

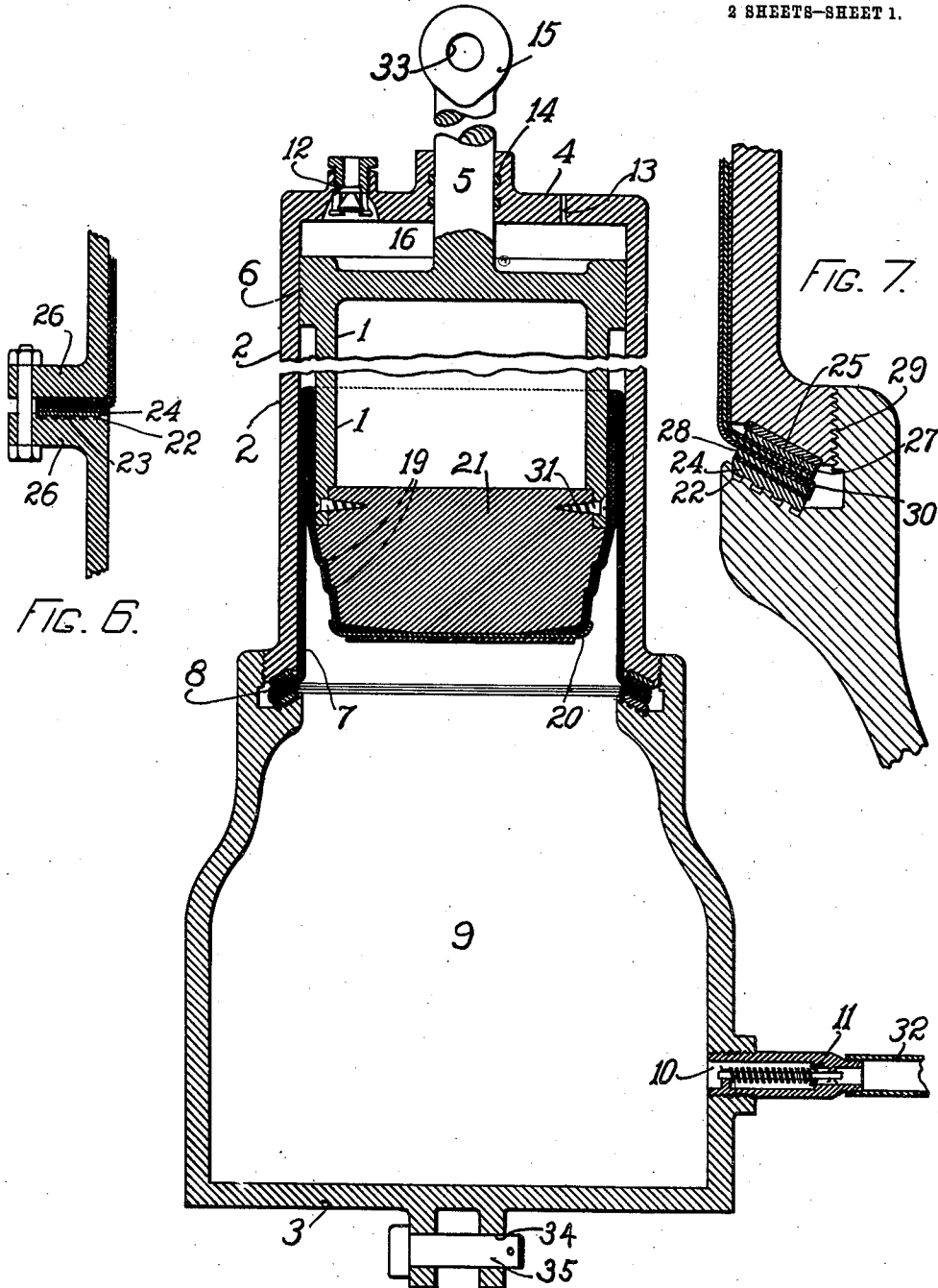
H. E. OXNARD.
EXPANSIBLE CHAMBER.

APPLICATION FILED AUG. 29, 1906. RENEWED MAR. 10, 1909.

1,085,818.

Patented Feb. 3, 1914.

2 SHEETS—SHEET 1.



WITNESSES

A. T. Palmer

Chas. P. Schramm

FIG. 1.

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2 SHEETS—SHEET 2.

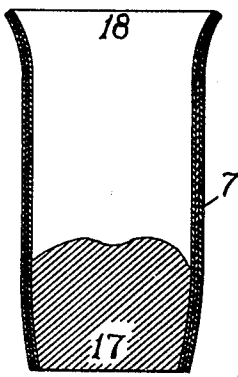


FIG. 3.

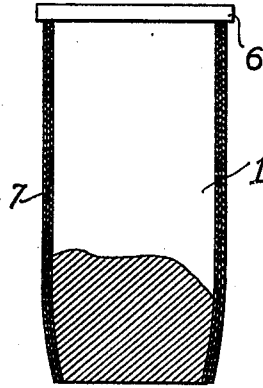


FIG. 4.

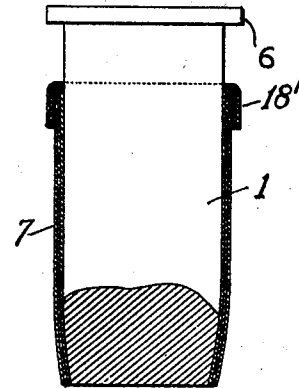


FIG. 5.

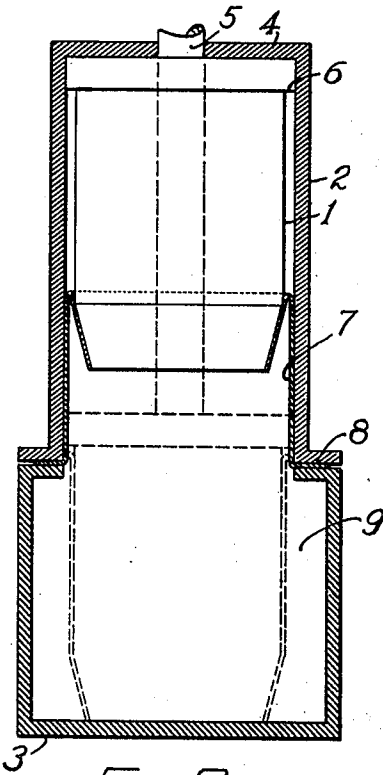


FIG. 2.

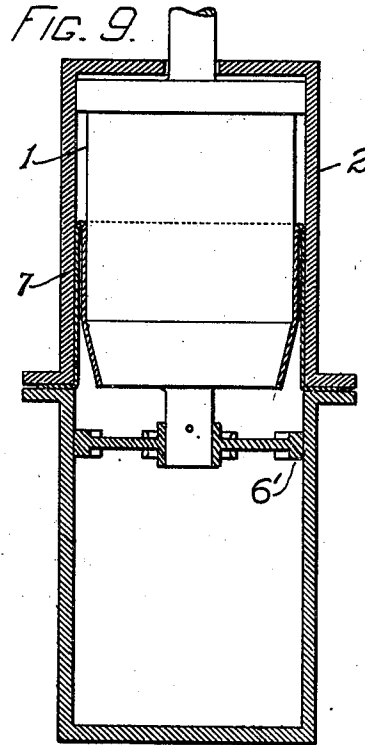
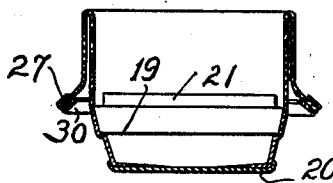


FIG. 9.

FIG. 8.



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UNITED STATES PATENT OFFICE.

HENRY E. OXNARD, OF NEWTON, MASSACHUSETTS.

EXPANSIBLE CHAMBER.

Specification of Letters Patent.

Patented Feb. 3, 1914.

1,085,818.

Application filed August 29, 1906, Serial No. 332,411. Renewed March 10, 1909. Serial No. 482,542.

To all whom it may concern:

Be it known that I, HENRY E. OXNARD, of Newton, in the county of Middlesex, and State of Massachusetts, have invented certain new and useful Improvements in Expansible Chambers, of which the following is a specification.

This invention relates to improvements in expansible chambers. More particularly, it is here described as it may be applied to pneumatic springs or cushions intended to sustain a weight elastically, or to act as a buffer for receiving any force; but it is applicable to a wide variety of other uses.

It is among the purposes of the invention to provide a chamber in which fluid may be contained at high pressures, having a plunger reciprocating inward and outward without leakage and almost without friction.

As applied to a pneumatic spring the invention seeks to provide wide limits for the range of travel between the expanded and the compressed positions of the spring; an easy and freely responsive action of the spring, with a minimum of wear, resulting from the elimination of friction; and great strength, resulting from the capability of containing air at exceedingly high pressures without leakage or rupture.

It is also the purpose of the invention to provide apparatus having the other advantages which pertain to the structure hereinafter described, too manifold and diverse to be specifically enumerated here.

According to this invention, a highly flexible septum, impervious to the fluid which is to be used, is arranged as a sleeve closely incasing a cylindrical plunger. At one end it is attached to the plunger. The other end is everted or rolled back upon itself and attached to the interior of a cylinder which closely incases both plunger and sleeve. Measured radially, the space between the plunger and cylinder is about the double thickness of the septum. In operation, as the plunger travels to and fro in the cylinder, the fold at which the sleeve is doubled back upon itself rolls to and fro to different parts of the sleeve, corresponding to the motion of the plunger. The air or other fluid enters between the plunger and cylinder, forces one part of the sleeve smoothly against the plunger and the remainder smoothly against the cylinder, and thus separates the adjacent surfaces of the

doubled sleeve slightly from each other and fills the intervening space with a thin film of the fluid. This eliminates all friction except that incidental to guiding the plunger in its travel, and the internal friction of bending the septum at its fold, both of which are so slight as to be negligible. The fluid pressure upon the septum is sustained, ultimately, by the cylindrical walls of the plunger, upon which it acts radially inward; and the walls of the cylinder, upon which it acts radially outward; and by the septum at the fold, which is the only place where there is any pressure tending to stretch or rend the septum. The stress at that point depends upon the annular or radial thickness of the film of fluid. As the latter may be very slight, and may under some circumstances be almost infinitesimal, the septum is well able to sustain it and is not liable to rupture, even under great intensity of pressure.

Hitherto, several methods have been used for confining a fluid under pressure in an expansible chamber, among which are: (1) sliding contact of a piston within a cylinder (either the piston or its packing sliding in such close contact with the cylinder that no fluid can pass); (2) the use of a transverse diaphragm; (3) forming the chamber of an elastic bag. The present invention works upon a different principle and comprises an arrangement which is novel in several respects. It differs from the first in that neither piston nor packing makes sliding contact with the cylinder. It differs from the second and third in that its flexible septum is highly flexible; and is arranged in a form redoubled upon itself and is, speaking generally, not subjected to a serious tensile stress by pressure of the fluid; and in that its travel or limit of expansion is not limited by the strength of material, but may be as long as the travel of a simple piston sliding within a cylinder. It also differs in that the pressure is not applied to any considerable area of the septum in the direction of travel, producing no stretching effect in that direction, no great stress upon its fastenings and requiring no relatively great strength in the septum.

The invention also comprises improvements in septa, in the method of fastening the same, in the arrangement of an auxiliary buffer, and other respects, as hereinafter more fully described.

In the accompanying drawings, which illustrate one embodiment of the invention, Figure 1 represents a longitudinal section through an air spring. Fig. 2 represents the same diagrammatically on a smaller scale, showing the extreme positions of the plunger. Figs. 3, 4 and 5 show successive stages in forming or molding the sleeve and assembling the same into position. Fig. 6 shows an alternative method of fastening the sleeve. Fig. 7 is an enlargement of the fastening shown in Fig. 1. Fig. 8 shows a form of the septum arranged for separate transportation. Fig. 9 shows an alternative method of guiding the plunger.

Referring to the drawings, 1 is a plunger, preferably of brass or steel, working in a cylinder 2 closed at one end by a head 3 and preferably closed at the other end by a head 4 through which the plunger rod 5 passes. The plunger is guided and maintained in a position approximately central within the cylinder 2 by the bearing of the plunger rod 5 where it passes through head 4, and by the bearing of a flange 6 on the plunger against the interior of the cylinder. The plunger may be guided in any other suitable way, one form being indicated in Fig. 9, in which a flange 6' attached to the inner end of the plunger spreads outward to the cylinder walls. The flange 6 makes a loose sliding contact with the cylinder walls without attempt to be tight against the passage of fluid. A highly flexible sleeve septum 7 is attached to the inner end of the plunger 1; lies loose along the surface of the plunger for a variable distance; and is turned back upon itself and lies loose along the inner surface of the cylinder to which it is fastened at 8. This sleeve and its construction and fastening are important features of the invention. The lower portion 9 of the cylinder which is to contain the fluid under high pressure is thus bounded by the head 3 and the septum 7. An opening 10, having an automatic check valve 11, permits the introduction and impounding of air or other fluid under pressure at pleasure. Depression of the plunger, forcing it farther into the cylinder, decreases the volume within, thus increasing the intensity of pressure and resisting the force which is depressing the plunger. While the diameter of the upper portion of the cylinder bears a close relation to that of the plunger, the lower portion may be of larger diameter, and when so constructed movement of the plunger through a given distance produces less proportionate effect, and by this means I contrive a safety device to prevent the application of too great pressure to the septum; and at the same time I shorten or condense the apparatus. To accomplish this I arrange the sleeve 7 of such length that the plunger may travel between the heads

3 and 4, each serving as the final limit of its movement, and the proportion of contents when the plunger is raised to that when depressed is so designed that the ratio of the space surrounding the plunger when depressed to the total contents when raised shall be inversely in proportion of the desired maximum pressure to the desired minimum pressure of contents. When the plunger is depressed, thus reaching the desired maximum of pressure, it rests upon the head or bottom 3 of the cylinder, and no application of pressure to the plunger can increase the pressure upon the fluid or sleeve. By thus enlarging the cylinder around the depressed position of the plunger I also shorten the apparatus, it being well understood that a residuum of space must be left to contain the fluid in its compressed condition, and that the ordinary method of accomplishing this is to make the cylinder longer than the intended travel of the plunger.

In constructing the sleeve septum any suitable material may be used capable of producing imperviousness to the fluid under high pressure; and flexibility in a very high degree with some elasticity, so that it can be turned partly inside out, without injury, and repeatedly rolled back and forth in this position as herein described, with little wear. There must also be a strength or firmness of texture, which while allowing the slight amount of stretching necessary to turn the sleeve inside out, at the same time prevents any considerable stretching of the fabric. No fabric or membrane hitherto known to me is entirely suitable for this purpose, so far as my experiments have gone; but I have found that a suitable fabric can be manufactured by a combination of leather and rubber, in which the external surface of the fabric on each side is a piece of flexible leather, and there is a film or layer of flexible rubber intervening, the whole being cemented firmly together so that it has the properties of one integral mass, acting as a unit, without looseness or friction between the layers. Two thicknesses of flexible leather cemented together can be made to work, but not as well. Rubber alone is unsuitable. In constructing the sleeve I use a form or mold, as shown in the Fig. 3, having the same external diameter as the plunger upon which the sleeve is to fit. The mold is preferably, but not necessarily, somewhat flaring at one end 18, and slightly tapering at the other end 17. A layer of flexible leather is first wound thereon in single thickness, with its edges beveled, overlapping and cemented together, so that the entire layer is of uniform thickness. The layer lies a little upon the flaring portion 18, and a little upon the tapered portion 17. A layer of rubber is next applied, completely

cemented to the leather, and its edges joined in like manner. Another layer of leather is then applied outside the rubber and firmly cemented thereto. When the whole has been dried and removed from the form, the part which was opposite 18 contracts into substantially the same cylindrical shape as the rest of the sleeve; but owing to the flaring character of the surface on which it was formed it can be more readily stretched outward for fastening to the cylinder. The sleeve may then be mounted on the plunger or a form like the plunger, as in Fig. 4, where it will be observed that in its normal form the sleeve is an open ended cylinder of uniform diameter throughout its length, fitting snugly the surface of the plunger. The next stage is to evert or turn back upon itself the end 18' ready for fastening to the cylinder. The fastening of the inner end of the sleeve to the plunger may be accomplished in any suitable way. The preferred method is to affix to the plunger a tapering cap 21 of wood having a series of steps or corrugations 19, as clearly shown in Fig. 1, to the conical exterior of which the sleeve is fastened by shellac. The pressure of the fluid seats this firmly upon the cap, automatically sealing the joint; but if desired a rubber cap 20 may be applied and cemented over the cylindrical end, as in Fig. 1. The plunger may then be inserted in the cylinder and the other end of the sleeve attached thereto. Any suitable method of attachment may be used; but I have devised a method having peculiar advantages, which is illustrated in the drawings. The end of the sleeve is turned or stretched outward and clamped between the two portions of the cylinder. The face of the lower clamping portion has a broad groove 22, having a series of minor grooves 23 cut in its bottom. A soft rubber ring or washer 24 is pressed into groove 22, and the minor grooves may be partly filled with red lead, if desired. When the parts are compressed the rubber 24 is bent sharply around the corners of the minor grooves, thus constituting a series of tight inclosing rings, and the pressure of the inclosed fluid tends further to force the rubber into the corrugations, compressing the air contained therein, if any, and tightening the joint. A metal washer 25 occupies a corresponding place on the other part of the cylinder, the portions being screwed together at 29, and the sleeve is inserted between the rubber 24 and metal 25, as clearly shown in Fig. 7, being separated from each by leather washers 27, 28. The sleeve may be prepared for this on a suitable form, in which the washer 27 is firmly cemented to the outer leather of the septum, the washer 28 to the inner leather layer of the septum, and a rubber connector 30 is cemented to the inner side of the rubber layer of the sep-

tum, as shown in Fig. 7, whence it is bent around and embraces elastically the inner leather layer of the septum and the leather washer 28. In this form the sleeve end will retain permanently its expanded shape ready for use at any time, upon which occasion it is expected that the under side of the rubber connector 30 will be firmly cemented to the rubber washer 24. The other end of the sleeve being attached only to the wood cap 21, which is detachable from the plunger upon removing screws 31, the entire sleeve may readily be put in place or removed. This permits a number of sleeves to be carried in duplicate, and one readily substituted for another in case of rupture, the joint between the rubber connector 30 and the rubber washer 24 being readily separable and renewable, as is the custom with rubber cement.

Another feature of the invention relates to the upper portion of the cylinder, which as represented in Fig. 1 contains a passage having a check valve 12 and a small passage 13, which is permanently open. Packing 14 is inserted to lubricate the stem of the plunger and prevent undue leakage of air. The weight which the spring is to carry is applied to the top 15 of the plunger rod. The shape of this top and the method of connecting it to the plunger stem, whether integrally or by a universal joint or otherwise, depends upon the use to which the apparatus is put. Hence, it is deemed sufficient to show a simple head 15 in the drawing. Depression of a spring by a momentary shock, to which vehicle springs are peculiarly liable, ordinarily results in a succession of vibrations of diminishing intensity. By the present invention these may be eliminated or modified as follows: When the plunger 6 is depressed air is drawn into the closed portion 16 through automatic valve 12. When the plunger rises on the rebound that valve closes, imprisoning the air and thus retarding the rise of the plunger. The small hole 13 allows the air thus imprisoned to escape gradually, the plunger resuming its normal position slowly.

In operation, let it be assumed that the lower portion 9 of the cylinder contains air at a pressure of 200 pounds per square inch, which pressure a sleeve septum, built as described, will readily sustain. If the diameter of the plunger and its incasing sleeve be 3 inches the upward pressure thereon will be approximately 1400 pounds, which is the external weight sustainable at the head 15. When an excess force is applied the plunger will sink, compressing the air beneath it until the excess pressure is balanced. The plunger moves in a free, resilient manner, falling and rising easily with the changes of weight. Although the everted portion of the sleeve while in the process of construc-

tion hugs tightly the portion it is turned back upon, yet when put in place in the apparatus and subjected to high pressure air enters between the plunger portion of the sleeve and its adjacent everted cylinder portion, separating these two portions and forcing each of them firmly upon the adjacent supporting surface of the plunger or cylinder, as the case may be. This prevents all friction between the adjacent surfaces of the everted septum. It also prevents all stretching of those portions of the septum which lie against either the plunger or the cylinder, because the pressure thereagainst holds them firmly together, and the stretching, which might be expected from the pressure of the fluid upon the fold in the axial direction, is not sufficient to overcome the friction. The result is that the septum is not under tension anywhere except at the fold, and there the part which is exposed is so closely supported on either hand that it can withstand a very high pressure. Assuming that the pressure is 200 pounds per square inch, and the thickness of the air film at the fold is $\frac{1}{16}$ inch, the pressure tending to expand or burst the septum at the fold would be about $12\frac{1}{2}$ pounds per linear inch of circumference around the plunger, and this being divided equally between the outer and the inner limbs of the septum would make a tension on the septum of $6\frac{1}{4}$ pounds per inch. This is manifestly very small compared with the 1400 pounds weight supported thereby. It can be made smaller still by providing a smaller distance between the folded portions of the septum, thus narrowing the unsupported portion of the septum; or by increasing the diameter of the plunger, thus taking advantage of the fact that the area increases numerically faster than the circumference. When thus constructed there is no leakage of the air contained, despite the high pressure, and the high friction manifest when a sliding tight fitting piston is used to contain so great pressure is not evident. There is, in fact, no friction except that of the plunger against its guides, which may be lubricated as much as desired, and the internal friction of the septum as its fold rolls backward or forward, which is so slight as to be negligible. No means is known to me by which so great pressure could be sustained in an operative manner by a flexible diaphragm set transversely to the direction of travel, after the manner hitherto practised, nor by a rubber bag, as in both cases the material is exposed to a large bursting stress and the material must either be so strong and thick as to lose its flexibility, or must be so reduced in size as to have an exceedingly limited travel. In the present invention the distance between the safe limits of travel of the plunger is wholly independent of the strength of material

composing the septum. It will be readily understood that it is important to provide mechanical stops at predetermined limits to prevent any strain except the pressure of the fluid from acting upon the septum; but with this exception the sleeve may be made as many inches or feet in length as desired. Each additional inch of length adds two inches to the travel: one inch in the outward direction and one inch in the inward direction, assuming that the stops for limiting the motion of the plunger are adjusted accordingly.

In some cases it is not necessary to employ a septum which is absolutely tight, provided it leaks air but slowly, as convenient means are sometimes at hand for replenishing the leakage. Thus, a supply reservoir may be carried on an automobile, railway car or other vehicle to which the spring is attached; or a pump may be attached. In Fig. 1 a tube 32 is represented which may lead to such reservoir, not shown in the drawings, which supplies air whenever the pressure in the cylinder 9 is less than in such reservoir, thus permitting the valve 11 to open automatically.

An alternative method of fastening the sleeve to the cylinder is indicated in Fig. 6, in which each portion of the cylinder has a flange 26, there being a rubber washer 24, corrugations 23 and a groove 22, as before.

If the friction between the parts where the sleeve is pressed against the plunger or cylinder, as the case may be, is not sufficient to prevent the sleeve from slipping on said surface, the surface may be roughened or a different material used, having a greater coefficient of friction when in contact with leather, thus securely preventing any slipping of the sleeve on said surface in a direction parallel to the axis. It will be understood that it is not absolutely essential that slipping be prevented, but this method is preferred because if the pressure on the septum at its fold be held entirely by the pressure of the sides of the septum against their adjacent walls, this strain does not have to be borne by the fastenings of the ends of the septum, thus reducing the likelihood of wear and breakage at those points.

As showing one method of mounting the spring, the head 15 is represented as provided with a hole 33 through which a bolt or pivot may pass, and another eye 34 at the bottom for holding a bolt 35 at right-angles to the top pivot is represented, thus obtaining by this method of mounting the effect of a universal joint without actually adding a separate element to the mechanism for that purpose.

Many other variations may be made from the particular form and arrangement here shown, without departing from the scope of the invention.

I claim:

1. The combination of a round casing and a plunger therein with a highly flexible everted sleeve joining them, the adjacent parts of the everted septum being close to each other radially, the said plunger having a flange 6 bearing against the casing, forming a guide protecting the adjacent septum parts from mutual contact.

2. The combination of a round casing and a plunger therein with a highly flexible everted sleeve septum joining them, the adjacent parts of the everted septum being close to each other radially, the said plunger having a flange 6 bearing against the casing, the adjacent end of the casing being closed, and there being a stem of the plunger passing through said closed end and having a bearing therein, cooperating with said flange in guiding said plunger within the casing.

3. The combination of a round casing and a plunger therein with a highly flexible everted sleeve septum rolling between the plunger and the casing surfaces, the sleeve-supporting part of the casing bearing a close relation to the diameter of the plunger, and the non-sleeve-supporting part of the casing occupied by the plunger when the sleeve is on the plunger bearing a relation not close thereto.

4. The combination of a round casing and a plunger therein with a highly flexible everted sleeve septum joining them and supported thereby, the junction of the septum with its support being on a surface inclined conically to the axis there being at said junction a series of corrugations transverse to the direction of tension of the septum on the junction.

5. The combination of a round casing and a plunger therein with a highly flexible everted sleeve septum joining them, and fastening means for the end of the septum wherein a part of the support is formed at an inclination to the adjacent surface supporting the septum, said inclined surface having a series of corrugations transverse to the direction of tension of the septum on such fastening.

6. The combination of a round casing and a plunger therein with a highly flexible everted sleeve septum joining them, and fastening means for the end of the septum wherein a surface, formed on the body to which the septum is to be attached, has a series of corrugations transverse to the direction of tension, there being means to press the ridges of said corrugations into the septum end.

7. The combination of a round casing and a plunger therein with a highly flexible everted sleeve septum joining them, and fastening means for the end of the septum, wherein is a surface adapted by friction or

the like to oppose movement of the septum in the direction of the axis; the septum thereon being exposed to the fluid pressure of the contents of the casing, whereby the septum is frictionally held at said surface.

8. A highly flexible septum arranged in everted sleeve form and attached at one end to a cap attachable to a plunger and attached at the other end to a ring attachable to a round casing, the whole adapted to be used in apparatus of the class described.

9. A highly flexible septum arranged in everted sleeve form and attached at one end to a disk attachable to a plunger and at the other end to a disk attachable to a round casing, the whole adapted to be used in apparatus of the class described.

10. The combination of a flexible everted sleeve comprising two layers of supporting material and one of rubber intervening with a contiguous continuation of the rubber everted about one of the supporting material ends and forming a superficial rubber ring outside said supporting material.

11. A flexible everted sleeve, adapted to form a septum, having a layer of rubber and a layer of supporting material, there being a rubber continuation of the end of the rubber which is again everted, contributing to the formation of a fastening pad for the end of the septum.

12. The combination with an expansible chamber of a flexible everted sleeve septum having a layer of rubber and a layer of supporting material; and fastening means for the end of the septum, wherein a rubber pad is provided, adapted to make an impervious joint with the chamber wall, there being a connection of contiguous rubber between said rubber of the septum and rubber of the pad.

13. The combination of a round casing and a metallic plunger within it with an everted flexible sleeve septum joining the two, the plunger having a cap of different material for adhesion of the septum thereto.

14. The combination of a round casing and a metallic plunger within it with an everted flexible sleeve septum joining them, the plunger having a cap of different material to the sides of which cap the septum adheres.

15. A composite septum, comprising the combination of a sheet of highly flexible strain-resisting material, combined with a sheet of highly flexible impervious material lining it, the two being arranged together in the form of an everted cylindrical sleeve, with the impervious lining on the interior.

16. A composite septum, having a sheet of highly flexible elastic material combined with a sheet of highly flexible supporting material and adapted to be everted surrounding a plunger and surrounded by a cas-

ing and to roll from one to the other, all contiguous parts of the two sheets of material which are subject to the eversion and rolling being adhesive to each other, whereby there is no superficial slip of one upon the other.

17. A composite septum, having a sheet of highly flexible elastic material combined with a sheet of highly flexible and somewhat expansible supporting material and adapted to be everted surrounding a plunger, and surrounded by a casing, and to roll from one to the other; all contiguous parts of the two sheets of material which are subject to the eversion and rolling being adhesive to each other, whereby the supporting material is expanded and contracted by the elastic material; the said supporting material being a fabric continuous in all directions and having its expansibility limited in all directions; whereby expansion of the elastic material by penetration through interstices of the supporting material is prevented.

18. A highly flexible septum, composed of two layers of leather and one of rubber intervening, all closely united together in the form of a sleeve, said sleeve being impervious, adapted to roll evertibly between a plunger and a casing surrounding the plunger, and to fit both plunger and casing when so rolled.

19. In an expansible chamber, the combination of a casing, a plunger and an impervious, everted sleeve septum within the casing; and a soft surfaced impervious plate of elastic material contiguous to the septum

for joining the septum to the adjacent chamber wall.

20. In an expansible chamber, the combination of a casing, a plunger and an impervious, everted sleeve septum within the casing, and a mass of soft surfaced impervious material contiguous to the septum; and means to hold said mass in place on the chamber wall.

21. The combination with a round casing and a plunger therein, capable of holding very high internal pressure, of a non-elastic highly flexible fabric arranged in the form of a sleeve between them, evertible, expansible and contractible to fit either casing or plunger, and having a texture of interlaced fibers rigidly resistant to separation from each other in any direction; and a highly flexible film, impervious to air, supported on said fabric, and closely united therewith, the said texture of the fabric preventing said film from bellying through the fabric under high pressure; the fabric and film comprising a septum whose adjacent surfaces when everted are close together radially whereby walls composed of said casing, plunger and septum may carry very high pressures exceeding the normal leakage or bursting stress of both components of the septum.

In testimony whereof I have affixed my signature, in presence of two witnesses.

HENRY E. OXNARD.

Witnesses:

EVERETT E. KENT,
OLIVER P. SCHOONMAKER.