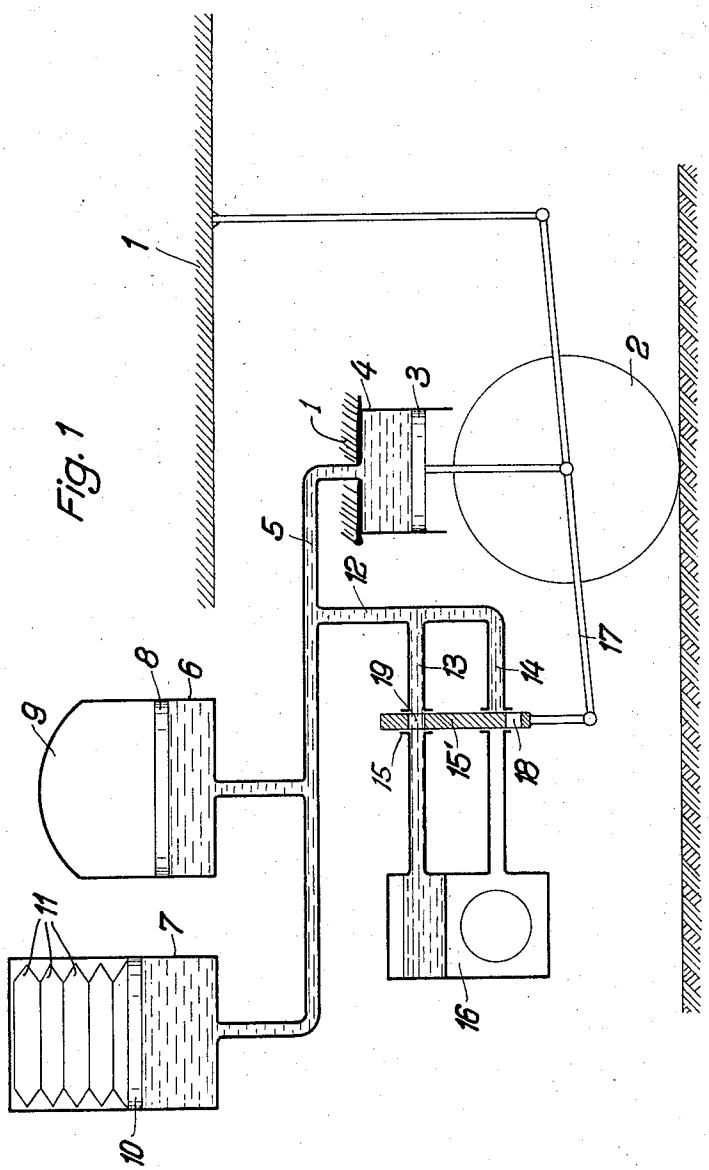
May 5, 1959 K. TRÜMPER 2,885,202

RESILIENT CUSHIONING ARRANGEMENT

Filed May 11, 1954 4 Sheets-Sheet 1

Fig. 1



Inventor:
KONRAD TRÜMPER
BY:

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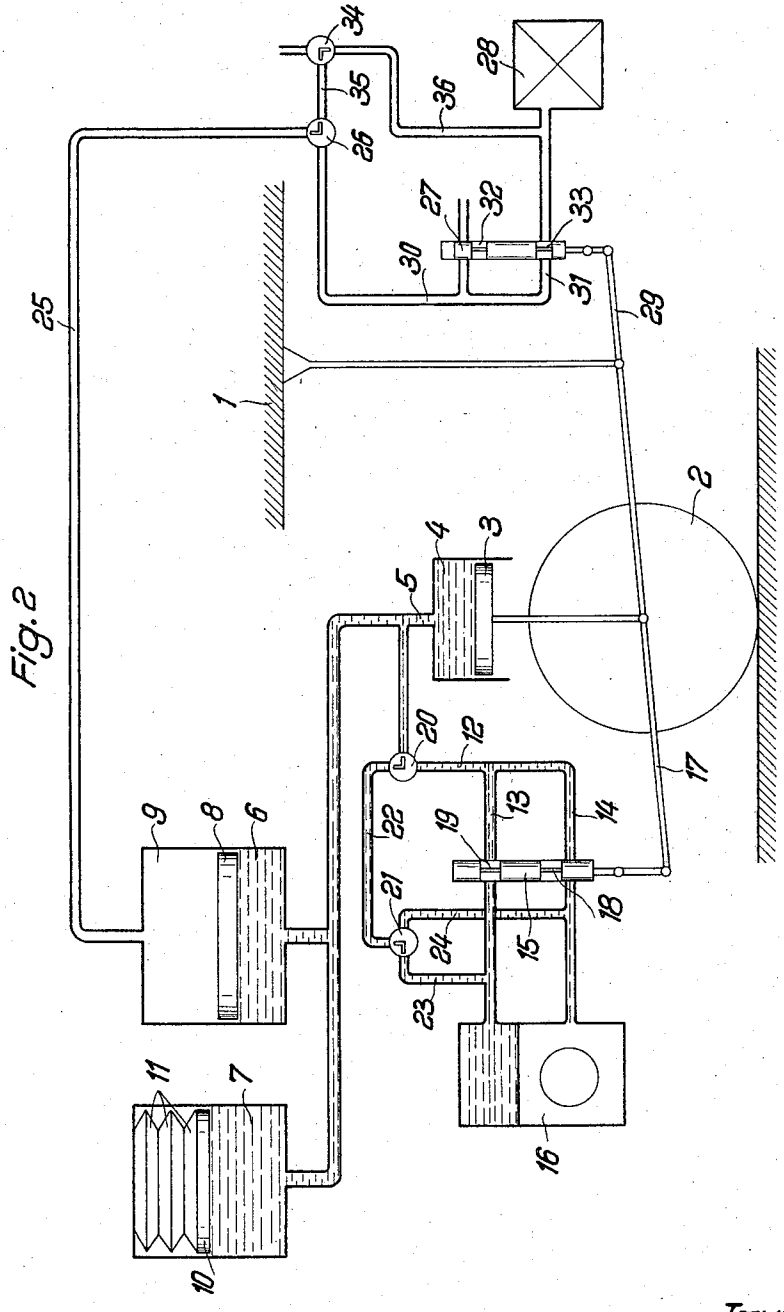

Fig. 2

Inventor:
KONRAD TRÜMPER
BY:

May 5, 1959 K. TRÜMPER 2,885,202

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Fig. 3

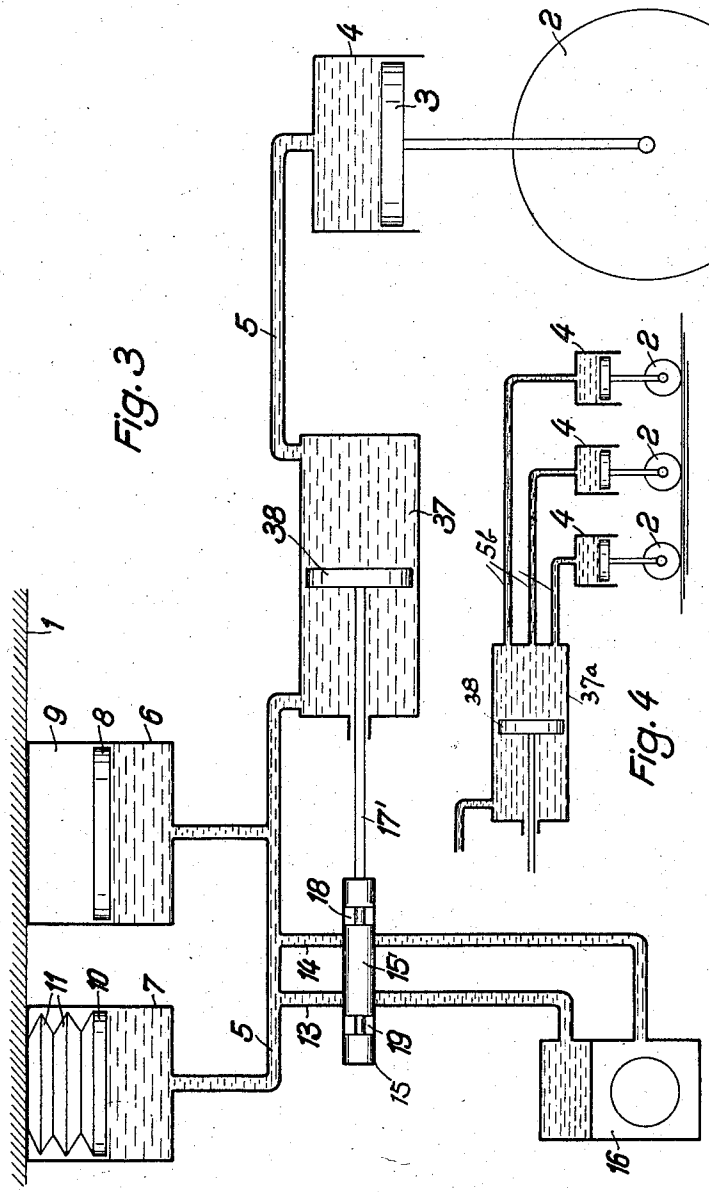

Fig. 4

Inventor:
KONRAD TRÜMPER
By:

May 5, 1959 K. TRÜMPER 2,885,202

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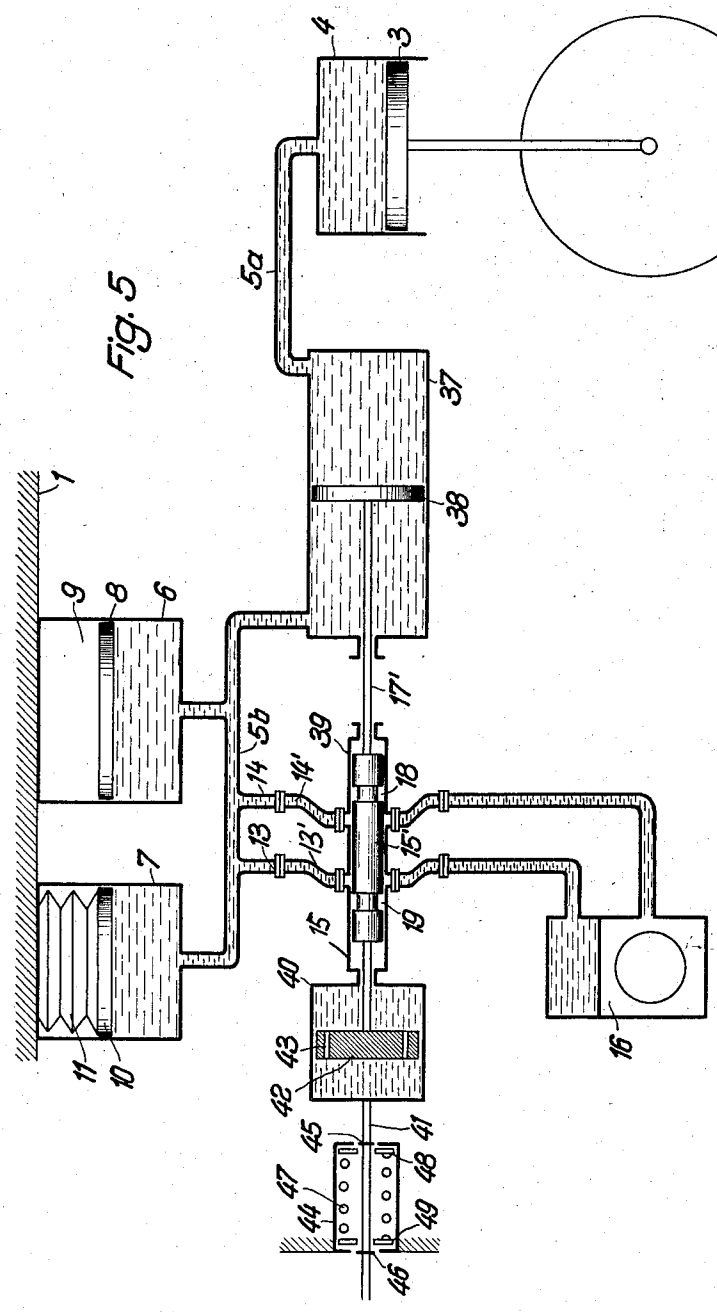
Fig. 5



Inventor:
KONRAD TRÜMPER
BY:

United States Patent Office

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RESILIENT CUSHIONING ARRANGEMENT

Konrad Trümper, Grotzingen, near Karlsruhe, Germany, assignor to Firma Siegener Eisenbahnbedarf Aktiengesellschaft, Krs. Siegen, Germany

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Claims priority, application Germany May 16, 1953

23 Claims. (Cl. 267—15)

The present invention relates to a resilient cushioning arrangement for resiliently connecting two elements, and more particularly to a cushioning arrangement for resiliently supporting a vehicle frame on wheel axles.

Progressively acting resilient suspensions are known which serve the purpose of producing a resilient support which is substantially uniform and independent of the weight of the load. Since it is very difficult to obtain this result with mechanical means, air is generally used as cushioning element for this purpose.

It has been found that an air cushion has a very hard resilient characteristic under full load, and therefore two consecutively acting air cushions having different pressure have been provided in the prior art. However, the characteristic of resiliency of suspensions of this type is unstable at the point in which the second air cushion is subjected to the load whereby unfavorable operational conditions are caused when a medium load acts on the cushioning arrangement.

It is one object of the present invention to overcome the disadvantages of the known air cushioning arrangements, and to provide a cushioning arrangement which has a substantially constant natural oscillation frequency.

It is another object of the present invention to provide a cushioning arrangement in which resilient air cushioning means having a hyperbolic characteristic, and solid resilient means having a linear characteristic of resiliency are simultaneously effective.

It is consequently an object of the invention to provide a resilient cushioning arrangement whose characteristic of resiliency is a combination of a linear characteristic and a hyperbolic characteristic of resiliency.

It is a further object of the present invention to connect the mechanical resilient cushioning means, and the air cushioning means to the resiliently connected elements by means of an operating liquid.

It is a still further object of the present invention to provide means for keeping the resiliently connected elements, such as a vehicle frame and the wheel axles at a substantially constant distance so that the height of the frame and of the body of the vehicle remains substantially constant.

It is also an object of the present invention to provide control means for automatically supplying operating liquid to the system, and for automatically supply air to the air cushioning means whenever the relative position between the resiliently connected elements changes so as to hold such elements in a substantially constant relative position.

With these objects in view the present invention mainly consists in a cushioning arrangement for resiliently connecting two elements, such as a frame and the wheel axle of a vehicle, and comprises, in combination, cylinder means adapted to be mounted on one of the elements, piston means arranged in the cylinder means slidably therein and adapted to be mounted on the other of the elements, operating liquid in the cylinder means within the space enclosed by the piston means, air cushioning

means operatively connected to the operating liquid for cushioning relative movement of the piston means and of the cylinder means, the air cushioning means having a hyperbolic characteristic of resiliency, and mechanical cushioning means including a resilient member consisting of a solid resilient material and being operatively connected to the operating liquid for cushioning relative movement of the piston means and of the cylinder means, the mechanical cushioning means having a linear characteristic of resiliency whereby the cylinder means and the piston means, and thereby the two elements, are resiliently connected according to the combined characteristics of resiliency of the cushioning means.

Preferably a liquid moving means, such as a pump, is provided for adding and removing operating liquid. The pump is controlled by control means which are actuated by the relative movement between the resiliently connected elements.

Preferably an air moving means, such as an air compressor, is provided which is connected to the closed air cushioning vessel. In this embodiment other operating means are provided for controlling the operation of the compressor in accordance with the relative position of the two resiliently connected elements for holding the same in a substantialyy constant relative position.

Preferably dampening means are provided for dampening the movement of the piston and cylinder control means.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

Fig. 1 is a schematic view showing a preferred embodiment of the present invention;

Fig. 2 is a schematic view showing the embodiment of Fig. 1 provided with automatic control means for holding the two resiliently connected elements in a substantially constant relative position;

Fig. 3 is a schematic view showing an embodiment of the present invention in which a control cylinder and piston is provided as operating means;

Fig. 4 is a fragmentary schematic view showing an arrangement according to the present invention applied to a set of wheel axles; and

Fig. 5 is a schematic view showing an embodiment of the present invention including dampening means for the control means.

Referring now to the drawings, and more particularly to Fig. 1, the frame 1 of a vehicle is arranged above the wheel axle and the wheels 2 of which only one is shown in Fig. 1. The frame 1 is resiliently supported on the wheels 2 through the cylinder 4 and the piston 3 slidably mounted in the same. A liquid conduit means 5 connects the cylinder 4 with a closed air cushioning vessel 6, and with a cylinder member 7. A piston 8 is movable in the closed vessel 6 and defines in one end portion of the same an air space in which an air cushion 9 of compressed air is contained. The other end of the vessel 6 is filled with operating liquid. A piston member 10 is slidably arranged in the cylinder member 7 and moves in accordance with the movement of the operating liquid in the same. A resilient member 11 consisting of a solid material urges the piston member 10 toward the end of the cylinder member 7 which communicates with the liquid conduit means 5. The arrangement is preferably such that both cushioning means, namely the compressed air cushion 9 and the resilient member 11, act simultaneously, but it is also contemplated to delay the

action of mechanical spring 11 by pretensioning the same, as will be understood by persons skilled in the art. The cylinder member 10 is open at the end in which the metal spring 11 is arranged so that the piston member 10 is only subject to the pressure of the resilient member 11.

Discharge and supply conduit means 13 and 14 connect liquid moving means, such as the pump 16 through conduit 12 with the liqiud conduit means 5. A liquid control valve 15 including a valve cylinder and a valve piston 15' is arranged in the supply and discharge conduits 13, 14. The valve piston has passages 18, 19 which cooperate with the conduits 13, 14. A lever system 17 connects the valve piston with the piston 3 and with the frame 1, so that relative movement between the frame 1 and the wheels 2 and between piston 3 and cylinder 4 effects a shifting of the control valve 15 between three positions. In one position liquid is supplied to the liquid conduit means 5, in the second position the conduits 13, 14 are closed, and in a third position a liquid is discharged from the conduit means 5 into the sump of the pump. The arrangement is such that the operating and liquid control means 16, 15, 17 tend to hold the piston 3 and the cylinder 4 in a substantially constant position whereby also the position of the frame 1 relative to the wheels 2 is held substantially constant.

In the embodiment shown in Fig. 2, the conduits 22, 23, 24 are provided in which manually operated liquid control valves 20 and 21 are arranged. By manual operation of the valves 20 and 21 liquid is supplied, or discharged respectively to and from the liquid conduit means 5 whereby the relative position between the cylinder 4 and the piston 3 can be adjusted at will for raising the frame 1 to a desired height, or for lowering the same.

Fig. 2 further shows air control means for adding compressed air to the air cushion 9 in the vessel 6, and for discharging air from the same. A compressor 28 is connected by air supply and discharge conduits 30, 31 and 25 to the closed vessel 6. An air control valve 27 is located in the air supply discharge conduit and includes a valve piston formed with two passages 32 and 33. The valve piston is connected to the operating means, shown to be a lever system 29 which is connected on one hand to the frame 1 and to the cylinder 4 and on the other hand to the wheel axle and to the piston 3 so that relative movement between the piston 3 and cylinder 4 shifts the air control valve between three positions. In one position air is supplied by the compressor 28 to the air cushion 9, and in the second position the supply and discharge conduits 30, 31 are closed, and in the third position air is discharged from the air cushion through conduit 30. In addition thereto conduits 35 and 36 are provided which can be closed and opened by manually operated air valve means 26, 34 for varying the volume of the air cushion 9 at will. By the compressor 28 and by the air control means 27 and 29 the position of the piston 3 and cylinder 4, and thereby the relative position between the frame 1 and the wheels 2 can be held substantially constant.

In the modified embodiment shown in Fig. 3 the liquid operating means is not a lever system, but a control cylinder and piston 37, 38, 17' arranged in the liquid conduit means 5. Relative movement between the piston 3 and the cylinder 4 effects movement of the operating liquid through conduit 5 whereby the control piston 38 is actuated. A piston rod 17' rigidly connects the control piston 38 with the valve piston of the liquid control valve 15, whereby the supply and discharge conduits 13, 14 are closed, and opened, respectively, as described with reference to Fig. 1, so that operating liquid is supplied to the piston 4 or discharged therefrom to hold the cylinder 4 and the piston 3 in a substantially constant relative position. Fig. 4 shows the arrangement for a set of wheel axles, each wheel axle being connected to a piston 3 moving in a cylinder 4. The cylinders 4 are connected by conduits 5*b* to the control cylinder 37*a* for moving the

control piston 38 as described previously with reference to only one cylinder and piston 4, 3. The arrangement of Fig. 4 is used for railroad care having relatively turnable wheel axles.

Referring now to Fig. 5 it will be appreciated that the arrangement corresponds to the embodiment shown in Fig. 3. The modified embodiment of Fig. 3 includes dampening means for dampening the movement of the valve piston 15' and of the valve cylinder 39 of the liquid control valve 15. The valve cylinder 39 is movably mounted and rigidly connected to a dampening cylinder 40. Consequently, the supply and discharge conduits 13, 14 have to be connected to the valve cylinder by means of flexible hoses 13' and 14'. The valve piston 15' is rigidly connected to the dampening piston 42 which has passages 43 passing therethrough, so that movement of the valve piston 15' and of the dampening piston 42 is dampened due to the action of a dampening liquid contained in the dampening cylinder 40. On the other hand, the dampening cylinder 40 is rigidly connected to a rod 41 which passes through a spring housing 44 which is secured to a fixed support. The spring 47 urges the discs 48 and 49 apart so that the movement of the rods 41 is resiliently dampened when the flanges 45 and 46 engage the discs 48 and 49.

The arrangement operates in the following manner:

When the frame and the wheel axles of a vehicle tend to move relative to each other, operating liquid is moved through the conduit means 5 or 5*a* so that the air cushioning means 6, 8, 9, and the mechanical resilient cushioning means 10, 11 in the cylinder means 6, 7 become operative. The mechanical resilient member 11 consists of metal or rubber and has a linear characteristic of resiliency, while the air cushioning means 8, 9 have a hyperbolic characteristic of resiliency so that the resilient action of the arrangement takes place in accordance with the characteristic of resiliency obtained by superimposing the characteristics of the two cushioning means.

At the same time the operating means, such as the lever system 17, or the control piston 38, actuates the liquid control valve 15 to move into a position in which the operation of the pump 16 will effect a relative movement of the cylinder 4 and the piston 3 which is opposite to the movement which causes the operation of the liquid control valve 15. Similarly, in the embodiment shown in Fig. 2, the operating means 29 actuates the air control valve means 27 to move to a position in which the action of the compressor 28 will increase the volume of the air cushion 9 for moving the piston 3 and cylinder 4 apart when the same were moved towards each other due to operational conditions. On the other hand, air will be discharged from the air cushion 9 when the piston 3 and cylinder 4 move apart.

The dampening means acting on the liquid control valve 15 will dampen the automatic operation in the event that the cushioning arrangement is subject to sudden jolts. In the event that the wheel 2 moves over an obstacle so that the piston 3 exerts a sudden pressure on the operating liquid, such pressure impulse is conveyed by the liquid and moves the poston 38 in a rapid motion whereby the dampening piston is also operated through the piston rod 17'. Since such movement is a rapid jolt, the liquid in cylinder 40 cannot pass through the passages 43 in the dampening piston 42 since the same moves too rapidly so that the sudden pressure impulse is transferred through the liquid to the rear wall of the cylinder 40 which in turn abuts against the spring disc 48 through the rod 41 and the flange 45, the spring disc 48 being spring-loaded by the pretensioned spring 47. Consequently, a movement of the piston 38 is possible due to the resilient mounting of the cylinder 40 on the spring 47, while no significant relative movement takes place between the dampening piston 42 and the cylinder 40 if the transmitted impulse is a sudden and rapid jolt.

The liquid control valve is not actuated by a short and rapid impulse.

When the load is gradually increased, which corresponds to a slow change of the pressure in the cylinders 4 and in the adjacent conduit portion 5*a*, the piston 38 and the dampening piston 42 are slowly displaced so that the liquid can flow through the passages 43 resulting in a relative motion between the piston 42 and the cylinder 40. During such operation the control valve 15 is actuated, and permits passage of liquid.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of cushioning differing from the types described above.

While the invention has been illustrated and described as embodied in air cushioning arrangement including solid and gaseous cushioning means, and control means for keeping constant the relative position between the frame and the axles of a vehicle, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. Cushioning arrangement for resiliently connecting the frame element of a vehicle with the wheel axle element of the same, and comprising, in combination, a set of cylinders adapted to contain an operating liquid, and adapted to be connected to one of said elements; a set of pistons slidably arranged in said cylinders, respectively, and adapted to be connected to the other of said elements; a closed air cushioning vessel adapted to contain a compressible gaseous medium in one end portion thereof; liquid conduit means connecting the other end portion of said air cushioning vessel wtih said cylinders so that said air cushioning vessel is adapted to contain operating liquid at the other end thereof; a cylinder member having one end communicating with said liquid conduit means for receiving operating liquid; a piston member movable in said cylinder member and adapted to be moved by said operating liquid when said pistons and cylinders move relative to each other; a resilient member consisting of a solid resilient material and having a linear characteristic of resiliency and urging said piston member toward said one end of said cylinder member whereby said frame element and said wheel element are resiliently connected for movement according to the linear characteristic of resiliency of said resilient member superimposed by the hyperbolic characteristic of resiliency of said gaseous medium; a liquid pump means for said operating liquid; liquid supply and discharge conduit means connecting said liquid pump means with said liquid conduit means; liquid control valve means in said liquid supply and discharge conduit means and being movable between a first position in which said pump means supplies operating liquid to said conduit, a second closing position, and a third position in which operating liquid is discharged from said liquid conduit means; a control cylinder located in said liquid conduit means so that operating liquid flows into and out of said control cylinder in accordance with the relative movement between said sets of cylinders and pistons; and a control piston slidably mounted in said control cylinder and being connected to said liquid valve means and moving the same between said positions in such manner that operating liquid is supplied to, or discharged from, said liquid conduit means to hold the respectively associated pistons and cylinders of said cylinders and pistons, and thereby said two elements in a substantially constant relative position.

2. A cushioning arrangement as claimed in claim 1 and comprising dampening means connected to said liquid control valve means for dampening movements of the same.

3. A cushioning arrangement as claimed in claim 1 wherein said liquid control valve means includes a movably mounted valve cylinder and a valve piston movable in said valve cylinder, said valve piston being connected to said control piston for movement therewith; a movable dampening cylinder rigidly connected to said valve cylinder; a dampening piston formed with passages therethrough and being movable in said dampening cylinder, said dampening piston being rigidly connected to said valve piston for movement therewith; a fixed support; and spring means abutting at one end against said fixed support and at the other end against said dampening cylinder for holding said dampening cylinder in spaced relationship to said fixed support.

4. A cushioning arrangement as claimed in claim 1 wherein said resilient member is a metal spring.

5. Cushioning arrangement for resiliently connecting two elements comprising, in combination, cylinder means adapted to be mounted on one of said elements; piston means arranged in said cylinder means slidable therein and adapted to be mounted on the other of said elements; air cushioning means having a hyperbolic characteristic of resiliency and including a first expansible and contractible working chamber means; mechanical cushioning means including a resilient member consisting of a solid resilient material and a second expansible and contractible working chamber means adjacent and resilient member, said mechanical cushioning means having a linear characteristic of resiliency; conduit means connecting said first and second working chamber means in parallel with each other and in series with said cylinder means; and an operating liquid in said conduit means, said first and second working chamber means, and said cylinder means so that said first and second working chamber means expand and contract simultaneously but independently of each other during movement of said piston means whereby said cylinder means and said piston means and thereby said two elements are resiliently connected according to the superimposed characteristics of resiliency of said cushioning means.

6. Cushioning arrangement for resiliently connecting two elements comprising, in combination, cylinder means adapted to be mounted on one of said elements; piston means arranged in said cylinder means slidably therein and adapted to be mounted on the other of said elements; air cushioning means having a hyperbolic characteristic of resiliency and including a first expansible and contractible working chamber means; mechanical cushioning means including a resilient member consiting of a solid resilient material and a second expansible and contractible working chamber means adjacent said resilient member, said mechanical cushioning means having a linear characteristic of resiliency; conduit means connecting said first and second working chamber means and said cylinder means and including a least one operating cylinder; an operatliquid in said conduit means, said first and second working chamber means, and said cylinder means whereby said cylinder means and said piston means and thereby said two elements are resiliently connected according to the superimposed characteristics of resiliency of said cushioning means; liquid moving means connected to said conduit means for adding additional operative liquid to said operative liquid and for removing part of said operative liquid; and control means including control valve means for controlling said moving means, and an operating piston slidable in said operating cylinder and actuated in accordance with relative movement between said cylinder means and said piston means, said operat-

ing piston being connected to said control valve means and actuating the same to control said liquid moving means in such manner that operative liquid is supplied to or discharged from said working chamber means to hold said piston means relative to said cylinder means and thereby said two elements in a substantially constant relative position.

7. Cushioning arrangement for resiliently connecting two elements comprising, in combination cylinder means adapted to be mounted on one of said elements; piston means arranged in said cylinder means slidably therein and adapted to be mounted on the other of said elements; air cushioning means having a hyperbolic characteristic of resiliency and including a first expansible and contractible working chamber means; mechanical cushioning means including a resilient member consisting of a solid resilient material and a second expansible and contractible working chamber means adjacent said resilient member, said mechanical cushioning means having a linear characteristic of resiliency; conduit means connecting said first and second working chamber means and said cylinder means and including at least one operating cylinder; an operating liquid in said conduit means, said first and second working chamber means, and said cylinder means whereby said cylinder means and said piston means and thereby said two elements are resiliently connected according to the superimposed characteristics of resiliency of said cushioning means; liquid moving means connected to said conduit means for adding additional operative liquid to said operative liquid and for removing part of said operative liquid; control means including control valve means for controlling said moving means, and an operating piston slidable in said operating cylinder and actuated in accordance with relative movement between said cylinder means and said piston means, said operating piston being connected to said control valve means and actuating the same to control said liquid moving means in such manner that operative liquid is supplied to or discharged from said working chamber means to hold said piston means relative to said cylinder means and thereby said two elements in a substantially constant relative position; and dampening means connected to said operating piston for dampening movement of the same.

8. An arrangement as set forth in claim 5 and including means for adding compressed air to said air cushioning means and for removing air from the same for holding said piston means and said cylinder means and thereby said two elements in a substantially constant relative position.

9. An arrangement as set forth in claim 8 and including means controlled by said piston means and connected to said conduit means for adding additional operative liquid to said operative liquid and for removing part of said operative liquid so as to hold said piston means and said cylinder means and thereby said two elements in substantially constant relative position.

10. An arrangement as set forth in claim 8 wherein said means for adding compressed air is controlled by said piston means.

11. An arrangement as set forth in claim 5 and including liquid moving means connected to said conduit means for adding additional operative liquid to said operative liquid and for removing part of said operative liquid; and control means actuated by relative movement between said cylinder means and said piston means and controlling said liquid moving means in such a manner that operative liquid is supplied to or discharged from said conduit means to hold said piston means and said cylinder means and thereby said two elements in a substantially constant relative position.

12. An arrangement as set forth in claim 5 and including air moving means for adding compressed air to said air cushioning means and for removing air from the same; and air supply control means actuated by relative movement between said cylinder means and said

piston means and controlling said air moving means in such a manner that air is supplied to or discharged from said air cushioning means to hold said piston means and said cylinder means and thereby said two elements in a substantially constant relative position.

13. An arrangement as set forth in claim 12 and including liquid moving means connected to said conduit means for adding additional operative liquid to said operative liquid and for removing part of said operative liquid; and control means actuated by relative movement between said cylinder means and said piston means and controlling said liquid moving means in such a manner that operative liquid is supplied to or discharged from said conduit means to hold said piston means and cylinder means and thereby said two elements in a substantially constant relative position.

14. An arrangement as set forth in claim 5 and comprising liquid moving means including control valve means and being connected to said conduit means for adding additional operative liquid to said operative liquid and for removing part of said operative liquid; and control lever means connected to said cylinder means and to said piston means and being actuated by relative movement between the same, said control lever means being connected to said control valve means for controlling said liquid moving means in such a manner as to maintain said two elements in a substantially constant relative position.

15. An arrangement as set forth in claim 14 and including means controlled by said piston means for adding compressed air to said air cushioning means and for removing air from the same for holding said piston means and said cylinder means and thereby said two elements in substantially constant relative position.

16. An arrangement as set forth in claim 5 wherein said cylinder means includes a set of cylinders; wherein said piston means includes a set of pistons slidable in said cylinders; wherein said air cushioning means include a closed vessel, a compressible gaseous medium in one end portion of said vessel, and a first piston member movable in said vessel; wherein said mechanical cushioning means include a spring cylinder member and a resilient member consisting of a solid resilient material and located in one end portion of said spring cylinder member, and a second piston member movable in said spring cylinder member and engaging said resilient member; and wherein said conduit means connect the other end portion of said vessel, and the other end portion of said spring cylinder member with said cylinders; and wherein said operating liquid is located in said conduit means, in said other end portions of said vessel and of said spring cylinder member, and in said cylinders.

17. An arrangement as set forth in claim 16 and including pump means for said operating liquid; supply and discharge conduit means connecting said pump means with said conduit means and containing part of said operating liquid; control valve means in said supply and discharge conduit means and being movable between a first position in which said pump means supplies said operating liquid to said conduit means, a second closing position, and a third position in which operating liquid is discharged from said conduit means into said pump means; and operating means connected to said sets of cylinders and pistons and being moved during relative movement of the same, said operating means being connected to said control valve means and operating the same to hold said two elements in a substantially constant relative position.

18. An arrangement as set forth in claim 17 and including manually operated valves in said supply and discharge conduit means, respectively, for supplying and discharging said operating liquid by a manual operation.

19. An arrangement as set forth in claim 17 wherein said operating means include lever means connected to

said control valve means and to said sets of cylinders and pistons.

20. An arrangement as set forth in claim 16 and including air compressor means; air supply and discharge conduit means connecting said air compressor means with said one end portion of said vessel, air control valve means located in said air supply and discharge conduit means and being movable between a first position in which said compressor means supplies air to said vessel, a second closing position, and a third position in which air is discharged from said vessel; and operating means for said air control valve connected to and removed by said cylinders and pistons during relative movement of the same, said operating means being connected to said valve means and moving the same between said positions in such a manner that air is supplied to or discharged from said vessel to hold said two elements in a substantially constant relative position.

21. An arrangement as set forth in claim 20 and including manually operated air valve means in said air supply and discharge conduit means.

22. An arrangement as set forth in claim 16 and including control means for controlling the positions of said first and second piston members; and hydraulic operating means connected to said sets of cylinders and pistons and being moved during relative movement of the same, said operating means being connected to said control means and operating the same to hold the respectively associated pistons and cylinders and thereby said two elements in a substantially constant relative position.

23. An arrangement as set forth in claim 6 wherein said control valve means includes a valve casing containing part of said operating liquid and a valve member movable in said valve casing, said valve member being rigidly connected to said operating piston for movement therewith; a dampening cylinder fixedly connected to said valve casing; operating liquid in said dampening cylinder; a dampening piston in said dampening cylinder and rigidly connected to said valve member for movement therewith; means for supporting said dampening cylinder and said valve casing for movement with each other in axial direction; and resilient means for urging said dampening cylinder and said valve casing into a normal position.

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