

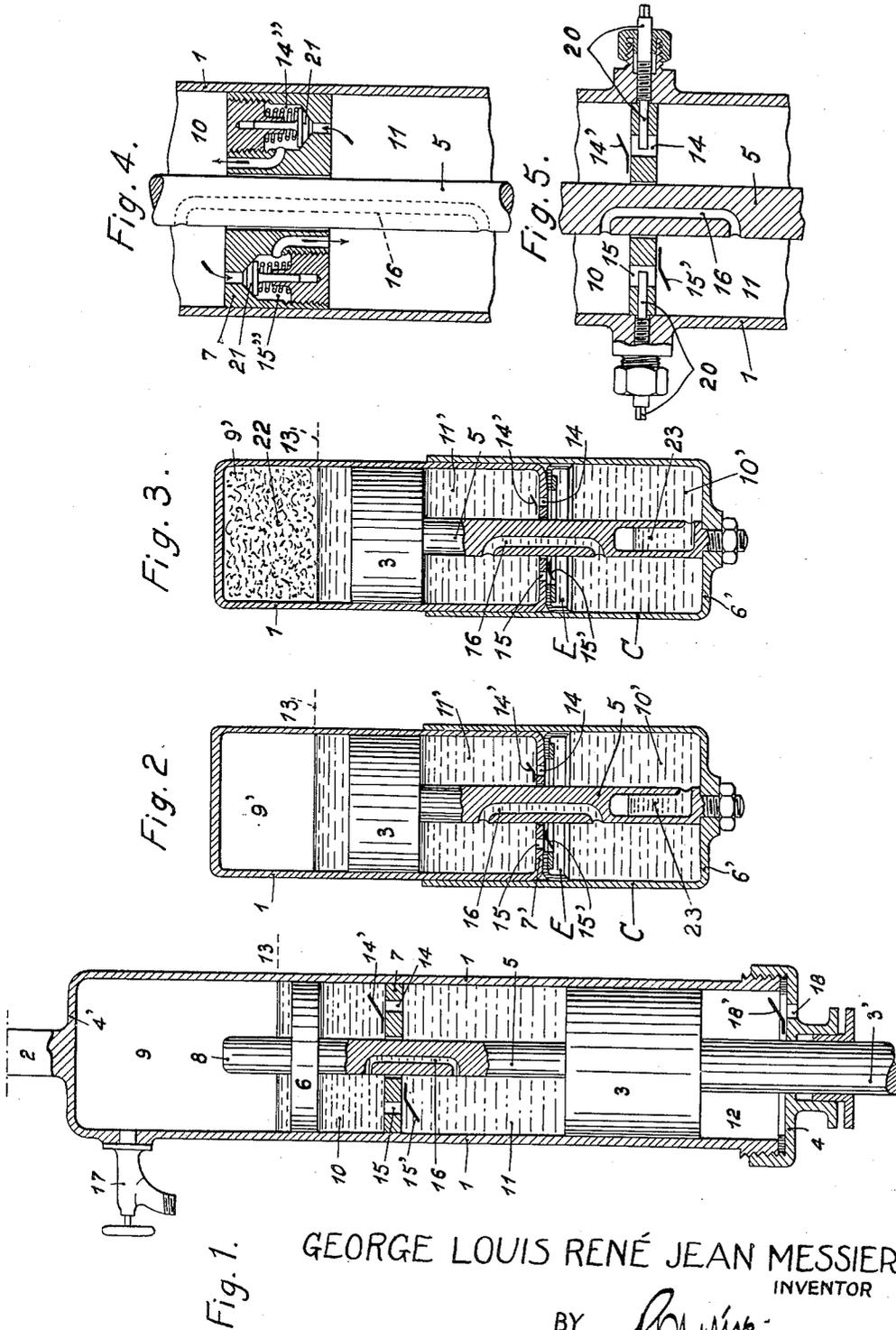
Nov. 8, 1932.

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1,886,712

SUSPENSION APPARATUS FOR AEROPLANES AND OTHER VEHICLES

Filed June 13, 1929



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# UNITED STATES PATENT OFFICE

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SUSPENSION APPARATUS FOR AEROPLANES AND OTHER VEHICLES

Application filed June 13, 1929, Serial No. 370,622, and in France September 14, 1928.

The invention relates to an apparatus adapted to transmit elastically the weight of aeroplanes to the landing train of these latter, or the weight of motor vehicles to the wheels.

This apparatus embodies the combination of an elastic braking by compression of air or of another gas with a hydraulic braking by forcing the liquid through apertures of reduced section. The apparatus may be provided with auxiliary devices for regulating the pressure.

In the application of the invention to an aeroplane provided with two wheels and with a skid the suspension comprises, in front, two apparatuses disposed respectively near each wheel and at the back an apparatus interposed between the skid and the fuselage.

In the annexed drawing:

Fig. 1 represents in axial section one embodiment of the invention.

Fig. 2 is another form wherein the inner piston 3 of Fig. 1 is replaced by an outer enveloping shell C, and in which the upper valve 17 is not shown, while on the other hand an air bell is included in the structure.

Fig. 3 is a similar modification in which the uppermost chamber is provided interiorly with spongy rubber at 22.

Fig. 4 is an enlarged fragmentary view of a different form of the interior valves of the preceding views.

Fig. 5 is a form of said interior valves, wherein control means are combined therewith for exterior manual control of the passages associated with said valves.

Throughout the views, the same reference characters indicate the same or like parts.

The apparatus (Fig. 1) mounted vertically or having a slight inclination from the vertical, comprises a cylinder 1 connected by an attachment 2 to the fuselage of the aeroplane. In this cylinder a piston 3 is adapted to move, the rod 3' of which, passing through the lower part 4, is pivoted upon the axle of the wheel or upon a part which is rigidly connected to the axle, or upon the skid (not represented). The piston 3 carries a second rod 5 which connects it to a second piston 6. The depth of this latter may be much less than that of the

principal piston 3 for where this latter is located it is not necessary that the tightness of the second piston should be perfect.

The rod 5 passes freely, but with a play which should be very small, through a diaphragm 7 rigidly fixed into the cylinder 1.

The interior of the cylinder is thus divided into four compartments indicated by the references 9, 10, 11 and 12.

The aeroplane being upon the ground the relative position of the various parts is, for example, that represented in Fig. 1 of the drawing.

The compartments 10 and 11 are full of liquid, there is a layer of liquid likewise in the compartment 9, up to the level indicated by the dotted line 13. This layer is surmounted by a cushion of compressed air or other gas.

The tightness of the piston 6 being imperfect, the same pressure exists in the compartments 9, 10 and 11.

This pressure is such that its product, according to the section of the cylinder, is equal to the weight of the apparatus; this weight is thus transmitted from the upper end of the cylinder 1 to the piston 3.

The vertical movements of the carriage constituted by the pistons 3 and 6 are possible due to the elasticity of the compressed gas in the compartment 9, but it will be seen that these movements cause variations of the volumes of the compartments 10 and 11 filled with liquid.

Liquid being incompressible, these variations of volume are only possible if the passage of the liquid is allowed between one of said compartments 10, 11 and another of them.

For this purpose the diaphragm 7 is formed with two apertures 14 and 15, provided with valves 14' and 15' opening in reverse directions; in the example shown the valve 14' allows the passage from the compartment 11 to the compartment 10, but does not allow a reverse passage. The valve 15' allows the passage from the compartment 10 to the compartment 11, but prevents a reverse passage.

It will be understood that it is easy to regulate braking during the compression and

braking during extension, and in an independent manner, by causing the section of one or other of these apertures to vary.

5 These variations may be regulated from the exterior by any suitable means, such as the screws 20 shown in Fig. 5.

Braking during the extension, being generally regulated in a manner which is greater than that during compression, one of said 10 two valves the valve 15', for example, may be omitted; in that case, the liquid may pass through the two orifices 14 and 15 during compression, but only through the orifice 15 during extension as the valve 14' is then 15 closed (Fig. 5).

In order to vary the braking according to the position of the piston and especially to prevent shocks upon the end, at the end of the extension stroke, any suitable devices may 20 be adopted for instance those described in the specification of the United States patent application filed on September 7th, 1928, Serial No. 304,403, now United States Patent 1,780,531 of November 4, 1930.

25 There may likewise be provided in the rod 5 connecting the two pistons 3 and 6, according to the present invention, a supplementary passage for the liquid constituted by a channel 16 open at both ends which only operates 30 during a part of the stroke, as will be understood by an examination of the drawing; the section of the orifice 15 is diminished in consequence and the braking at the end of the stroke is increased because at this time the 35 channel 16 does no longer act.

The diaphragm 7 may, on the other hand, be provided, as in Fig. 4, with orifices 14'' and 15'' having spring pressed valves 21, so as 40 to limit the maximum difference of pressure between the two faces of the diaphragm 7, in the case of a violent shock or too great viscosity of the liquid (due to cold for example).

The piston 6 may be provided as shown in Fig. 1 with a central projection 8 which, 45 when there is no pressure in the apparatus, abuts against the upper cover 4' of the cylinder and thus carries the weight of the aeroplane.

50 A filling tap 17 (Fig. 1) may be fixed at such a height that it serves to control the level of the liquid in this position of maximum compression, which facilitates the adjustment of the apparatus.

In order to better absorb the shock at the 55 end of the lower stroke, the bottom 4 of the cylinder (Fig. 1) may be formed with an orifice 18 provided with a valve 18', opening from the exterior towards the interior, this arrangement allows air to enter the compartment 12 during the ascending movement 60 of the piston, but opposes the escape of air during the reverse downwards movement.

Fig. 2 shows a device presenting the same characteristic combination as the preceding 65 one, but under a simplified form, allowing,

for an equal travel of the carriage, to give to the whole a reduced length.

In this modification, use is made, as second piston 6', of the bottom of an auxiliary cylinder C, slidably mounted on the main cylinder 70 1. The bottom 7 of the latter then plays the part of a diaphragm.

The rod 5 connects in this case the cylinder's bottom acting as second piston 6' to the main piston 3 movable in the cylinder 1. 75

The fluid-tight joint between this cylinder 1 and the cylinder C is ensured in any suitable manner, for instance by a cup leather packing E.

In the cylinder's bottom acting as diaphragm 7' are formed apertures 14 and 15 80 respectively provided with valves 14' and 15', opening in reverse directions, as in the previously described arrangement.

The liquid completely fills the compartments 10' and 11'. 85

On the piston 3 is formed a compartment 9' in which rests a liquid layer up to the level 13, and this layer is surmounted by a cushion of compressed gas, either in a free state, or 90 (Fig. 3) enclosed in spongy rubber 22.

The channel 16 in this case offers to the liquid a supplementary passage-way between the compartments 10' and 11', for a portion 95 of the stroke of the pistons.

It will be understood that, owing to the differences of the bore diameters of the cylinders 1 and C, the total volume of the compartments 10' and 11' is less when the carriage 100 has come to the upper end of the stroke than when it is at the bottom of its stroke.

For compensating the difference of the capacities thus offered to the liquid, an air bell 23 (Fig. 3) is provided in the base of the rod 5, this bell collecting the excess of liquid, during 105 the compression stroke.

Variations may be resorted to within the scope of my invention, and parts may be modified or used without others.

Having now fully described my invention, I claim: 110

1. Pneumatic suspension apparatus for aeroplanes and other vehicles, comprising a cylinder, a first piston movable in this cylinder, a second piston connected to the first 115 piston, a diaphragm secured within said cylinder and arranged between the two pistons, apertures of reduced section formed in this diaphragm, one of which at least is controlled by a non-return valve, a liquid always substantially filling the space between the two pistons, a layer of liquid upon one of the said pistons, and a cushion of compressed gas above the said layer of liquid. 120

2. Pneumatic suspension apparatus for aeroplanes and other vehicles, comprising a cylinder, a first piston movable in this cylinder, a second piston connected to the first piston, a central rod interconnecting said two 125

pistons, a diaphragm integral with the cylinder and arranged between the two pistons, two apertures of variable section in this diaphragm, two opposite non-return valves controlling these apertures, a liquid always substantially filling the space between the two pistons, a layer of liquid upon one of said pistons and a cushion of compressed gas above the said layer of liquid.

3. Pneumatic suspension apparatus for aeroplanes and other vehicles, comprising a cylinder, a first main piston movable in this cylinder, a second auxiliary piston connected to the first piston, a central rod interconnecting said two pistons, a diaphragm integral with the cylinder and arranged between the two pistons, two apertures in this diaphragm, valves opening in reverse directions and arranged opposite the said apertures, means for varying the section of said apertures, a longitudinal channel laterally open at both ends and formed in the central rod, a liquid always filling the space between the pistons, a layer of liquid upon the auxiliary piston and a cushion of compressed gas above this layer of liquid.

4. Pneumatic suspension apparatus for aeroplanes and other vehicles, comprising a cylinder, a first main piston movable in this cylinder, a second auxiliary piston connected to the first piston, a central rod interconnecting said two pistons, a diaphragm integral with the cylinder and arranged between the two pistons, two apertures of reduced section formed in this diaphragm, valves opening in reverse directions opposite the said apertures, a liquid always filling the space between the pistons, a layer of liquid upon the auxiliary piston, a cushion of compressed gas above this layer of liquid and a projection carried by said auxiliary piston and constituting an abutment when there is no pressure in the apparatus.

5. Pneumatic suspension apparatus for aeroplanes and other vehicles, comprising a cylinder, a first main piston movable in this cylinder, a second auxiliary piston connected to the first piston, a rod interconnecting said two pistons, a diaphragm integral with the cylinder and arranged between the two pistons, two apertures of reduced section formed in this diaphragm, valves opening in reverse directions opposite the said apertures, a liquid always filling the space between the pistons, a layer of liquid upon the auxiliary piston, a cushion of compressed gas above this layer of liquid and an aperture provided with a non-return valve, formed in the bottom of the cylinder.

6. Pneumatic suspension apparatus for aeroplanes and other vehicles, comprising a main cylinder, a first piston movable in this cylinder, a second piston connected to the first piston and constituted by the bottom of an auxiliary cylinder slidably mounted on the

main cylinder, a diaphragm constituted by the bottom of the main cylinder, apertures of reduced section formed in the said diaphragm, non-return valves opposite the said apertures, means insuring fluid tightness between the two cylinders, a liquid always filling the space between the first piston and the bottom of the auxiliary cylinder, a layer of liquid upon the first piston and a cushion of compressed gas above this layer of liquid.

7. Pneumatic suspension apparatus for aeroplanes and other vehicles, comprising a main cylinder, a first piston movable in this cylinder, a second piston connected to the first piston and constituted by the bottom of an auxiliary cylinder movable on the main cylinder, a rod interconnecting said two pistons, a diaphragm constituted by the bottom of the main cylinder, two apertures of reduced section formed in the said diaphragm, non-return valves arranged opposite the said apertures, means insuring fluid tightness between the two cylinders, a liquid always filling the space between the first piston and the bottom of the auxiliary cylinder, a layer of liquid upon the first piston, a cushion of compressed gas above this layer of liquid and a longitudinal channel sidely open at both ends and formed in the rod connecting the first piston to the bottom of the auxiliary cylinder.

8. Pneumatic suspension apparatus for areoplanes and other vehicles, comprising a main cylinder, a first piston movable in this cylinder, a second piston connected to the first piston and constituted by the bottom of an auxiliary cylinder movable on the main cylinder, a central rod interconnecting said two pistons, a diaphragm constituted by the bottom of the main cylinder, two apertures of reduced section formed in the said diaphragm, non-return valves arranged opposite the said apertures, means insuring fluid tightness between the two cylinders, a liquid always filling the space between the first piston and the bottom of the auxiliary cylinder, a layer of liquid upon the first piston, a cushion of compressed gas above this layer of liquid, a longitudinal channel laterally open at both ends and formed in the rod connecting the first piston to the bottom of the auxiliary cylinder and means for collecting the excess of the liquid enclosed between the two pistons, during the compression stroke.

9. Pneumatic suspension apparatus for aeroplanes and other vehicles, comprising a cylinder, a first main piston movable in this cylinder, a second auxiliary piston connected to the main piston, a diaphragm integral with the said cylinder and arranged between said two pistons, two apertures of reduced section formed in this diaphragm, spring loaded non-return valves opening in reverse directions and arranged within said apertures, a liquid always filling the space between the two pistons, a layer of liquid upon one of the said pis-

tons, and a cushion of compressed gas above the said layer of liquid.

The foregoing specification of my "improvements in suspension apparatus for aeroplanes and other vehicles"; signed by me this 5 29th day of May, 1929.

**GEORGE LOUIS RENÉ JEAN MESSIER.**

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