

May 20, 1947.

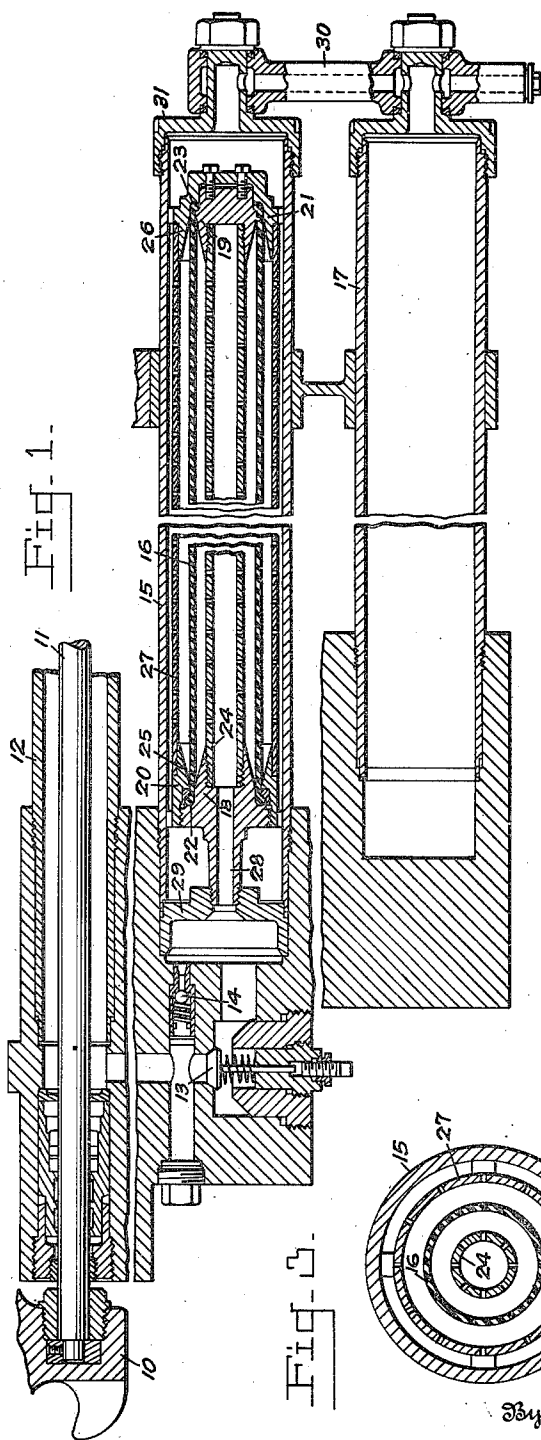
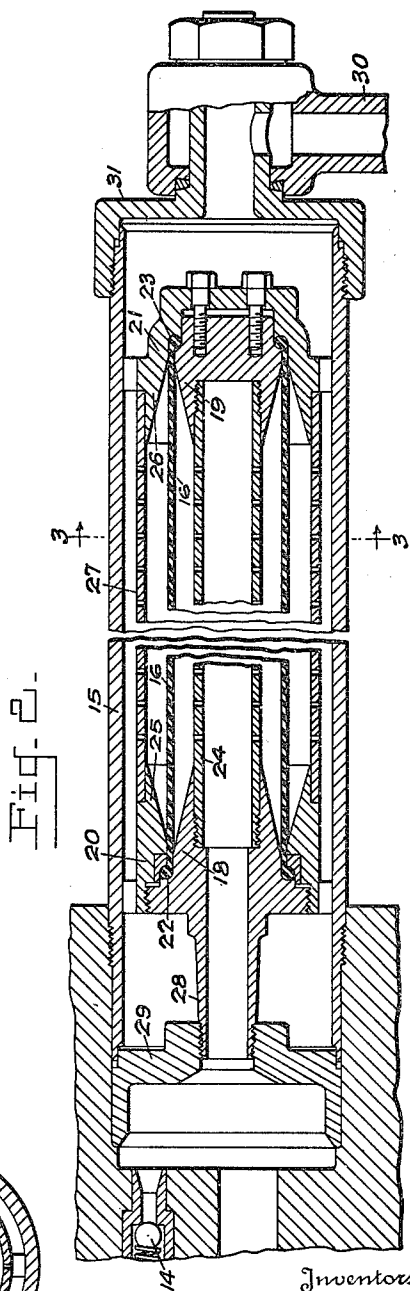
J. F. JOY ET AL

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HYDRO-PNEUMATIC RECUPERATOR FOR GUNS

Filed Sept. 12, 1941

3 Sheets-Sheet 1



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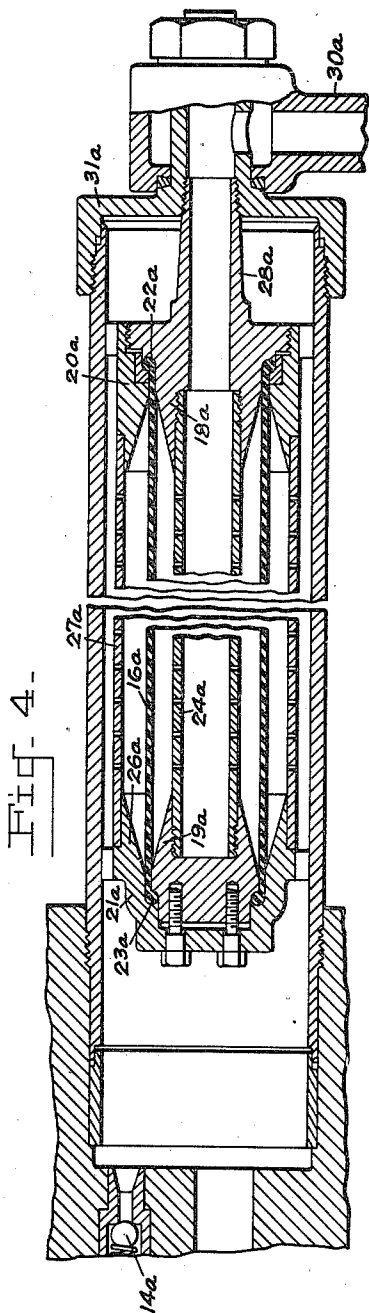
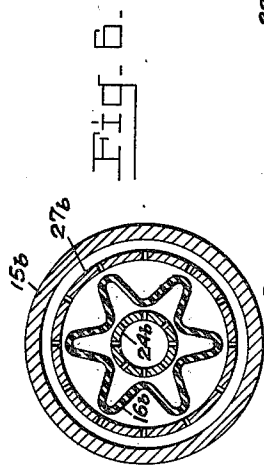
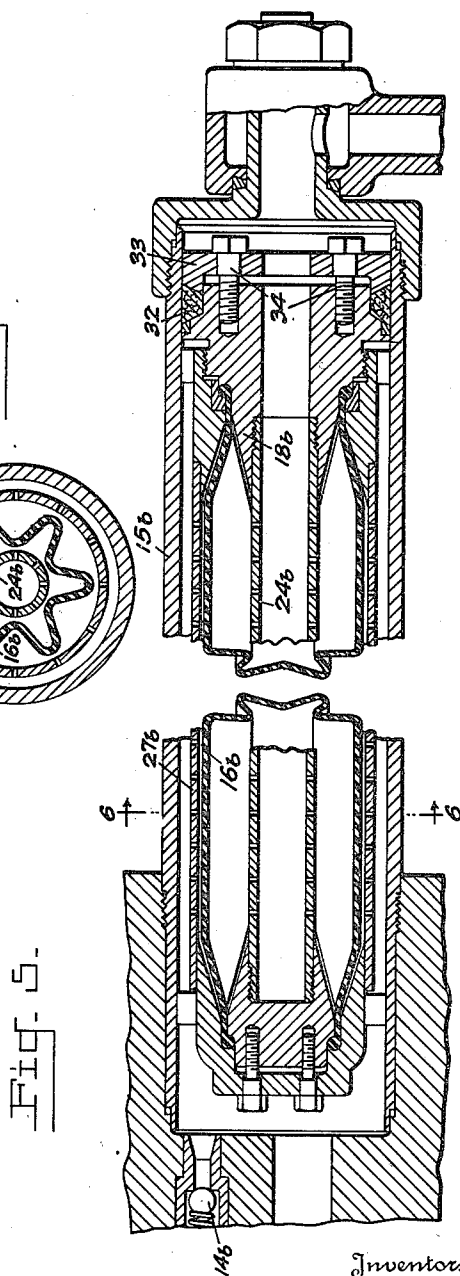
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HYDRO-PNEUMATIC RECUPERATOR FOR GUNS

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Fig-7-

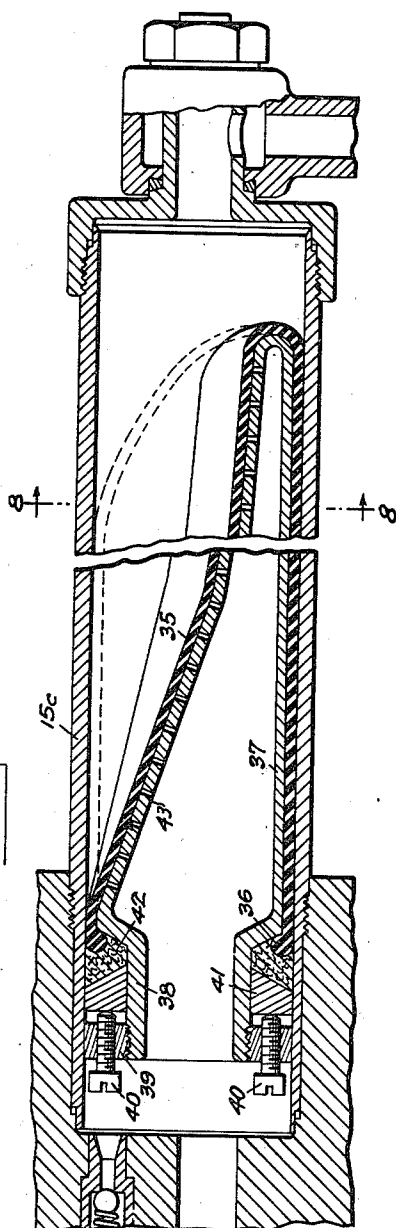
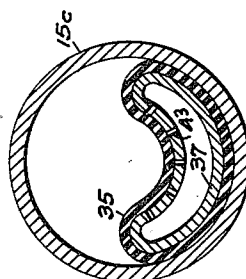


Fig-8-



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UNITED STATES PATENT OFFICE

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HYDRO-PNEUMATIC RECUPERATOR
FOR GUNSJoseph F. Joy, Claremont, N. H., and Dayton A.
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7 Claims. (Cl. 89—43)

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The invention described herein may be manufactured and used by or for the Government for governmental purposes, without the payment to us of any royalty thereon.

This invention relates to a hydro-pneumatic recuperator and more particularly to such a device as used in connection with a gun recoil system.

In known mechanisms of this character there have been provided a recoil cylinder adapted to contain oil and a recuperator cylinder adapted to contain oil and air under pressure, the air and oil in the recuperator cylinder being separated by a floating piston. In such mechanism oil is forced through a suitable throttling device from the recoil cylinder into the recuperator cylinder thereby further compressing the air behind the floating piston which acts to cushion the recoil movement and in its reaction against the piston serves to restore the mechanism to its original position. This construction is objectionable in view of the enormous amount of work and expense entailed in its manufacture. The recuperator cylinder and its cooperating floating piston must be machined and polished to the highest precision to withstand the high pressure involved without permitting mixture of the gas and oil. The high packing pressures necessitated in maintaining such a separation give rise to a high degree of static friction between the piston packing and cylinder walls. Since static friction is much greater than moving friction it follows that the gun supporting structure must absorb the heavy shock required to overcome static friction before yield can occur. Furthermore, by reason of their precision manufacture, replacement or repairs in the field are not practical and such work can only be properly done at the factory or at an arsenal especially equipped for such work.

Attempts have been made to maintain oil and gas separation and eliminate the floating piston in such mechanisms by the provision of a separate collapsible air container or bellows placed within the recuperator cylinder.

Such attempts, however, have not proven to be practical, one of the reasons for their failure being that provisions have not been made to prevent the rupture of the flexible container or sealing means therefor in the event of the leakage of a considerable quantity of oil.

In view of the foregoing it is an object of this invention to provide for a practically frictionless separation of the oil and gas in a construction of simple form which is capable of less costly manufacture and is more convenient to use.

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Another object is that of providing for quick and convenient repair and replacement in the field or at other points remote from the factory or arsenals.

It is a further object to provide means for the protection of the mechanism in the event of oil leakage to an extent sufficient to unbalance the pressures in the mechanism.

While, obviously, the unit herein described is suitable for use in any hydro-pneumatic system in which it is desired to maintain a separation between gas and fluid the description appended will refer particularly to its application in a recoil brake for guns.

The specific nature of the invention as well as other objects and advantages thereof will clearly appear from a description of a preferred embodiment as shown in the accompanying drawings in which:

Figure 1 is a longitudinal cross section of a portion of a gun recoil mechanism embodying our invention.

Figure 2 is an enlarged longitudinal cross section of a portion of the mechanism shown in Fig. 1.

Figure 3 is a vertical section taken on the line 3—3 of Fig. 2.

Figure 4 is a view similar to Figure 2 showing a modified form of our invention.

Figure 5 is a similar view of another modification.

Figure 6 is a vertical section taken on the line 6—6 of Fig. 5.

Figure 7 is a view similar to Fig. 2 showing another modification.

Figure 8 is a vertical section taken on the line 8—8 of Fig. 7.

Referring to the drawings by characters of reference, there is shown in Fig. 1 a breech lug 10 of a gun mounted for recoil in the normal manner, the breech lug being secured to the piston rod 11 of the recoil mechanism in any convenient manner. Broadly the recoil system shown comprises a conventional recoil cylinder 12 connected through suitable throttling valves 13 and 14 with a recuperator cylinder 15. Upon recoil of the gun oil is forced from the recoil cylinder in the usual manner into the recuperator cylinder. In our invention separation between the oil and air or other gas in the recuperator cylinder is maintained by a substantially frictionless diaphragm or flexible member 16 of synthetic rubber or other flexible oil resisting material. In the recoil system shown an accumulator cylinder 17 is connected to the recuperator to allow for in-

creased gas volume and added length of recoil, but it must be understood that the usefulness of the invention is not limited to use with a separate accumulator as such means can be as well provided by proper selection of the volume of the recuperator cylinder.

Referring more specifically to the recuperator cylinder there is shown in Figure 2 an enlarged view of the recuperator cylinder illustrated in the organization shown in Fig. 1. The flexible member 16 is secured at its ends upon conical thimbles 18 and 19 by means of cooperating gland members 20 and 21 provided with means adapted to engage the ferrules 22 and 23 formed on the ends of the flexible member 16. The conical ends of the thimbles 18 and 19 are internally threaded for securement to the threaded ends of an inner steel tube or supporting sleeve 24. Engaging shouldered extensions 25 and 26 on the gland members is another supporting sleeve in the form of an outer steel tube 27. Both of the supporting sleeves are perforated or drilled with a multiplicity of small holes which permit the free passage of oil or gas but are of such a small size as to effectively limit the movement of the flexible member in the event of an unbalanced pressure condition tending to abnormally expand or contract the flexible member. It will be noted that the conical form of the thimbles and of the interior of the extension on the gland members prevents any local concentration of strain which would occur if the chamber were forced to accommodate itself to abrupt variations in the cross section of the supporting structure. The thimble 18 is provided with a hollow, threaded male extension 28 for securing the flexible member in the cylinder 15 by engagement with the oil inlet head 29. Communication with the accumulator 17 is provided through suitable tubing 30 connected with the gas inlet head 31.

The procedure in placing the recoil mechanism in service after mounting consists in filling the accumulator cylinder and that part of the recuperator cylinder exterior to the flexible member with gas to a predetermined working pressure. In so doing the flexible member will be forced into contact with the outer wall of the inner supporting sleeve 24. As a second step the recoil cylinder and the interior of the flexible member are charged with oil or other fluid forming the hydraulic medium. Care should be exercised during the introduction of fluid to eliminate air bubbles or voids within the system as such may result in the aeration or emulsification of the fluid, a condition conducive to erratic and generally unsatisfactory performance at the throttling orifices. When the system has been completely filled and purged of all imprisoned air bubbles it should be closed to the atmosphere and a sufficient supply of reserve fluid added to force the flexible tube away from the outer surface of the inner supporting sleeve 24 to what might be called a working distance.

The recoil resulting from gun firing causes a displacement of fluid in the recoil cylinder as the recoil piston forces the contained oil under high pressures and velocities through the throttling orifice into the interior of the expansion chamber unit in the recuperator cylinder. In so doing the fluid pressure resulting from the recoil reacts through the apertures in the tube 24 upon the inner surface of the flexible member 16 causing the latter to expand against the external gas pressure. Since the separation afforded by the flexible member is practically frictionless there

will be no severe peak shock to the gun supporting mechanism on firing as is the case with a so-called floating piston and the increase in fluid pressure will be reflected almost simultaneously by an increase in gas pressure. Fluid flow from the recoil cylinder to the recuperator will continue until the recoil energy of the gun has been absorbed by the combined action of fluid throttling and the above mentioned increased gas pressure in the recuperator system. Upon conclusion of the recoil the energy absorbed therefrom is available for returning the gun to its normal firing position. During this counterrecoil the pressure exerted by the compressed gas acts to substantially reverse the operations described above, the reversed flow of fluid taking place through the one way valve 14 to act upon the piston in the recoil cylinder.

Figure 4 discloses a modification in the method of applying the invention to the recuperator cylinder. In this case the threaded male extension 28(a) is connected to the gas inlet head 31(a). The structures are substantially identical and the operation is the same except that in the modified form gas is used inside the expansion chamber with oil surrounding the chamber. The chamber therefore contracts on recoil and expands on counterrecoil, the reverse of the operation hereinbefore described. The reference numerals applied to Fig. 4 are the same as those used in Fig. 2 with the addition of the subscript (a).

It has been found from experiments that the more elastic materials, possessing relatively high strain limits, are as a general thing more permeable than materials possessing less elasticity. High permeability permits gas absorption by the oil through the walls of the separating material, particularly under conditions of high pressure. Under the latter conditions it may be desirable to sacrifice the quality of elasticity for a decrease in permeability. The construction shown in Figures 5 to 8 provides for the use of such material.

In the modification of the invention shown in Figures 5 and 6 an expansion chamber of material having relatively low strain limits but considerable flexibility is secured in the mechanism in a manner similar to that used with the above described constructions. In this case, however, the flexible chamber 16(b) is formed with a section intermediate its ends of enlarged diameter. The chamber is installed under sufficient longitudinal tension to cause the large diametered section to assume a fluted outline as shown in the cross section, Fig. 6. In this case as in Fig. 4, gas is used inside the bag and fluid on the outside. Obviously as the gas is initially charged into the bag-like chamber 16(b) the walls thereof will be caused to conform to the contour of the outer steel retaining tube 27(b). It is also clear that as oil is forced from the recoil cylinder into the recuperator 15(b) the chamber will be caused to collapse about the inner steel tube 24(b). By means of this construction the expansion chamber is required to stretch only that limited amount necessary for flexibility and hence may be formed of a more nearly impermeable material. Figure 5 also shows a modified means of securing the expansion chamber unit within the recuperator cylinder. The thimble 18(b) is in this case provided with a packing ring 32 and a clamping ring 33 forced into engagement with the packing ring by bolts 34 whereby the packing ring is expanded into sealing engagement with the walls of the recuperator cylinder 15(b). In view of the foregoing descriptions of the operation of the other

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embodiments the operation of this modification will be obvious.

Figure 7 shows another modification adaptable to the use of flexible materials having relatively low strain limits. In this modification the expansion chamber is formed in the shape of a tube 35 having a closed end and having a ferrule 36 surrounding its open end. A steel inner tube member 37 is formed in the shape of a closed tube and collapsed to form a crescentoid cross section, as shown in Figure 8. A diametrically reduced extension 38 is formed on the open end of the member 37 and externally threaded to engage an annular member 39 slidably engaging the recuperator cylinder 15(c). Set screws 40 threadably engaging the member 39 act upon a clamping ring 41 placing the packing ring 42 under compression and engaging the ferrule 36 to secure the assembly against longitudinal movement and to securely seal the tube member 35 to the wall of the recuperator 15c. The collapsed wall portion of the inner steel member 37 is perforated or drilled with a plurality of holes 43 of sufficient size and number to freely pass fluid while offering a positive support to the flexible member in case of a deficient amount of fluid.

To place the unit in service the gas pressure in the accumulator and recuperator is built up to a predetermined level. Obviously the flexible bag will be collapsed about the collapsed tube member and upon fluid being forced into the recuperator from the recoil cylinder will be opened up to its original shape. Since the expansion of the chamber in this case consists largely in the filling of a collapsed bag member it will be apparent that the stretching of the bag member may be held to very low limits.

Obviously an expansion chamber of the type herein described has a wide application in hydro-pneumatic devices of all kinds. It must, therefore, be understood that in describing the invention as applied to a gun recoil mechanism no limitations upon the invention are intended other than those imposed by the appended claims.

We claim:

1. In a hydro-pneumatic device, a cylinder containing a first fluid, an apertured member in said cylinder in communication with a supply of second fluid, flexible, tubular separating means on said member in fluid-tight engagement therewith, and supporting means exterior to said separating means extending substantially coextensive therewith and engaging said member whereby the expansion of said separating means by the second fluid is limited, said supporting means being provided with apertures whereby the first fluid may have access to the exterior of said separating means, said apertures being of insufficient size to allow the separating means to be displaced therethrough by pressure of the second fluid in the interior of said separating means.

2. In an artillery weapon a hydro-pneumatic recoil mechanism for absorbing the recoil forces of firing said weapon comprising means operatively connected to said weapon and adapted to produce pressure in a liquid medium associated therewith, means defining a source of gas under pressure operative to oppose the force within said pressure liquid, a recuperator cylinder containing at least a part of said pressure liquid and said pressure gas, an elongated generally cylindrical elastic diaphragm within said recuperator cylinder separating said gas from said liquid therein, and a pair of axially spaced clamping devices lying within said recuperator cylinder and oper-

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ative to secure opposite ends of said diaphragm within said cylinder, said clamping devices each including a pair of inwardly and outwardly tapering faces adjacent their connection with said diaphragm, said mechanism being constructed and arranged whereby substantially no initial mechanical friction opposing recoil movement of said weapon is produced by said mechanism upon firing said weapon.

3. In an artillery weapon a hydro-pneumatic recoil mechanism for absorbing the recoil forces of firing said weapon comprising means operatively connected to said weapon and adapted to produce pressure in a liquid medium associated therewith, means defining a source of gas under pressure operative to oppose the force within said pressure liquid, a recuperator cylinder containing at least a part of said pressure liquid and said pressure gas, an elongated generally cylindrical elastic diaphragm within said recuperator cylinder separating said gas from said liquid therein, and a pair of axially spaced clamping devices lying within said recuperator cylinder and operative to secure opposite ends of said diaphragm within said cylinder, said clamping devices each including a pair of inwardly and outwardly tapering faces adjacent their connection with said diaphragm, at least one of said clamping devices having an aperture therein and being secured in an end of said recuperator cylinder in such manner as to admit said pressure gas into the interior of said diaphragm but excluding liquid therefrom, said mechanism being constructed and arranged whereby substantially no initial mechanical friction opposing recoil movement of said weapon is produced by said mechanism upon firing said weapon.

4. In an artillery weapon a hydro-pneumatic recoil mechanism for absorbing the recoil forces of firing said weapon comprising means operatively connected to said weapon and adapted to produce pressure in a liquid medium associated therewith, means defining a source of gas under pressure operative to oppose the force within said pressure liquid, a recuperator cylinder containing at least a part of said pressure liquid and said pressure gas, an elongated generally cylindrical elastic diaphragm within said recuperator cylinder separating said gas from said liquid therein, and a pair of axially spaced clamping devices lying within said recuperator cylinder and operative to secure opposite ends of said diaphragm within said cylinder, said clamping devices each including a pair of inwardly and outwardly tapering faces adjacent their connection with said diaphragm, at least one of said clamping devices being apertured and including a gland structure operative to seal the interior of said diaphragm against the admission of liquid from said cylinder while permitting free access of said pressure gas thereto, said mechanism being constructed and arranged whereby substantially no initial mechanical friction opposing recoil movement of said weapon is produced by said mechanism upon firing said weapon.

5. In an artillery weapon a hydro-pneumatic recoil mechanism for absorbing the recoil forces of firing said weapon comprising means operatively connected to said weapon and adapted to produce pressure in a liquid medium associated therewith, means defining a source of gas under pressure operative to oppose the force within said pressure liquid, a recuperator cylinder containing at least a part of said pressure liquid and said pressure gas, an elongated generally cylin-

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drical elastic diaphragm within said recuperator cylinder separating said gas from said liquid therein, said diaphragm being formed with longitudinally running corrugations in at least part of its length, and a pair of axially spaced clamping devices lying within said recuperator cylinder and operative to secure opposite ends of said diaphragm within said cylinder, said clamping devices each including a pair of inwardly and outwardly tapering faces adjacent their connection with said diaphragm, said mechanism being constructed and arranged whereby substantially no initial mechanical friction opposing recoil movement of said weapon is produced by said mechanism upon firing said weapon.

6. In an artillery weapon a hydro-pneumatic recoil mechanism for absorbing the recoil forces of firing said weapon comprising means operatively connected to said weapon and adapted to produce pressure in a liquid medium associated therewith, means defining a source of gas under pressure operative to oppose the force within said pressure liquid, a recuperator cylinder containing at least a part of said pressure liquid and said pressure gas, an elongated generally cylindrical elastic diaphragm within said recuperator cylinder separating said gas from said liquid therein, said diaphragm being formed with longitudinally running corrugations in at least part of its length, said mechanism being constructed and arranged whereby substantially no initial mechanical friction opposing recoil movement of said weapon is produced by said mechanism upon firing said weapon.

7. In a hydro-pneumatic device, a cylinder in communication with a source of liquid pressure, a member having an opening therethrough secured in an end of said cylinder, said opening being in communication with a source of gas pressure, flexible tubular separating means having one end secured to said member in gas tight engagement therewith, closure means for the

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other end of said separating means, said tubular separating means being formed with a portion intermediate its ends of enlarged diameter, means securing said separating means between said member and said closure means under longitudinal tension sufficient to cause the section of enlarged diameter to assume a longitudinally fluted form, and apertured tubular supporting means exterior to said separating means and engaging said member and said closure means whereby the expansion of said separating means is limited, said apertures being of insufficient size to allow the separating means to be displaced therethrough by gas pressure inside said separating means.

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