Feb. 15, 1944. J. F. JOY 2,341,556

FLEXIBLE BELLOWS

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Fig. 1.

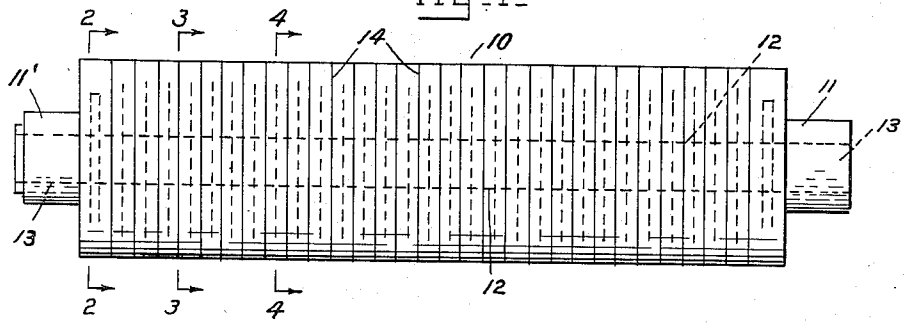


Fig. 2.

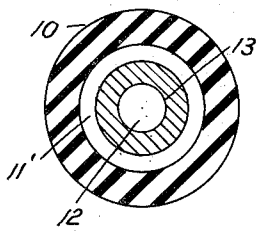


Fig. 3.

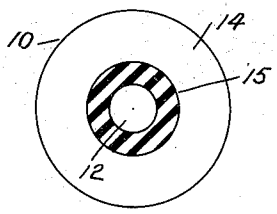


Fig. 4.

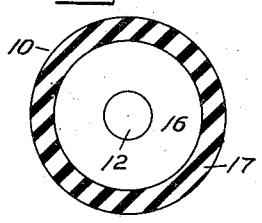


Fig. 5.

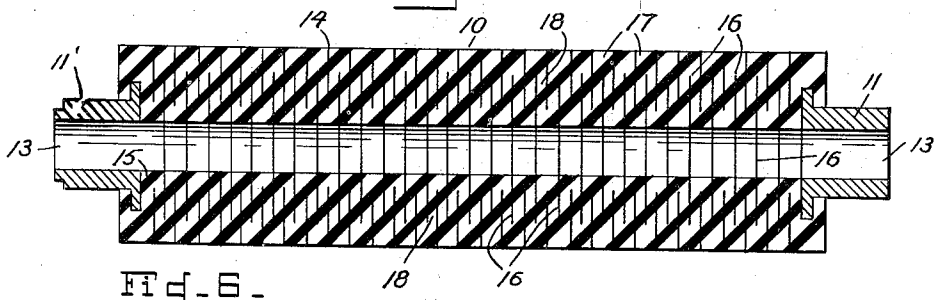
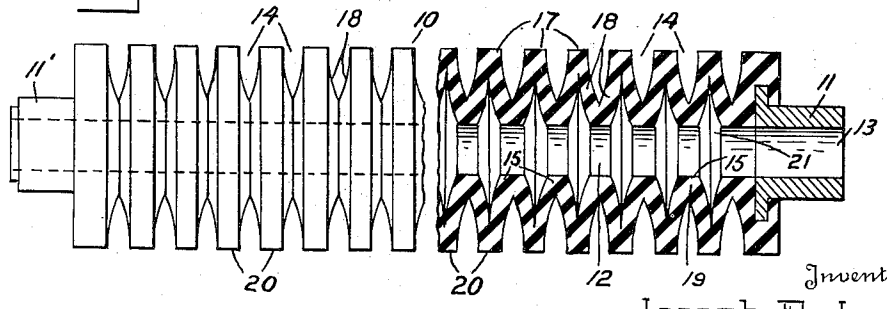


Fig. 6.



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Fig. 8.

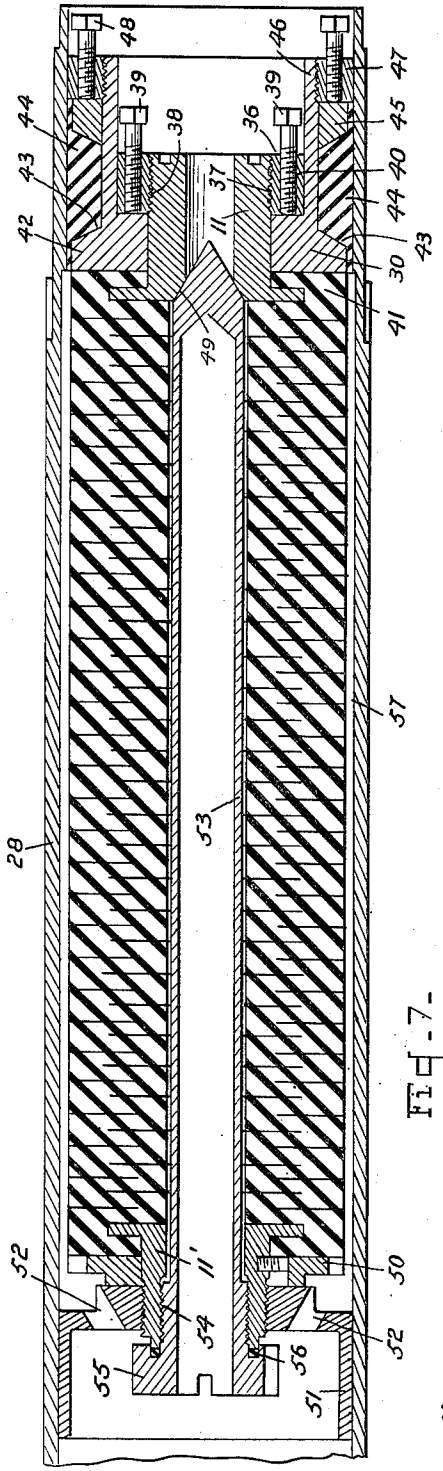


Fig. 9.

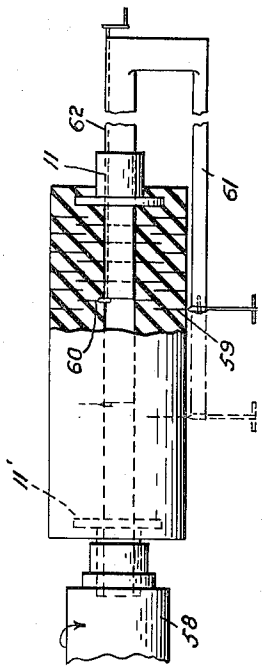
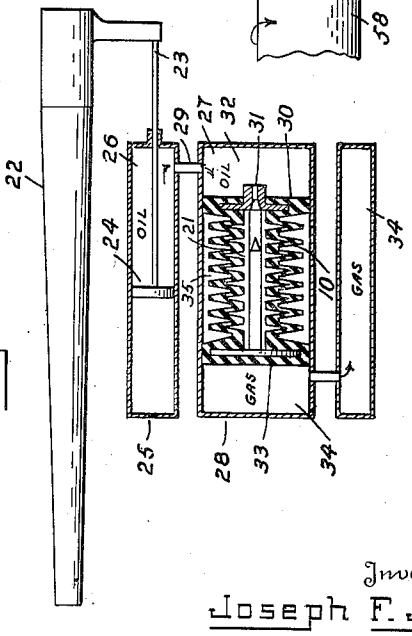


Fig. 7.



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Patented Feb. 15, 1944

2,341,556

UNITED STATES PATENT OFFICE

2,341,556

FLEXIBLE BELLOWS

Joseph F. Joy, Claremont, N. H.

Application March 18, 1942, Serial No. 435,190

6 Claims. (Cl. 138—30)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

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

This invention relates to a flexible bellows and its method of manufacture. More particularly it pertains to an extensible sleeve of elastic material which is highly adapted for use in a fluid pressure system that is arranged to sustain a weight elastically or to act as a buffer for receiving a force.

Equilibrator, recoil and recuperator systems constitute essential organizations on many guns. These customarily employ hydro-pneumatic arrangements for sustaining a portion of the weight of a heavy gun, or for yieldingly checking the momentum of the gun in recoil and as means for placing the gun back in battery in counter recoil. Elaborate devices such as floating pistons and regulators with ports and valves are often required. These demand accurate and costly machining thus adding to the initial cost and that of maintenance and repair. Piston components are individually fitted to cylinders and when failure occurs they are not replaceable in the field with available facilities.

Since high pressures are often employed or developed in the fluid system of a gun, a leak-proof seal between the hydraulic and the pneumatic portions is imperative at all times to insure satisfactory operation. Extensible diaphragms of flexible metal or elastic material have been used in the past in lieu of pistons as the barriers between the liquid and the gaseous media in devices of the character described. These have proved impracticable because of failure due to fatigue, rupture as a result of inability to withstand repeated operation under high pressures, or permeability of the septum to fluids and gases at high pressures. Flexible bags of the prior art which have been employed to separate gas and oil have been unsatisfactory because of their inability to withstand higher pressures and also because gas passed through the bag into the oil at normal device pressures so that the oil became aerated to such an extent that the device would not function properly.

It is therefore an object of this invention to provide a flexible bellows which has a long life under repeated flexing and which in addition is capable of withstanding high pressures.

An additional object of the invention is to provide a flexible extensible diaphragm of elastic material which is relatively impervious to fluids under high device pressures.

An important object of the invention is to provide a flexible extensible diaphragm of elastic material which retracts into a compact, substantially solid mass.

Another object of the invention is to provide a practical pressure element for use in the hydro-pneumatic system of a gun, said element being adapted for removal and convenient replacement in the field during military operations.

A further object of the invention is to provide a flexible bellows which is characterized by its facile longitudinal or axial extension and limited lateral expansion;

Another object of the invention is to provide an elastic bellows which is simple in construction, inexpensive to manufacture, strong, and durable.

An additional object of the invention is to provide a simple convenient method for manufacturing a rugged extensible bladder.

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:

Fig. 1 is a side elevational view of the device in a retracted or compact position,

Fig. 2 is a sectional view on the line 2—2 of Fig. 1,

Figs. 3 and 4 are sectional views on the lines 3—3 and 4—4, respectively, of Fig. 1, illustrating the two types of cuts in the bellows,

Fig. 5 is a longitudinal sectional view through the axis of the bellows,

Fig. 6 is a side elevational view with a portion in section representing the bellows extended axially and showing the configuration which the device assumes when pressure is applied to its interior,

Fig. 7 is a diagrammatic representation with parts in section of a recoil and recuperator mechanism coupled to a recoiling gun showing the bellows in an extended position. The proportions of the recuperator cylinder are exaggerated to illustrate more clearly the hydro-preumatic pressure organization with respect to the bellows,

Fig. 8 is an axial sectional view of a practical embodiment of a recuperator assembly showing the shape of the bellows unit when it is in a retracted position, and

Fig. 9 is a diagrammatic illustration of one method of making the radial cuts in a bellows block.

In accordance with a practicable embodiment of the invention, the bellows per se is formed from a cylindrical block of elastic or rubber-like ma-

terial. Thermoreactive substances such as rubber, neoprene, vinylite resins, and similar products have proved satisfactory for the purpose. The selection of the material to be employed is governed somewhat by its property of remaining unimpaired by the chemical action of the fluids with which it will be used.

Fig. 1 represents a compacted or collapsed cylindrical bellows 10 provided with a pair of hollow metal inserts 11—11' which are bonded in the opposite ends. A uniform axial bore 12 communicates with the passages 13 in these inserts. While the device shown is open at both ends, it is to be understood that it may be manufactured with one closed end. In accordance with a preferred method of manufacture, a series of spaced radially disposed circumferential cuts 14 are made around the outer periphery of the block. These cuts penetrate almost to the bore 12 but leave a substantial thickness or internal web 15 as shown in Figs. 5 and 6. Intermediate the external cuts 14 are a series of radially disposed internal, circular cuts 16. The depth of these cuts corresponds to that of the adjacent external cuts, according to a practical embodiment of the invention, thus forming an outer web 17. The pattern of the cuts delineated in Figs. 5 and 6 produces web portions 18 which have substantially the same dimensions as those of the internal and external webs 15 and 17. However, this arrangement is only representative and may be modified in numerous ways to form bellows with different extensible and permeable characteristics. In fact the cuts need not necessarily be perpendicular to the axis of the bore.

The alternate arrangement of internal and external circular cuts in conjunction with the axial bore 12 produces a cylindrical block with a series of interconnected disks or convolutions 19 and 20. When fluid pressure is applied to the interior of the block (one end of the bore being sealed), the device elongates axially as shown in Fig. 6 and the internal cuts 16 assume the shape of disk-like cavities 21 which communicate with the bore 12. Likewise the external cuts 14 open up so as to produce therebetween a series of separated disks or convolutions 20.

While the series of cuts made in the block are represented as radial cuts, it has been contemplated that a continuous helical internal cut and an offset helical external cut be employed to produce a bellows which is similar in character. The convolutions thereby generated would be true convolutions.

Fig. 7 illustrates diagrammatically the adaptation of the extensible bladder to the buffer mechanism of a gun. The gun 22 is represented as being in recoil and is coupled by a connecting rod 23 to a piston 24 in a recoil cylinder 25. The hydraulic end 26 of the recoil cylinder communicates with the corresponding portion 27 of a recuperator cylinder 28 through a conduit 29. Anchored within the cylinder 28 in a fluid-tight relationship is an unyielding ring 30 which is provided with a centrally located fluid orifice 31. One end of the bellows 10 is secured to the ring whereby oil 32 is permitted under certain conditions to pass through the orifice 31 and into the bellows.

As shown in Fig. 7, the recoil of the gun has forced oil into the bellows thereby elongating it along its axis and forcing the closed movable end 33 against the resistance of gas 34 which is under high pressure. The gas flows into the interstices 35 around the bellows as it elongates. This elongation compresses and increases the pressure of the gas. In this extended position gas has the tendency to permeate the walls of the bellows. Since wall thicknesses influence permeability, this factor may be controlled to a material degree by selecting a bladder with thicker webs. Web dimensions are governed by the depth of the radial cuts and also their spacing as may be perceived by observation of Figs. 5 and 6. These same dimensions also affect the strength and flexing properties of the bladder. By taking these elements into consideration in conjunction with the length factor as determined by fluid displacement, a satisfactory bellows may be selected for any recuperator.

Figs. 1 and 5 represent the position of the bellows arrangement in a collapsed condition and exists when the gun has returned through the counter recoil stage and has arrived in battery. Since a gun is in battery during the greater portion of its existence, it is important that the tendency of gas to permeate the walls of the bellows be then restrained to the utmost. As the gun comes into battery the gas in the interstices 35 (Fig. 7) and the oil in the cavities 21 are squeezed out. With the gun in battery, all the fluid has been effectively eliminated from these portions and the gas pressure in the recuperator effectively compresses the bellows into a solid block. The gas will now have to pass through the distance between the outside cylindrical surface of the collapsed bellows 10 and its bore 12 instead of through the comparatively thin walls when the bellows is distended. This mass of rubber-like material offers a most effective resistance to the seepage of gas and provides a substantially perfect seal.

The recuperator organization shown in Fig. 8 embodies a positive closure which functions in conjunction with the bellows when the gun is in battery. Ring 30 slides into the recuperator cylinder 28 and slidably receives the hollow metal insert 11. A collar 36 is provided with internal threads 37 which engage the externally threaded portion 38 on the insert. Spaced jack screws 39 are received in threaded bores 40 in the collar 36 and when tightened compress the end portion 41 of the rubber bellows and insure a leak-proof seal between the ring and the insert. Ring 30 has a shoulder 42 with a tapered face 43 which engages a corresponding face on a deformable anchor and seal ring 44 preferably made of a rubber-like material. An annular wedge 45 surrounds the skirt 46 on the ring 30. Collar 47 is in threaded engagement with the end of the skirt and carries a plurality of jack screws 48. When tightened these screws depress the annular wedge 45, deform the seal ring 44 and anchor this end of the bellows organization securely within the recuperator cylinder 28. A fluid-tight seal is simultaneously established. The valve insert 11 at this end is provided with a bevelled face 49 which acts as a valve seat in a manner which will be subsequently described.

A washer 50 is confined on the body of the free insert 11'. A cup-shaped slidable guide 51 screws on to the insert in back of the washer 50 and serves to keep the free end of the bellows in proper axial alignment in the recuperator cylinder. A series of ports 52 appear in the base of the guide 51 and permit gas to surround the outer periphery of the bellows. An elongated metal valve rod 53 extends through the hollow insert 11' and into the bellows. The rod is coupled to the insert by complementary threads 54 and is

provided with a head 55 and a fluid seal 56. The opposite end of rod 53 is conical and is adapted to confrom to the bevelled face 49 on the other insert so as to provide an effective fluid seal when they are in the mating position.

When oil pressure on the right side of the recuperator cylinder exceeds the gas pressure, the free end of the bladder, the guide 51 and the valve rod 53 are urged to the left thereby extending the organization. Since insert 11 is stationary, the valve is opened and oil flows into the bore 12 in the bellows and opens up the diametrically disposed cavities 21 (Fig. 6). Gas flows through the ports in the guide into the space 57 and fills the circumferential cuts or interstices 14. This in conjunction with the outer convolution arrangement of the bellows prevents any appreciable diametrical enlargement of the bellows. The web structure of the outer convolutions has sufficient rigidity due to its particular configuration to resist circumferential expansion. This feature virtually eliminates the possibility of wear on the outer bellows structure which might result from frictional engagement with the interior of the recuperator cylinder.

When equilibrium is established the bellows cease to elongate and on counter recoil the structure assumes the position represented in Fig. 8. The most satisfactory condition exists when the gas pressure is regulated so as to slightly compress the compact bladder 10 axially whereby the valve rod 53 is forcibly urged into its seat 49 thereby insuring a leak-proof closure. As may be understood from an examinaiton of Fig. 8, this prevents any infiltration of gas through the bellows into the oil compartment. Since the recuperator system of a gun is nominally at rest during the greater portion of its life, this feature is important and enables the recuperator mechanism to function perfectly whenever it is called upon to absorb a shock load.

The method of making the bellows is as follows. A block of uncured rubber-like material is placed in a cylindrical mold provided with a coaxial core or mandrel. Heat and pressure are applied to the thermoreactive material and a hollow block is formed. Where inserts are to be employed they are properly positioned in the mold when the rubber-like product is in the uncured state so that the stock will flow about the inserts and be bonded thereto in a manner well understood in the molding art. The mandrel is removed from the block and then a series of staggered, radially disposed circumferential slits are made on the two cylindrical surfaces of the block. This is most satisfactorily accomplished by rotating the block at a fair rate of speed about its axis in conjunction with relatively stationary cutters. The device and a specific method for cutting a bellows block is fully set forth in my copending application, now Patent Number 2 304,328. Fig. 9 illustrates diagrammatically the manner in which this is accomplished. A chuck 58 engages the insert 11' in one end of the block and rotates the block about its axis. Cutters 59 and 60 having retracting blades are mounted on suitable supports 61 and 62 and are positioned to make staggered external and internal cuts 14 and 16 in the block. The cutters are retracted and their supports 61 and 62 advanced one step into the block whereupon the cutters are exposed and a second pair of cuts is made. This procedure is continued until a series of evenly spaced cuts are made and the bellows is completed.

I claim:

1. In combination with an extensible member having a chamber therein, coupling means at one end of the member having a passage communicating with the chamber, a bevelled seat in said means around the passage, an insert at the other end of the member having a bore communicating with the chamber, guide means having ports therein coupled to said insert, and a valve rod in the bore of said insert and extending into the chamber, said rod having a free end conditioned to engage said seat to form a closure for said passage upon contraction of the extensible member and to clear the seat and open the passage upon extension of the member.

2. In an organization of the class described, a cylinder closed with the exception of fluid admission and emission openings adjacent its ends, a stationary mounting adjacent one end of the cylinder in fluid sealed relation thereto, and including a member having a fluid passage therethrough and a valve seat thereon, a bellows in said cylinder and secured at one end to the stationary mounting, a slidable mounting adjacent the other end of the cylinder and secured to the other end of the bellows, a valve element secured in the slidable mounting and extending through the bellows and cooperating with the valve seat to normally close the fluid passage, and arranged to be operated to open the passage to permit the extension of the bellows when the pressure in the valve end of the cylinder exceeds that in the opposite end.

3. In an organization of the class described, a cylinder closed with the exception of fluid admission and emission openings adjacent its ends, a stationary mounting adjacent one end of the cylinder in fluid sealed relation thereto and including a member having a fluid passage therethrough and a valve seat thereon, a bellows in said cylinder and spaced therefrom and secured at one end to the stationary mounting, a slidable mounting adjacent the other end of the cylinder and secured to the other end of the bellows, said slidable member being provided with openings communicating with the space between the bellows and cylinder, a valve element secured in the slidable mounting and extending through the bellows and cooperating with the valve seat to normally close the fluid passage and arranged to be unseated to open said passage to permit the extension of the bellows when the pressure in the valve end of the cylinder exceeds that in the opposite end.

4. In an organization of the class described, a cylinder closed with exception of fluid admission and emission openings, a bellows in said cylinder and spaced therefrom, a stationary ring in said cylinder in sealed relation thereto and secured to one end of the bellows, a guide member slidable in the cylinder and secured to the other end of the bellows, a member carried by the stationary ring and having a fluid passage therethrough and a valve seat thereon, said passage communicating with the interior of the bellows, openings in the slidable guide member to facilitate flow of fluid to the space between the bellows and cylinder as the bellows is extended, a valve rod mounted on the guide member and extending through the bellows and cooperating with the valve seat to open said fluid passage to permit fluid to enter the bellows to extend the same when the pressure at the valve end of the cylinder exceeds that at the opposite end.

5. In an organization of the class described,

a cylinder closed with the exception of fluid admission and emission openings therein, a bellows of rubber-like material in said cylinder, a stationary ring in one end of the cylinder in fluid sealed relation thereto, a member secured to said ring and having a fluid passage therethrough and a valve seat, said member being further provided with a flange embedded in the material of the bellows whereby said bellows is connected to the ring, a guide member slidable in the other end of the cylinder and mounting a valve rod extending through the bellows and cooperating with the valve seat to normally close said passage and arranged to be unseated to open said passage to permit the extension of the bellows when the pressure in the valve end of the cylinder exceeds that in the opposite end.

6. In an organization of the class described, a cylinder, a stationary mounting at one end of the cylinder and a slidable mounting at the other, the mountings dividing the cylinder into separate compartments, a bellows of rubber-like material between the mountings, means carried by each mounting and embedded in the material of the bellows whereby the bellows is secured to the mountings, means carried by one mounting to admit fluid to the interior of the bellows, and means carried by the other mounting cooperating with the first mentioned means to control admission of fluid to the bellows and its exclusion therefrom accordingly as the pressure at one end of the cylinder exceeds that at the other.

JOSEPH F. JOY.