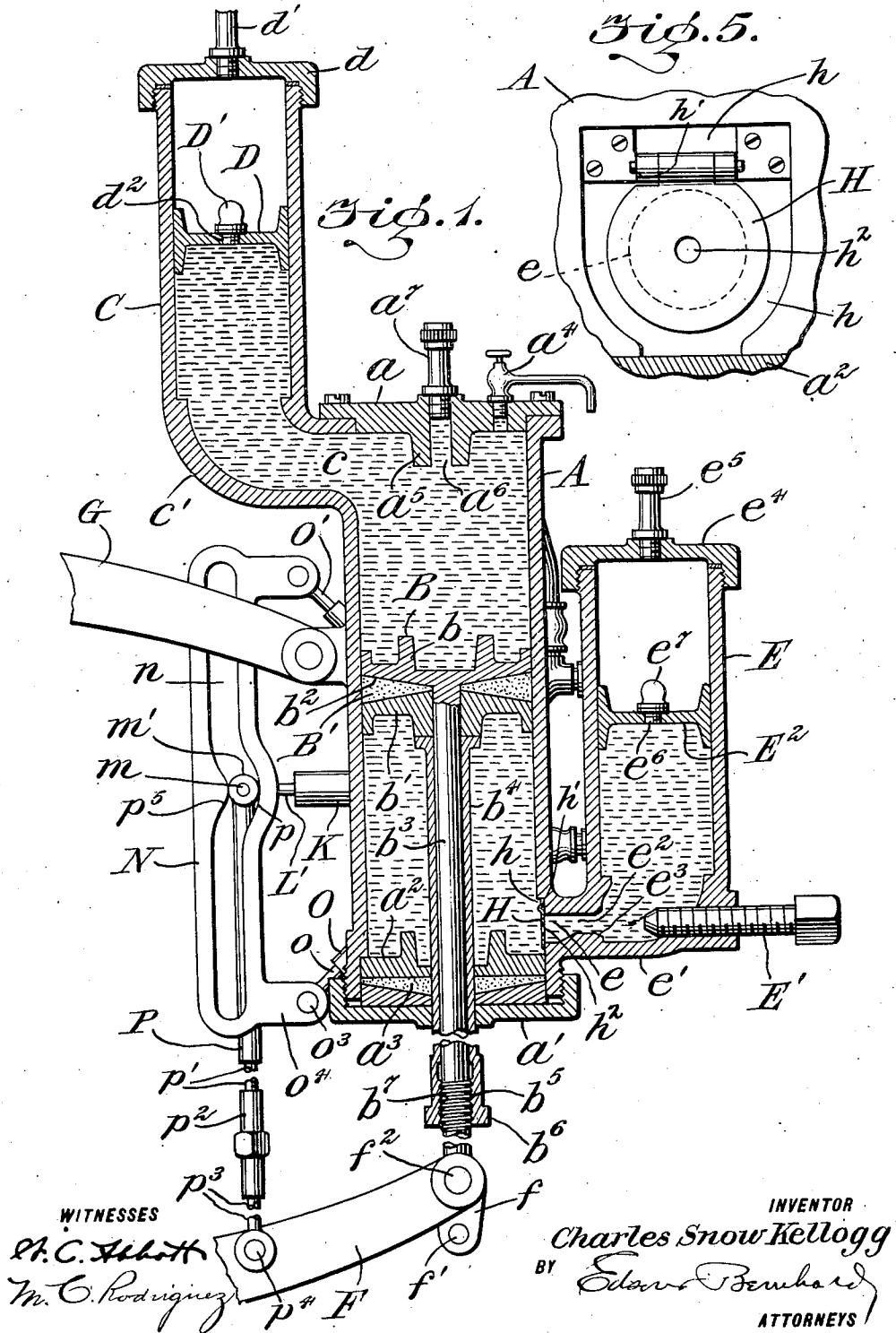


C. S. KELLOGG.
 FLUID CUSHION DEVICE FOR AUTOMOBILES.
 APPLICATION FILED APR. 16, 1914.

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Patented Jan. 14, 1919.
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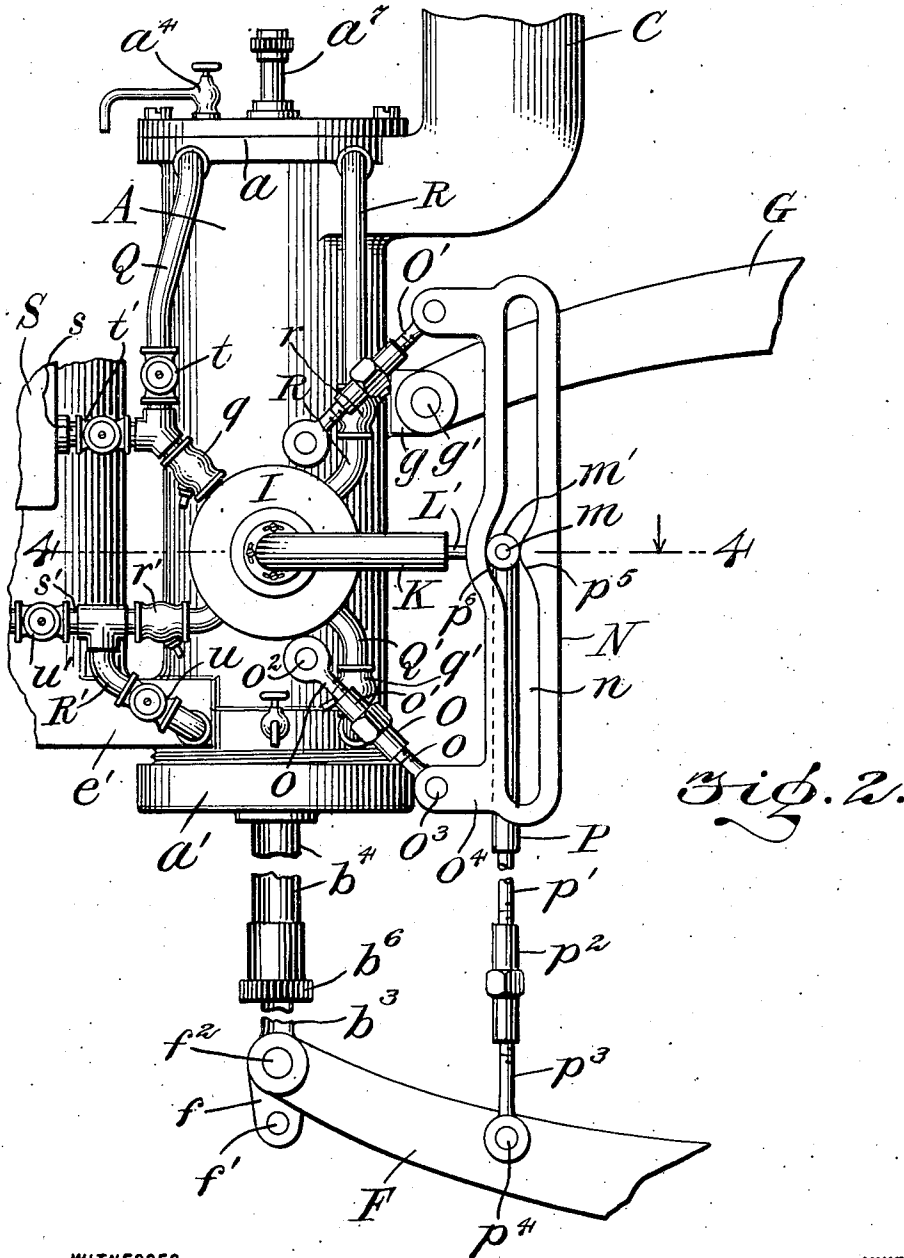


Fig. 2.

WITNESSES

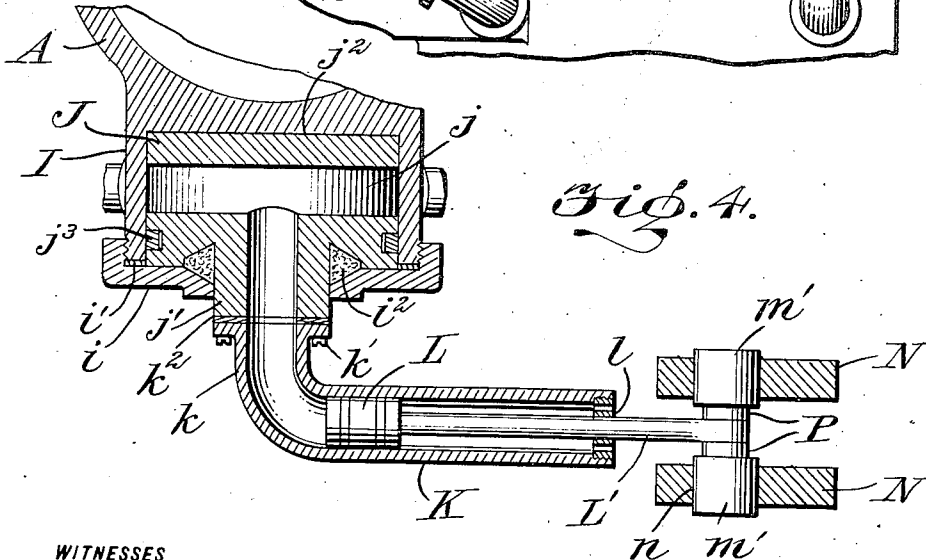
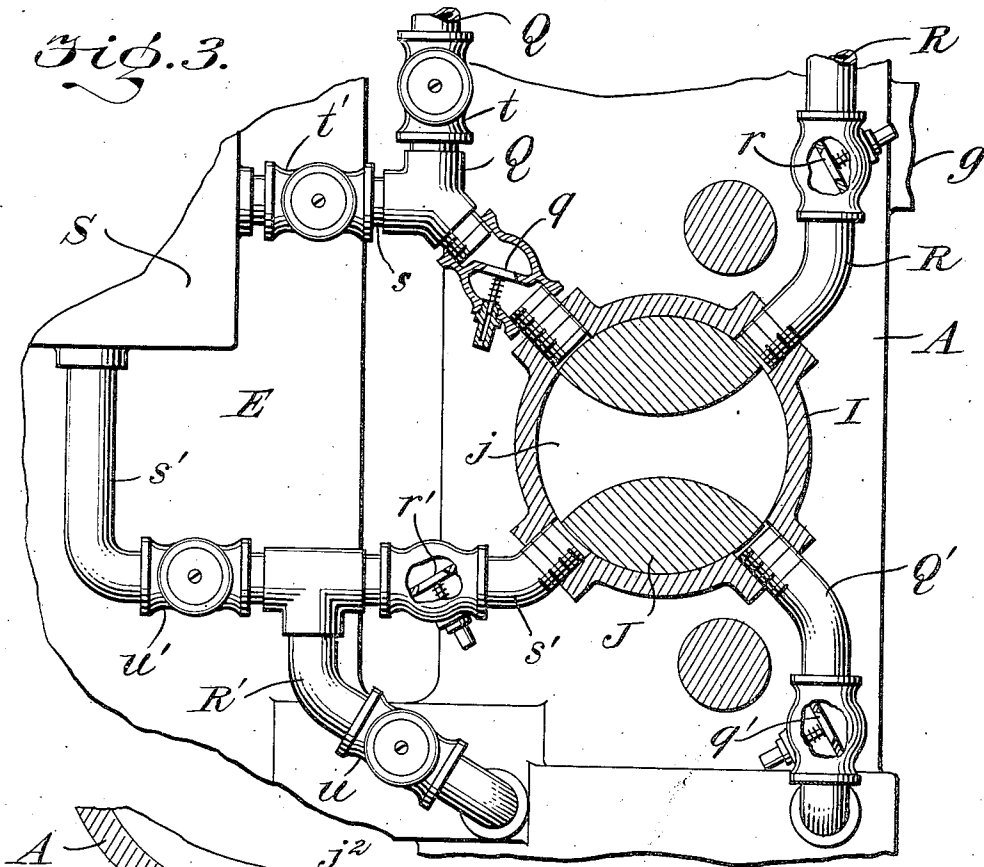
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1,291,016.

3 SHEETS—SHEET 3.



WITNESSES

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UNITED STATES PATENT OFFICE.

CHARLES SNOW KELLOGG, OF NEW YORK, N. Y., ASSIGNOR OF ONE-HALF TO HARRY I. BERNHARD, OF BROOKLYN, NEW YORK.

FLUID-CUSHION DEVICE FOR AUTOMOBILES.

1,291,016.

Specification of Letters Patent.

Patented Jan. 14, 1919.

Application filed April 16, 1914. Serial No. 832,150.

To all whom it may concern:

Be it known that I, CHARLES S. KELLOGG, a citizen of the United States, residing at the city of New York, borough of Manhattan, county and State of New York, have invented a certain new and useful Fluid-Cushion Device for Automobiles, of which the following is a specification.

This invention is a fluid spring for use on vehicles generally, although it is adapted; more particularly, for motor-driven vehicles. It may be, and preferably is, employed in connection with mechanical springs of one form or another, but in some instances my fluid spring is employed to the exclusion of, or as a substitute for, the mechanical spring, or can be used as a shock-absorber by attaching one part to the body and the other to the axle.

The purposes of the invention are, first, to utilize liquid and air in such manner that the jar and vibration on the vehicle body, due to the contact of the vehicle-wheels with obstacles and depressions in the road surface, will be communicated to a limited extent only to said body, special provision being made for taking care of or absorbing the recoil of the spring, which recoil immediately follows a compression of the spring and which recoil imparts a more or less violent shock to the car body dependent in most cases upon the extent of compression of the spring; second, to absorb the recoil due to the return to normal position of the moving parts of the fluid spring, and, third, to automatically control the liquid within the fluid springs (the latter being positioned usually at the respective corners of the vehicle body) so as to retain said body flexibly at a predetermined normal height irrespective of the load imposed upon said body, or the distribution of the load upon the body; whereby such automatic control of the fluid within the group of cushion devices tends to maintain the car body in a normal horizontal position, and thus precludes automatically the body from assuming a tilted or canted position relative to the running gear, it being understood that under all conditions the movable parts of the fluid spring are free to have a limited relative movement owing to the road conditions so that the fluid spring will act with a certain resiliency so as to absorb road shocks or jars.

Broadly stated, the first part of this inven-

tion embodies, in connection with a piston, two moving columns of liquid in contact with the respective faces or sides of said piston, the movement of said liquid columns being opposed by suitable cushions which in some cases may be mechanical springs but which are preferably composed of air or gas the compressibility of which is governed or controlled by the extent of movement of the liquid columns within the piston cylinders. The movement of each liquid column is opposed to greater or less extent by the compressible cushion and by the frictional resistance due to the flow of such liquid through ports connecting the piston cylinder with separate liquid and cushion chambers. In a practical embodiment of the invention, the piston is reciprocable within a cylinder, and means are provided for mechanically connecting said piston and the cylinder with the running gear and the body, respectively, of the vehicle. Although the piston and the two cushioned liquid columns may be operatively positioned within a single chamber, it is preferred to employ distinct chambers for containing the compressible air or gas cushions and the liquid columns, one of said chambers being connected by a port with the cylinder above the point normally occupied by the piston within said cylinder, whereas the other chamber is in communication with said cylinder by a port positioned below the normal position occupied by the piston within said cylinder, whereby the liquid columns, in contact with the upper and lower faces respectively of the piston, extend into the chambers, the upper parts of which chambers contain the compressible air or gas cushions.

Provision is made for establishing air or gas at different pressures within the separate chambers, *i. e.* air is under considerable pressure in that chamber the liquid column of which is in contact with the upper side of the piston, so as to afford a considerable degree of resiliency or flexibility to the liquid body when the wheels travel over a hump or other obstruction in the road, whereas the air or gas confined within the other chamber is under very considerable lower pressure, the relatively low pressure air cushion being relied upon, mainly, to insure a prompt flow of the liquid column into contact with the under face of the piston.

It is apparent that the attachment of the

piston and the cylinder to the gear and the body may be reversed, *i. e.* the piston being connected to the body and the cylinder to the gear.

5 Provision is made to secure two practical conditions which may, under some circumstances, be regarded as of minor importance, to wit:—the employment of a loose piston head or mechanical separator between
10 the liquid and the air or gas within the cushion chamber, so as to minimize the contact of the air or gas with the liquid, thus precluding to a very marked degree the emulsification of the air or gas with oil,
15 should the latter be used as the liquid column, and, further, to control or throttle the flow of liquid from beneath the piston, so as to result in a slow movement of the liquid check when the wheels descend into a comparatively deep rut in the road surface, thus
20 precluding a sudden drop of the wheels relative to the body and overcoming a violent recoil of the mechanism, such slow movement of the liquid check operating, also, to
25 overcome swaying movements of the body in traveling around a corner.

It is to be understood that the lower liquid column, or that body of liquid in contact with the under surface of the piston, performs important functions in my device for the reason that its movement in one direction is throttled or checked in order to absorb or take care of the sudden, if not violent, movement due to the recoil of the
35 spring, which recoil immediately follows a compression of the spring due to the wheels being lifted by an obstacle in the road. Furthermore, should the wheel drop into a rut or depression, or should the car when traveling at speed clear an obstacle, the car
40 spring has a tendency to force the unsupported wheel with great force in a downward direction, thus resulting in a more or less violent shock; but all such objections are
45 overcome in my device owing to the fact that the liquid column in contact with the under face of the piston is throttled, checked, or retarded when flowing into the lower chamber, thus overcoming any sudden movement
50 or shock on the car body. At the same time, however, the lower liquid column is free to follow an upward movement of the piston so as to remain in contact therewith, such free movement being due to the pressure of the
55 gas or air cushion upon the column and to the suction established in the piston cylinder by a relative movement between the piston and its cylinder; and, furthermore, the recoil of the movable parts of the fluid
60 spring is absorbed when said movable parts return to their normal positions.

Accordingly, it is to be understood that the first part of my invention embodies any means whereby two fluid columns are maintained in contact with the respective sur-

faces of a piston, it being preferred to employ two liquid columns, and, further, to oppose the movement of the liquid columns by compressible cushions of air or gas.

The second part of the invention embodies means whereby the car body is flexibly retained under all load conditions at a predetermined normal height with respect to the running gear. In accomplishing this end, it is preferred to employ on each liquid
75 spring a pump operating to automatically shift the liquid within the cylinder in one direction or the other with respect to the piston so as to return said piston under all load conditions to a predetermined flexible position within the piston cylinder, whereby the
80 body of the car, when said car is at rest, is maintained in a level position and at normal height with respect to its road contact regardless of the amount or distribution of the
85 load imposed upon the car body.

It is apparent that a number of my liquid springs are to be used, two, three or more as may be required, but it is preferred to employ four of such liquid springs, the same
90 being positioned at the respective corners of the car body. Now, should an excess weight be imposed upon the car, it is obvious that the body and its load will have a tendency to depress the cylinders to such an extent
95 with respect to the pistons that there results a disproportionate displacement of liquid below the pistons, tending to interfere to a great extent with the proper action of the liquid springs. Again, should the weight
100 imposed on the car body be unevenly distributed, one or more liquid springs will be depressed to a greater extent than the other liquid spring or springs, so that it follows the car body will be tilted or canted to an
105 undesirable position relative to the running gear.

My liquid-equalizing mechanism associated with each of the individual fluid springs operates when the vehicle is running
110 for a short period of time so as to impart, practically constantly, a limited relative movement to the parts composing each fluid spring, as a result of which the fluid is shifted so as to automatically correct or
115 overcome these two serious objections due to overloading or to an unequal distribution of the weight, such liquid-equalizing mechanism of one fluid spring acting independently of the similar equalizing mechanism of
120 the other fluid springs. It follows that, when the car is in motion and a relative movement between the body and running gear takes place, the liquid-equalizing devices of the fluid springs are brought into
125 action for the purpose of returning the piston or pistons to a normal predetermined position within the cylinder or cylinders, and as each fluid spring operates under such abnormal conditions to substantially cen-
130

tralize the piston within its corresponding cylinder, the result is that in a short time all the fluid springs will be restored to a normal condition, whereby the car body will be returned to a normal predetermined height relative to the running gear in event of an overload, and in the case of unequal distribution of the load the car body will be returned to and flexibly maintained at the desired level position so as to prevent the body from assuming a canted or tilted position with respect to the running gear.

Other features and advantages of the invention will appear in the course of the following detailed description.

In the drawings,

Figure 1 is a vertical central section through a fluid spring embodying this invention.

Fig. 2 is a side elevation, on a somewhat smaller scale, illustrating one embodiment of the automatic pump mechanism for shifting the fluid from a point above said piston to a point below said piston, or vice versa, according to a variation in the load imposed upon the car body, or to an unequal distribution of said load.

Fig. 3 is a vertical section, on an enlarged scale, illustrating the controlling valve and the liquid connections between a pump and the respective end portions of the fluid containing piston cylinder.

Fig. 4 is a horizontal section through the pump mechanism and a part of the controlling valve, the plane of the section being indicated by the dotted line 4-4 of Fig. 2.

Fig. 5 is a detail sectional view illustrating the automatic throttle for controlling the flow of that liquid column which is normally in contact with the under surface of the piston.

A designates a piston cylinder, and B a piston reciprocable therein. The cylinder and the piston are adapted to be connected respectively with a car body and the running gear thereof, although it is apparent that the parts may be reversed by connecting the piston with the car body and the cylinder with the running gear.

Cylinder A is closed at its top by a head a and at its bottom by a head a' , the latter being screwed on the lower end of the cylinder so as to cooperate with a false bottom a^2 in a manner to compress a packing material a^3 between the false bottom and the lower head, thus minimizing leakage. The upper head a is fastened by bolts, screws, or other equivalent means to the cylinder. Said upper head a is provided with a draw-off cock a^4 and with a boss a^5 , the latter being provided with a passage a^6 adapted to be closed by a plug a^7 . It is apparent that surplus liquid in the upper part of the cylinder may be discharged by opening the cock a^4 . Furthermore, the plug a^7 may be removed in

order that additional liquid may be poured through passage a^6 into the cylinder above piston B therein.

C designates a chamber positioned exteriorly to cylinder A and connected thereto by a port c positioned above the piston B. This chamber C is provided at its lower part with an elbow c' which is attached to, or made in one piece with, the cylinder, said elbow c' forming the port c which establishes communication between the lower part of chamber C and the upper part of cylinder A. This chamber and the upper part of the cylinder contains a suitable quantity of liquid, such as oil, glycerin, or the like, adapted to form a liquid check above piston B. The upper part of the chamber C is closed by a head d to which is attached an inflating valve or a pump connection d' , whereby air or gas may be forced into the upper part of chamber C so as to establish pressure within the chamber and above the liquid column, which latter partly fills chamber C and the upper part of cylinder A.

Operating loosely within the chamber C is a piston head D with floats on the surface of the liquid contained in chamber C and the upper part of cylinder A. This piston head is free to rise and fall within the chamber C by a variation in the level of the liquid within said chamber, and, if desired, said piston head may be provided with a central aperture d^2 which is adapted to be closed by a plug D' , thus making provision for replenishing the supply of liquid within the chamber C. The main purpose of the piston head D is to mechanically separate the air or gas from the liquid, whereby emulsification of the liquid is substantially prevented. The air or gas which is forced in the upper part of chamber C above the piston head or mechanical separator D establishes an elastic cushion within said chamber and above the moving liquid column, the pressure of said cushion being sufficient to sustain a proportional part of the weight of the car body and the weight imposed thereon.

E is another chamber positioned exteriorly to cylinder A, and having a liquid connection with the piston chamber through a port e positioned normally below the lowermost limit of travel of piston B within said cylinder A. Like the chamber C, the other chamber E is separate from, and is positioned exteriorly to, the piston cylinder A, it being preferred to arrange chamber C on one side of the cylinder A above the piston B therein, whereas the other chamber E is positioned at the opposite side of cylinder A and preferably parallel thereto. Chamber E is attached to or made integral with cylinder A, and the bottom part e' of said chamber E is constructed to form a passage e^2 , one end

of which terminates in a port e , whereas the other end of said passage terminates in a valve seat e^3 . The chamber C is in communication normally with the piston cylinder through an unobstructed port c , the area of which is less than the cross sectional area of the chamber, but in the case of the other chamber E the liquid connection between said chamber E and the lower part of the piston cylinder is by means of a port the cross-sectional area of which is variable in order to throttle the flow of liquid from the cylinder to the chamber, or vice versa.

The flow of liquid through the port is throttled by suitable means, herein shown as a valve E' , consisting of a threaded stem screwed into an opening tapped in the wall of chamber E, one end of said stem being conical to fit the valve seat e^3 , whereby said valve may be adjusted toward or from the valve seat so as to control or throttle the flow of liquid through the passage e^2 . The upper part of chamber E is closed by a head e^4 to which is attached an inflating valve or pump connection e^5 , thus providing means for establishing the pressure of air or gas within the upper part of chamber E. Within said chamber is a piston head or mechanical separator E^2 adapted to float on the surface of the liquid column which partly fills the chamber E and the lower part of the piston cylinder below said piston B. From the foregoing description it is apparent that the upper part of the cylinder A above the piston B is filled with a column or body of liquid which also fills a chamber C below the piston head D therein, whereas the lower part of cylinder A is filled with liquid below the piston B, which liquid below the piston fills the passage e^2 and the chamber E up to the level of the piston head E^2 within said chamber, thus providing two separate bodies or columns of liquid which are normally in contact with the upper and lower surfaces of piston head B. These independent columns of liquid are free to move within the piston chamber and chambers C E by a relative movement between cylinder A and piston B, but in each instance the movement of the liquid column is opposed by an elastic cushion of air or gas under pressure within the upper part of the chamber within which the liquid column is movable. In this connection it may be stated that the pressure of the air or gas cushion within chamber C is much greater than the corresponding air or gas cushion within the upper part of chamber E. For example, the pressure of the air or gas cushion within chamber C may be eighty pounds to the square inch, more or less, in order that the fluid and the cushion of chamber C will be of a capacity to sustain the weight of the car body and the load, whereas the pressure of the air or gas cushion within the upper part of cham-

ber E may not exceed five or ten pounds to the square inch, such air or gas pressure being employed within chamber E for the purpose of insuring a prompt flow of the liquid from chamber E into the lower part of cylinder A so that the liquid will at all times be in contact with the under side of said piston B.

The piston B is constructed in a novel way to enable the packing thereof to be adjusted or tightened without requiring said piston to be removed from the cylinder or obtaining access to the piston interiorly of the cylinder. As shown, said piston consists of two members b b' , the opposing faces of which are inclined reversely to each other at b^2 , and between such inclined faces of the two members is interposed packing B' adapted to be compressed by a relative movement of the members b b' . The member b of the piston is provided with the stem b^3 , whereas the other member b' is a part of a sleeve b^4 , the latter incasing the stem b^3 . The stem and the sleeve extend through the lower head a' of the cylinder, and said sleeve is provided at its lower exposed part with an internal thread b^5 , and with a polygonal or square end b^6 , said threaded part of the sleeve being screwed upon a threaded lower extremity b^7 of the stem b^3 , whereby the sleeve may be rotated upon the threaded part of the stem to secure a relative movement of member b' with respect to member b , thus compressing the packing B' so that the piston will have the desired frictional contact with the walls of the cylinder A to prevent leakage of the liquid from one part of the cylinder into another part thereof.

As shown in Fig. 1 the lower extremity of the piston stem b^3 is connected with a link f by a pin f' , and the upper end of this link is connected by another pin f^2 to a spring F or other part of the running gear, thus operatively connecting piston B to a member, as F, of said running gear. The cylinder A is connected with the body of the car by means of an arm or bracket G, as shown more particularly in Fig. 2, said cylinder being provided exteriorly with an attaching member g having pivotal connection with the arm or bracket G by a pin g' .

The valve E' is a manually operable throttle which is adapted to be set into any number of predetermined positions for controlling the flow of liquid between the chamber E and the piston B, but in addition to this throttle it is preferred to employ an automatic throttle, the same being in the form of a valve H, the position of which is indicated in Fig. 1, and which is shown more clearly in Fig. 5. The automatic throttle is a check valve positioned within a recess h provided in the wall of the cylinder A at or adjacent to the throttle port e . This automatic throttle valve is hinged or piv-

oted at h' , and it is provided with a port h^2 , the area of which is less than the cross sectional area of passage e^2 and port e . The automatic throttle valve is adapted to be shifted by the movement of the liquid column in o and out of the chamber E , but when the piston B is moved in a downward direction by the recoil of spring F , said piston acts upon the lower column of liquid which in turn presses the automatic throttle valve H to its seat, but at this time the liquid flows through the port h^2 of the automatic throttle, whereby the speed of movement of the liquid column under the recoil of the spring is checked to a substantial degree, thus eliminating the violent shock which ordinarily would be transmitted to the car body by the recoil of the spring acting through the piston upon the lower liquid column. Upon the return of the piston to a normal position within cylinder A , the lower liquid column flows from the chamber E into the cylinder below the piston, and at this time the automatic throttle valve H is shifted to a substantially wide open position due to the flow of the liquid, it being observed at this point that said lower liquid column is returned to the cylinder by two forces acting in conjunction, namely, the suction of the piston as it travels upward within the cylinder A and the pressure of the air or gas cushion within chamber E upon the piston head E^2 and the column of liquid which extends from piston head E^2 within said chamber E to the piston B within cylinder A , said compressible cushion acting upon the lower fluid column to insure a prompt return of said liquid body into the cylinder and to maintain said liquid column normally in contact with the under surface of said piston.

Piston head E^2 is shown as having a port e^6 which is normally closed by a plug e^7 , thus enabling the operator to remove the plug e^7 and pour the liquid through port e^6 into the chamber E below piston head E^2 , whereby the supply of liquid in chamber E and in the lower part of the piston cylinder may be replenished when desired.

The fluid spring as thus far described operates as follows: The fluid spring is mounted on the vehicle by connecting cylinder A with bracket G , and piston B with spring F , although the arrangement may be reversed. The piston B occupies a position within cylinder A substantially midway between ports e and e^2 , the space between piston B and piston head D being filled with liquid so as to constitute one body of liquid in contact with the upper surface of the piston B , whereas the space between piston head E^2 and piston B is filled with another body of liquid which is in contact with the under surface of the piston B . Air or gas under pressure is now forced through nipple or

pipe d' into the space of chamber C above piston head D , and the air or gas under pressure is also admitted through inflating valve or pipe e^5 into chamber E above piston head E^2 therein. In this connection it is desired to state that the pressure of the air or gas cushion within chamber C is much greater than the pressure of the compressible air or gas chamber within chamber E , for the reason that the cooperating liquid column above the piston B , and the air or gas cushion within the chamber C which oppose the movement of said upper liquid column, should be great enough to sustain a proportional part of the weight of the car body and its load.

It should be understood that the liquid to form the two liquid columns, and the air or gas to constitute the compressible cushions which cooperate with the respective liquid columns, should be introduced into the fluid spring while the piston B is maintained in a substantially central position, the mechanical spring F of the running gear being under restraint; but after the liquid bodies and the air or gas shall have been introduced into the fluid spring, the restraint of mechanical spring F is taken off so that the weight of the car body will be imposed upon the fluid spring. The quantities of liquid and the air or gas under pressure may be proportioned to sustain the weight of the car body and its load. It is to be understood that a number of fluid springs constructed as herein described are employed in connection with the body and the running gear. In some cases it may be sufficient to employ only two of the fluid springs; in other cases three of the springs may be used, but it is preferred to employ four of said fluid springs, the same being positioned substantially at or adjacent to the respective corners of the car body, whereby the weight of the body and its load will be distributed substantially uniformly upon the four fluid springs. The parts composing the fluid spring are indicated to occupy the positions illustrated in Fig. 1 under a normal load and a substantially equal distribution of the load on the body.

When a wheel of the vehicle is lifted by an obstacle in the road, the spring F is compressed, thus imparting an upward movement to piston B within cylinder A , which upward movement of the piston imparts an impulse to the upper liquid column so as to move piston head D within chamber C , as a result of which the upward thrust of the piston when the spring is first compressed will be cushioned by the compressed air or gas in chamber C so that a very slight shock or vibration will be transmitted to the car body, but when the spring F recoils then, ordinarily, the tendency would be to communicate a violent shock or jar

to said car body. In my invention, however, the recoil of the spring F is checked by the liquid column below the piston B. In the ordinary spring suspended body the recoil of the spring following the compression thereof operates to impart a severe jolt to the car body, but by throttling the lower liquid column when the piston moves downward in the cylinder this shock or jar is almost entirely eliminated. It is apparent that when spring F recoils and pulls on piston B so as to move in a downward direction within cylinder A, the piston will act upon the lower liquid column, forcing the valve H to its seat, and causing the liquid to flow through the port of the valve, the port *e* of passage *e*² and into the lower part of chamber E so as to raise the piston head E² against the compressibility of the air or gas cushion within said chamber. Now as the flow of liquid is throttled under the downward movement of the piston brought about by the recoil of the spring, it follows that the displacement of the lower liquid column will be comparatively slow owing to the restricted port of the throttle H, as a result of which the piston cannot be pulled downward suddenly by the recoil of the spring and the speed of movement of the parts is checked to a marked extent so that no violent shock or jar will be communicated to the car body under the recoil of the spring. When the spring is restored to equilibrium the piston moves upwardly within the cylinder to resume a normal position, and this upward movement of the cylinder is followed by a quick responsive movement of the lower liquid column due first to the suction created by the upwardly moving piston, and, second, by the pressure of the air or gas within chamber E acting through the piston head E² to return the column to the lower part of cylinder A below the piston B therein.

The throttled movement of the liquid composing the lower column in contact with the under surface of the piston performs another important function in the operation of the fluid spring when the wheels drop into a rut or depression in the road surface. In the case of ordinary spring supported vehicle bodies, the wheel when dropping into a rut or depression is thrown forcibly in a downward direction by the action of spring F, thus resulting in a severe jolt on the car body, but a vehicle equipped with my fluid springs is free from this jolt or jar upon the wheels dropping into a rut or depression for the reason that the downward movement of the spring is checked and controlled by the liquid column below the piston. It is apparent that under these conditions the downward movement of the piston will force the lower liquid column through the restricted port in the automatic throttle valve,

the liquid flowing from the lower part of cylinder A through the valve, passage *e*² and upwardly into chamber E against the resistance offered by the compressible cushion therein, but as this flow of liquid is comparatively slow the piston is prevented from having any sudden downward movement, thus minimizing the shock on the car. When the wheels again travel on level ground the piston is returned to its normal position and this upward movement of the piston is followed by a corresponding upward movement of the liquid column in the cylinder, but such upward movement of the piston displaces the upper liquid column the movement of which is resisted by the compressible air or gas cushion within the upper part of chamber C, whereby the liquid columns in contact with the respective surfaces of the piston absorb any sudden or undue movement of the wheels or running gear owing to the fact that the compressible air cushion cooperating with the upper liquid column will cushion the upward movement of the piston, whereas the movement of the lower liquid column is throttled and controlled so as to overcome a sudden downward movement of the piston within the cylinder.

It will be noted that each liquid column is free to move in a direction which compresses the cushion formed by the air or gas in the upper part of the chamber, and while it is preferred to employ a compressible cushion formed by a gaseous medium, it is not desired to limit the invention to such a cushion, for the reason that a mechanical yielding device may be substituted for the air or gas cushion.

The loose piston head employed upon the top surface of the moving body or column of liquid performs an important function in my structure, for the reason that said loose piston acts as a mechanical separator between the body of liquid and the air or gas under pressure so as to preclude any direct contact of the air or gas with the liquid, whereby the air or gas will not mix or emulsify with the liquid. It is apparent that each column of liquid is continuous between one face of the cylinder piston and one face of the piston head in the liquid containing chamber, said piston head being free to rise or fall within the chamber so that the liquid column will respond instantly to the movement of the piston, and said liquid column will remain normally in contact with a face of the piston, but this prompt movement of the piston head within the compression chamber is due, mainly, to the fact that the piston head is exposed to the pressure of the air or gas cushion.

As hereinbefore stated, it is preferred to employ a number of the fluid springs between the running gear and the body, and, furthermore, the springs are positioned at

the respective corners of said body. It is essential that the pistons and the cylinders of the respective fluid springs shall be movable relative to each other in order to perform the functions of absorbing the shock and jar brought about by the wheels of the vehicle traveling over obstacles and depressions in the road surface, but it is apparent that the imposition of an excessive load upon the car body will depress the cylinders to an undesirable extent (with respect to the pistons and, furthermore, that an unequal distribution of the load upon the body will depress the cylinders of one or more of the fluid springs to a greater extent than will take place in the cylinders of the other fluid springs, as a result of which excessive loading or unequal distribution of the load the body will either be depressed too close to the running gear or the body will be caused to assume an inclined or tilted position with respect to said running gear. To overcome these and other objections which are or may be brought about in the practical use of a car equipped with fluid springs of this invention, I have provided means whereby the distribution of the liquid in the fluid springs will be equalized so as to compensate for either excessive loading or an unequal distribution of the load, and to this end each fluid spring is equipped with means, usually an automatic pump, operated in a suitable way or by appropriate means, but preferably by a relative movement between the body and the running gear for shifting the liquid within the cylinders of the fluid springs so as to return the piston or cylinders to such relative positions that each piston will be substantially central between the ports by which the liquid containing chambers are in communication with the piston cylinders.

Positioned exteriorly on the cylinder A of each fluid spring is a chest I, preferably in the form of an annular casing within which is operatively arranged a controlling valve J, the latter being provided with a transverse liquid way or passage *j* and with a tubular trunnion *j'*. The valve is proportioned and constructed to fit tightly within the chest I, but it is free to oscillate or rock therein, the inner face *j²* of the valve having tight engagement with a corresponding inner face of the valve chest, whereas the peripheral portion of the valve is provided with one or more packings *j³* so as to substantially preclude leakage. The free end of the valve chest I is closed by means of a head *i* which has screw-threaded engagement with the chest, the packing *i'* being interposed between the head and the edge of the chest, see Fig. 4. The tubular trunnion *j'* of the controlling valve passes through a suitable opening provided in head *i* of the valve chest, it being preferred to employ a packing *i²* around this tubular trunnion so

as to substantially preclude leakage. The passage in the tubular trunnion is in direct communication with the port or way *j* of the controlling valve, and communicating with this tubular trunnion is a pump cylinder K, the latter being provided at one end with an elbow *k* which is attached fixedly by bolts *k'* and a packed joint *k²* with the protruding end of said tubular trunnion *j'*. The pump cylinder thus has direct communication with the port *j* of valve J through the tubular trunnion *j'* thereof, and this pump is attached fixedly to said valve in order that the pump and the valve may have a simultaneous rocking or turning movement, such turning movement being communicated by the pump to the valve as will presently appear. As disclosed more particularly in Figs. 2 and 4, the pump cylinder K is positioned alongside of the valve chest and extends in a generally radial direction therefrom, said pump cylinder being shown in Fig. 4 as having a guide *l* at its outer portion, within which guide is fitted the rod *L'* of a pump piston L, the latter being reciprocatory within the cylinder K. The outer end of the pump piston is provided with a cross-pin *m*, on the end portions of which are loosely mounted friction rolls *m'*, said friction rolls being positioned to travel within slots *n* of vertically positioned cam bars N, the cross pin *m* and guide rolls *m'* thereon constituting a cross head. The cam bars N are parallel to each other and occupy vertical positions adjacent to the outer end of the pump cylinder, said cam bars being shown as occupying normally vertical positions in cooperative relation to the cylinder and the piston rod of the liquid circulating pump. Any suitable means may be provided for supporting the cam bars in fixed relation to the pump, but it is preferred to employ means for adjustably supporting said cam bars in cooperative relation to the pump piston so as to vary the stroke of said piston as may be desired. In Fig. 2 the bar supporting means is shown as extensible arms O O' each composed of sections *o* adjustably coupled by a sleeve *o'*, whereby the bar may be lengthened or shortened as desired. One end of each bar is attached fixedly to cylinder A by bolts *o²*, whereas the other end of the bar is fastened by a bolt *o³* to a lug *o⁴* on the cam bar N. It is apparent that by lengthening one bar O and shortening the other bar O' the lower end portion of the slotted cam bar may be shifted outwardly and the upper end portion shifted inwardly with respect to the valve chest, but a reverse adjustment of the cam bar may be obtained by shortening the lower bar O and lengthening the upper bar O'. The cam bar may also be raised or lowered by adjusting the supporting bars O O', and thus provision is made for changing the position of the cam bars with respect to the

shaft of the cross head on the pump piston, whereby the stroke and capacity of the pump may be varied as desired. The slot n in each cam bar is offset at $p^5 p^6$, said offsets being intermediate the straight end portions of the slot.

It will be seen that the pump mechanism is carried by the cylinder A which is attached to the body, and in order to operate the pump by a relative movement between the body and the running gear means are provided for connecting the cross head of the pump piston with the spring F or other part of the running gear. Accordingly, I employ links P the upper ends of which are fitted loosely on the cross-pin m' so as to lie between the parallel bars N, said links being connected at their lower ends to a threaded stem p' which is coupled by a sleeve p^2 to a rod p^3 , the lower end of which is connected by a bolt p^4 to the spring F. It will be noted that the links P are connected with the spring of the running gear and the pump K is carried on the cylinder A attached to the body, as a result of which a relative movement between the spring and the body will reciprocate the links P so as to impart movement to the cylinder K, piston rod L' and the valve, thus turning the parts in a manner for the pump and the valve to adjust themselves to the relative movement of the body and running gear and for the cross head of the pump piston to travel in the cam slot of the bars N, whereby the pump is self-adjusting and the cam bars act through the cross head to impart reciprocating movement to the pump piston L within cylinder K.

The valve chest is connected by two independent liquid connections with the upper and lower parts of cylinder A. One set of liquid connections consists of pipes Q Q', whereas the other set of liquid connections consists of pipes R R'. The pipes Q Q' are attached to the valve chest at diametrically opposite points to each other so that in one position of valve J the adjacent ends of pipes Q Q' will communicate with the liquid passage j of said valve. The pipe Q is connected at its upper part to the top end of cylinder A, whereas the pipe Q' is connected to the lower part of said cylinder, the pipes Q Q' communicating with the cylinder at opposite sides of the limit of travel of piston B within cylinder A. Said pipe Q is provided with a check valve q and the other pipe Q' is provided with a check valve q' , said check valve q operating in a direction to permit the liquid to pass from the upper part of cylinder A through the port j in the controlling valve J and into the lower part of said cylinder A, said check valves of the two pipes Q Q' operating to preclude a reverse flow of the liquid, i. e. to prevent the liquid from flow-

ing from the lower part of the cylinder A into the upper part of said cylinder. The other set of pipes R R' are similarly arranged, that is to say, the adjacent ends of the pipes R R' are connected with valve chest I at diametrically opposite points to each other so that the pipes R R' will permit the flow of liquid through them when the valve J is adjusted for the port j thereof to register with the open adjacent ends of the pipes R R'. The other end of the pipe R is connected to the upper part of cylinder A, whereas the other pipe R' is connected to the lower part of said cylinder, said pipes R R' being provided with check valves $r r'$, respectively, which check valves $r r'$ open in opposite directions to the check valves $q q'$ in the pipes Q Q', respectively. It is thus apparent that the valves in the pipes Q Q' open in a direction which permits the flow of liquid from the upper part of cylinder A into the lower part thereof, whereas the check valves in the pipes R R' open in a contrary direction for the liquid to flow from the lower part of cylinder A into the upper part of the same cylinder.

In the normal position of the body with respect to the running gear the cylinder K and piston L are substantially horizontal, as in Fig. 2, for the cross head of the piston to occupy the offset part of the slot in the cam bars, and in the described position of the parts the valve J is adjusted for its port j to be out of register with the two sets of liquid connecting pipes, thus precluding the flow of liquid through the valve from either the top or bottom part of cylinder A. The piston B within the cylinder occupies a substantially normally central position between the ports $c e$, although said piston is free to reciprocate within the cylinder under the relative movement between the body and the running gear under normal load conditions and under an equal distribution of the load on the body.

The imposition of an excessive load upon the body, however, is followed by a downward movement of cylinder A with respect to piston B so that the piston will occupy a position within the cylinder too close to port c , as a result of which the upper liquid column is elevated within chamber C so as to undesirably compress the air or gas cushion therein and, furthermore, the lower liquid column will be raised to an undesirable level within the lower part of cylinder A and lowered to a similar undesirable level within chamber E. Under these conditions the slotted bars N attached to cylinder A will be lowered along with the cylinder A, and thus the crosshead of the piston L will work in the slots of the bars at a point above the middle of said bars. Now, when the vehicle is running and a relative movement takes place between the body and the run-

ning gear, such movement will actuate the links P to raise and lower the cross-head of the pump within the slot *n* of the cam bars and the piston L will thus be reciprocated within the pump cylinder, but when the mechanism is lowered by the load upon the body, the pump cylinder and the valve will be turned so that the port *j* in said valve will register with the pipes Q Q'. Now, the operation of the pump piston within the cylinder will draw liquid from the upper part of cylinder A and pipe Q forces the liquid through pipe Q' and into the lower part of the cylinder, this operation being continued until fresh liquid is pumped into the lower part of cylinder A to restore the piston B to a normal predetermined position within said cylinder A, thus equalizing the distribution of liquid within cylinder A. This action takes place in the cylinder of each fluid spring, the operation being performed when the car runs for a comparatively short distance, and thus all the fluid springs will be operated by the pumps so as to restore the pistons to normally predetermined positions within the cylinders of said springs, as a result of which operation the body will be restored to a predetermined height relative to the running gear. It is apparent, furthermore, that upon the removal of the excessive load, a reverse action of the parts will take place, such reverse action being brought about by the relative movement between the body and the running gear so as to shift the pump cylinder and the valve J to a position wherein the port *j* of the valve will register with the pipes R R', respectively, whereupon the pump will operate to draw liquid from the lower part of cylinder A through pipe R' and to force the liquid through the pipe R into the upper part of the cylinder, thereby effecting a re-distribution of the liquid in the cylinders of the fluid springs so as to again restore the pistons to a normal predetermined position between the ports *c e*. Should the load be unequally distributed upon the rear of the body it is apparent that the cylinders of the rear springs will be depressed to abnormal positions so as to shift the valve J and operate the pumps in a way to re-distribute the liquid in the cylinders of said fluid springs until the pistons within said cylinders are restored to the normal predetermined positions, thereby bringing the car body to a normally horizontal position and at a predetermined height relative to the running gear.

The operation of shifting the liquid in the cylinders of the fluid springs takes place automatically to compensate either for excessive loading of the car body or for an unequal distribution of the load, said operations being effected by a displacement of the car body from a normal predetermined dis-

tance relative to the running gear and to the relative movement between the car body and the running gear when the car is in motion.

Provision is made for replenishing the supply of liquid in cylinder A either above or below the piston by the operation of the pump. To this end a liquid reservoir S is employed and the pipes Q R' are shown as having branch connections *s s'* with said reservoir. The pipe Q is provided with a valve *t* which is closed when the valve *t'* in the branch pipe *s* is open. Similarly, the pipe R' is provided with a valve *u* which is closed when the valve *u'* in the branch pipe *s'* is open, whereby the pump will draw liquid from the reservoir S when valves *t u* are closed and valve *t' u'* are open, thus allowing liquid to be forced into the upper or lower parts of cylinder A by the automatic operation of pump K L.

Although I have described that the liquid is shifted in the cylinders by the automatic operation of certain pumps which are actuated by the relative movement between the body and gear, it is apparent that this shifting of the liquid may be performed by manual operation through suitable valves, and, further, that a liquid circulating pump operated from any source of power may be employed to obtain the effect desired.

While I have described that the pressure of the air or gas cushion in chamber E is considerably lower than the corresponding pressure in chamber C, it is evident that the pressures in the two chambers may be equal under certain conditions, or the relative pressures in the two chambers may be proportioned as found necessary or desirable.

In my fluid spring the area of surface exposed to contact of liquid on its top side (termed the compression surface) exceeds the area of surface exposed to liquid on its bottom surface (termed the expansion surface) by reason of the presence of the piston rod connected to said lower piston surface. This variation in the area of the piston surface is important for the reason that in a device of this character it is the difference in pressure of the cushioned liquid columns which controls the suspending power of the spring, and, further, it is desired to maintain elastic pressure in contact with the compression and expansion sides of the piston to insure the requisite movement of the liquid cushions.

It is apparent that the compression stroke of the piston should be as easy and as soft as possible, and of as great length as possible, being limited only by the distance the piston can travel without hitting the top of the cylinder; and, in the case of fast driving, by the amount of swaying and its interference with control of the car, and with driving on steep side grades

where there is danger of upsetting. It is also advantageous, after the spring has become compressed, for the piston to return as speedily as possible to normal position. When said piston reaches that normal position, however, its return movement should be softly resisted, and it is at this stage of the operation that the retarded flow of one liquid column by the valves H, E are of special utility, said retarded flow or choke of the liquid column taking effect shortly before the piston reaches its normal position.

The advantage of a greater or less expansion beyond normal in the spring is almost entirely dependent upon the amount of speed at which the vehicle is to be driven. In fast driving, the expansion should be slight and rather slow, for the reason that if it is rapid the wheels will drop into many road depressions or holes where they would otherwise be carried over by the inertia of the vehicle, whereas in slow driving the spring should expand and allow the wheels to seek the bottom of the road depressions or holes as quickly as possible, and with as little tendency to carry the body down as possible. Excessive expansion will have a tendency, also, to permit the danger of the car tipping over, and the danger of swaying when going around corners, for as one side of the car is going down the other side of the car will go up.

The adjustment of the liquid columns and of the various working parts in my fluid spring will depend upon the character of roads to be traveled, the speed at which the car is to be driven, the weight of the body, and the ratio between the weight of the body and the running gear of the car. The adjustments which it has been sought to accomplish in this device are the control of (a) the length of the compression stroke of the piston; (b) the resistance opposed to the compression stroke; (c) the length of the expansion stroke; (d) the resistance opposed to the expansion stroke; (e) the speed at which the expansion stroke can take place; (f) the relative speed at which the recoil from both strokes can take place; and (g) an automatic arrangement whereby the relative pressure below and above the piston may be altered by the transfer of liquid one way or the other in order that the normal position of the piston may be the same irrespective of the amount of load sustained.

The pump employed in a preferred form of the fluid spring is so arranged that it is actuated by the expansion and compression of the spring and the recoil from expansion and compression, and the valve is automatically moved with the pump, so that when the pump is being actuated by compression and its recoil, liquid is moved from below the piston to above the piston, and

that the reverse action takes place while the pump is actuated by expansion and recoil from compression. When the spring is unduly compressed, the constant road vibrations will pump the liquid from below the piston to above the piston until the piston shall have been returned to its normal position. Then, if the load is removed and the spring expands to a position beyond normal, the road vibrations will cause the pump to deliver liquid from above the piston to a point below it until the piston shall have been returned to a normal position. The pump operates automatically, but it is capable of manual adjustment in such a manner as to vary the normal position of the piston by changing the length of the rod P, whether in conjunction with the main piston rod or not, and a further adjustment is secured by the rods R and O, thereby controlling the position of the slot. No action of the pump can take place when the valve is closed but it never closes entirely.

When an obstruction is hit by the wheel, the wheel is thrown up and compresses the spring, the spring in turn tends to cause the body to move upward, or rather deflects it from its forward movement in an upward direction. If the speed at which the car is moving is sufficient, the wheel will leave the ground, and as the car body is being forced up the spring will have a tendency to greatly expand beyond normal, and during its expansion will constantly be exerting an upward pressure upon the car body so that the latter will be forced higher into the air than if the expansion of the spring were limited. This is the chief reason for permitting a small expansion in the spring when driving at a high rate of speed, which renders a great expansion of the spring undesirable, as when a depression or hole in the road is crossed and by reason of the great expansion the wheel is forced down to the bottom of the hole, said wheel receives the impact from the farther side or shoulder of the road depression or hole.

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

1. In a fluid spring, the combination with a piston, of means whereby a plurality of fluid columns are directed into contact with the respective surfaces of said piston, said fluid columns being separate from each other and affording yielding resistances to the movement of the piston in one direction or the other.

2. In a fluid spring, the combination with a piston, of means whereby a plurality of cushioned liquid columns are maintained normally in contact with opposite surfaces of said piston, each of said liquid columns being independent of the other.

3. In a fluid spring, the combination with a piston, of means whereby a plurality of cushioning fluid columns are maintained normally in contact with opposite surfaces of said piston, the resistance afforded by the cushion of one fluid column being greater than the resistance of the cushion of the other fluid column.

4. In a fluid spring, the combination with a piston, of a plurality of liquid containing chambers independent of each other, said chambers operating to direct separate cushioned liquid columns into contact with the respective surfaces of said piston and each chamber being provided with means whereby the quantities of liquid and a gaseous cushioning medium may be varied for controlling the thrust of said cushioned liquid column.

5. In a fluid spring, the combination with a cylinder and a piston, of a plurality of chambers separate from the cylinder and connected with said cylinder chamber at points respectively above and below the position normally occupied by the piston, said separate chambers containing columns of cushioned liquid which are directed into contact respectively with the upper and lower surfaces of said piston.

6. In a fluid spring, the combination with a cylinder and a piston, of a plurality of chambers separate from the cylinder and connected therewith by ports the area of which is less than the cross sectional area of the chambers, said chambers operating to direct cushioned columns of liquid into contact with the respective faces of said piston.

7. In a fluid spring, the combination with a cylinder and a piston, of a plurality of chambers connected with said cylinder by ports positioned respectively above and below the position normally occupied by the piston within said cylinder, said chambers operating to direct cushioned liquid into contact with the upper and lower surfaces respectively of said piston, and means for throttling the flow of that body of liquid which is in contact with the lower surface of said piston.

8. In a fluid spring, the combination with a piston and a cylinder, of means for containing separate cushioned columns of liquid and for directing said separate cushioned columns normally into contact with the respective faces of said piston, and means for throttling the flow of that column of liquid having contact with the under surface of said piston.

9. In a fluid spring, the combination with a piston and a cylinder, of separate chambers connected to the cylinder by ports positioned respectively above and below the position normally occupied by the piston within the cylinder, said chambers containing separate columns of liquid which are re-

tained under air or gas pressure into contact with the upper and lower surfaces respectively of the piston.

10. In a fluid spring, the combination with a piston and a cylinder, of a plurality of chambers communicating with said cylinder and operating to direct bodies of liquid into contact with the respective faces of said piston, and means through which said chambers can be inflated for establishing air or gas pressure therein.

11. In a fluid spring, the combination with a piston and a cylinder, of a plurality of chambers communicating with said cylinder and operating to direct bodies of liquid into contact with the respective faces of said piston, and means through which the chambers can be inflated for establishing air or gas pressure therein to act as cushions for said bodies of liquid, the air or gas pressure in one chamber exceeding the similar pressure in the other chamber.

12. In a fluid spring, the combination with a piston and a cylinder, of a plurality of chambers communicating with said cylinder and operating to direct bodies of liquid into contact with the respective faces of said piston, and means through which said chambers can be inflated for establishing different pressures of air or gas within said chamber, the pressure within the chamber having the liquid body in contact with the under surface of the piston being less than the pressure in the other chamber.

13. In a fluid spring, the combination with a piston and a cylinder, of means for directing a liquid column normally into contact with the upper surface of the piston, said liquid column being cushioned and affording a yielding medium to a relative movement between the cylinder and the piston, means for maintaining a separate liquid column into contact with the under surface of said piston to operate as a liquid check therefor, and means for throttling the flow of the liquid composing said separate liquid column.

14. In a fluid spring, the combination with a cylinder and a piston, of a chamber for containing a liquid adapted to check a relative movement between the cylinder and piston, said chamber also containing air or gas to act as a cushion to the liquid check, and a mechanical separator between the air cushion and the liquid check.

15. In a fluid spring, the combination with a cylinder and a piston, of a chamber for containing a liquid adapted to check a relative movement between the cylinder and piston, said chamber also containing air or gas under pressure so as to act as a cushion to the movement of the body of liquid, and a piston head operating as a mechanical separator between the air or gas and the body of liquid.

16. A fluid spring embodying a cylinder and a packed piston operable therein, said piston embodying separate heads and means accessible exteriorly of the cylinder for securing a relative adjustment between said piston heads to expand the packing without removing the piston from the cylinder or taking off the cylinder heads.

17. In a fluid spring, the combination with a cylinder and a piston, of means whereby a movable liquid column is directed into contact with a surface of the piston, the movement of which liquid column is opposed by a compressible air or gas cushion, and a mechanical separator interposed between the liquid column and the compressible cushion.

18. In a fluid spring, the combination with a cylinder and a piston, of means whereby a movable liquid column is directed into contact with a surface of the piston, the movement of which liquid column is opposed by a compressible air or gas cushion, and a loose piston head positioned intermediate the liquid column and the compressible cushion so as to follow the movement of said liquid column.

19. In a fluid spring, the combination with a piston and a cylinder, of means for directing a plurality of liquid columns, backed by compressible cushions, into contact with the respective surfaces of the piston, and separators positioned to isolate the compressible cushions from contact with the liquid columns.

20. In a fluid spring, the combination with a cylinder and a piston, of means for directing a liquid column, backed by a compressible cushion, into contact with the upper surface of said piston, means for directing a second liquid column, backed by a compressible cushion, into contact with the under surface of said piston, and means for throttling the flow of liquid composing the second liquid column upon a relative movement between the piston and cylinder, said throttling means being effective in retarding the second liquid column when flowing in a direction to oppose the recoil of a spring and said throttling means being non-effective when the second liquid column is restored within the cylinder by a return of the parts to normal position.

21. In a vehicle the body of which is displaceable under varying load conditions with respect to a running gear, the combination with a liquid spring embodying a cylinder and a piston, of means for directing separate bodies of liquid into contact with the upper surface and the under surface respectively of said piston, each body of liquid being cushioned by an air or gas column, and means for shifting the liquid with respect to the piston whereby said piston is retained in a position substantially centrally with respect to the cylinder.

22. In a vehicle the body of which is dis-

placeable under varying load conditions with respect to a running gear, the combination with a liquid spring embodying a cylinder and a piston, of means for directing separate bodies of liquid into contact with the upper surface and the under surface respectively of said piston, each body of liquid being cushioned by an air or gas column, and pumping mechanism for shifting the liquid so as to equalize the distribution thereof relatively to the piston according to the imposition of the load upon the vehicle body.

23. In a vehicle the body of which is displaceable under varying load conditions with respect to a running gear, the combination with a piston and a cylinder one of which parts is to be connected with the body and the other part with the running gear, of means for directing separate liquid bodies into contact with the upper surface and the under surface respectively of said piston, each body of liquid being cushioned by an air or gas column and automatic means for shifting the liquid with respect to said piston whereby an excess of liquid on one side of the piston is forced by the action of the liquid shifting means to the opposite side of the piston.

24. In a vehicle the body of which is displaceable under varying load conditions with respect to a running gear, the combination with a piston and a cylinder one of which parts is to be connected with the body and the other part with the running gear, of means for directing separate liquid bodies into contact with the upper surface and the under surface respectively of said piston, each body of liquid being cushioned by an air or gas column, and pumping mechanism operable by a relative movement between the body and the running gear for shifting the liquid from a point above the piston to a point below the piston, and vice versa, according to the imposition of a load upon the body.

25. In a fluid spring, the combination with a piston and a cylinder, of means for directing cushioned liquid columns into contact with the load-sustaining and expansion-resisting surfaces respectively of said piston, and means for shifting said liquid columns relatively to said piston, whereby said piston is returned to any predetermined operable position within said cylinder upon displacement by a load or by leakage of the liquid.

26. In a fluid spring, the combination with a piston and a cylinder having means whereby they may be connected respectively with a running gear and body of a vehicle, said cylinder containing liquid at the respective sides of the piston, of means controllable by a relative movement between the body and the running gear for shifting the

liquid in the cylinder so as to return the piston to any predetermined position with said cylinder.

27. In a fluid spring, the combination
5 with a piston and a cylinder having means whereby they may be connected respectively with a running gear and body of a vehicle, said cylinder containing liquid at the
10 respective sides of the piston, of an automatic pump having liquid connections with said cylinder at points above and below the normal level of the piston therein, whereby the volume of the liquid may be shifted from above the piston to a point below it, or vice
15 versa, according to the weight and disposition of the load on said body.

28. In a fluid spring, the combination with a piston and a cylinder having means whereby they may be connected respectively
20 with a running gear and body of a vehicle, said cylinder containing liquid at the respective sides of the piston, of a pump operable by a relative movement between the body and the running gear and having liquid connections with said cylinder at points above
25 and below the normal level of the piston therein, whereby the volume of the liquid may be shifted from above the piston to a point below it, or vice versa, according to the weight and disposition of the load on
30 said body.

29. The combination with a cylinder, and a piston, of means for retaining a fluid under pressure and in contact with the respective
35 surfaces of said piston, and means operating to transfer such fluid from one side of the piston to the opposite side of said piston, and vice versa, said fluid-transferring means being effective in distributing
40 the fluid proportionately to a variation of load sustained by one of two relatively movable parts of a vehicle.

30. The combination with a cylinder, and a piston, adapted to be connected respectively to relatively movable parts, of means
45 for retaining fluid under pressure and in contact with the respective surfaces of said piston, a pump separate from said cylinder and connected therewith, and means for operating said pump so as to transfer the
50 fluid under pressure from one side of said piston to the other side thereof whereby the fluid within the cylinder is distributed proportionately to a variation of load imposed
55 upon one or the other of said relatively movable parts.

31. The combination with a cylinder, and a piston, adapted to be connected respectively to parts movable relatively one to the
60 other, of means for retaining a fluid under pressure and in contact with the respective surfaces of said piston, a pump separate from the cylinder and piston and having fluid connections with said cylinder, and means operated by the relative movement

between said parts, said means being associated with said pump for driving the latter to distribute the fluid within the cylinder proportionately to a variation in the load sustained by one of said relatively movable parts. 70

32. The combination with a fluid containing cylinder and a piston adapted to be respectively connected with the relatively
movable body and gear of a vehicle, of 75 pump mechanism having fluid connections with said cylinder at points above and below the normal travel of the piston within said cylinder, said pump mechanism being operable by the relative movement between
80 the body and gear for distributing the fluid within said cylinder proportionately to the load upon the body.

33. The combination with a fluid containing cylinder and a piston adapted to be
85 respectively connected with the relatively movable body and gear of a vehicle, of a pump mechanism for distributing the fluid within said cylinder proportionately to the load imposed upon the body, said pump
90 mechanism having fluid connections with said cylinder at points above and below the normal travel of the piston within said cylinder, and means for controlling the direction of flow of the fluid. 95

34. The combination with a fluid containing cylinder and a piston adapted to be respectively connected with the relatively
movable body and gear of a vehicle, of a 100 pump mechanism for distributing the fluid within said cylinder proportionately to the load imposed upon the body, and an automatic valve the piston of which is controllable by the relative distance between the
105 body and gear, said valve operating to control the direction of flow of the fluid through the pump mechanism and with respect to the chambers within said cylinder.

35. The combination with a cylinder and a piston one adapted to be connected with
110 a body and the other connected with a running gear of a vehicle, a pump for distributing a fluid within said cylinder proportionately to a variation in the load imposed upon the vehicle body, and valve mechanism
115 for controlling the flow of fluid to said pump, said valve mechanism being operable by a change in the relative distance intervening between the body and the gear.

36. The combination with a cylinder and
120 a piston whereof one part is adapted to be connected with a body and the other part is adapted to be attached to a running gear of a vehicle, a pump operable for distributing a fluid within the cylinder proportionately
125 to a variation in the load imposed on the vehicle body, and a valve mechanism for controlling the flow of fluid to said cylinder, said valve mechanism and said pump being shiftable to different operating posi- 130

tions by a variation in the position of the vehicle body relative to said vehicle gear.

37. In a fluid spring, the combination with a piston and a cylinder, of means for directing cushioned liquid columns into normal contact with the compression and expansion surfaces respectively of said piston, and means for controlling the flow in two directions of that liquid column which is normally directed into contact with the expansion surface of the piston whereby on the expansion stroke of the piston due to the recoil of a vehicle spring, a relatively slow movement is obtained, and upon the compression stroke of said piston the liquid column offers a decreased resistance to said stroke.

38. In a fluid spring, the combination with a piston and a cylinder, of means for directing cushioned liquid columns into normal contact with the compression and expansion surfaces respectively of said piston, and a throttle valve positioned for controlling the flow of that liquid column which is in contact with the expansion surface of the piston, said throttle valve operating to retard the movement in one direction of that liquid column in contact with the expansion surface of the piston, and said throttle valve being opened automatically upon the movement in the other direction of said liquid column, so as to permit substantially free movement in said opposite direction unrestrained by said valve.

39. In a fluid spring, the combination with a piston and a cylinder, of means for directing cushioned liquid columns into contact with the compression and expansion surfaces respectively of said piston, a throttle valve in the line of movement of that liquid column in contact with the expansion surface of the piston, said valve being provided with a normally open port, and a manually operable valve for controlling the flow of that liquid column which is in contact with the expansion surface of the piston.

40. The combination with a cylinder, and a piston, adapted to be respectively connected with a body and a gear of a vehicle, a pump connected with the cylinder and operating to distribute a fluid within the cylinder proportionately to a variation in the load imposed upon the body, and valve mechanism for controlling the flow of fluid to said pump, said valve mechanism being controllable by a change in the relative distance between said body and the gear and said valve mechanism being effective in determining the direction of flow of the fluid with respect to the cylinder.

41. The combination with a cylinder, and a piston, adapted to be respectively connected with a body and a gear of a vehicle, a pump connected with the cylinder and

operating to distribute a fluid within the cylinder proportionately to a variation in the load imposed upon the body, and valve mechanism for controlling the flow of fluid to said pump, said valve mechanism being controllable by a change in the relative distance between said body and the gear and said valve mechanism being effective in determining the direction of flow of the fluid with respect to the cylinder, said pump and the valve mechanism being conjointly shiftable to variable operative positions by a variation in the relative positions of said body and the vehicle gear.

42. The combination with a fluid containing cylinder and a piston adapted to be respectively connected with the relatively movable body and gear of a vehicle, of a rotative valve for controlling the direction of flow of the fluid with respect to the cylinder, means connected with a part of the vehicle for imparting rotative movement to the valve, and a pump having fluid connections with the cylinder, said pump being carried on one vehicle-part and mechanically connected with another vehicle part so as to be operated by a relative movement between said vehicle parts.

43. The combination with a fluid containing cylinder and a piston adapted to be respectively connected with the relatively movable body and gear of a vehicle, of a pump for distributing the fluid in the cylinder, a valve for controlling the direction of flow of the fluid, means for shifting the valve, and means for operating said pump.

44. The combination with a fluid containing cylinder and a piston adapted to be respectively connected with the relatively movable body and gear of a vehicle, of a pump having fluid connections with the respective end portions of said cylinder, means for operating said pump, and a valve coöperating with the pump and the cylinder for controlling the direction of flow of the fluid through said pump.

45. The combination with a fluid containing cylinder and a piston adapted to be respectively connected with the relatively movable body and gear of a vehicle, of a valve chest having two sets of fluid connections with said cylinder at points above and below the travel of the piston therein, a valve for controlling the direction of flow of the fluid through one set of said fluid connections to the exclusion of the other set, and vice versa, means for shifting the valve, a pump, and means for operating said pump.

46. The combination with a fluid containing cylinder and a piston adapted to be respectively connected with the relatively movable body and gear of a vehicle, of a valve chest having two sets of fluid connections with said cylinder at points above and below the travel of the piston therein, a valve

rotatable in the valve chest and operable to shut off the flow of fluid and to control the direction of flow through one set of fluid connections, a pump cooperating with said valve, and means for operating said pump.

47. The combination with a fluid containing cylinder and a piston adapted to be respectively connected with the relatively movable body and gear of a vehicle, of a valve chest connected with said cylinder, a valve within said chest for controlling the flow of fluid relative to the cylinder, a reciprocating piston pump cooperating with said valve, and means operated by a relative movement between the body and gear for operating the pump.

48. The combination with a fluid containing cylinder and a piston adapted to be respectively connected with the relatively movable body and gear of a vehicle, of a valve chest connected to the cylinder, a valve within said chest, a pump the cylinder of which is connected with the valve, a cam cooperating with the piston of said pump, and means for imparting movement to said pump piston.

49. The combination with a fluid containing cylinder and a piston adapted to be respectively connected with the relatively movable body and gear of a vehicle, of a valve chest on said cylinder, multiple fluid connections between said valve chest and the respective portions of the cylinder, said fluid connections having check valves for controlling the direction of flow of the fluid, a reversing and shut off valve operable within said valve chest, a pump cooperating with the valve, and means for operating said pump.

50. The combination with a fluid containing cylinder and a piston adapted to be respectively connected with the relatively movable body and gear of a vehicle, of pumping mechanism cooperating with the cylinder

for distributing the fluid therein proportionately to the load upon the body, and means for replenishing the liquid supply to said pump.

51. The combination with a fluid containing cylinder and a piston adapted to be respectively connected with the relatively movable body and gear of a vehicle, of pumping mechanism cooperating with the cylinder for distributing the fluid therein proportionately to the load upon the body, a reservoir, and means cooperating with the pump for replenishing the liquid by feeding the same from the reservoir to the cylinder.

52. In a fluid spring, the combination with a cylinder and a piston, of a plurality of chambers containing cushioned liquid columns one of which is directed normally into contact with the load sustaining surface of the piston and the other into contact with the recoil retarding surface of the same piston.

53. In a vehicle, the combination with a running gear, and a body displaceable under varying load conditions with respect to said running gear, of liquid controlled spring mechanism for returning the body to, and retaining it yieldably at, a normal predetermined distance with respect to the attachment to the running gear, said liquid controlled spring mechanism embodying a cylinder, a piston, means for retaining separate cushion bodies of liquid in contact with the upper surface and the lower surface respectively of said piston, and pump mechanism for shifting the liquid with respect to the piston.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

CHARLES SNOW KELLOGG.

Witnesses:

M. C. RODRIGUEZ,
H. I. BERNHARD.