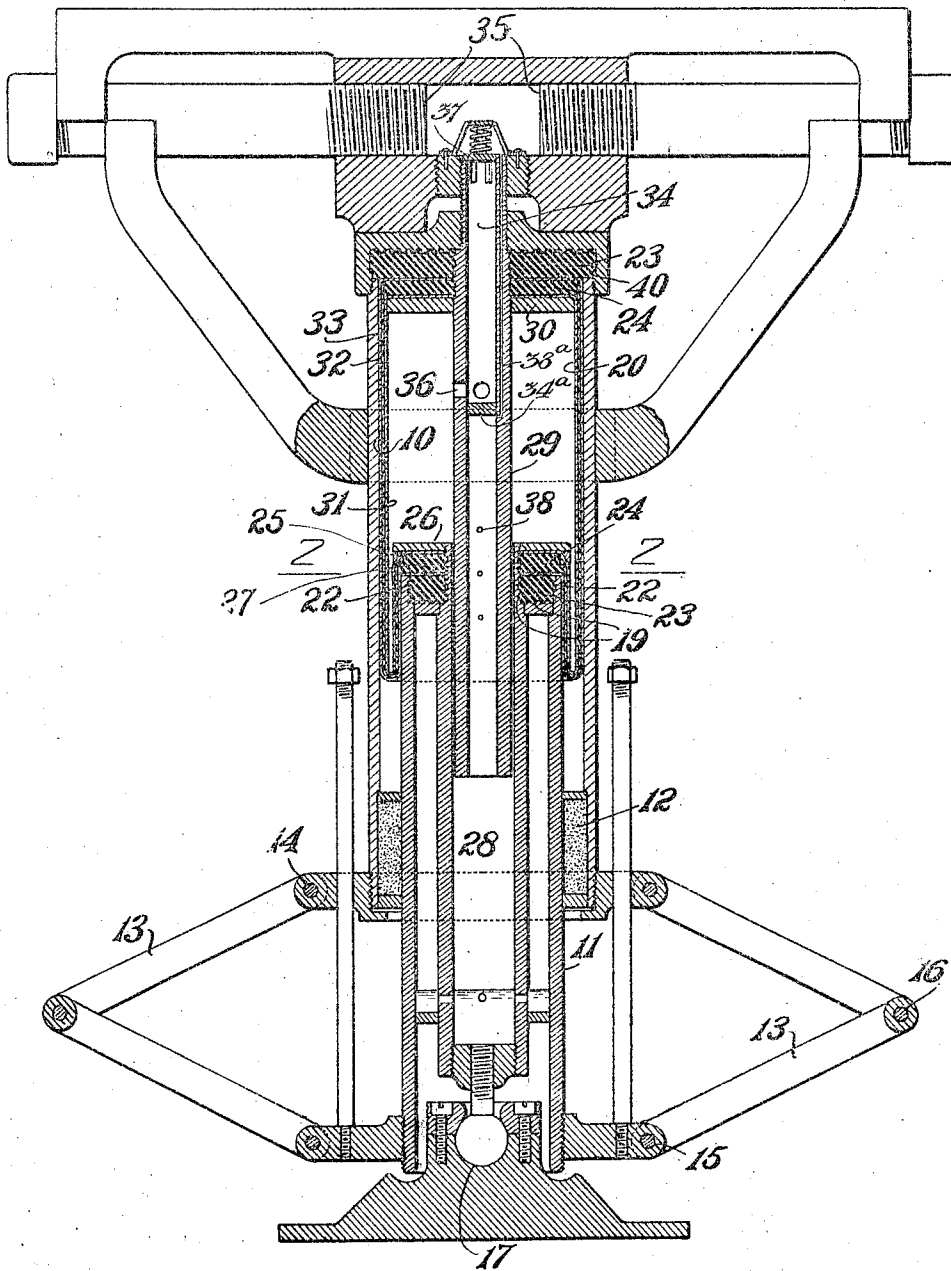


H. E. OXNARD.
EXPANSIBLE CHAMBER.
APPLICATION FILED MAY 18, 1910.

1,038,636.

Patented Sept. 17, 1912.

4 SHEETS—SHEET 1.



WITNESSES
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Mary A. Nychan

FIG. 1

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4 SHEETS—SHEET 2.

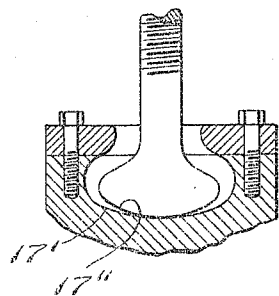
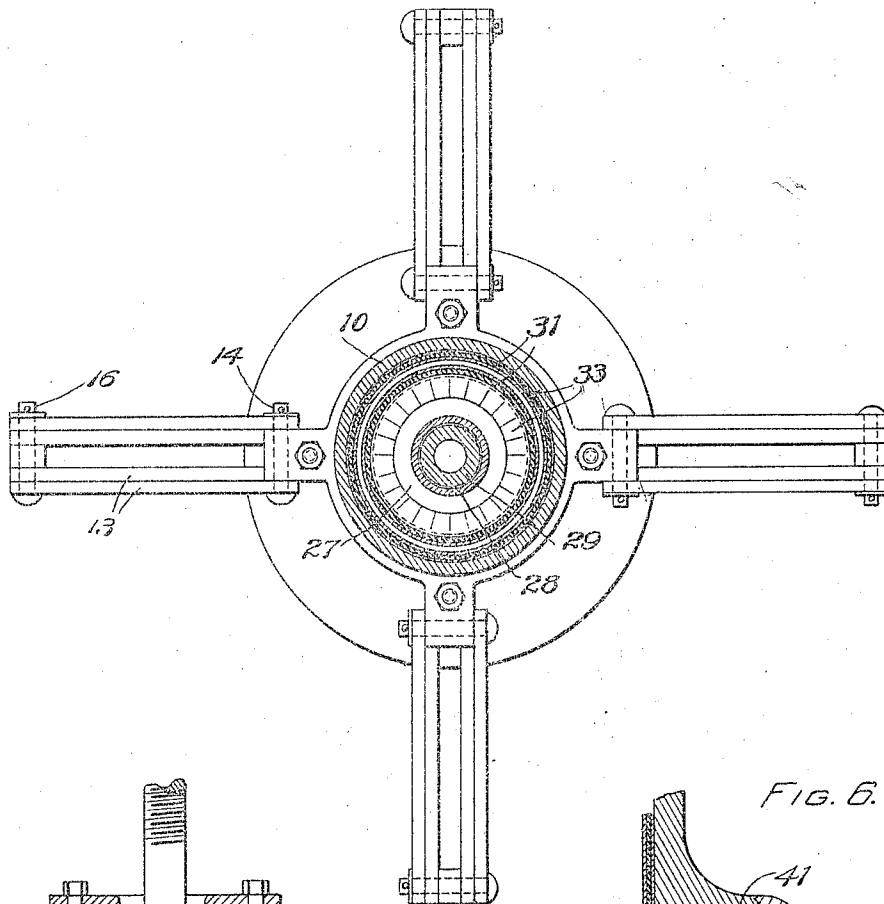


FIG. 5.

FIG. 2.

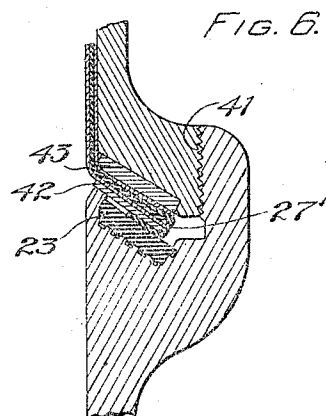


FIG. 6.

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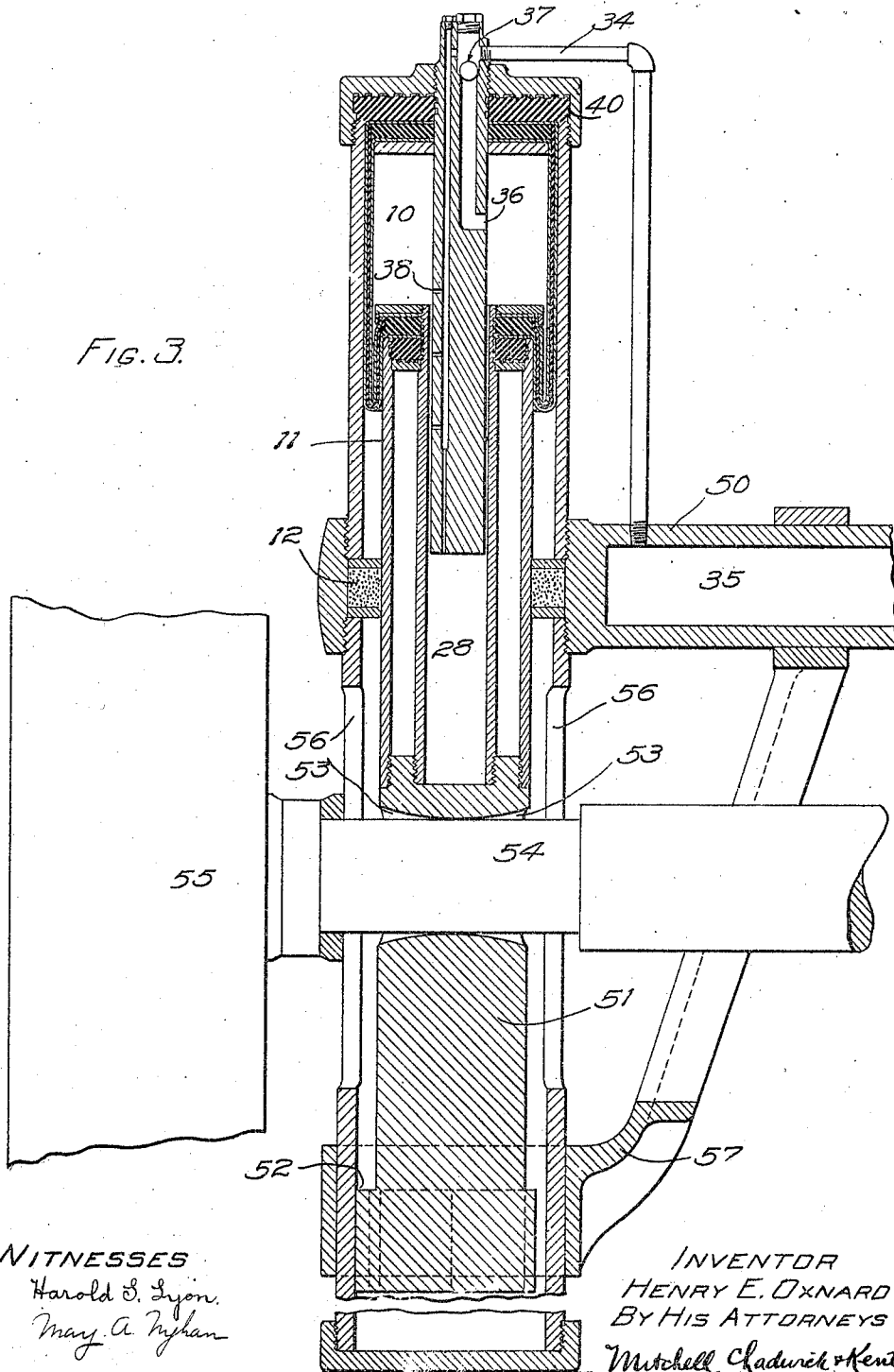
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4 SHEETS—SHEET 3.



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4 SHEETS—SHEET 4

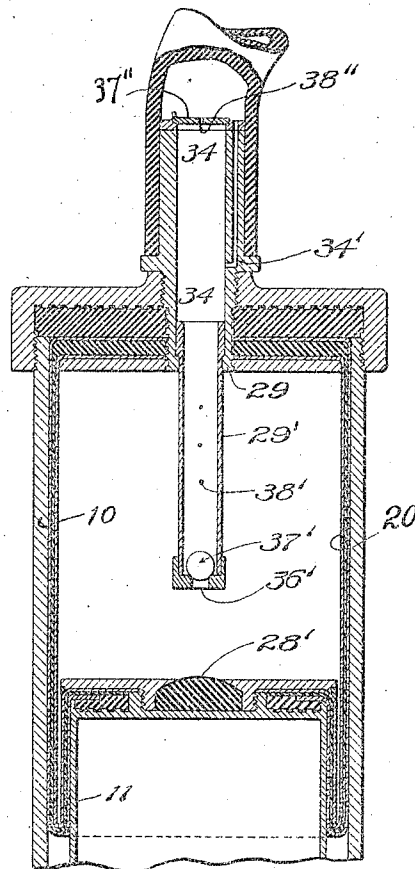


FIG. 4.

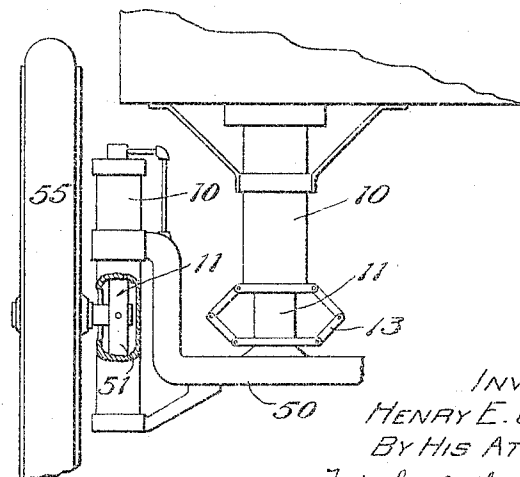


FIG. 7.

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UNITED STATES PATENT OFFICE.

HENRY E. OXNARD, OF NEWTON, MASSACHUSETTS.

EXPANSIBLE CHAMBER.

1,038,636.

Specification of Letters Patent.

Patented Sept. 17, 1912.

Application filed May 18, 1910. Serial No. 562,011.

To all whom it may concern:

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

This invention relates to expansible chambers.

It is here described more particularly as it may be applied in chambers adapted to contain air or other expansible fluid for sustaining stresses elastically, or to act as a buffer for receiving any force; and it is here represented as a spring for absorbing shocks and jolts of a vehicle, although the apparatus here described and suitable modifications of it may be used in many other connections without departing from the scope of the present patent.

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.

The invention also comprises improvements in a number of details of construction of such apparatus, and in the method of arranging the same in connection with the parts to which it is attached.

It comprises improvements in the structure, arrangement and the fastening of the septum; also improvements in the form of the air space, dividing the same into two parts; and in the connections between the parts, eliminating the violence of reaction heretofore common in springs; and in the combination thereof with the vehicle frame or body; also improvements in the methods of guiding the travel of the movable portions of the chamber; and improvements in other respects which appear in the following detailed description.

In the drawings: Figure 1 is an elevation, sectioned through the center, of apparatus

embodying the invention; Fig. 2 is a plan view of the same, sectioned on the line 2—2 of Fig. 1; Fig. 3 is a sectional elevation of a different embodiment of the invention; Fig. 4 is a sectional elevation of still another embodiment of the invention; Fig. 5 is a sectional view of a detail; Fig. 6 shows a slightly different form of septum fastening; and Fig. 7 shows application of the invention to a vehicle.

Referring to the drawings: An expansible chamber having correlatively moving opposite walls is here shown in the form of a round casing here represented as a cylinder 10, containing a plunger 11 which slides in packing 12 and (in the form represented in Fig. 1) is guided and sustained with its axis coincident with the axis of the cylinder by hinged braces 13, which are pivoted at 14 to the casing, at 15 to the plunger and at 16 to each other. One member of the chamber, here the plunger, rests loosely in a bearing, which may be rigid on an axle of a vehicle; and the other member, here the cylinder, supports the vehicle frame. The function of the packing 12 is to lubricate and assist in guiding the plunger. For retaining air within the chamber, reliance is placed upon a septum 20 which is fastened to the plunger and to the cylinder. This septum is of highly flexible material, impervious to air, and arranged in the form of an everted sleeve. Owing to the peculiar construction of the septum, the surface thereof which fits against the exterior of the plunger 11 is also capable of fitting against the interior of the cylinder 10, notwithstanding the larger diameter and area of the latter. The diameter of the plunger is made slightly less than that of the cylinder, in which it travels, differing by an amount but little greater than the double thickness of the septum. The thickness of the septum and the diversity of diameter of the cylinder and plunger are exaggerated in the drawings, for the sake of clearness, over the dimensions which are found best in practice and which are preferred. The septum may be composed of two layers of highly flexible leather 31 and 33, with a layer of rubber 32 intervening, the whole being fastened together adhesively so that they work as one integral piece. The plunger end of the septum may be fastened in the manner shown in the drawings, in which an annular cup 22 is formed in the plunger

head, filled with a rather thick bed of rubber 23. A ring or disk 24 presses down upon this, and the outer leather 33 of the septum is embraced between them, being here separated from its rubber 32 and crimped inward toward the axis or cut into flaps which are bent inward. The rubber 32 is fitted outside the rubber disk 24, to the cylindrical periphery of which it adheres by rubber cement; the other leather 31 is next outside; and the whole is preferably protected by a light inclosing ring or fillet 25 surrounding the plunger head; and a brass cap 26, which may be screwed upon the plunger head, holds all the parts in place. The walls of the cup 22 are serrated with a considerable number of ring shaped depressions 19 clearly represented in cross section in the drawings. The rubber bed 23 fits with sufficient tightness radially, and is pressed inward with sufficient force axially, so that it bulges into these serrations, as represented in another fastening shown enlarged in Fig. 6. By this means a joint impervious to air is obtained on all the interior surfaces of the cup, both by the bed 23 and by the ring or disk 24. The space between these rings which is not occupied radially by leather 33 may be filled with a thin ring filling of rubber 27 if desired, in order to maintain a rectangular bearing of rubber ring 24 upon the sides of cup 22. It will be observed that whether this ring filling be employed or not, the approach of air to the end of leather layer 33 is occluded by mutually contacting surfaces of rubber. The other end of the septum may be arranged at the opposite end of the cylinder, as indicated in Fig. 1. The fastening is similar to that just described. The plunger has an axial recess 28 into which fits a stiff rod 29 projecting from the other end wall 30 of the cylinder; and this rod preferably fits rather loosely, so that there will be some leakage past it, the looseness being exaggerated in the drawings.

The chamber as here represented is of uniform diameter throughout its length, but has an extension 35 which is reached through passage 34, which may be of any desired diameter and of any desired shape and capacity. This extension is a closed receiver between which and the chamber air flows automatically, in either direction, during the normal operation of the apparatus. It is one feature of the invention that this extension may constitute part of the frame of the vehicle, which may be hollow or tubular; and if one spring be placed at each wheel, the same receiver, comprised in the various members of the tubular frame, may communicate with each of the spring chambers. In Fig. 1 this is represented conventionally by indicating a tubular piece surmounting the cylinder, which may extend

as far as desired in either direction, or be connected with any other tube, its ends being represented closed. The effect of this receiver or extension of the expansible chamber is to increase the distance of elastic yield of the spring when its load is increased, or a shock is encountered, over the extent of such yield if there were no extension. The capacity and dimensions of the extension may be computed in any given case by consideration of the normal increase of load which it is assumed will be encountered, and the capacity of the chamber 10 under normal conditions, the computation being made in accordance with the well known law that the product of the volume by the pressure of a confined body of air is a constant quantity. Accordingly, if it is desired that a small force or addition of weight shall produce a relatively large yielding of the spring, the extension of the chamber should be relatively large, because thereby the proportionate change of volume, corresponding to that increase of pressure upon the contents, would amount to more inches of travel of the plunger in chamber 10 than if the capacity of the receiver were so small as to add relatively little to the capacity of the chamber. It will be understood that the foregoing assumes the existence of a copiousness of communication between the chamber and extension so that when an impact is received they act substantially as a unit, the rapidity of contraction of the chamber under working conditions being substantially unretarded by smallness of the passage thence into the extension. The vertical space available for a spring under a vehicle, or, for example, within the hub of the wheel of a vehicle is frequently so limited that heretofore the easy, resilient effect of a plunger having a long travel could not be had, because the rapid proportionate compression per inch of travel quickly stops the plunger. The device above described, of providing an external receiver constituting an extension of the chamber, which may be placed elsewhere, wherever there is room, and need not be vertical, enlarges the uses of this type of spring, and improves the action, because by this device practically the whole of the available vertical space can be included within the plunger's travel.

The invention further comprises means whereby the spring under ordinary conditions will afford the vehicle an easy resiliency, the plunger rising and falling with freedom in the chamber, enlarged by its free communication with the receiver; but when an unusually heavy pressure or shock is received which would perhaps throw the plunger to the limit of its travel without even thus making the full proportional decrease of volume corresponding to the increase of pressure, the apparatus automati-

cally "dampens" or retards itself, imposing a compression of the fluid contents at a higher rate, thus bringing the plunger to rest gently, short of its limit of travel and without impact against the end of the cylinder. This is accomplished by locating the port connecting chamber 10 with receiver 35 at 36 in the axial rod 29. When the chamber is contracted to such an extent that this port passes within the recess 28 the port becomes closed, or nearly closed; and further compression of the spring compresses only, or mainly, the air contained in the chamber 10 between the point 36 and the chamber wall 30. The contents of this space being small, relative to the capacity of the chamber, when normally expanded, and relative to the total capacity of chamber and extension, the resistance which the spring affords increases thereafter at a more rapid rate, and a complete and at the same time gentle stop is provided for the compressing action. Another feature of the invention relates to the recovery from such compression, which under ordinary circumstances, is sudden and practically equal and opposite; so that if the compressing force be but momentary, as by the vehicle passing over a hummock in the road, the spring ordinarily throws the occupants to a corresponding extent. The invention contemplates elimination of this sudden upward throw and the substitution of a gentler action. This is accomplished by providing means to retard the expansion of the air which has been compressed by the shock. As shown in the drawings, a check valve 37 is set in the passage between the chamber and its extension. A plug 34 stops access of air from the extension 35 through the passage 34 to holes 38; but a small by-passage 38^a is always open permitting slow passage of air from the extension 35 to holes 38. The air compressed between 26 and 30 which is that contained in the chamber when the plunger reached the level of the port 36, will tend as usual to return the parts to their expanded position, but owing to the check valve the duty devolves upon the expansive force of this air alone to expand the chamber, until the expansion has proceeded far enough to withdraw port 38 from the recess 28, allowing communication again to be established from extension 35 through passage 38^a and port 38 to chamber 10. In operation the result of this arrangement is that upon cessation of the external compressing force the air compressed in the much contracted chamber begins to expand the same, but quickly expends the most of its power. Therefore, it expands the chamber slowly and comfortably during the greater portion of its travel; and when expansion has proceeded far enough to uncover port 38, air enters from receiver 35 and sustains the

spring in its expanded position. If the vehicle be too heavily loaded, or if for any other cause the expansion caused by the highly compressed air between 26 and 30, which was originally comprised between port 36 and 30, does not extend far enough to open port 38, the spring will nevertheless expand, because air can leak slowly from the receiver through port 38 and between rod 29 and the walls of recess 28 into chamber 10. The check valve 37, therefore, prevents a sudden reacting expansion of the spring, and the opening of port 38, admitting pressure, prevents secondary contraction which ordinarily succeeds the initial expansion in the normal fluctuating action of a spring on which a weight is balanced.

The brace arms 13 and their pivots 14, 15 and 16 enable the spring to resist sidewise shocks which might buckle it when extended; and for this purpose pivots 14, 15 and 16 are relatively long; and it is preferred to provide sets of such brace arms in different planes, so that there will be a brace against a shock received from any direction. The connection of the external plunger end to its support is designed to permit a limited amount of play, the plunger end having a spherical surface and rolling or sliding in a spherical cup which may have its radius of curvature slightly larger. In Fig. 1 a ball and socket universal joint is represented, giving flexibility to the mounting of the spring. If springs be set on each side of a vehicle, their casings will ordinarily be fixed rigidly in parallel planes. In Fig. 5 the cup support is curved on a radius larger than that of the plunger end, thus permitting a limited sliding of the spring in its support when such a vehicle encounters an obstacle on one side only. This permits the spring on one side of the vehicle to be contracted or expanded, drawing the spring on each side slightly from its seat toward the other spring, without racking the vehicle; and the curvature of the under support causes each plunger end to return again, by gravity, to its normal position at the lowest point in the curvature.

The sleeve septum, and its construction and fastening, are important features of the invention. In operation, this lies loose along the surface of the plunger for a variable distance from its fastening thereto; and is turned back upon itself and lies loose along the inner surface of the casing to which its other end is fastened. In constructing the 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, with little wear. There must also be a strength or firmness of

texture which, while allowing the slight amount of stretching necessary to evert the sleeve, 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; but I have found that a suitable fabric can be manufactured by a combination of leather and rubber. In making the septum here shown a wooden form may be used of the size of the plunger or a little larger. A sheet of leather, which when made into sleeve form is to fit against the plunger and, when everted, against the casing surface, is first placed loosely on the form in single thickness with its edges beveled, overlapping and cemented together, so that the entire layer is of uniform thickness. A sheet of elastic rubber is next applied, slightly stretched, completely cemented to the leather and having its edges joined in like manner. This is conveniently accomplished by using rubber tubing. 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 it acts much as though it were an integral whole, and the contractive force of the rubber causes the whole to shrink a little in diameter, introducing minute superficial wrinkles throughout the texture of the leather, so that without destroying its general regularity of cylindrical form it shrinks to a size which fits the plunger tightly, yet upon being everted is capable of expansion so that it will fit the larger area comprising the interior casing surface, by stretching the rubber and incidentally enlarging the leather to its original size and stretching it a little beyond if need be. It is well to choose leather stock of high flexibility and expansibility. If the inherent expansibility of the leather chosen be slight the mold of which the sleeve is formed should have a larger diameter than otherwise. The leather is contracted to fit the plunger by contraction of the rubber, and its expansion to fit the casing is preferably but little more than a return to its original uncontracted state. Thus, the strength and normal flexibility and elasticity of the leather are retained unimpaired.

The preferred dimensions of parts are such that the space between the plunger and casing is but little more than the double thickness of septum which occupies this space. In operation, the air or other working fluid within the chamber enters between the portion of the sleeve lying on the plunger and its adjacent everted portion, and, separating these two portions, forces them each smoothly upon the adjacent supporting surface of the plunger or casing, as the case may be, leaving a minute space between them. This prevents all friction be-

tween the adjacent surfaces of the everted septum. It also prevents the pressure in the axial direction from stretching those portions of the septum which lie against either the plunger or the casing, because such axial pressure is so slight, relative to the static friction resulting from the pressure in radial directions. The result is that the septum is not under tension anywhere except at the fold, and at that place the part which is exposed is so closely supported on either end that it can withstand a very high pressure. Under these circumstances the plunger slides in and out of the chamber freely, according to the balance of internal and external pressures, with no leakage and almost without friction, despite the very high pressure within, the sleeve septum merely rolling from one surface to the other. All friction is eliminated 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 casing, upon which it acts radially outward; and by the septum at the fold, which is the only place theoretically having 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.

In fastening one end of the septum to the plunger and the other end to the casing head the problem is to provide a connection impervious to the fluid and mechanically strong and firm enough to withstand the varying experience it will encounter in use. This problem is solved by providing a rubber bed in the casing head and in the plunger head, and a continuous series of contiguous rubber pieces between the two beds, the rubber surface of one piece bearing against the rubber surface of the next piece. Thus, a rubber bed 23 contacts directly with a rubber disk 24, or else contacts directly with a rubber piece 27 which contacts directly with the rubber ring 24; and the rubber 32 of the septum is in direct contact therewith, the same connections being repeated in opposite order at the other end of the rubber 32 of the septum. Leakage of air between the rubber of the bed and the metal surface of the cup in which it is held is prevented by the succession of corrugations above described, against which the bed may be forcibly compressed mechanically, and against which it is automatically highly compressed by the fluid pressure contained

within the chamber. It will be observed that the outer leather layer 33 of the septum is incased between rubber at its termination, and that no air can pass from within the chamber to either side of this leather without passing between two contiguous rubber surfaces under high compression, or passing between a rubber surface and a long series of successive corrugations. The turning of the leather ends radially inward brings them in the direct line of compression in axial direction caused by the high pressure within the chamber, thus giving strong mechanical support to the septum; while the peripheral fastening of the rubber 32 to the cylindrical edge of the thick disk 24 makes an impervious joint which is free from mechanical strain. It is obvious that any material of like qualities might be used in place of the rubber, and the word "rubber" is therefore used in this specification and in the claims more in a generic sense, as indicating a material having the well known attributes of rubber, than as a limitation to any specific material. The rubber to rubber connection is also shown in Fig. 6, in which one of the leathers of the septum would naturally come between two rubber surfaces; but a thin everted rubber connector is introduced passing around the end of the leather and joining the two rubbers, notwithstanding the intervening leather. Another feature of the rubber to rubber connection is the easy separability of joints thus made. With this in mind it is preferred not to cement the leather 33 either to the plunger head or to the casing head. The rubbers 23 and 24, with perhaps intervening parts 21, are, however, cemented together for a short distance. This has an important bearing upon the commercial utility of the invention, because it enables the septum, with its attached disks 24, to be separated easily at each end and a new one inserted in its place, without dislocating the rubber bed 23. The rubber bed may be more securely held in location, if desired, by providing a retaining shoulder 40; and in the construction indicated in Figs. 1 and 3 the upper edge of the cylindrical casing impinges annularly against the bed contained in the end cap forming the head of the cylinder, serving also to retain the said bed in place.

In Fig. 1 the septum and its attached end disks are represented as covering the entire interior of the chamber, the disks being pierced where necessary for passage of the central rod, at which point the joint is made tight by the same methods and with equal facility, as elsewhere; and the axial location of this rod assists in guiding the parts and also contributes to solve the mechanical problem of piercing the impervious coating of the chamber to establish communication

with the outside. The upper half of the septum as shown in Figs. 1, 3 and 4, and its end disk fastening, may be dispensed with if that end of the septum be fastened to the side casing. A fastening which may be used midway of either a casing or a plunger is shown enlarged in Fig. 6, in which the cylindrical wall of the casing or plunger is parted into two sections screwed together at 41 and clamping between them the septum end. The latter may be arranged upon the principle already described. As shown, it embodies also stiff leather rings 42, 43 which hold the septum end in shape to fit the seat provided. In this form the rubber filling 27 of Fig. 1 takes the shape of an everted connector 27', making contact with the rubber of the septum, passing around the end of the leather and making contact with the rubber bed.

In the modification of the invention shown in Fig. 3 the casing is held by a laterally extending beam 50 of the vehicle frame, in which the receiver extension of the chamber 10 is contained. In this figure an alternative arrangement of the passages in the central rod is shown. The stock of the plunger has a downward extension 51, which has a bearing at 52 against an extension of the casing for the purpose of guiding the plunger accurately in its travel. The plunger stock is pierced by a hole 53 through which the axle bar 54 of the vehicle passes, the vehicle wheel being represented at 55. A slot 56 in the casing permits the axle bar to travel up and down with the plunger, according to the elastic action of the apparatus. The lower extension of the casing may be supported by a bracket 57. The ends of the slot 56 furnish stops which may limit the travel of the plunger to prevent excessive strain upon the septum. As thus arranged, the weight of the vehicle and all shocks received from the road by the wheels are transmitted through the frame 50, the compressed contents of chamber 10, the plunger, the axle bar 54, and the wheel 55. The bearing between the plunger and the axle bar is tangential, one surface being curved. In case an obstacle is encountered by the wheels on one side only of the vehicle, this construction permits such shock to be absorbed through the spring on that side; and the incidental elevation of one end of the axle bar does not rack the vehicle, because the axle bar is free to roll and slide a little at its bearing with the plunger to make compensation.

Another form of the invention is shown in Fig. 4, in which the axial rod 29 pierces one end wall only of the expansible chamber, and has a sliding extension 29', with a port 36' at its extremity in position to be engaged and closed by a rubber piece 28' in the plunger head. The upward motion

of the plunger, which corresponds to the compression of the spring resulting from a shock encountered on the road, proceeds freely, but its downward motion is retarded by the closing of ball check valve 37'. If the upward motion proceed far enough for pad 28' to close port 36' it is retarded from there onward by this partial impairment of free communication through passage 34 with the receiver, and when the last of the ports 38', in the extension has been driven within the fixed portion of the tube 29 all communication with the receiver is cut off and the volume of the resisting chamber is limited correspondingly. Upon the downward or return motion, air is gradually admitted to chamber 10 from the receiver through ports 38' after the upper end of extension rod 29' has uncovered port 34' when free communication is again established from the receiver to passage 34; but until then it is restrained by check valve 37'' and can flow only as permitted by the small by-passage 38''.

In assembling the sleeve in the casing the ends of the supporting leather 33 may first be turned inwardly upon the end of the plunger, on bed 23; the filling strip 27 put in place; the rubber disk 24 placed next, and the rubber 32 of the septum joined to its periphery; the ends of the other leather 31 turned over it, and the fillet and retaining cap put in place. After this, the upper leather washer 30, which is ultimately to be attached to the opposite end of the chamber, may be laid loosely on the retaining cap 26, the inner leather 31 of the septum crimped over upon it, the top disk 24 placed thereon and the other end of the rubber 32 of the septum joined to its periphery; the end of the supporting leather 33 bent radially inward thereon and the upper filling strip 27 laid with it. Then the parts thus assembled may be inserted in the casing with rod 29 entering the recess 28; and when the casing and plunger are pressed firmly together the parts inclosing the upper end of the septum, which have been lying loosely on ring 26, will be forced into the upper end of the casing and become seated against the upper bed 23, and will be retained there by the corrugations on the axial rod 29 and also, when the apparatus is in operation, by the expansive forces of the fluid within the chamber. To remove the septum when thus arranged, it is only necessary to remove the packing 12 and other obstacles, so that the plunger can be pulled downward, when the fold of the septum will travel to its limit and, becoming bent around the fillet 25, will, upon further pulling, separate from the upper bed 23, to which it has been attached with only a narrow cemented surface for this purpose. Upon removal from the apparatus

a tool can be inserted through the upper end for unscrewing cap 26, and the lower end of the septum may then be similarly detached from lower bed 23. It is contemplated that septa shall be sold commercially ready assembled with rings 24, 25 and 26; so that a fresh septum can easily be put in place of one thus removed, by an amateur, in case of need arising at a distance from the ordinary facilities of a shop.

The principles herein described may be applied in a variety of equivalent ways, depending upon the needs of the particular problem in hand, without departing from the scope of the patent. Thus, the terms "ring" and "disk" as related to the part 24 or bed 23 are equivalent, the disk being a perforated plate or not, according as an axial rod is used or not; or it may take the form of having a very large central perforation, as indicated in Fig. 6. The passages and ports 34, 34', and others may be made of larger capacity, as the case may require, by multiplying their number. In the form shown in Fig. 1 the hinged brace bars 13 form an inexpensive and powerful support for guiding the motion of the two parts of the chamber in their movement relative to each other, saving the expense and risk of breakage of tempered metal, which has heretofore been used for springs, also requiring less metal to provide the necessary strength against torsional strains, owing to the short length of these arms. The bearings of the moving parts may be lubricated in any suitable manner. In Fig. 1 a quantity of oil is shown in the bottom of recess 28 for lubricating the rod 29; and outside stop rods are shown for preventing undue expansion of the chamber. Any other suitable means of guiding the parts may be employed, and in Fig. 3 an arrangement is shown which is especially useful in connection with stub axles. The axle bar 54 may be considered either as extending across to the wheel on the other side of the vehicle or as constituting merely a stub (see Fig. 7) stopping where it is here represented as broken off. The stub form has many advantages in that it permits the wheel which encounters a minor obstruction on the road to rise and pass over the obstruction, its spring yielding as necessary, without raising the weight of the body of the axle or vehicle frame; and this momentary elevation of the wheel is facilitated by the extraordinarily long bearing which this invention provides for up and down sliding, one end of the bearing being in the packing 12 and the other a considerable distance below at 52, the stress being received midway where the axle pierces the stock of the plunger. Each wheel may be mounted, as shown in Fig. 7, on a stub axle under a spring of the type shown in Fig. 3, and the vehicle body itself may be mounted

on springs, intervening between it and the vehicle frame, of the type shown in Fig. 1. When this arrangement is made the springs may bear a correlation, being designed on the principles hereinbefore described, by which, upon encountering minor obstructions in the road, any wheel rises easily over them with an unusually free and resilient action, without lifting the main weight of the vehicle; but if the obstruction be larger the wheel spring reaches its limit of contraction and the shock is transmitted through the automatic cushion thus formed in the wheel spring, lifting the vehicle frame, whose spring further absorbs it before transmission to the vehicle body. These two springs may be arranged with different degrees of resilience, so that shocks due to minor obstructions will not generally be transmitted to the springs under the vehicle body; while those of more serious importance will be cared for by that spring with a resiliency suited to such conditions. When thus arranged the parts attached to the plunger and moving with it consists of the wheel, the stub axle, and no more, relative weight and inertia of which as against the vehicle frame and the parts it supports should be as little as possible, thereby enabling these two parts to rise over obstructions with a facility which approximates the effect of a pneumatic tire on the wheel. The resilience of the chamber should be adjusted according to the load upon the wheel, so that the plunger when at rest under the load is near the limit of expansion. It will be noted that the pressure within may be adjusted according to the load by adding or removing air, which purpose may conveniently be accomplished by providing a connection to the extension receiver from an air pump carried on the vehicle or from a reservoir containing air at high pressure, and also an escape valve to the atmosphere, by means of which the conditions within the chamber may be varied by the operator as occasion requires.

If the septum be manufactured according to the method above mentioned, in which the sheet of rubber is in tubular form at the outset, the procedure may be first to place the rubber tubing on a form of suitable size, next to wrap a sheet of leather about it and make it fast, as before described; next to remove the rubber and leather thus united from the form, evert them, and place them again on a form with the rubber outside; and then to add the second sheet of leather.

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 continuously, such as an air pump or an air supply reservoir.

Therefore, the word "impervious" is not used in its strictest sense, but covers materials which are substantially impassable by air, even though not absolutely so.

I claim:

1. An expansible chamber, comprising the combination of a round casing with a plunger therein, an everted sleeve septum between them, and a soft, resilient disk septum at each end of the sleeve, mounted on the opposing chamber ends, and each joined to one of the sleeve ends.
2. In an expansible chamber comprising a round casing, a plunger and an everted sleeve septum; a fastening for the sleeve, comprising a soft, resilient disk septum; the sleeve septum being arranged in contact with the periphery thereof.
3. In an impervious chamber comprising a round casing, a plunger and an everted sleeve septum, composed of rubber and a supporting material; a fastening for the septum, comprising an annular peripheral adhesive attachment of rubber; a radial arrangement of ends of the supporting material, and means to grip the said supporting material in an axial direction.
4. In an expansible chamber comprising a round casing, a plunger and an everted sleeve septum, composed of rubber and a supporting material; a fastening for the septum, comprising two rubber disks, having the said supporting material of the septum end intervening between them in part, and the disks being connected by contiguous rubber in part, thus enveloping the supporting material end in rubber.
5. A laminated everted sleeve septum, in combination with means to fasten the same in place, comprising disks lapping alternately with the layers of the septum, one of the disks being soft, resilient and impervious.
6. The combination of an expansible chamber and an everted sleeve septum having a rubber layer and a supporting layer of other material; and a fastening therefor, comprising a rubber bed in the chamber wall, there being a connection therefrom to the septum of contiguous rubber.
7. The combination of an expansible chamber and an everted sleeve septum having a rubber layer; and a fastening therefor, comprising a cup formed in the chamber wall and a rubber bed inclosed therein.
8. The combination of an expansible chamber and an everted sleeve septum; there being a fastening therefor, comprising a cup in the chamber wall and a rubber bed therein, there being non-communicating grooves in the said cup against which the rubber bed is pressed.
9. The combination of an expansible chamber and an everted sleeve septum;

there being a fastening therefor, comprising a cup in the chamber wall and a rubber bed therein, there being a projecting part of the chamber wall locking said bed in place.

5 10. The combination, in an expansible chamber comprising a round casing and a plunger, of an everted sleeve septum, and a thick impervious disk in the chamber wall, the septum being arranged in impervious
10 contact on the periphery thereof, and a fillet retaining it in place.

11. The combination, in an expansible chamber comprising a round casing and a plunger, of an everted sleeve septum, and a
15 thick impervious disk in the chamber wall, the septum being arranged in impervious contact on the periphery thereof, a fillet retaining it in place, and means to sustain the fillet against displacement in the axial direction.
20 tion.

12. In apparatus of the class described, a septum having an external supporting layer, and an end fastening therefor comprising rubber disks between which said layer is
25 non-adhesively inserted; there being also

adhesive rubber connection between said disks.

13. In apparatus of the class described, a septum having an external supporting layer, and an end fastening therefor comprising 30 rubber disks between which said layer is non-adhesively inserted radially; there being also a rubber layer inserted between said disks, adhesively attached to each; and the whole arranged subject to expansive pres- 35 sure of the chamber.

14. An expansible chamber, comprising a round casing, a plunger therein, soft, resilient, impervious disks covering the opposing heads of the plunger and the casing, 40 and an everted sleeve septum joined to each; there being a passage piercing one head and disk, affording communication with the exterior of the chamber.

Signed by me at Boston, Mass., this 16th 45 day of May, 1910.

HENRY E. OXNARD.

Witnesses:

HAROLD S. LYON,
EVERETT E. KENT.