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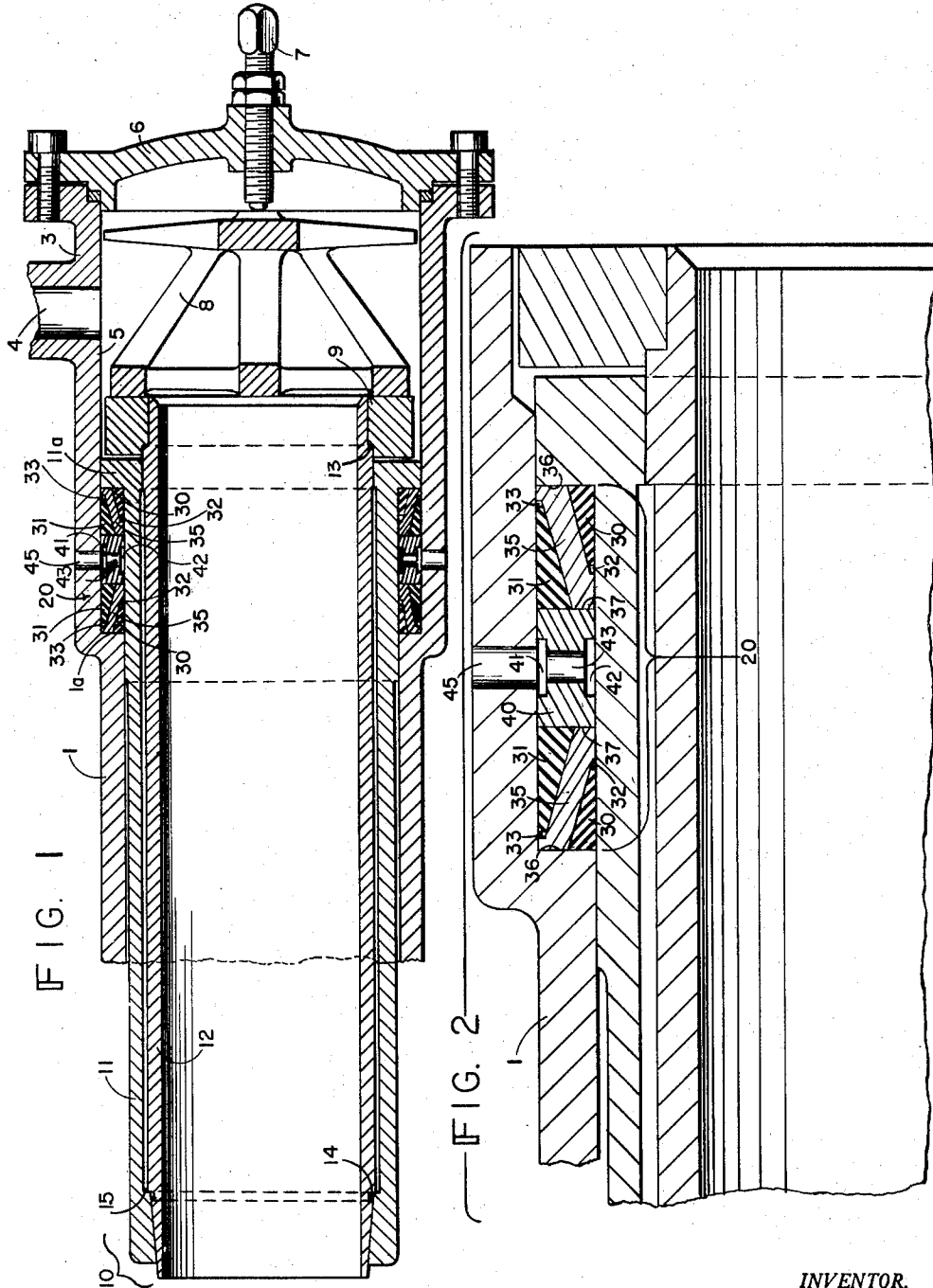
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2,856,249

HIGH-PRESSURE PUMP LINER AND PACKING

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3 Sheets-Sheet 1



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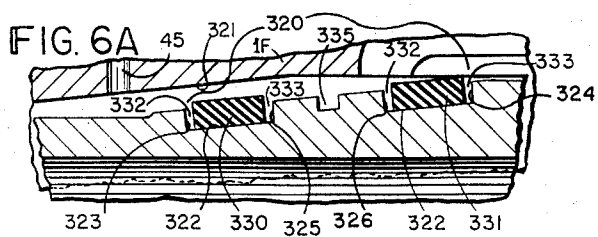
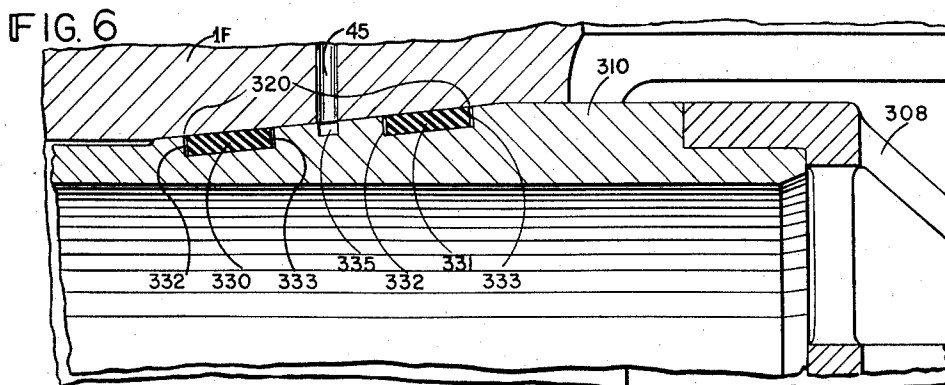
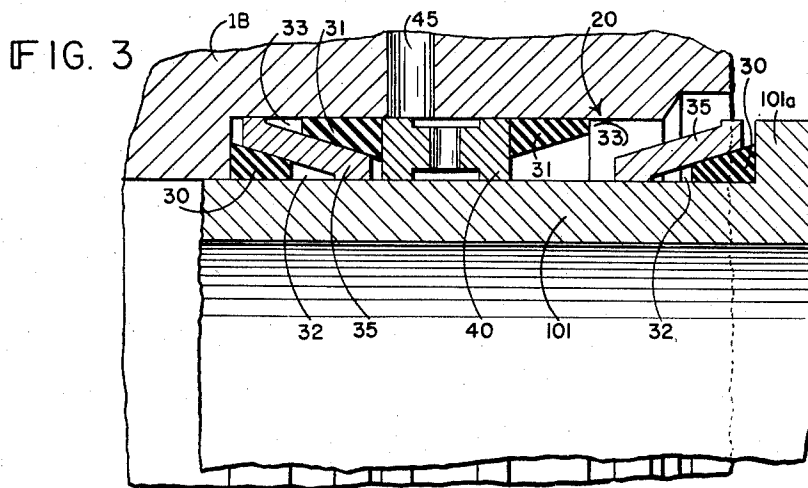
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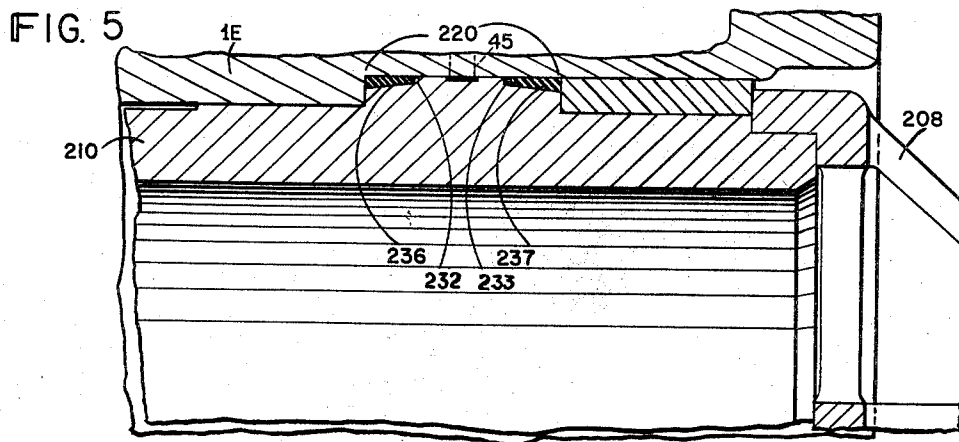
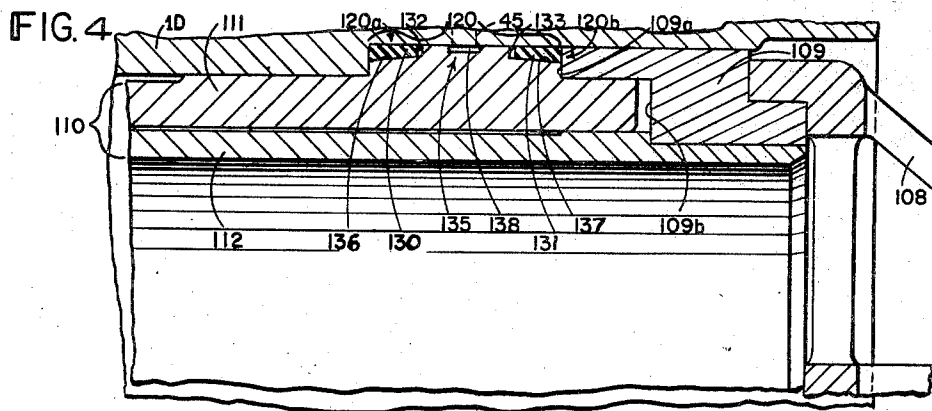
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HIGH-PRESSURE PUMP LINER AND PACKING

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## HIGH-PRESSURE PUMP LINER AND PACKING

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11 Claims. (Cl. 309—3)

My present invention relates to reciprocating pumps such as those known in the oil field as slush pumps. It aims to provide an improved cylinder and liner assembly for such pumps including novel packing means in an interspace between the liner and cylinder and correlated with them to withstand the increasingly high fluid pressures now employed in oil field and other pumping operations.

Heretofore and until the advent of high fluid pressures the customary sleeve packing for pump cylinder liners has served with reasonable satisfaction. Examples of such standard liner packing are seen in my prior Patents 2,640,434 and 2,686,090. More recently pump pressures have substantially increased, along with reduction in size of the liner bore, until the load on the usual liner packing has exceeded the tensile strength of the constituent rubber.

It will be evident that reduced-bore liners create loading on the liner packing in the ratio of the cross-sectional annular areas of the liner to the packing. For example, with a 5 in. bore liner having  $9\frac{3}{4}$  in. O. D. x  $8\frac{3}{4}$  in. I. D. liner packing, 1000 lb. sq. in. fluid pressure would build up 3680 lb. sq. in. pressure in the line packing rubber.

Since pump fluid pressures now commonly exceed 2000 lb. sq. in. and the ultimate strength of conventional rubberous packing is less than 3500 lb. sq. in., such prior packings, as for example those of my prior patents mentioned, are no longer satisfactory for the high pressure pumping operations. Deterioration or destruction of the liner packing with resultant leakage of sandy fluid at the interface of liner and cylinder has caused costly damage to pump cylinder bodies under the cutting action of the leaking fluid on the steel.

One proposed remedy has been to provide tell-tale holes through the cylinder wall at which leakage past the packing might be detected, thereby warning of likely damage to the pump cylinder body unless given appropriate attention. Such expedient affords merely detection rather than reduction or prevention of the leakage under high pressure operation. Other efforts have been directed toward substitute packing materials for high pressures such as rubber covered with fabric or even an all-fabric packing. Such efforts have not proved particularly helpful in practice.

The present invention now for the first time to my knowledge affords a satisfactory solution of the stated cylinder and liner packing problem for high-pressure pumping service such as at oil wells. As will be apparent from the following more detailed description the invention proceeds upon a new principle of radially compressing a rubberous or other yieldable packing annulus while affording it opportunity for axial flow and simultaneously stopping or axially retaining the liner relative to the pump cylinder by positive direct metal-to-metal contact by-passing and relieving the packing from the burden of having to oppose by itself axial pressures between the liner and cylinder.

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In the drawings illustrating by way of example certain embodiments of the invention:

Fig. 1 is a longitudinal sectional view including the head end of a pump fluid cylinder and inserted two-part liner and packing assembly typifying the invention;

Fig. 2 shows a portion of the pump cylinder assembly of Fig. 1 including the packing region, upon an enlarged scale;

Fig. 3 is a view similar to Fig. 2 showing the packing means thereof in course of assembly with a one-piece liner;

Fig. 4 illustrates another modification in longitudinal section and wherein the packing and stop means built upon the outer member or shell of a two-part liner;

Fig. 5 is another modification similar to that of Fig. 4 in association with a one-piece liner;

Fig. 6 shows in longitudinal section a still further modification wherein the pump cylinder body and the liner are mutually tapered at the packing region; and

Fig. 6A corresponds to a portion of Fig. 6 with the parts in course of assembly.

Referring now more particularly to Figs. 1 and 2, also also Fig. 3, I have represented in Fig. 1 sufficient of a typical pump structure to locate and identify the elements with which the invention is primarily concerned. Such structure comprises a fluid cylinder 1 of a reciprocating piston pump including the head end 3 thereof having a fluid outlet as at 4 to a discharge valve, not shown. The cylinder has the conventional or other counterbore as at 5 closed as by the bolted cover plate or head 6 in which a lock-up screw 7 takes against a spider 8 bearing axially against the cylinder liner means, in this instance through an annular thrust bearing ring or gland 9 received on and in axially abutting relation to the liner element.

The liner means in the example of Figs. 1 and 2, also Fig. 4, is a two-part element designated as a whole at 10. It comprises an outer cylindrical shell 11 having a portion directly received in and by the inner wall of the pump cylinder 1, and an inner sleeve 12 having portions directly received in the shell 11. The two-part liner 11, 12 of Figs. 1 and 2 represents one preferred form of liner construction, being that disclosed and claimed in my previously mentioned Patent No. 2,686,090. The invention however is equally applicable to other cylinder and liner constructions.

For the purposes of the invention the fluid cylinder such as 1 of Fig. 2 and the liner represented by the two-part element 10 of Figs. 1 and 2 are mutually formed to provide between them an annular interspace or cavity for the packing and stop means to be described. Such cavity is designated generally at 20, being in this case adjacent the head end of the cylinder 1. Depending on the manufacture and design of the particular pump the total cavity may comprise a number of cavity portions along the cylinder.

The packing cavity such as 20 of Figs. 1 to 3 is defined between the inner wall of the counterbore portion 5 of the cylinder and the outer wall of the liner element, here the outer member or shell 11 thereof. Said elements provide for the cavity opposed longitudinal side or circumferential walls and opposed transverse or radial end walls, one of the latter at 1a on the cylinder at the inner end of the counterbore portion 5 and the other at the inner face of a retainer flange 11a on the liner shell 11. As will be evident from the other figures, such transverse cavity walls may comprise integral portions of the fluid cylinder and of the liner or may be otherwise presented as by an element corresponding to the retainer ring or gland 9 of Fig. 1; see Figs. 4 and 5. In any case the cavity cross walls are such as to be subject to axial forces in one and the opposite direction in the operation of the pump.

In the particular example of the two-part liner 10 of

Figs. 1 and 2, the gland 9 engaged by the spider 8 thrusts against an annular projection 13 on the liner sleeve 12 and the latter at its opposite end has longitudinal limiting abutment at a stop shoulder 14 engaging an infacing stop shoulder 15 on the liner shell 11 whereby longitudinal compression upon the sleeve 12 is balanced by longitudinal tension upon the shell 11. Hence the packing cavity outer end wall 11a is under axial force in the direction toward and resisted at the opposite or inner end wall 1a of the cavity.

In cooperation with such cylinder and liner interspace or packing cavity 20 the invention provides packing and positive stop means such that the liner is positively positioned and held in the pump metal to metal against axial movement and the packing or seals pack off the fluid but do not themselves retain the liner axially, being left free to flow axially into space provided therefor in the cavity while attendantly being radially compressed.

Such packing and stop means in the example of Figs. 1 and 2, and similarly in Fig. 3 showing a one-part liner 101, comprises a plurality of yieldable annular packings or ring seals preferably of rubber or rubberous material correlated with longitudinally inclined wall means at or in the cavity and affording a positive metal-to-metal longitudinal stop with respect to the packing or seals. In this example the seal means includes a plurality of pairs of the yieldable annular packings, of tapered or wedge-like cross-section. Each such seal pair comprises an inner ring seal or packing ring 30 and an outer ring seal or packing ring 31. Between the inner and outer seals 30, 31 of each pair is interposed a flared or tapered metal ring 35, herein for identification termed a cone. Such cones 35 each comprises an inclined bar-like body and opposite end portions 36, 37 adapted to abut respectively an adjacent end wall 1a or 11a of the cavity and to thrust axially against each other either directly or through interposed metal. In the example of Figs. 1 and 2, or Fig. 3, such interposed metal comprises a lantern ring 40 medial along the cavity 20 and in transverse line with an aperture or tell-tale hole 45 opening from the liner to atmosphere through the wall of cylinder 1. Such lantern ring may be variously constructed and arranged to provide a path to the tell-tale hole for such, if any, leakage of fluid as may after long wear periods or in the event of faulty construction or installation work past the packing means. As represented it is in the form of a metal ring of general rectangular section having annular channels 41, 42 at the outer and inner circumferential faces and one or more of circumferentially distributed holes 43 communicating between said channels and via the outer one to the tell-tale hole 45. Thus the cavity 10 contains the yieldable packing pairs 30, 31 at opposite sides of the tell-tale opening 45 in the direction axially of the cylinder.

Said packings 30, 31 are adapted to be radially compressed at and by the inclined or taper surface at the cavity and in this instance presented through the medium of the cones 35. Said cones 35 also provide a longitudinal stop between the liner and the fluid cylinder by effectively interposing a strut between the opposite end walls of the cavity, the total strut in this instance including the interposed metal of lantern ring 40.

A further important feature of the invention lies in the attendant shaping, dimensioning and relative positioning or arrangement of the yieldable packing members 30, 31 and the strut-forming metal and associated inclined longitudinal wall so that packing cavity space is provided for free elongation and longitudinal flow of the packing at one or the other or both longitudinal ends thereof. Such longitudinal packing expansion space of the cavity 10 is indicated in Figs. 1 and 2 at 32 and 33 at the narrower ends of the wedge-forming packing rings 30 and 31 respectively. The latter as shown are oppositely positioned and said expansion cavity portions 32, 33 accordingly are at opposite ends of each packing pair.

It will be understood that the yieldable packings are so formed and dimensioned that in the initial or unstressed state ample expansion space is provided in the cavity as at the points 32, 33 such as indicated, and that in the intalled or assembled position of Figs. 1 and 2 the resultant axial elongation of the packings reduces the expansion space accordingly, even to substantial end contact of the packings and cross walls. But the initial spacing and dimensioning of the parts in any case is such that any objectionable axial thrust or force upon the packing is relieved and shunted or by-passed through or around the packing by the direct metal-to-metal abutment and strut-like action of the described metal parts, leaving the packing to assume no material part of the burden of opposing axial forces between the liner and the cylinder.

The manner of installation and operating principles concerned are further illustrated in the embodiment of Fig. 3. There the packings 30, 31, the cone elements 35 and general dimensioning and arrangement thereof in the fluid cylinder 1 are similar as in Figs. 1 and 2. The Fig. 3 example differs mainly in that the cylinder liner 101 is a one-part cylindrical element including an integral flange 101a presenting an end wall for the cavity 20. In the process of assembly one inner ring seal or packing ring 30, one cone 35, the lantern ring 40 and both outer packing rings 31 are set into the packing cavity 20 of the pump body. The packings and cones may be preparatorily lightly greased and for easy entrance the inner seal 30 should be but lightly placed in the cone 35. The other inner packing ring 30 and the associated cone 35 are placed on the liner 101 as seen at the right in Fig. 3, the liner and packing desirably being greased. The liner 101 is then fully inserted into the cylinder 1 and set up tightly as by turning up a lock-up screw like 7 of Fig. 1, this being followed by retightening after a brief period of operation of the pump, say 30 minutes. In this manner the liner is set up tightly in complete metal-to-metal longitudinal force-bearing relation to the pump fluid cylinder 1. At the same time the packing is relieved of axial stress and left free to flow longitudinally at the expansion zones 32, 33 through the medium of the described strut action of the metal parts and while receiving radial compression under the action of the tapered surface.

In Figs. 4 and 5 I have represented modifications wherein the packing and the longitudinal stop means are in effect built onto the liner in lieu of separately assembled parts such as the cones 35 and 35a of the previous figures. In Fig. 4 the pump cylinder 1D and the insert liner 110 comprising an outer shell 111 and inner sleeve 112 are mutually formed to present an annular packing cavity designated as a whole at 120. In this instance an outer end wall of the cavity is provided by retainer ring means 109 having endwise engagement with both parts 111 and 112 of the liner as at 109a, 109b and engaged at its outer portion by the lock-up means such as the head spider 108.

The inclined longitudinal wall means at and in the cavity is in this example of Fig. 4 formed on and provided by an annular projection or collar designated as a whole at 135, integrally or otherwise located on the outer wall of the liner, in this case on the liner shell 111. It includes at opposite end portions oppositely inclined longitudinal walls 136, 137 radially spaced from the opposite longitudinal wall portion of the cylinder 1D to provide therewith packing cavity portions 120a, 120b together constituting the entire packing cavity 120. Yieldable packing rings 130, 131 are disposed in the respective cavity portions 136, 137.

Here again said packings or sealing annuli 130, 131 are cross-sectionally shaped and proportioned so that when assembled they are placed under radial compression at and by the respective inclined surfaces 136, 137 but are left with capacity for free axial elongation by reason of expansion spaces or zones such as 132, 133 in the cav-

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ity at one or both ends of the respective packings. As in the previous forms an opening to atmosphere from the liner is afforded at the region of the packing cavity such as the tell-tale hole 45 in line with a medial circumferential channel 138 on the liner shell 111 intermediate the plural packing cavity portions 136, 137. It will be seen in Fig. 4 that the collar 135 of the liner serves to present inclined longitudinal wall means coactive with the packing to place it under radial compression and that the parts are relatively dimensioned to afford axial expansion space for the packing, said wall means simultaneously posing a longitudinal strut affording a positive stop as between the liner and the cylinder and relieving the packing of excessive axial thrust.

The embodiment of Fig. 5 is similar to that of Fig. 4 but shows a single or one-part liner 210 for the cylinder 1E. Corresponding parts in Fig. 5 are similarly numbered as in Fig. 4 raised by 100.

Figs. 6 and 6A illustrate another modification including the pump cylinder 1F and an insert liner 310 shown as a one-piece element but which may comprise two or more concentric cylindrical members. The liner 310 is locked up and retained at the head end as by the usual spider 308. In this instance the annular packing cavity between the cylinder and liner is defined circumferentially by inclined longitudinal walls 321 and 322 formed respectively at the inner wall of the bore of the cylinder 1F and at an opposed portion, in the assembled Fig. 6 position, of the insert liner 310. In other words, the cylinder and the liner are provided with radially opposed and generally conformant longitudinal wall portions 321 and 322 tapered or inclined relative to the cylinder axis. Transverse walls for the packing cavity 320 may be provided either on the cylinder or on the liner or partly on each, being shown on the liner 310, the latter being circumferentially channeled to present cavity transverse end walls 323, 324 and also intermediate transverse walls 325, 326 for the respective cavity portions. The respective portions of the cavity 320 each receive a rubberous or other yieldable packing ring 330, 331, in this instance shown as of substantially rectangular cross-section.

As best seen in Fig. 6A with the cylinder and liner at an intermediate stage of installation the cavity or cavity portions 320 and the yieldable packings 330, 331 are shaped and relatively proportioned so that in the initial unstressed state the packing exceeds in radial dimension that of the cavity and is lesser in axial dimension than the cavity to provide axial expansion zones as at 332, 333 at one or the other or both longitudinal extremities of the packing. By comparison of Fig. 6A with Fig. 6 it will be seen that under full insertion and locking up of the liner 310 into the cylinder 1F the packing rings 330, 331 are by reason of the inclined longitudinal wall means of the cylinder and liner placed under radial compression with attendant axial elongation and with the longitudinal wall means of the liner serving in strut fashion to provide with the opposed wall portion of the cylinder a positive metal-to-metal stop preventing longitudinal stress from being effective upon the packing. As in the previous embodiments communication from the liner to atmosphere preferably is provided at the region of the packing cavity such as the tell-tale hole 45 disposed between the packing members and communicating with a circumferential groove 335 on the liner substantially medial of the of the packing cavity 320. Thus the yieldable packings 330, 331 are disposed at opposite longitudinal sides of the opening 45 to atmosphere.

It will be understood that for the high-pressure pumping operations with which the means of my invention is particularly useful the yieldable packings or seal rings such as 30, 31 of Figs. 1 to 3, 136, 137 and 236, 237 of Figs. 4 and 5, or 330, 331 of Fig. 6, of rubber, rubberous or other material adapted to yield radially and flow or elongate axially under the high pressures concerned may be comparatively dense and more or less solid in body

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giving them a self-sustaining or semi-rigid character such that the radial compressibility and axial flow capacity under the described installation may not readily be evident under ordinary handling prior to installation. For similar reasons the cross-sectional shapes of the packings may be considerably varied within the mentioned requirements of provision for radial compression and axial elongation. Hence, depending on the pressures and other operating circumstances and the particular make or design of pump for which the cylinder and liner assembly of the invention is intended, the packings may be in the unstressed state and as to any of the exemplary embodiments be of substantially rectangular cross-section as in Fig. 6 or of a more or less tapered or wedge-form so long as they are adapted for coaction with the inclined longitudinal wall or surface means of the packing cavity and to be subject to radial compression and axial elongation therein as in the manner herein disclosed.

My invention is not limited to the particular embodiments thereof illustrated and described herein, and I set forth its scope in my following claims.

I claim:

1. For a reciprocating pump, an assembly comprising a cylinder and a liner concentric therein, the cylinder having a lateral opening to the atmosphere, the cylinder and liner having an annular packing cavity defined between them on each side of the cylinder opening, a yieldable annular elastomeric packing in each cavity, each cavity having longitudinal wall structure presenting radially opposed longitudinally extensive circumferential surfaces of which at least one is disposed at a small angle to the cylinder axis whereby axial thrust forces on the liner impart radial compression to the packing, each cavity having axially opposed transverse end wall structure predeterminedly spaced to provide cavity space for axial movement and flow of the packing under radial compression thereof, such end wall structure at the opposite ends of the respective cavities being subject to opposed abutitive longitudinal thrust effective on the packing in adjustment of the liner to the cylinder, and said longitudinal wall structure defining a metallic strut for directly assuming axial thrust forces on the liner and relieving the packing of the same up to the maximum expectable in the assembly and operation of the given pump.

2. A reciprocating pump cylinder and liner assembly comprising an axially elongate packing cavity between the cylinder and liner, yieldable annular non-metallic packing in the cavity, and metal means at the cavity presenting a longitudinally extensive wall inclined at a small angle to the cylinder axis, said wall disposed radially opposite the packing and placing the latter in radial compression and posing a strut relieving the packing of axial forces as between the cylinder and liner, the cavity having transverse end walls subject to opposed abutitive thrust of said axial forces effective on the packing as limited by said relieving strut action.

3. A reciprocating pump cylinder and liner assembly according to claim 2 wherein the longitudinally inclined wall is integrally formed on one of the assembly parts comprising the cylinder and liner.

4. A reciprocating pump cylinder and liner assembly according to claim 2 wherein the longitudinally inclined wall is integrally formed on the liner.

5. In a reciprocating pump, a fluid cylinder defining an axis, a removable liner, a packing cavity between the cylinder and liner, an opening in the cavity from liner to atmosphere, the cavity containing at opposite axial sides of the opening a longitudinally extensive metal wall member tapering axially of the cylinder at an acute angle to the axis thereof and posing a strut between the cavity ends, and yieldable annular elastomeric packings radially opposite said wall members with longitudinal expansion zones in the cavity at an end of each packing, the pack-

ings being radially compressed at the tapering wall members and being free to elongate axially by reason of a positive stop maintained by said strut, the cavities further defined by transverse end wall structure imposing radially compressive axial thrust on the packings up to limitation thereof by the strut action.

6. In a reciprocating pump having a cylinder and a cylinder liner concentrically receivable therein, the opposed walls of the cylinder and liner mutually formed to present between them an annular packing cavity with longitudinal and transverse metal walls including longitudinal wall means inclined at an acute angle of markedly less than 45° to the cylinder axis, and yieldable annular packing of initial unstressed form and dimension to receive under opposed axial thrust forces as between the cylinder and liner on installation in the cavity radial compression at the inclined wall means and axial elongation toward the cavity end walls, said cavity walls simultaneously affording a positive metallic stop as between the cavity end walls.

7. In a pump cylinder and liner assembly comprising in combination with the cylinder bore a cylindrical liner for reception therein, the liner and cylinder bore mutually formed to define between them an annular cavity presenting radially disposed transversed walls and longitudinal circumferential outer and inner walls, the latter including a wall portion inclined at a small angle to the cylinder axis, and yieldable annular packing in the cavity and of elongate and angular cross-sectional shape and dimensioned relative thereto to provide for free axial flow of the packing under radial compression thereof by a wedging action at the inclined wall portion, said walls adapted to limit said packing wedging action by affording direct metal-to-metal abutment positive shunting relief to the packing as against axial thrust between the cylinder and liner.

8. In a reciprocating piston pump having a fluid cylin-

der and a removable liner including wall means defining an annular packing cavity between the liner and cylinder, an opening in the cylinder from said cavity to atmosphere, said wall means including at opposite sides of the opening acutely longitudinally tapered surfaces, yieldable annular packing at the respective sides of the opening and initially shaped and dimensioned cross-sectionally relative to the cavity to afford the packing freedom to elongate axially and adapting it to be radially compressed between the tapered surface and a radially opposite wall of the chamber, opposed transverse end wall means for the cavity adapted to effect such radial packing compression by axial thrust thereon as between the liner and the fluid cylinder, and positive stop means to limit said axial thrust.

9. A reciprocating pump cylinder and liner assembly according to claim 12 wherein the longitudinally inclined wall is on a cone assembled into the cavity.

10. A reciprocating pump cylinder and liner assembly according to claim 2 wherein the longitudinally inclined have radially opposed axially tapering wall portions defining longitudinal walls of the cavity.

11. In a reciprocating piston pump according to claim 8, the construction wherein the inner wall of the cylinder and the outer wall of the liner are conformantly tapered at the packing region.

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