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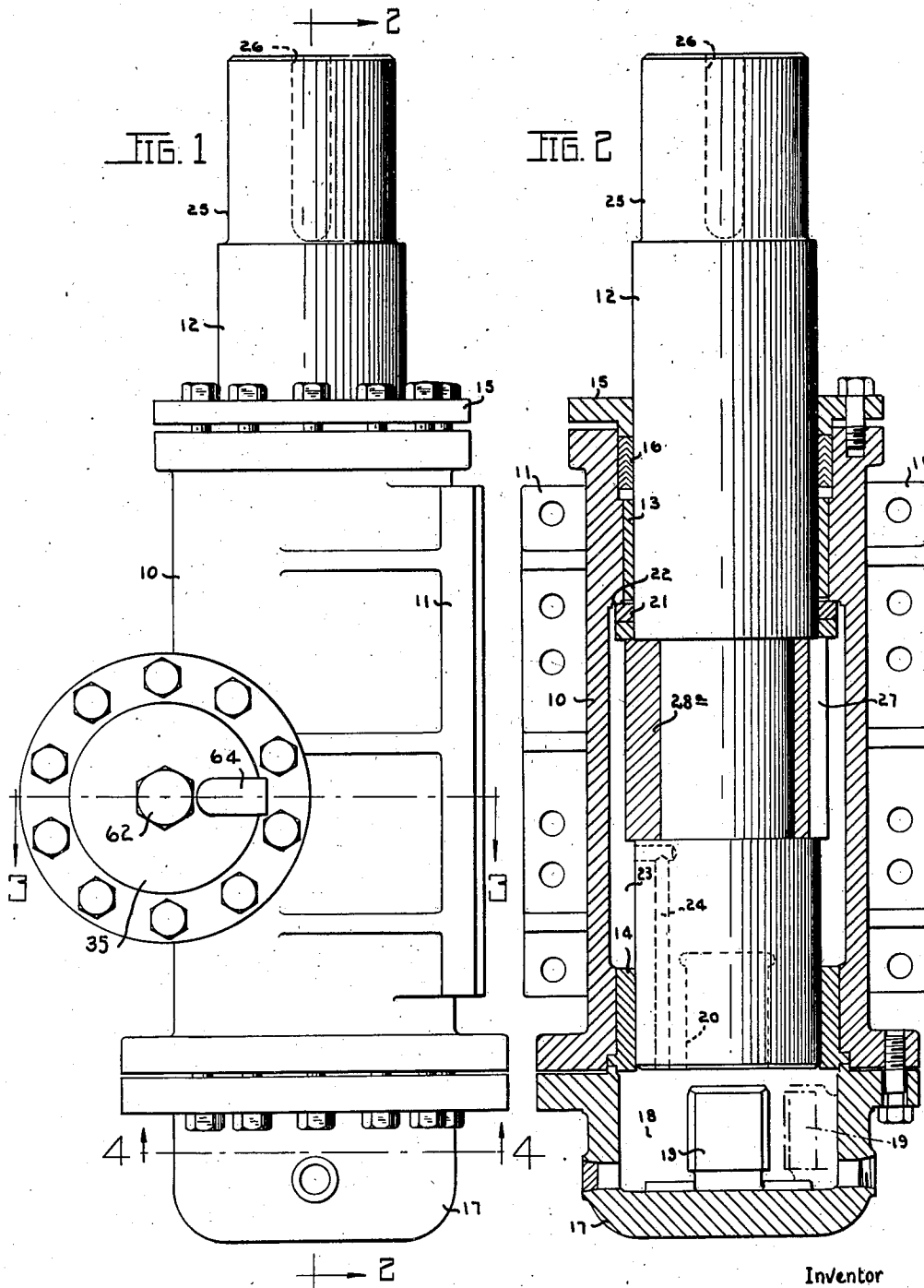
T. L. FARNHAM

2,292,336

CUSHIONING VALVE

Filed Dec. 15, 1939

4 Sheets-Sheet 1



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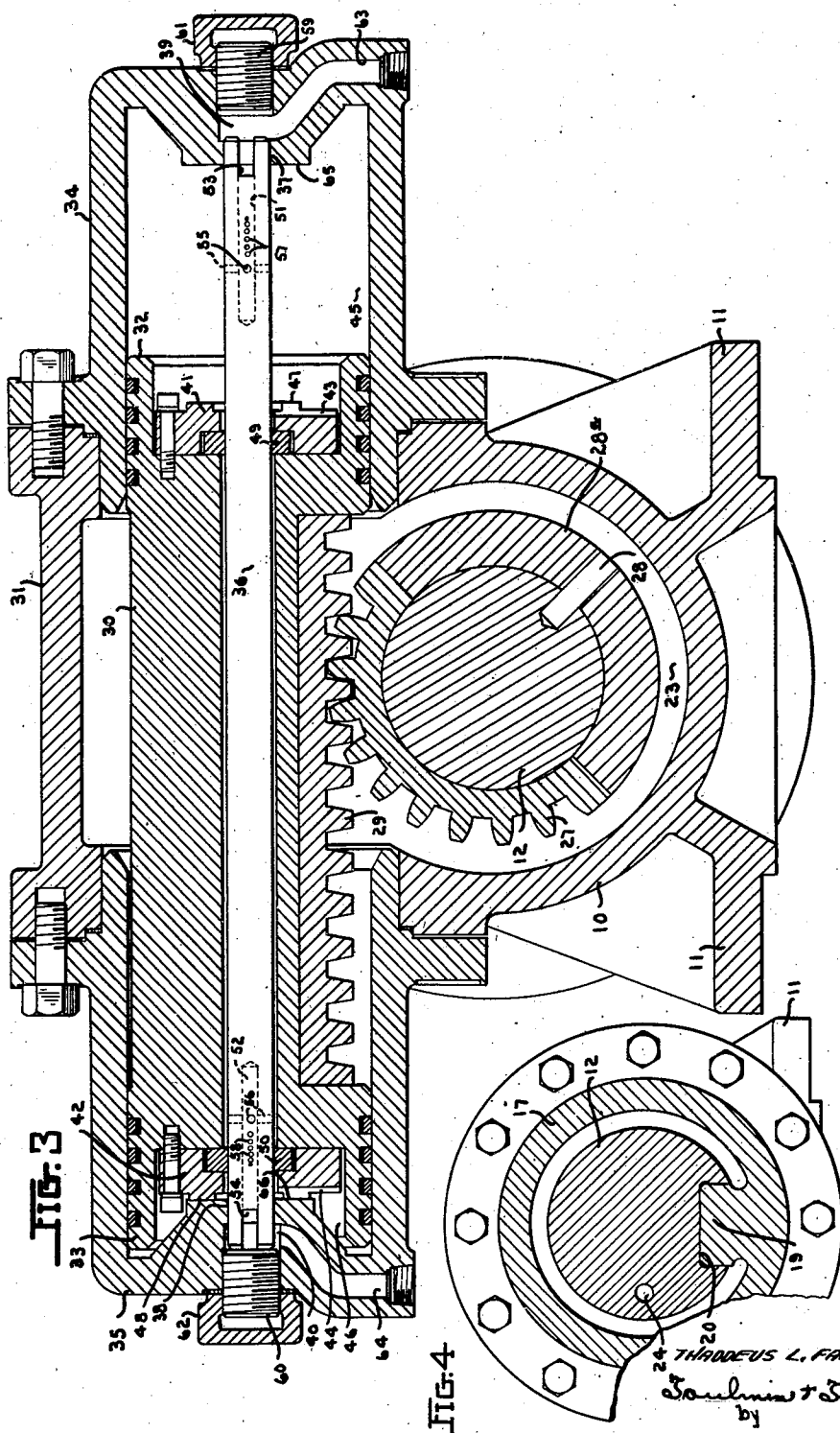
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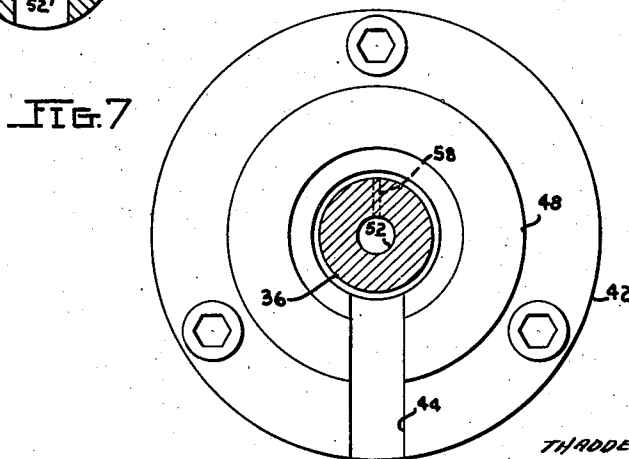
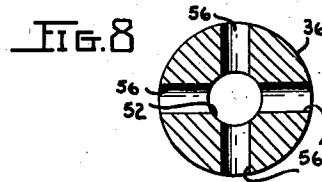
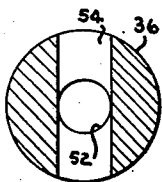
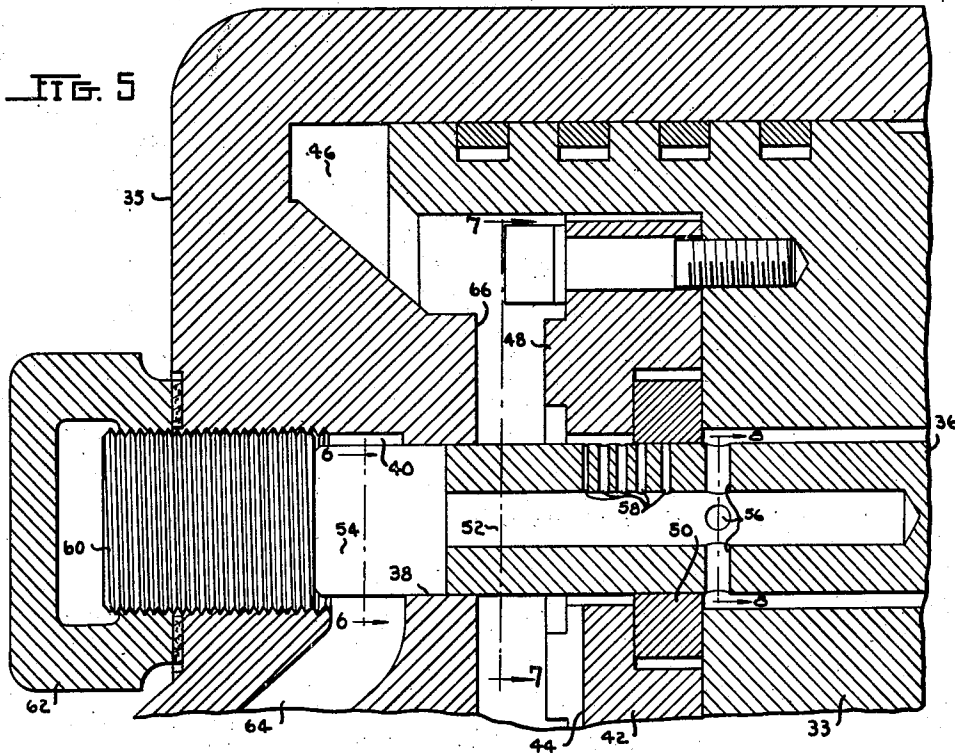
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CUSHIONING VALVE

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4 Sheets-Sheet 3



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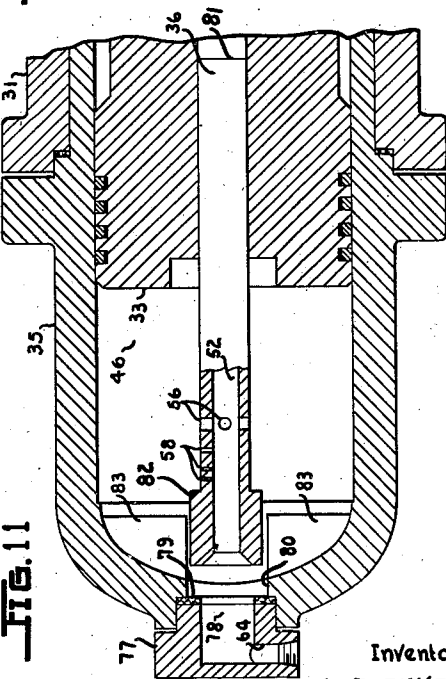
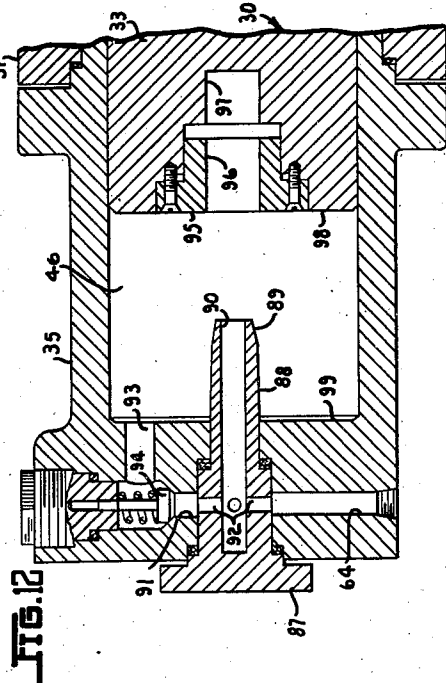
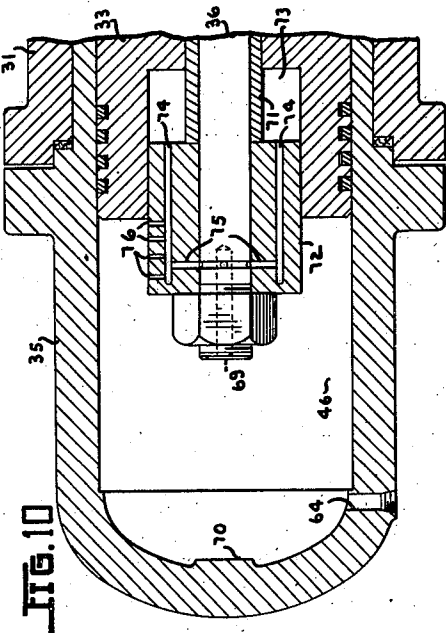
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T. L. FARNHAM
CUSHIONING VALVE

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4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,292,336

CUSHIONING VALVE

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Application December 15, 1939, Serial No. 309,453

16 Claims. (Cl. 121-44)

This invention relates to a cushioning device for bringing a hydraulic ram to rest with an absolute minimum of shock. Such a device is advantageously employed when the hydraulic ram controls mechanism of considerable mass or weight moving at high speeds and where the moving mechanism comprises a considerable proportion of more or less fragile parts carried by supports which are not very rigid. An example is a hydraulic motor which is employed in connection with an electric melting furnace where the heavy carbon electrodes are mounted in the furnace cover. For charging such a furnace, it is necessary to lift the cover clear of the furnace top and to rotate it at high speed to one side so that a fresh charge can be placed in the furnace from above. As the electrodes are long and heavy and are easily broken if caused to vibrate, it is necessary that the furnace cover after being lifted clear of the furnace and rotated out of the way at high speed be brought to rest without perceptible shock at any point since vibration of the cover will cause breakage of the electrodes which are very expensive and troublesome to replace and since other parts of the equipment might also be damaged. After the loading of the furnace, the cover must be rapidly swung into exact position over the furnace, being stopped in this position without perceptible jar, and lowered onto the furnace. It will be seen that the operation calls for the use of considerable power, that the cover is moved at high speed, and that stopping of the motion of the cover must be performed without shock or vibration.

The present invention provides for the cushioning of the hydraulic ram which rotates the cover at either end of the movement thereof. While the invention is described herein with reference to a hydraulic motor whereby a mass is rotated, it will be understood that it is applicable to any hydraulic ram for cushioning of the stopping thereof in either direction, regardless of the function which is performed by the ram. Likewise, while the invention is described with reference to a double-acting hydraulic ram, it will be obvious that it may be applied to only one end of the ram where cushioning in only one direction is desired, or that it may be applied to a single-acting hydraulic ram wherein, for example, the return stroke is accomplished by the influence of gravity.

It is an object of the present invention to provide a cushioning or decelerating device for a hydraulic ram which is adapted to bring the

hydraulic ram to rest at the desired limit of motion thereof without appreciable shock.

It is another object to provide a positive stop for the ram at the proper point; in a preferred embodiment, the invention provides for adjustment of the point of stopping the ram so as to substantially coincide with the point where the positive stop is engaged after assembly of the ram with the mechanism which it moves.

Another object is to provide mechanism in which the moving mass is brought to rest by the throttling of the outlet of the hydraulic medium from the discharge side of the ram; in a preferred form the device permits for the free discharge of hydraulic medium and full speed of the ram until the point of retardation is reached, and at the point of retardation the device so restricts the opening for the hydraulic medium as to gradually build up the retarding pressure to the desired point and thereafter by progressive further restriction maintains a constant retarding pressure or effort in spite of the decreased speed of ram movement; the ram is finally brought to rest exactly at the positive stop point, provision being made for the quick and easy adjustment of the point at which the ram is finally brought to rest as conditions change from time to time.

Another object is to provide a device of the foregoing type wherein the hydraulic fluid freely enters on the forward stroke of the ram and at the same time on the exhaust stroke, the outflow is entirely under the control of the throttling device with a minimum amount of leakage at any point; it is preferred to employ a combination valve and throttling rod which is a piston valve positively operated by hydraulic pressure and is capable of shearing off any bits of packing or the like which might lodge in its ports and which would prevent closure of a check valve or a positively seated poppet valve.

Another object is to provide a mechanism of the foregoing type wherein the valve and cushion rod may move freely without binding in spite of slight misalignment thereof and still maintain a close valving fit both in the moving piston and in the cylinder head; in a preferred form this is accomplished by the employment of a floating packing such as a floating ring around the valve rod at a suitable point on the length thereof.

Still other objects will more fully hereinafter appear as the description of the embodiment of the invention portrayed in the drawings proceeds.

In the accompanying drawings;

Fig. 1 is a side elevation of the lifting cylinder

and an end view of the rotating cylinder which is equipped with a cushioning device embodying the present invention.

Fig. 2 is a vertical sectional view taken on the line 2-2 of Fig. 1 looking in the direction of the arrows.

Fig. 3 is a horizontal sectional view on the line 3-3 of Fig. 1 looking in the direction of the arrows.

Fig. 4 is a horizontal sectional view on the line 4-4 of Fig. 1 but with the lifting ram lowered.

Fig. 5 is an enlarged sectional view of the left hand portion of Fig. 3 but with the motive piston approaching the end of its movement towards the left hand and with the cushioning rod rotated at right angles to its position in Fig. 3 so as to show the cushioning orifices more clearly.

Fig. 6 is a detailed sectional view on the line 6-6 of Fig. 5.

Fig. 7 is a transverse sectional view on the line 7-7 of Fig. 5.

Fig. 8 is a transverse section on the line 8-8 of Fig. 5.

Figs. 9 to 12 are sectional views of modified forms of cushioning devices.

Referring to the drawings in detail, the casing of the vertical lifting cylinder is designated as 10. Casing 10 has formed thereon integral flanges 11 for attachment of the device to any suitable support such as the wall of the electric furnace with which the device is employed. The casing 10 is generally cylindrical and contains the lifting ram 12 which is guided in bushings 13 and 14. Gland 15 compresses packing 16 to prevent leakage along the ram 12. The lower end of the casing 10 is closed by cylinder head 17 which forms pressure cavity 18. Cast integral with the internal surface of cylinder head 17 is key 19 which is received within a keyway 20 formed in the lower end of ram 12. This key 19 serves to position the ram 12 and to thereby prevent rotation of ram 12 during the operation of moving the ram up or down, thereby insuring alignment of the furnace cover carried by the ram 12 with the furnace as it is raised or lowered at the beginning of its removal or at the end of its replacement. Key 19 and keyway 20 are located at any desired angular position relative to ram 12. For example, they may be so located that key 19 is in the dotted line position shown in Fig. 2. The upward movement of the ram 12 is limited by the engagement of ring 21 carried by the ram 12 in any suitable manner with the shoulder 22 of the casing 10. An annular space 23 is formed between the ram 12 and the casing 10 and oil under pressure is admitted to this space 23 by means of passageway 24 which insures lubrication of the ram and of the enmeshing gear teeth for rotating the ram which will be hereinafter described. In order to elevate the ram 12, oil under pressure is admitted into pressure chamber 18, a portion of this oil being admitted to space 23 when the mechanism is first placed in operation by means of passageway 24. In order to lower the ram and with it the mechanism carried thereby, the oil is allowed to discharge from space 18, whereupon the ram 12 descends under the influence of gravity. The furnace cover or other device to be lifted and rotated by the rams is carried on the reduced upper portion 25 of the ram 12, a recess 26 of suitable type being provided within this portion 25 to aid in the attachment of the furnace cover or the like to the ram 12.

A gear sector 27 having vertically extending

teeth is attached to ram 12 within the annular space 23 by any suitable means, as by fastening it suitably to the half collar 28a, the dowel pin 28 serving to prevent the ring 28a from turning on the ram 12. This sector 27 engages rack 29 which is attached to rotating ram 30 which is disposed within the casing 31 mounted intermediate casing 10 on one side thereof. Ram 30 operates to rotate ram 12 after ram 12 has been elevated. It will be understood that the teeth on sector 27 and on rack 29 are preferably so elongated as to remain enmeshed even when the ram 12 is in its lowermost position. The cushioning device of the present invention is applied to the rotating ram 30 and is adapted to cushion the stopping of ram 30 at the ends of its travel.

Rotating ram 30 has piston heads 32 and 33 operating in cylinders 34 and 35 respectively, which are attached to casing 31 in any suitable manner.

Ram 30 has an axial bore within which is reciprocally disposed the cushioning valve rod 36 which extends through the ram 30 and beyond the ends of piston heads 32 and 33. The ends of rod 36 extend slidably through extremely close fitting guides 37 and 38 formed in the ends of cylinders 34 and 35, respectively, extending into the cavities 39 and 40 formed in the heads of cylinders 34 and 35, respectively. Fixedly carried on the outward ends of piston heads 32 and 33 are plates 41 and 42 respectively disposed, these plates surrounding the rod 36 with considerable clearance, which is comparable to the clearance existing between ram 30 and rod 36. These plates 41 and 42 are each formed with a radially extending groove 43 and 44 respectively which serves to admit the pressure fluid into the pressure cavities 45 and 46 formed in cylinders 34 and 35 respectively, in a manner which will presently appear. The plates 41 and 42 are formed with an annular abutting portion 47 and 48 respectively, which is adapted to about the inner faces 49 and 50 of the ends of cylinders 34 and 35, respectively. Plates 41 and 42 are each further provided with an annular recess within which is received floating rings 49 and 50, respectively.

Floating rings 49 and 50 are held in place by plates 41 and 42 and are allowed to move radially to prevent binding of valve rod 36 due to any misalignment thereof with rings 49 and 50 and with guides 37 and 38. Rings 49 and 50 slidably engage the surface of rod 36 with an extremely close clearance, whereby the escape of pressure liquid along the rings toward the middle of rod 36 is prevented. This construction is exceedingly reliable and compact and allows the valve rod 36 to shift readily without having the seal destroyed. It will be understood that rings 49 and 50 likewise engage the surfaces of plates 41 and 42 and of piston heads 32 and 33 slidably but with extremely close clearance.

Valve rod 36 has axial holes 51 and 52 drilled from its right hand and left hand ends, respectively, as viewed in Fig. 3, and the ends of the valve rod 36 are machined with slots 53 and 54 respectively connecting with holes 51 and 52. On the right hand end of the rod 36 towards the inward end of hole 51 are four radial connecting holes 55, these connecting holes 55 being relatively large in diameter and being adapted to freely connect bore 51 with the chamber 45 in cylinder 34. The left hand end of rod 36 is similarly provided with identical holes 56. Located outwardly from these holes 55 and 56 are

a series of longitudinally spaced connecting holes 57 and 58 respectively, these holes 57 and 58 being progressively more closely spaced and of progressively smaller diameter as one proceeds outwardly from holes 55 and 56. These holes 57 and 58 are disposed in a single row on only one side of the rod 36 instead of extending in four directions as do holes 55 and 56, and these holes 57 and 58 likewise communicate with bores 51 and 52.

The ends of rod 36 are adapted to abut against threaded plugs 59 and 60 which are threadably mounted in the ends of cylinders 34 and 35 respectively. These plugs 59 and 60 are covered by removable end caps 61 and 62 respectively, which serve to prevent unauthorized changes in the position of the threaded plugs and also serve to prevent oil leakage around the threads of the plugs.

Communicating with chambers 39 and 40 are conduits 63 and 64 respectively which are adapted to act either as inlet or discharge conduits, depending upon in which direction ram 30 is being moved. Plugs 59 and 60 are so adjusted that when rod 36 abuts against one of them, the slot 53 or 54 in the other end of rod 36 is adapted to freely interconnect passageway 63 or 64 and chamber 39 or 40 with pressure cavity 45 or 46, this being accomplished by having slots 53 and 54 of a length such that the slots extend into the interior of chamber 45 or 46. This is indicated at the right hand end of Fig. 3, wherein slot 53 has a considerable portion disposed within chamber 45 and hence is adapted to allow free entry of the pressure fluid from conduit 63 into the chamber 45 where it may act upon the piston head 32 of ram 30 to move the same away from the fluid inlet. When rod 36 abuts either of the plugs 59 or 60, its slot 53 or 54 is in non-communicating relationship with the pressure cavity 45 or 46, as is indicated in the left hand portion of Figure 3, whereby when the pressure fluid is first admitted its first action is to move the rod 36 axially into engagement with the other plug 59 or 60, this action also serving to place the slot 53 or 54 in communication with the chamber 45 or 46, thereby allowing the pressure fluid thence to act upon the piston head 32 or 33.

The stroke of rotating ram 30 is sufficient to produce the desired rotation of vertical lifting ram 12. After this desired rotation has been accomplished, the finished surface 47 or 48 of the plate 41 or 42 on ram 30 will be in contact with the finished surface 65 or 66 respectively on the inward surface of cylinder 34 or 35. The reverse rotation to the same extent of lifting ram 12 in the opposite direction will bring the corresponding surfaces 47 or 48 into contact with surfaces 65 or 66. Thus, Figs. 2 and 3 have been drawn with the ram 12 lifted and rotation about to commence, the surface 48 of plate 42 on the left hand end of ram 30 being in contact with the surface 66 on the inward face of the end of left hand cylinder 35. Upon completion of the rotation of ram 12 by right hand movement of ram 30, the right hand surface 47 of plate 41 will be in corresponding contact with the surface 65 formed on the inward right hand end of cylinder 34. Likewise, in Fig. 3, the rod 36 is shifted leftwardly and upon the admission of fluid pressure to conduit 64, rod 36 will first be shifted rightwardly until it abuts plug 59, whereupon pressure fluid will freely flow through slot 54 into chamber 46 where it acts upon piston head 33 to move ram 30 rightwardly.

As ram 30 approaches the limit of its rightward travel, the cushioning action will take place, this cushioning action being more fully described below.

Operation

In operation, pressure fluid is admitted to the chamber 18 at the lower end of ram 12, producing an upward axial movement of ram 12 to the extreme upper position shown in Fig. 2. It will be noted that no rotation of this ram 12 can take place until the ram is in its upward position as shown in Fig. 2, as key 19 will be engaged in keyway 20 until the ram has reached its upward position.

With the ram 12 in its upward position as in Fig. 2 and with the ram 30 in the position shown in Fig. 3, pressure will be admitted through conduit 64 at the left of Fig. 3 to the cavity 40, whereupon valve rod 36 will be moved to the right until it contacts plug 59. When this movement of rod 36 has been completed, slot 54 in the left hand end of valve rod 36 will have passed partly through the close-fitting guide 38 so that oil under pressure can pass from chamber 40 through the slot 54 into the chamber 46 in cylinder 35, thus applying pressure rightwardly upon piston head 33.

Ram 30 will now move to the right, displacing pressure oil from chamber 45 in cylinder 34 through the holes 55 and 57 into the bore 51, through slot 53 into the chamber 39 and thence out through conduit 63.

As ram 30 moves well to the right, ring 49 covers up the relatively large radial holes 55 in rod 36, thereby producing a reduction in the discharge area and a throttling of the oil discharge from chamber 45. As ram 30 continues in its movement rightwardly, ring 49 covers up holes in the group 57, thereby gradually still further reducing the discharge area and still further exerting a throttling effect on the discharge of the oil. This progressive throttling effect slows up the rightward movement of ram 30 and continues until ring 49 has just covered the outwardmost hole 57, at which point the ram 30 has substantially stopped and the face 47 is in abutting relation with the face 65 of cylinder 34.

In moving ram 30 leftwardly of Fig. 3, pressure fluid will be admitted to conduit 63 whereupon the reverse action will take place, this action being identical with that just described for the rightward movement of ram 30.

The holes 55, 56, 57 and 58 are so dimensioned and so spaced that the throttling effect brings the ram to rest at precisely or substantially the moment when the surface 47 or 48 contacts the surface 65 or 66, thereby preventing any shock or jar on ram 30 and on the parts operatively connected thereto. The operation may be adjusted by removing caps 61 and 62 and screw-threadedly adjusting plugs 59 and 60. The rod 36 may be easily removed and another having different throttling characteristics substituted without dismantling the machine by removing the caps 61 or 62 and the plugs 59 or 60 and withdrawing the valve rod 36. Plugs 59 and 60 may be subsequently adjusted slightly in the manner described above to provide for changes in operating conditions.

Modifications

The construction shown in Fig. 9 is similar to that described above except that the threaded plug 60 is threadably carried in a removable cap

plate 67 and has a head 60a against which the end of rod 36 is adapted to abut. The chamber 40 is in communication with the conduit 64 through holes 56 and 58, axial bore 52 and slots 60b cut in the end of rod 36. The piston head 33 is formed with a close fit around rod 36. The end of rod 36 is received within a bore 68 in a circular member 84 integral with the end of cylinder 35. Member 84 is provided with a plurality of angularly spaced radial bores 85 which are disposed just outwardly of the end of rod 36 when rod 36 is in its retracted position and which are sealed off by rod 36 when it abuts against the head 60a of plug 60. The end of rod 36 is provided with a plurality of snap rings 86 which cause the end of rod 36 to be tightly sealed relative to flange 84 even though axial misalignment of rod 36 relative to bore 68 exists.

In the modification of Fig. 9, the operation is as follows. The parts are shown in Fig. 9 as they would be with the ram and piston head 33 beginning their movement leftwardly with the rod 36 shifted so as to seal the free hydraulic connection between chamber 46 and inlet conduit 64 by way of ports 85. Upon the application of fluid pressure to the right hand end of the ram, the rod 36 was moved leftwardly by the fluid pressure so exerted, closing off the ports 85 and compelling the exhaust from chamber 46 to take place through large ports 56 and small ports 58 and thence through axial bore 52 and slots 60b to chamber 40. When the movement of the piston head 33 leftwardly has closed the ports 56, the discharge continues through ports 58 and the cushioning effect is determined as before by the number, size and spacing of these ports 58.

In Fig. 10 the construction is generally similar to that shown in Figs. 3 and 5 but the cushioning means is modified therefrom. The end of rod 36 has an axial bore 69 and is adapted to abut against a projection 70. Fixedly carried on rod 36 are an elongated sleeve 71 and an annular piston 72 which forms with sleeve 71 and piston head 33 an annular cushioning chamber 73. Chamber 73 is in communication with pressure chamber 46 by means of the axial bores 74 which are in communication with bore 69 by means of radial bores 75. One of the bores 74 is in additional communication with the chamber 46 by the spaced radial bores 76. Thus, there is a free flow of oil to and from the cushioning chamber except when the end of rod 36 is seated against the cylinder head abutment 70. With this design, pressure applied to the other end of the double-acting ram would immediately place the cushioning piston 72 in the cushioning position as in Fig. 10, cushioning space 73 being thus filled with oil by reason of the suction created by this movement of the end of rod 36 outwardly away from piston head 33. The piston 72 and the ram would then move as a unit until the rod 36 contacted the abutment 70, closing orifice 69 and causing a cushioning action by reason of the limited discharge area of ports 76. Successively, these ports 76 would be cut off by the continued movement of the ram and of piston 33 relative to piston 72, thus exerting a throttling action and bringing the ram and piston head 33 to a stop at the desired position. This construction does not have the advantages of the construction shown in Figs. 3 and 5, since there is a possibility of not making a tight seat between the end of the rod 36 and the abutment 70, and the possibility of the rod being held off of its seat 70 by any for-

eign substance such as a piece of packing which might get into the cylinder.

In the modification shown in Fig. 11, the oil under pressure is admitted through conduit 64 which is located in a cap 77 which has an axial bore 78 and which is separated from the end of cylinder 35 by a fiber washer 79, the inner annular portion of which extends inwardly of the coaxial bore 80 in the end of cylinder 35. The rod 36 is formed in two pieces, the joint being indicated at 81, in order to facilitate assembly. The outward end of the left rod half 36 is enlarged at 82, this enlarged portion being received between radial guide vanes 83 which guide it into the bore 80 and into engagement with the fiber washer 79. The rod 36 has an end bore 52 as before and radial discharge orifices 56 and 58. When pressure is applied to the opposite end of the ram, that pressure first acts upon rod 36 to move its head 82 into seating engagement with fiber washer 79, thereby closing off the direct passage from conduit 64 and bore 78 into the pressure chamber 46. The ram piston head 33 will then be moved leftwardly, causing the oil in chamber 46 to be discharged into conduit 64 through orifices 56 and 58. As soon as the piston head 33 closes the large orifices 56, the discharge of oil from the cylinder is confined to the small orifices 58 and the cushioning effect is controlled by the number, size and spacing of these orifices 58. The use of the large diameter head 82 is for the purpose of insuring that when the end of head 82 is once seated against washer 79, there will be a differential in area between this head 82 and the rod 36 so that as the cushioning pressure increases, it will force this head against the fiber seat 79 still more forcibly.

In the modification shown in Fig. 12, the rod 36 is dispensed with and a member 87 is fixedly mounted in the end of cylinder 35 in any suitable manner, this member 87 projecting into the space 46 where it is formed with a slightly tapered portion 88 and a more tapered portion 89. This member 87 is hollow, being provided with an axial bore 90 which is in communication with the inlet conduit 64 and with a conduit 91 by means of radial bores 92. Conduit 91 is adapted to be placed into communication with a conduit 93 which leads to the pressure chamber 46, by the opening of a spring pressed check valve 94 upon the admission of fluid under pressure to conduit 64 with piston head 33 in its extreme leftward position. The piston head 33 is provided with an inserted member 95 which has an axial bore 96 in line with a similar bore 97 in the piston head 33. Thus, with the parts as in Fig. 12, if pressure is applied at the right hand end (not shown) of ram 30, the liquid in chamber 46 is forced outwardly, causing check valve 94 to close very tightly, whereby the liquid is compelled to make its exit through bore 90. As the piston head 33 moves leftwardly, its bores 96 and 97 accommodate the inwardly projecting end of member 87, gradually restricting the outlet area by reason of the tapers 88 and 89 being received within the bores 96 and 97 until the ram 30 is brought to a stop with the surface 98 of piston head 33 abutting against the inward surface 99 of the head of cylinder 35, the ram 30 having been brought to rest at substantially the instant when surface 98 strikes surface 99.

The construction of Fig. 12 is particularly adapted to be used with water as the hydraulic medium although it may be operated with oil as

the pressure liquid. The parts 87 and 95 are made of high chrome high carbon steel which has been heat hardened, when employing water as the hydraulic medium, in order to prevent corrosion and erosion. When it is desired to move the ram 30 from its leftward position rightwardly the pressure medium will be admitted through conduit 64, opening check valve 94 and passing into chamber 45 through conduit 93. As the ram 30 is moved rightwardly, some of the incoming pressure medium will be admitted through bore 90 and check valve 94 may close partially or completely under the action of its spring.

From the foregoing, it will be seen that the present invention provides an unusually effective method of bringing a hydraulic ram or the like to rest without shock or jar. The construction is not unduly complex and is adapted to operate over long periods without the necessity for maintenance. Accordingly, the present invention is highly advantageous and is desirably used whenever it is desired to bring a hydraulic ram or the like to rest without appreciable shock or vibration.

The device as illustrated permits an adjustment of the positive point of stop of the ram 30 by machining or turning down the surfaces 47 and 48 on the members 41 and 42. This provides an initial adjustment which may be taken care of by the erector when assembling the device. This turning down adjusts the relationship of the piston, the ram and the rack at the end of the stroke making them closer to the surfaces 65 and 66. The theory of operation may be stated otherwise than that implied above, as follows: referring to Fig. 3, when the ring 49 starts to close the holes 55, decelerating pressure begins to appear in chamber 45. Theoretically this pressure should rise to the maximum desired very quickly and thereafter the arrangement and size of the additional holes 51 should be such as to maintain, as nearly as possible, a uniform pressure in chamber 45 in spite of the fact that the movement of the ram 30 is continually growing slower and the flow of oil is thereafter continually less. This produces, theoretically, a constant and uniform deceleration of the ram 30 and in practice this theoretical result is closely approached.

Instead of employing a series of holes there might be employed a slot or other type of passage in the valve rod 36 which passage would be gradually closed in the same way as the series of holes shown. In fact, if a slot or a series of slots or a groove or a series of grooves is provided, the size of the passageway for the oil could be made at each point theoretically correct. An additional advantage of the use of a slot or groove or a plurality thereof is that it is much easier to accurately designate on a drawing and to accurately duplicate in successive constructions.

I wish it to be understood that I intend to include as within my invention such modifications as may be necessary to adapt the same to varying conditions and uses and as fall within the terms or the spirit of the appended claims.

Having thus fully described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A cushioning device for decelerating a moving member in one direction of movement comprising means forming a chamber adapted to receive fluid, means forming a fluid operable piston operating in said chamber, one of said means being operatively connected to said moving member so as to move together with said moving

member relative to the other of said means to expel fluid from said chamber when said moving member moves in said direction, means carried by said piston forming a bore parallel to the axis thereof, and means projecting into said chamber parallel to the axis thereof and adapted to move in said bore of said piston, said last-named means having a longitudinal outlet bore therein and being adapted to cooperate with said means carried by said piston to progressively increasingly throttle the discharge of fluid from said chamber through said outlet bore as said member moves in said direction and to thereby decelerate said moving member.

2. A cushioning device for decelerating a moving member in one direction of movement thereof comprising means forming a hydraulic chamber, means forming a hydraulic piston operating therein, a hydraulic medium in said chamber, an outlet for said chamber, one of said means being operatively connected to said moving member so as to move together with said moving member when said moving member moves in said direction of movement and to expel said medium from said chamber through said outlet, means on said piston forming a bore parallel to the axis thereof, means forming a projection extending into said chamber and adapted to reciprocate in said bore, said means forming a projection having a longitudinal bore in communication with said outlet and having a plurality of longitudinally spaced transverse bores extending from said longitudinal bore to the surface of said projection, said piston successively sealing said transverse bores as said member moves in said direction and thereby progressively increasing throttling the expulsion of said medium from said chamber and decelerating said moving member.

3. A cushioning device for decelerating the movement of a moving member in one direction comprising a chamber adapted to receive fluid, means forming an inlet and outlet for said chamber, a fluid operable piston movable therein and adapted to be operatively connected to the moving member in such manner as to expel fluid from said chamber to said outlet as said member moves in said direction, a reciprocable member extending through said piston and having a longitudinal outlet bore in communication with said outlet and a plurality of longitudinally spaced transverse bores adapted to connect said chamber to said outlet bore and to be progressively sealed off by the advance of said piston as said moving member moves in said direction, to thereby progressively increasingly throttle the discharge of fluid from said chamber and decelerate said moving member, means for freely connecting said inlet to said chamber when said reciprocable member is moved in one direction, and means for sealing said last-named means when said reciprocable member is moved in the opposite direction.

4. A cushioning device for decelerating the movement of a hydraulic ram comprising a hydraulic cylinder by receiving said ram, means on the head of said cylinder forming a bore parallel to the axis thereof, a reciprocable rod tightly but slidably mounted in said bore and extending through said chamber and into said ram, means on said ram for tightly but slidably engaging said rod, means on said cylinder head forming a stop for the end of said rod in one direction of movement thereof, an inlet and outlet conduit on said cylinder head in communication with the end of said rod, means forming a transverse recess

in the end of said rod which is adapted when said rod is moved away from said stop to place said conduit in free communication with said chamber and which is out of such communication when said rod engages said stop, a longitudinally extending bore in said rod, a plurality of longitudinally spaced transverse bores in said rod extending from said longitudinal bore to the surface thereof, said transverse bores being located in the chamber portion of said rod and being adapted to be progressively sealed as said piston moves toward the head of said cylinder.

5. In a cushioning device, a hydraulic piston, a hydraulic cylinder in which said piston is reciprocable, a hydraulic medium in said cylinder, means associated with said cylinder for receiving said medium from the interior of said cylinder, reciprocable controlling means having longitudinally extending outlet means associated with said cylinder and in communication with said receiving means for conducting said medium from the interior of said cylinder to said receiving means, and means carried by said piston and movable relative to said controlling means for progressively covering said outlet means as said cylinder and said piston move relatively towards one another and for thereby progressively increasingly throttling the discharge of said medium from said cylinder.

6. In a cushioning device, a member to be cushioned, means forming a cushioning space, a hydraulic medium in said space, outlet means leading from said space for conducting said medium therefrom, expelling means operatively connected with said member to be cushioned for expelling said medium from said space through said outlet means, and a control member adapted in response to fluid pressure acting thereupon sequentially to initiate movement of said expelling means and in cooperation therewith to reduce the effective area of said outlet means for throttling the discharge of said medium from said space through said outlet means, and positive stop means adapted to be engaged by said expelling means for limiting the movement thereof.

7. In a fluid operable motor, a double-acting fluid operable ram, a cylinder at each end thereof for receiving said ram, inlet means associated with each of said cylinders for freely conducting pressure fluid alternatively to the interior of said cylinders, outlet means associated with each of said cylinders for conducting said fluid from the interior thereof, and a control member movable independently of said ram and having means operated by said ram for progressively diminishing the effective area of said outlet means as said ram moves towards the cylinder with which said outlet means is associated, said control member automatically cutting off direct communication between said inlet means and the adjacent cylinder in response to a predetermined fluid pressure in the other cylinder.

8. In a fluid operable motor, a double-acting fluid operable ram, a cylinder at each end thereof for receiving said ram, conduit means associated with each of said cylinders and adapted to be supplied with pressure fluid, a rod slidably mounted in said ram parallel to the axis thereof, said rod extending into said conduit means, a recess in each end of said rod adapted when said rod is moved in a direction away from the adjacent conduit means to place the said conduit means in free communication with the cylinder adjacent said recess to thereby admit pressure fluid to move said ram in the direction of move-

ment of said rod, said free communication being adapted to be sealed by movement of said rod towards the said conduit means, and longitudinally extending discharge means on each end of said rod between said recess and the adjacent end of said ram and adapted to be progressively covered up by said ram as it is moved towards the adjacent recess.

9. In a fluid operable motor, a double-acting fluid operable ram, a cylinder at each end thereof for receiving said ram, conduit means associated with each of said cylinders and adapted to be supplied with pressure fluid, a rod mounted in said ram parallel to the axis thereof and movable independently of said ram, said rod extending into said conduit means, a recess in each end of said rod adapted when said rod is moved in a direction away from the adjacent conduit means to place the latter into free communication with the cylinder adjacent the said recess to thereby admit pressure fluid to move said ram in a direction away from the established free communication, longitudinally extending discharge means on each end of said rod between said recess and the adjacent end of said ram and adapted to be progressively covered up by said ram as it is moved towards the adjacent recess, and means carried by each of said cylinders for adjusting the limit of endwise travel of said rod towards said cylinder.

10. In a fluid operable motor, a double-acting fluid operable ram, a cylinder at each end thereof for receiving said ram, conduit means associated with each of said cylinders and adapted alternately to be supplied with pressure fluid, a valve member slidably mounted in said ram and adapted to extend into said conduit means, means at each end of said valve member adapted selectively to effect or break free communication between one of said cylinders and the adjacent conduit means depending on the movement of said valve member in one or the other direction, and discharge means on each end of said valve member communicating with the adjacent conduit means and adapted to be progressively covered up by said ram as it is moved towards the respective discharge means for gradually slowing down said ram.

11. In a fluid operable motor, a double-acting fluid operable ram, a cylinder at each end thereof for receiving said ram, conduit means associated with each of said cylinders and adapted alternately to be supplied with pressure fluid, a rod slidably mounted in said ram parallel to the axis thereof, said rod extending into said conduit means, a recess in each end of said rod adapted when being moved in a direction away from its adjacent conduit means to place said conduit means in free communication with the adjacent cylinder to admit pressure fluid for moving said ram in the direction of movement of said rod, axially extending discharge means provided on each end of said rod and communicating with the adjacent recess in said rod and adapted to communicate with the adjacent cylinder by transverse bores in said rod.

12. In combination, a cylinder having a port at each end thereof adapted selectively to admit fluid to one end thereof and to exhaust fluid from the other end and vice versa, a fluid operable piston reciprocably mounted in said cylinder and having opposed piston areas adjacent the ends of said cylinder, a rod reciprocably mounted in said piston and having means for selectively effecting unrestricted hydraulic communication

between one cylinder end and its adjacent port and also being provided with metering ports and a passageway for selectively effecting restricted hydraulic communication between one cylinder end and its adjacent port, said metering ports decreasing in diameter toward the adjacent end of said rod and being arranged so as to be progressively closed by said piston when the latter moves toward the other end of said rod, and means associated with said rod and responsive to the supply of pressure fluid through one of said ports to shift said rod to interrupt unrestricted hydraulic communication between the other port and the adjacent cylinder end, while establishing hydraulic communication between said first port and the adjacent piston to cause a stroke of said piston.

13. In combination, a cylinder having ports at each end thereof for alternately admitting and exhausting fluid, a reciprocably mounted rod having metering ports and passageways in either end thereof, a fluid operable reciprocable piston mounted on said rod adapted to freely reciprocate thereon and within said cylinder, said piston being so arranged as to progressively cover said metering ports at either end of said piston rod when approaching the respective end of said cylinder, and means associated with said rod and responsive to the admittance of pressure fluid through one of said ports for shifting said rod and for admitting pressure fluid to one end of said piston, thereby initiating movement of said piston and subsequently causing the latter progressively to cover up the metering ports adjacent the other piston for slowing down the piston movement.

14. In a cushioning device, a cylinder adapted to receive fluid means, outlet conduit means adapted directly to be connected with said cylinder, a fluid operable reciprocable member operable to expel fluid from said cylinder through said outlet conduit means, and a control member operable by fluid pressure independently of said reciprocable member and being provided with means adapted to interrupt direct communication between said cylinder and said conduit means

and also being provided with a passageway there-through for establishing indirect communication between said cylinder and said conduit means, said reciprocable member being adapted in response to fluid pressure acting thereupon to gradually decrease the effective discharge area of said passageway to gradually slow down the movement of said reciprocable member.

15. In a cushioning device, a cylinder having an outlet opening and being adapted to receive double-acting fluid means, a fluid operable reciprocable member movable to expel fluid from said cylinder through said outlet opening, and a fluid operable control member extending into said reciprocable member and being movable independently thereof, said control member having a passageway therein for the admission of pressure fluid to said reciprocable member for operating the same, and means associated with said reciprocable member and adapted in response to movement of said reciprocable member, gradually to decrease the effective discharge area of said passageway for gradually reducing the flow of fluid therethrough, thereby slowing down the movement of said reciprocable member.

16. In a cushioning device, a cylinder having an outlet opening and being adapted to receive fluid means, a fluid operable reciprocable member operable to expel fluid from said cylinder through said outlet opening, a fluid pressure responsive control member movable independently of said reciprocable member and extending entirely through said reciprocable member, said control member having a passageway therethrough for establishing hydraulic communication between said cylinder and said outlet opening, and means carried by said reciprocable member and operable in response to fluid pressure acting upon said reciprocable member to reduce the effective area of said passageway for slowing down the movement of said reciprocable member, said control member having two opposed piston areas for selectively moving said control member in one or the other direction in response to fluid pressure acting upon one or the other piston area.

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