July 24, 1956 F. S. FLICK ET AL 2,755,775

FLOATING CUSHION FOR A PISTON AND CYLINDER DEVICE

Filed Dec. 27, 1954 4 Sheets-Sheet 1

FIG. 1

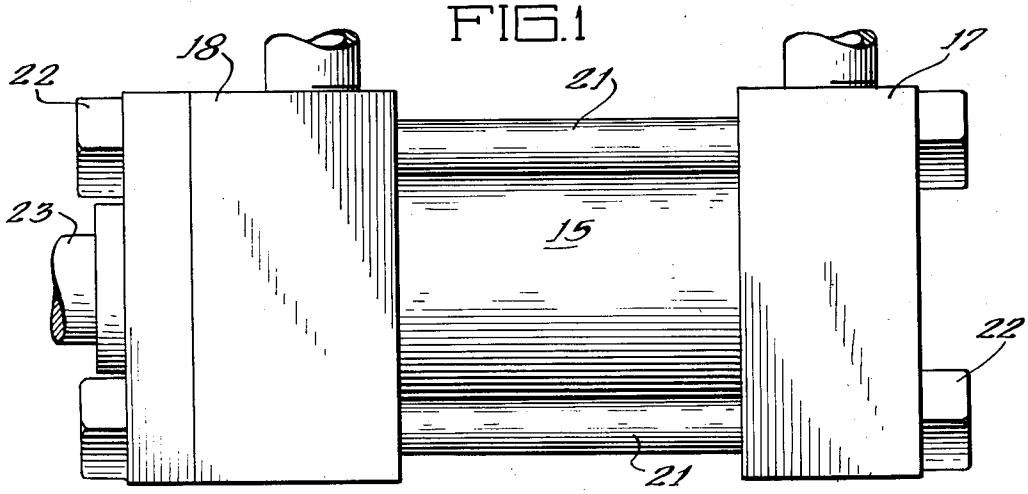


FIG. 2

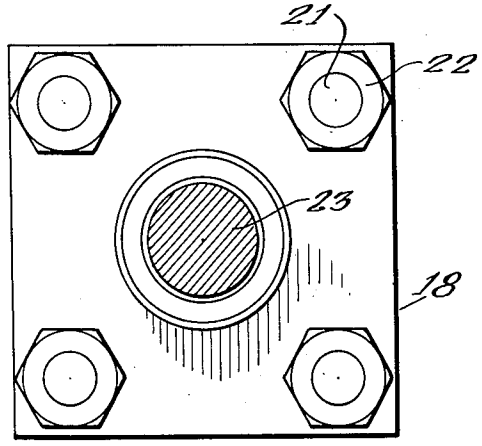


FIG. 3

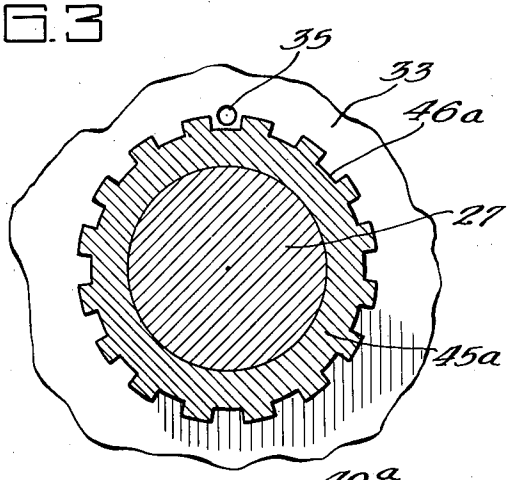


FIG. 4

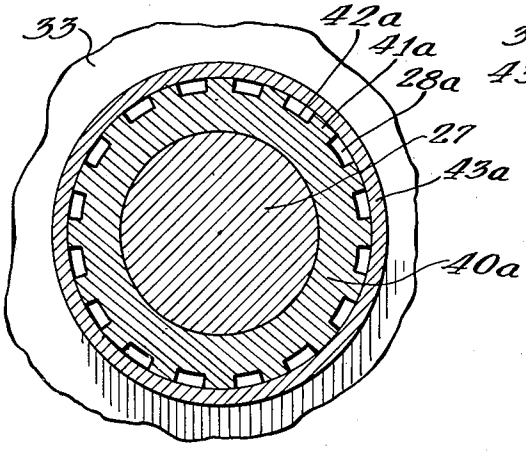
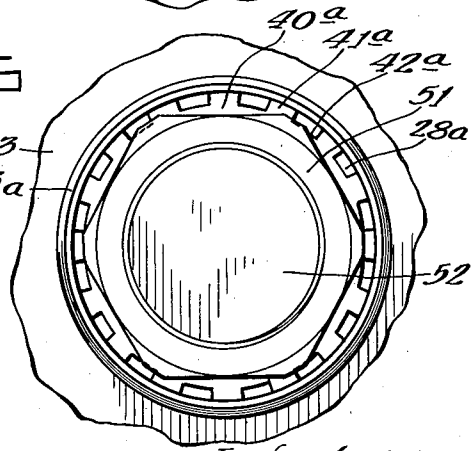


FIG. 5



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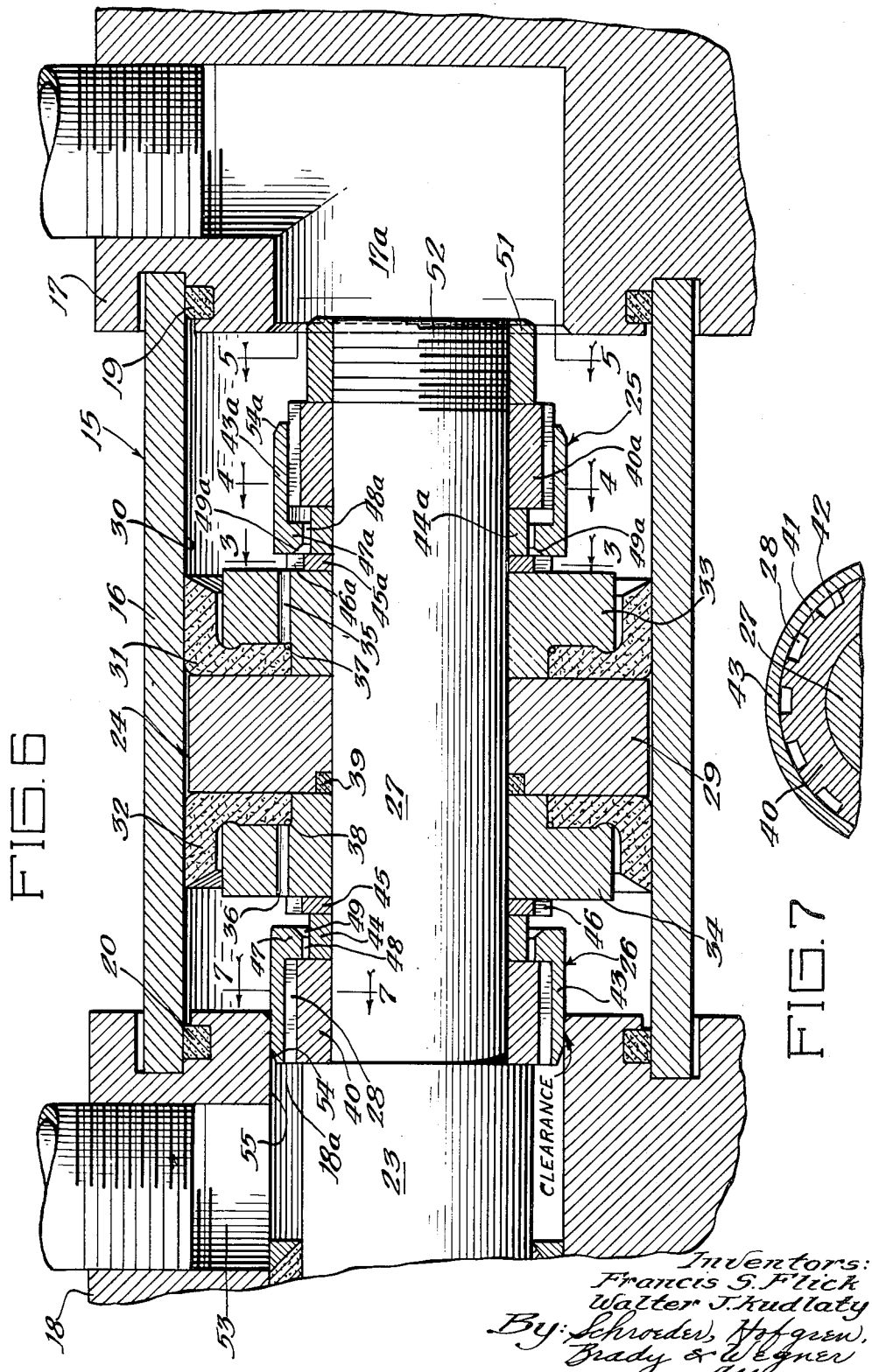


FIG. 6

FIG. 7

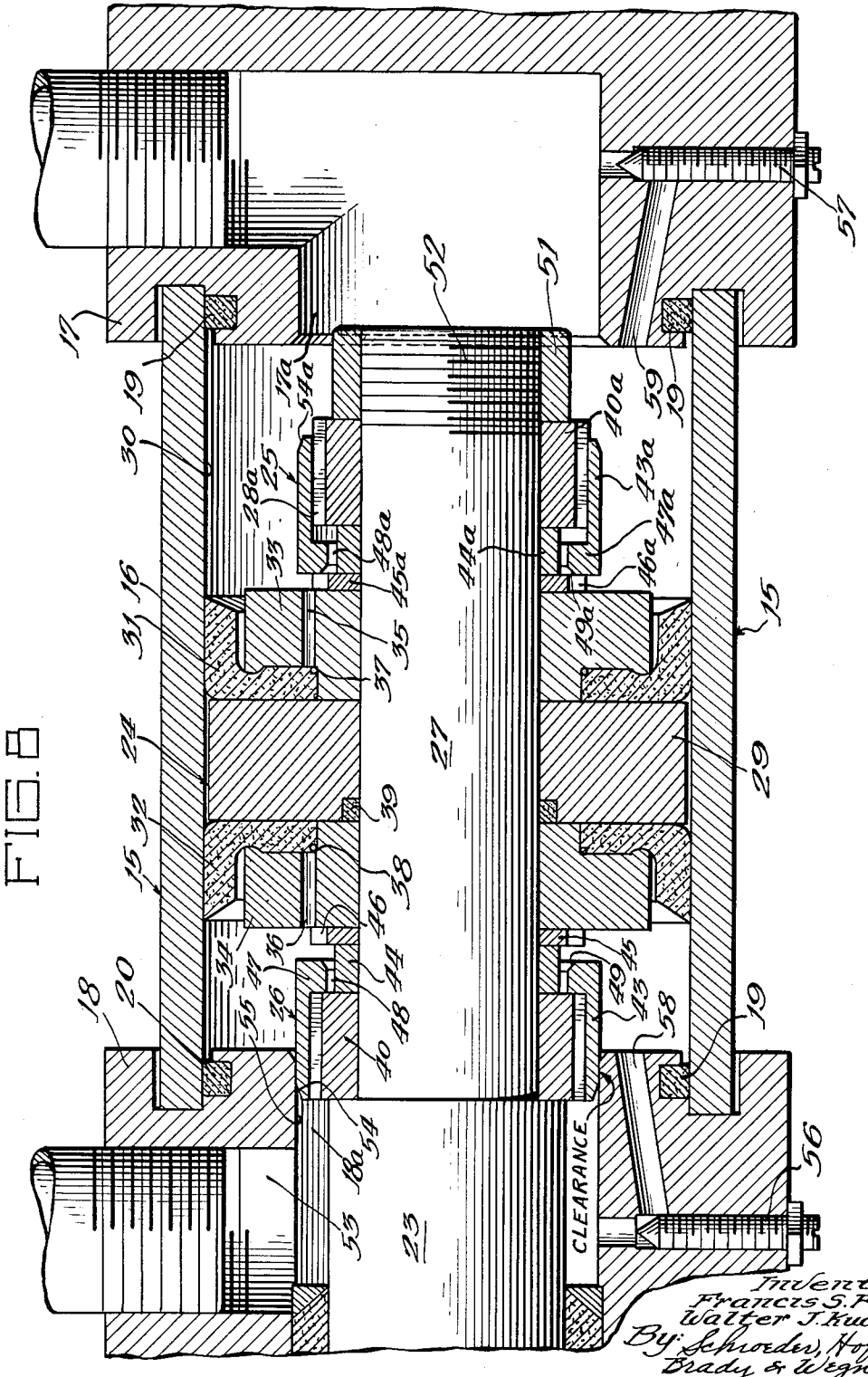
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FLOATING CUSHION FOR A PISTON AND CYLINDER DEVICE

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FIG. 8



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FLOATING CUSHION FOR A PISTON AND CYLINDER DEVICE

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FIG. 9

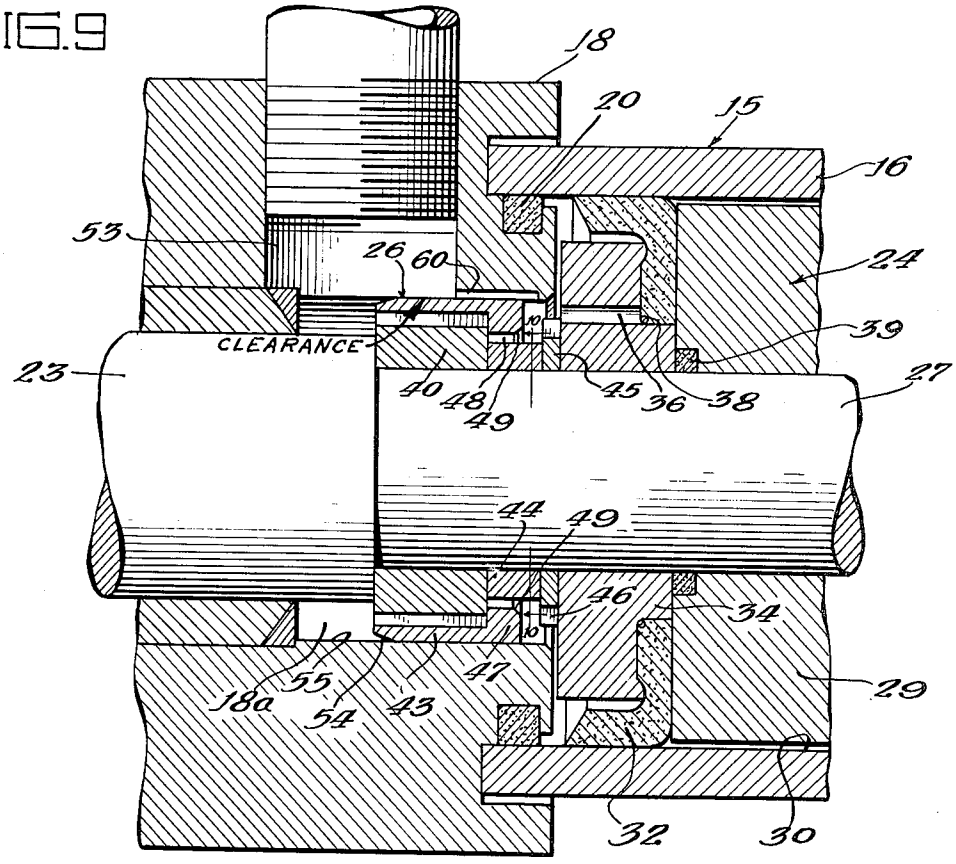
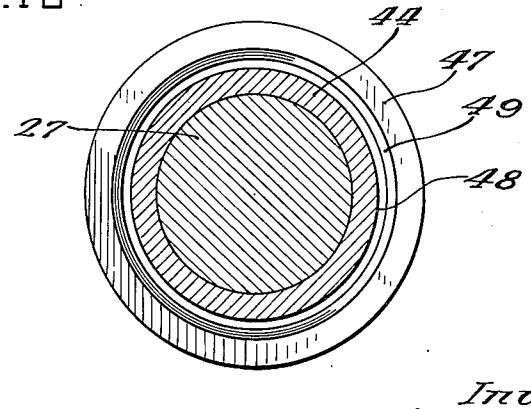


FIG. 10



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FLOATING CUSHION FOR A PISTON AND CYLINDER DEVICE

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Application December 27, 1954, Serial No. 477,702

17 Claims. (Cl. 121—38)

This invention relates to a piston and cylinder device, and more particularly to a cushion including a valve mechanism adapted to close the exhaust port of a cylinder to cushion a piston at the end of its stroke, and adapted to be opened quickly by fluid pressure so that the piston is given rapid break-away at the start of a reverse stroke.

Conventiontal piston and cylinder devices, whether of the single or double acting type, usually have a ball-check valve in each cylinder head which allows or permits rapid entry of fluid pressure into the cylinder at the start of a piston stroke. Such check-valves are generally restrictive in size and permit only a gradual build-up of pressure in the cylinder due to restricted flow so that the piston is moved slowly until the piston cushion rides out of the main port in the cylinder head, at which time larger amounts of fluid under pressure enter the cylinder through the main port, causing the piston to move more rapidly. The cushion of the present invention is constructed to provide a rapid build-up of fluid pressure, and a consequent rapid break-away of a piston at the start of its stroke.

Another feature of the present invention is the provision of a plunger assembly having a floating cushion sleeve of a size to make a close fit with the end port in a cylinder head. The structure is such that the exhaust fluid flow maintains the cushion sleeve in floating condition upon the plunger assembly, and centers the cushion sleeve with respect to both the piston rod and plunger port in the cylinder head so that entry of the cushion sleeve into the end port eliminates the possibility of scoring exposed surfaces on either member. The structure decreases wear upon both close fitting surfaces, and increases the effective life of a piston and cylinder device.

The invention has a further feature which may be characterized as an automatic pressure relief provided by the structure of the plunger assembly. The trapped fluid on the non-pressure side of a piston may build up to extremely high proportions and the structure of the present invention, in effect, limits the extent of such build-up.

One embodiment of the present invention is particularly useful in air-driven piston and cylinder devices. Trapped air on the non-pressure side of the piston may build up to an extremely high pressure value more rapidly than the air may escape through the normal clearances provided. In such instances, the piston may rebound at the end of its stroke. The present floating cushion sleeve can be constructed to open to port just before the end of a piston stroke to release the trapped air pressure, permitting the piston to smoothly finish its stroke, and eliminating the undesirable results described above.

The primary object of the present invention is to provide an improved valve mechanism which will cushion a piston at the end of its stroke.

Another object is to provide a valve mechanism which will slide open immediately when fluid under pressure is admitted to the port and while the cushion plunger assembly is still in the main port to permit rapid build-up of operating fluid pressure in the cylinder chamber so that the piston will break away rapidly at the start of a stroke.

Another object is to provide a cushion sleeve on a piston rod which will function as a valve mechanism and eliminate the necessity of ball-check valves and needle-valves in the piston and cylinder device.

Another object is to provide a function of automatic pressure relief against build-up of trapped fluid pressure beyond a predetermined value by the structure of the cushion plunger of the invention.

Another object is to provide a cushion sleeve which is arranged to ride clear of an exhaust port just before the end of a piston stroke allowing complete exhaust of trapped compressible fluid so that the piston may move to the extreme end of its stroke without rebound.

Another object is to provide a cylinder cushion adapted to be incorporated in a conventional piston and cylinder device without necessitating any change in the structure of the cylinder head.

A further object is to provide a floating cushion which is adapted to be centered with respect to an end port in a cylinder head before and while entering the port.

The invention is illustrated in the accompanying drawings, in which:

Figure 1 is a fragmentary side elevational view of the piston and cylinder device;

Figure 2, an end elevational view of the piston and cylinder device;

Figure 3, a fragmentary sectional view taken as indicated on line 3—3 of Figure 6;

Figure 4, a view similiar to Figure 3, taken as indicated on line 4—4 of Figure 6;

Figure 5, a view similiar to Figure 3, taken as indicated on line 5—5 of Figure 6;

Figure 6, a fragmentary sectional view of the piston and cylinder device;

Figure 7, a fragmentary sectional view taken as indicated on line 7—7 of Figure 6;

Figure 8, a fragmentary sectional view of a modified form of the piston and cylinder device showing needle valves in the cylinder head and cylinder cap;

Figure 9, a fragmentary sectional view of another modification of the piston and cylinder device showing a relief passage in the port opening which permits exhaust of trapped fluid to port just before the end of a piston stroke; and

Figure 10, a sectional view taken as indicated on line 10—10 of Figure 9.

In the embodiment illustrated, a high pressure cylinder, generally designated 15, preferably is formed with tubular cylinder walls 16 having at its rear end a cylinder cap 17 provided with a central port 17*a* and at its front end a cylinder head 18 provided with a central port 18*a*. A plurality of tie-rods 21, each having a threaded end portion, are passed through the cylinder cap 17 and head 18 exterior of the cylinder wall 16, and the parts of the cylinder 15 are held together by a nut 22 on each of the threaded end portions. At the juncture of the front and rear ends of the cylinder walls 16 with the cylinder cap 17 and cylinder head 18 is a pair of cylinder O-rings 19 and 20 which seal the cylinder 15 against leakage.

A piston rod 23 is provided to support a piston assembly, generally designated 24, and two cushion plunger assemblies, generally designated 25 and 26. All three of the assemblies are mounted on the free end 27 of the piston rod which is of smaller diameter than the rod 23.

The piston assembly is preferably of the type more particularly described in the application of Francis S.

Flick, Serial No. 365,657, filed July 2, 1953. This assembly comprises a piston disk 29 which makes a close sliding fit with the inner surface 30 of the cylinder wall 16, a pair of similar cup-shaped seals 31 and 32 each adjacent opposite faces of the piston disk 29, and a pair of similar piston followers 33 and 34 which fit within the cup-shaped seals 31 and 32 to hold them in proper position. Small openings 35 and 36 in each of the piston followers lead from fluid collecting channels 37 and 38 formed in the inside periphery of each of the cup-shaped seals 31 and 32. As is more completely explained in the aforementioned application, these openings and channels provide a ready outlet for fluid under pressure which may have collected between the piston follower and its cup-shaped seal so that blowing out of the seal is prevented upon rapid release of pressure from one side of the cylinder. A piston O-ring 39 may be provided to prevent leakage about the piston rod between opposite sides of the piston assembly 24.

The plunger assembly 26 is mounted on the front side of the piston assembly 24 and abuts the enlarged piston rod 23. As best seen in Figures 4 through 7, a cushion sleeve support or base 40, normally circular in cross-section, makes a close sliding fit with the free end 27 of the piston rod for purposes of assembly. The base 40 is provided with a plurality of lands 41 and grooves 42 running longitudinally of its outer peripheral surface. The lands 41 provide bearing surfaces for a cup-shaped cushion sleeve 43 slidably mounted thereon, the sleeve 43 being of a size to enter and make a close fit with the inner surface 55 of the port 18*a*. The lands 41 and sleeve are carefully fitted so that the lands both support and guide the sleeve in its limited movement relative to the piston. The sleeve 43 has an annularly tapered leading edge 54 which aids in centering the sleeve as it initially enters and substantially closes the port 18*a*. There is a slight clearance between the sleeve 43 and the inner surface 55 so that some fluid may be "metered out" even after the port is closed.

A plurality of passages 28 are formed by the longitudinal grooves 42 between the cushion sleeve 43 and its base 40 to provide communicating channels from the port 18*a* to the interior of the cylinder 15 for admitting fluid for initiating a return stroke of the piston. A spacer 44 separates the base 40 from a washer 45 mounted adjacent the piston assembly 24. As can be seen in Figure 3, the washer 45 has a plurality of circumferential notches 46 in its outer periphery, the purpose of which will hereafter be made apparent. If desired, the base 40 and spacer 44, or the spacer 44 and washer 45, may be made integral.

The cushion sleeve 43 is provided at its rear end with an inwardly extending flange 47 whose inner annular surface is spaced outwardly of the spacer 44 to form an annular opening 48 around the spacer 44. The flange 47 acts as a valve means in that it is adapted to make a close fit with the rear face of the base 40 and will close the passages 28 to flow of fluid under pressure from the cylinder when in contact with the base 40. The rear or trailing edge of the flange 47 has a beveled portion 49 so that the flange 47 will not cover the notches 46 in the washer 45 when the flange is in its rearward position. Thus, when the cushion sleeve 43 is in the port 18*a* and the flange is slid rearwardly of the base 40, a continuous passageway for fluid is provided from port 18*a* through the passages 28, the opening 48, the notches 46 and into the cylinder 15. In addition to controlling the flow of fluid through the passages 28, the flange 47 limits the sliding movement of the cushion sleeve 43 by abutting adjacent faces of the base 40 and the washer 45. The cushion sleeve is moved by fluid pressure on either side as will be explained.

The other plunger assembly 25 is mounted on the rear side of the piston assembly 24 and has the same general structure as the plunger assembly 26 described above.

The assembly 25 comprises a cup-shaped cushion sleeve 43*a* having a tapered leading edge 54*a* and slidably mounted upon a base 40*a* which in turn makes a close sliding fit with the free end 27 of the piston rod. The base 40*a* has a plurality of lands 41*a* and grooves 42*a* extending longitudinally in its outer surface, and is spaced from the piston assembly by spacer 44*a* and washer 45*a*. Notches 46*a* in the washer 45*a* serve as part of the passageway for fluid from the port 17*a* through passage 28*a* and annular opening 48*a* formed between flange 47*a* and the spacer 44*a* into the interior of the rear part of the cylinder 15. The plunger assemblies and the piston assembly are held in position upon the piston rod 23 by a nut 51 upon threaded end 52 of the free end 27 of the piston rod.

The embodiment illustrated is a double acting piston and cylinder device, and each of the plunger assemblies 25 and 27 operates in the same manner. Therefore, a description of the operation of one of them will suffice.

While the operation of the cushion assembly may vary slightly as operating conditions are varied, its usual operation is believed to be as follows. Assuming that the piston is just beginning a stroke, and that it is being driven to the left as shown in Fig. 6, the advancing face of the piston assembly 24 initially forces the exhaust fluid in the cylinder out through the open main port 18*a*. As the leading end of the cushion sleeve 43 approaches the main port 18*a*, the annular opening between the leading edge of the sleeve 43 and the end port 18*a* becomes more and more constricted, and the velocity of fluid flow through this annular opening is greatly increased. Since the cushion sleeve 43 is floating upon its base 40, the fluid flow past the leading edge of the sleeve and through the annular opening tends to become equalized and centers the sleeve with respect to the end port 18*a* and the piston rod 27.

The decease in size of the annular opening between the sleeve 43 and the main port 18*a* causes an increase in the velocity of fluid flow through the annular opening, and is accompanied by a rapid build-up in fluid pressure near the advancing face of the piston assembly 24. This increased pressure causes the sleeve 43 to slide and close the passages 28 just before entry of the sleeve into the end port 18*a*. It is believed that some amounts of fluid under pressure pass through the annular opening 48 and into the passages 28 before they are closed so that additional centering fluid pressures are applied to the floating cushion sleeve 43.

In Figure 6 the piston assembly 24 is shown approaching the end of a stroke. The tapered end 54 of the sleeve 43 has entered the end port 18*a* and the fluid has been trapped in the left end of the cylinder 15. Since the passages 28 have already been closed by the flange 47, pressure on the trapped fluid is relieved only by fluid seepage between the outer surface of the cushion sleeve 43 and the inner surface 55 defining the port 18*a* and the cylinder head 18. As the piston assembly continues its movement and the annular passage between the sleeve 43 and the surface 55 lengthens, the ease with which the molecules of fluid are "metered out" is decreased. Thus the pressure in the trapped fluid is gradually built up at the end of a stroke, and the pressure difference upon the rear and front sides of the piston is decreased. Accordingly, the speed of the piston assembly is diminished near the end of a stroke, and the "metering out" of the fluid cushions the piston assembly, permitting it to glide gradually to the end of its stroke.

At the point of travel of the piston assembly which moves the cushion sleeve into the port opening in the head of the cylinder, an additional function may occur. As described above, the only escape for the trapped fluid is in the clearance space between the outer diameter of the cushion sleeve and the port opening. Normally, this clearance is a total of from .002" to .003" and with the sleeve centered, one-half of this clearance will be on dia-

metrically opposite sides. The sleeve is also given some clearance over the support upon which it slides, ordinarily from .004" to .006" total. As the pressure of the trapped fluid increases because the volume of fluid cannot escape rapidly enough to relieve the pressure, a pressure relieving phenomenon results. The cushion sleeve itself may actually be compressed or shrink a slight amount, perhaps of the order of .001" so as to increase the size of the clearance between the sleeve and the port opening. This small increase in the clearance space size permits a slightly more rapid escape of the trapped fluid from the space between the piston and the cylinder head.

The effect of the foregoing function is to automatically relieve excessive pressures from building up in the space between the piston and the cylinder head. The clearance built into the cushion sleeve and its support and between the sleeve and port opening thus can change under influence of the high pressures to limit the pressure to a predetermined maximum amount. As the sleeve moves further into the port opening, the slot through which the trapped fluid must pass is increased in length increasing the resistance to flow of the trapped fluids out of the space. In this manner, the piston may still be decelerated gradually to a soft stop at the end of its stroke. Even though the sleeve may collapse a slight amount, it does not move against its support but will remain centered since the pressures on all sides are equal.

When it is desired to move the piston assembly rearwardly of the assembly, fluid pressure is admitted through the port 18*a*. This pressure immediately flows into the passages 28, exerting a pressure on the flange 47 and moving it rearwardly of the cylinder, opening a passage for fluid into the cylinder and permitting an immediate and rapid build-up of fluid pressure against the piston assembly 24 in the forward end of the cylinder. This action of the cushion sleeve 43 and flange 47 rapidly admits large volume of fluid under pressure so that the piston assembly can immediately break away from its rest position adjacent the head of the cylinder.

The operating cycle is then repeated with the plunger assembly 25 at the rear end of the cylinder 15.

Figure 8 discloses a modified form of the piston and cylinder device in which adjustable needle valves 56 and 57 are provided in the cylinder head 18 and cylinder cap 17, respectively. The needle valves may be adjusted to regulate further the cushioning of the piston assembly at the end of a stroke. As is apparent in the drawings, the openings 58 and 59 may be closed or partially opened by the needle valves in order to accelerate or retard the rate of exhaust of fluid from the cylinder as the piston assembly is nearing the end of its stroke.

Figures 9 and 10 disclose a further modification of the present invention. An annular internal relieving bore 60 is formed in the port opening to assist the piston assembly 24 in completing the last fraction of an inch of its stroke when air is used as the motive fluid. As can be seen in Figure 9, the relief bore 60 is placed so that the cushion sleeve may clear the inner edge thereof to open the trapped fluid space to port 53 just before the piston assembly 24 completes its full stroke. This opening to port permits rapid exhaust of the remaining air under high pressure to release completely the pressure in an end of the cylinder so that the piston will smoothly finish its stroke.

The foregoing detailed description is given for clearness of understanding only and no unnecessary limitations should be understood therefrom, for some modifications will be obvious to those skilled in the art.

We claim:

1. A cushion for a piston and cylinder device having a central end port, comprising: a piston rod movable within the cylinder; a cushion sleeve slidable on the piston rod and positioned to enter and substantially close the port near the end of a piston stroke; a flange on the cushion sleeve and cooperating abutments on the piston rod limiting sliding movement of the sleeve relative to the piston rod; one of said abutments having a fluid passage between the sleeve and rod, said sleeve being movable by pressure within the cylinder to close said flange over the passage.

2. A cushion as specified in claim 1 wherein the said flange is on the inner end of said sleeve so that the sleeve end and flange are exposed to pressure in the end port for sliding the flange relative to the piston rod to open said fluid passage.

3. A cushion as specified in claim 1 wherein said cushion sleeve and flange are integral with the flange extending radially inwardly on the inner end of the sleeve so as to close and open said fluid passage under action of pressure in said cylinder and end port respectively.

4. A cushion as specified in claim 1 wherein an annular cushion support is positioned on the piston rod for slidably supporting said sleeve, said support having a plurality of longitudinally extending peripheral grooves forming said fluid passages.

5. A cushion as specified in claim 1 wherein the outer leading edge of said cushion sleeve is tapered to guide said sleeve into the end port and said end port having a relief passage therein to exhaust trapped fluid in the cylinder into the port upon full entry of the sleeve into the port.

6. A cushion for a piston rod and piston assembly movable in a cylinder having a head with a central fluid port, comprising: a cushion sleeve floatingly mounted for limited slidable movement on said piston rod and of a size to enter and make a close fit with said port; means forming a passage for fluid between said sleeve and said piston rod to permit fluid to pass from the cylinder to the port; and valve means on said sleeve slidable to a position closing said passage when said sleeve enters said port, closing of said passage trapping fluid between the piston assembly and the head at the end of a stroke.

7. A cushion for a piston rod and piston assembly movable in a cylinder having a head with a central fluid port, comprising: a cushion sleeve mounted for limited slidable movement longitudinally of the piston rod and of a size to enter and make a close fit with said port; a base for said sleeve mounted on the piston rod, the outer surface of said base having a plurality of bearing surfaces on which said cushion sleeve may slide and a plurality of passages joining said port and cylinder when the sleeve has entered the port, said base and cushion sleeve having sufficient clearance to permit said sleeve to float to a centered position about the piston rod under influence of fluid flow about the sleeve; and fluid pressure responsive valve means slidable with the cushion sleeve and adapted to close said passages after said cushion sleeve enters the port to substantially confine fluid pressure between said piston assembly as said assembly approaches said head.

8. A cushion for a piston rod and piston assembly movable in a cylinder having a head with a central fluid port, comprising: a cushion sleeve on the piston rod floatingly mounted for limited slidable longitudinal movement and of a size to enter and make a close fit with said port; an annular base for said sleeve mounted on the piston rod and spaced from the piston assembly, said base having a plurality of lands and grooves, the lands providing bearing surfaces for said cushion sleeve and the grooves providing longitudinal passages permitting fluid access to the cylinder when the sleeve is in the port; and an inwardly extending flange integral with said sleeve and positioned between said base and said piston assembly, said flange being slidable with said sleeve to close said longitudinal passages when said sleeve has entered said port.

9. A cushion for a piston rod and piston assembly movable in a cylinder having a head with a central fluid port, comprising: a cushion sleeve floatingly mounted

for limited slidable movement longitudinally of the piston rod, the front end of said cushion sleeve being of a size to enter and make a close fit with said port; a base for said cushion sleeve mounted on the piston rod, the outer surface of said base having a plurality of bearing surfaces on which said cushion sleeve is floatingly and slidably mounted and a plurality of passages joining said port and cylinder when the sleeve has entered the port; and said sleeve including a fluid pressure responsive valve portion slidable with the cushion sleeve and adapted to close said passages after said cushion sleeve enters the port to substantially confine fluid pressure between said piston assembly and said head to slow movement of said piston assembly as said assembly approaches said head, the head of the cylinder having a relief passage in the port with said cushion sleeve being adapted to enter the portion to a position opening to port through said passage just before said piston assembly completes its stroke to permit exhaust of the remaining confined fluid pressure so that said piston assembly may slowly glide to the end of its stroke.

10. A cushion for a piston rod and piston assembly adapted for reciprocal movement in a cylinder having at its opposite ends a head and a cap member, each having a central fluid port, comprising: a pair of similar cushion sleeves, each mounted for limited slidable movement on the piston rod on opposite sides of the piston assembly and each adapted to enter and make a close fit with the fluid port on its respective side of the piston assembly; each cushion having means forming a passage for fluid between each sleeve and the piston rod; and each sleeve having a valve portion slidable therewith to close the passage between the piston rod and its respective sleeve when the sleeve enters its respective port trapping fluid in an end of the cylinder to slow movement of the piston assembly as it approaches said end of the cylinder.

11. A check valve for a piston rod and piston assembly movable in a cylinder having a head with a central fluid port, comprising: a base member secured to the piston rod and having a plurality of bearing surfaces and longitudinally extending passages for fluid under pressure; and a cup-shaped cushion sleeve slidably mounted for limited movement on said bearing surfaces, the front end of said cushion sleeve being of a size to make a close fit with said port so that substantially all exhaust fluid from cylinder to port must pass through said passages, and the rear end of said cushion sleeve having an inwardly extending flange slidable under exhaust fluid pressure to a position adjacent said base member to close said passages, said flange also being slidable rearwardly under fluid pressure from the port to permit rapid flow of fluid under pressure to the cylinder and piston assembly upon a return stroke.

12. In a piston and cylinder device, having a port for flow of fluid therethrough, a check valve for the port, comprising: a base member having an outer periphery notched to provide alternate longitudinal fluid passage grooves and bearing areas; a sleeve member slidably and floatingly mounted upon said bearing areas and closing one side of said notches to form said fluid passages; a flange on the sleeve member extending inwardly a sufficient distance to close said passages when the flange and base member are in contact, said sleeve member having a close fit within the port so that passage of fluid may be checked by movement of said sleeve.

13. In a piston and cylinder device having a port for flow of fluid therethrough, a check valve for the port, comprising: a base member having a peripheral portion notched to provide alternate longitudinal fluid passage grooves and bearing areas; a sleeve member slidably mounted upon said bearing areas and closing one side of said notches to form said fluid passages; a flange on the sleeve member extending from the sleeve a distance to be aligned with and close said passages when the flange and base member are in contact, the surface of the sleeve opposite said bearing areas having a close fit within the port so that passage of fluid may be checked by movement of said sleeve to close said notches.

14. A combination cushion and valve for a piston rod and piston assembly movable in a cylinder having a head with a central fluid port, comprising: an elongated generally circular base member secured to the piston rod and having a plurality of alternate longitudinally extending grooves and lands in its outer surface; an annular spacer member adjacent the rear face of the base member, said spacer member having an outside diameter smaller than the diameter of said base member; a circumferentially notched washer separating said spacer member from the piston assembly; and a cup-shaped cushion sleeve of uniform outside diameter floatingly mounted for slidable movement on said lands of the base member and of a size to enter and make a close fit with said port, the rear end of said cushion sleeve having an inwardly extending flange having an inside diameter greater than the diameter of said spacer to form an annular opening about said spacer, said flange making a close fit with the rear face of said base member under fluid pressure from the cylinder to close said grooves to fluid passage when said cushion sleeve enters said port, and said flange being slidable rearwardly under fluid pressure from the port to permit said fluid pressure to flow from port, through said grooves, said annular opening, and said notches in said washer into the cylinder.

15. A cushion for a piston and cylinder device operated by fluid under pressure and having a central end port, comprising: a piston rod movable within the cylinder; a cushion sleeve floatingly and slidably mounted for limited longitudinal movement on the piston rod and adapted to enter and substantially close said port near the end of a piston stroke; and means forming a passage for fluid between the sleeve and piston rod, said fluid flowing through said means as said sleeve approaches the end port to center said sleeve in floating condition for entry into the end port.

16. A cushion for a piston and cylinder device operated by fluid under pressure and having a central end port, comprising: a piston rod movable within the cylinder; a cushion sleeve floatingly and slidably mounted for limited longitudinal movement on the piston rod and adapted to enter and substantially close said port near the end of a piston stroke; a base on the rod having outer surfaces supporting said sleeve for said limited movement, said base and sleeve being provided with clearance to permit floating of the sleeve to a centered position about the rod.

17. A cushion as specified in claim 16 wherein the clearance between the sleeve and its support permits the sleeve to float clear of the support when centered and the sleeve has a wall subjected to pressure trapped in the cylinder to slightly shrink the sleeve increasing a space between the sleeve and port as the sleeve enters the port.

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