accordingly, to eliminate this "swabbing action" as the
bridge plug 16 is being shifted within a fluid-filled well,
radial ports 54, 55 are provided respectively in the hous-
ing 19 and mandrel 18. These ports are appropriately ar-
ranged to equalize any fluid pressure differential across
the inner and the outer surfaces of the packing cups 20,
21 whenever the bridge plug 16 is being shifted in a fluid-
filled well bore. Annular grooves around the annulus 74
between the mandrel 18 and the housing 19 above and
below the port 55 receive O-rings 56, 57 which seal-off
the port whenever the mandrel is not secured by the latch-
ing means 22. Thus, it will be appreciated that whenever
the equalizing valve 42 is open and the mandrel 18 is
secured against shifting relative to the housing 19, the
fluid pressure intermediate the packing cups 20, 21 will
always be equal to the fluid pressure above and below the
packing cups.

Turning now to the hydraulic system of the present
invention, an elongated annular space 58 is formed in
the housing 19 above the anchor 27. Spaced-apart an-
nular piston members 59, 60 are slidably mounted at in-
termediate positions within the annular space 58 inter-
mediate inwardly projecting housing shoulders 61, 62 and
outwardly projecting mandrel shoulders 63 and 64. O-
rings 65–68 around the outer and inner surfaces of the
piston members 59, 60 fluidly seal the slidable piston
members relative to the housing 19 and mandrel 18 to
provide a hydraulic chamber 69 between the piston mem-
bers. A radial port 70 through the housing 19 provides
fluid communication from the exterior of the bridge plug
16 to the upper surface of the upper piston member 59.
Similarly, a second radial port 71 through the mandrel 18
provides fluid communication from the axial bore 38 of
the mandrel to the lower surface of the lower annular
piston 60.

O-rings 72, 73 around the inner bore 74 of the housing
19 above and below the anchor 27 fluidly seal the hous-
ing relative to the mandrel 18 as well as seal the annular
clearance space 75 between the mandrel 18 in that por-
tion of the housing 19 adjacent to the anchor 27. A plu-
rality of radial ports 76 through the housing 19 adjacent
the elastomeric sleeve 28 provide fluid communication
from this clearance space 75 into the sealed space 35 be-
neath the elastomeric sleeve. A fluid passage 77 formed
through the housing 19 provides fluid communication from
the annular clearance space 75 to the hydraulic chamber
69 between the slidable piston members 59, 60.

The hydraulic chamber 69 between the piston members
59, 60, as well as the fluid passage 77, annular clearance
space 75 and fluid-tight space 35, is of course filled with
a suitable hydraulic fluid. A ten...
between the opposed ...
60 normally ...

...other to develop a slight hydraulic pressure within the
fluid-filled system. This slight pressure will expand the
elastomeric sleeve 28 of the anchor 27 and extend the
casing-engaging members 29, 30 against the casing. Ac-
cordingly, the spring 78 is appropriately selected to press
the casing-engaging members 29, 30 against the casing
with a force sufficient to restrain the housing 19 from
moving as the mandrel 18 is being manipulated but not
so great as to prevent the bridge plug 16 from being
shifted easily along the casing.

Once, however, the mandrel 18 is freed from the latch

rection will bring one or the other of the mandrel shoulders **63**, **64** into engagement with its corresponding piston member and shift that piston to increase the hydraulic pressure further. It will be realized of course that this increase of hydraulic pressure will be proportionately related to the extent of longitudinal movement of the mandrel **18**.

Turning now to the operation of the bridge plug **16**, whenever the bridge plug has been positioned at a desired point in the well bore, the tubing string **11** is lowered slightly, slowly rotated to the right and then picked up a short distance as it is rotating. This action successively rotates the J-pins **40** of the overshot **14** into the bottom of the open portion of the J-slots **39** in the fishing neck **15** and then engages the J-pins against downwardly facing shoulders formed in one side of the open slot portions. The lug **23** is simultaneously shifted into alignment with the longitudinal portion **25** of T-groove **24** on the mandrel **18**. Once the lug **23** moves into this longitudinal slot portion **25**, the upward travel of the tubing **11** will carry the mandrel **18** upwardly as well. As the mandrel moves, mandrel shoulder **64** will engage the lower piston **60** and shift it upwardly to increase the hydraulic pressure acting on the anchor **27**. Upper piston member **59** is of course forced upwardly against the housing shoulder **61** by this pressure increase. This concerted action sets the anchor **27** and allows the overshot **14** to be released from the fishing neck **15**. The tubing **11** is rotated slightly to the left and then pulled upwardly to remove the overshot **14** and, as previously described, shift the sliding valve member **42** upwardly to close the equalizing ports **41**. The upward travel of the mandrel **18** will also move the port **55** upwardly out of registration with the port **54**.

As soon as the overshot **14** has been removed from the fishing neck **15** and the slidable valve member **42** pulled upwardly to close the equalizing ports **41**, whatever pressure differential there is across the packing cups **20**, **21** will act against the concave side of one of these cups to press it into sealing engagement against the casing.

It will be appreciated, therefore, that after the equalizing ports **41** are closed, should the pressure in the well bore above the bridge plug **16** be greater than the pressure below, the pressure differential acting on the upper end of the mandrel **18** will tend to shift the mandrel downwardly. Downward shifting of the mandrel **18**, of course, drives the upper slidable piston member **59** further downwardly, which action will further increase the hydraulic pressure within the system to press the casing-engaging members **29**, **30** of the anchor **27** even more tightly against the well casing. It will be realized, of course, that the developed hydraulic pressure will be proportionately related to the pressure differential.

Should, perchance, the pressure in the well bore below the bridge plug **16** becomes greater than that thereabove, the mandrel **18** will similarly be shifted upwardly. As the mandrel **18** shifts upwardly, the hydraulic pressure will be momentarily reduced as the hydraulic fluid forces the upper piston member **59** upwardly against housing shoulder **61**. As the mandrel **18** continues to travel upwardly, however, the lower slidable piston member **60** is quickly engaged by the lower mandrel shoulder **64** which shifts this piston upwardly. This upward movement will, of course, again increase the hydraulic pressure within the fluid-filled system to maintain the casing-engaging members **29**, **30** tightly pressed against the well casing.

Accordingly, it will be appreciated that the present invention provides new and improved packing apparatus having hydraulically actuated wall-engaging members. These members are arranged to be pressed into anchoring engagement with a well casing with a force proportionately related to whatever pressure differential is acting across the packing apparatus. Furthermore, this new and improved well-packing apparatus is capable of being releasably anchored in a packed-off condition to resist extreme pressure differentials acting from either longitudinal direction.

While a particular embodiment of the present invention has been shown and described, it is apparent that changes and modifications may be made without departing from this invention in its broader aspects and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What is claimed is:

1. A well packer sized and adapted for reception in a well bore for packing-off the well bore comprising: an outer tubular member; a body member telescopically arranged and slidably disposed within said outer member and operatively arranged to shift longitudinally relative thereto in response to a differential of fluid pressure above and below said members in a well bore; first and second annular elastomeric packer cups mounted around one of said members and having their enlarged portions facing in opposite directions and their reduced portions adjacent one another; valve means responsive to shifting of said body member for selectively providing fluid communication across said packer cups between said oppositely facing portions and said reduced portions whenever said body member is in one position relative to said outer member and blocking this fluid communication whenever said body member shifts longitudinally to another position relative to said outer member; anchoring means for securing said packer against movement relative to the well bore including outwardly-extendible wall-engaging means mounted on said outer member and fluidly sealed relative thereto to provide a fluid-tight space therebetween, said wall-engaging means being adapted for extension into engagement with the well bore upon application of hydraulic pressure in said fluid-tight space; and hydraulic means responsive to shifting of said body member from said one position for applying a hydraulic pressure in said fluid-tight space to press said wall-engaging means into anchoring engagement with a force proportionately related to said pressure differential.

2. A well packer sized and adapted for reception in a well bore for packing-off the well bore comprising: an outer tubular member; a body member telescopically arranged and slidably disposed within said outer member and operatively arranged to shift longitudinally relative thereto in response to a differential of fluid pressure above and below said members in a well bore; first and second annular elastomeric packer cups mounted around said outer member and having their enlarged portions facing in opposite directions and their reduced portions adjacent one another; valve means responsive to shifting of said body member for selectively providing fluid communication across said packer cups between said oppositely facing portions and said reduced portions whenever said body member is in one position relative to said outer member and blocking this fluid communication whenever said body member shifts longitudinally to another position relative to said outer member, said valve means including first passage means providing fluid communication from the annulus between said telescoped members to the exterior of said adjacent reduced portions of said packer cups, and second passage means providing fluid communication from said annulus to the exterior of said other member at a point longitudinally displaced from said packer cups; anchoring means for securing said packer against movement relative to the well bore including outwardly-extendible wall-engaging means mounted on said outer member and fluidly sealed relative thereto to provide a fluid-tight space therebetween, said wall-engaging means being adapted for extension into engagement with the well bore upon application of hydraulic pressure in said fluid-tight space; and hydraulic means responsive to shifting of said body member for applying a hydraulic pressure in said fluid-tight space to press said wall-engaging means into anchoring engagement with a force proportionately related to

said pressure differential including a piston member slidably disposed within the bore of said tubular member and adapted to be advanced therein by said body member whenever said body member shifts in one direction, first means fluidly sealing said tubular member bore at a point longitudinally spaced from said piston member in said one direction, second means fluidly sealing said piston member for providing a fluid-tight chamber in said tubular member bore intermediate said piston member and said longitudinally displaced point, and third passage means providing fluid communication between said fluid-tight chamber and said fluid-tight space, said fluid-tight chamber and space being filled with a hydraulic fluid.

3. The apparatus of claim 2 further including a second piston member spaced from said first-mentioned piston member and slidably disposed within said tubular member bore; and first means for advancing said first piston member toward said second piston member whenever said body member shifts in one direction and second means for advancing said second piston member toward said first piston member whenever said body member shifts in the opposite direction.

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