PATENT SPECIFICATION

679,155

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COMPLETE SPECIFICATION

Improvements in Liquid Springs

I, GEORGE CONSTANTINESCO, British Subject, of Oxen House, Torver, Coniston, Lancashire, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to resilient devices in which use is made of the elasticity of liquids under very high pressures.

In the Specifications of my prior Letters Patent Nos. 105,053 and 125,604 I have described such liquid springs in which the resilience is obtained by the compression of a liquid contained in a strong cylinder or capacity; e.g. in the Specification 125,604 I have described the use of a tube to transfer the liquid from a cylinder in which a plunger works to a cylindrical capacity to act as a radiator for cooling the liquid heated by the loss of energy due to various damping devices on its way to and from the capacity containing the resilient liquid. However, in such an arrangement only a portion of the total liquid enclosed in the system is circulating through the tube during the damping process; the bulk of the resilient liquid contained in the capacity does not participate in damping during the motion of the plunger. Moreover, the use of such a capacity for the liquid spring introduces the risk of explosion under the very high pressures required.

According to the present invention a liquid spring comprises a cylinder in which slides a plunger or piston, the cylinder being in open communication with at least one tube of considerable length and which is of relatively small internal diameter compared with the diameter of the cylinder, the total liquid capacity of the cylinder being substantially smaller than that of the tube, the arrangement being such that the damping effect is obtained mainly by wave transmissions through the liquid in the tube.

In liquid springs as foreseen by this invention, the necessity of containing the resilient liquid in a vessel likely to explode is eliminated and thus higher pressures can be used with safety. At the same time damping is obtained as effectively as desired by using small bore tubes of great length.

The invention in its simplest forms is diagrammatically illustrated in the accompanying drawings in which Figure 1 is a vertical section of one form, Figure 2 showing a similar view of a modified form.

Referring to Figure 1, I use a plunger or piston P working in a cylinder C of sufficient displacement to produce the required stroke for the spring under the maximum load. The plunger works through a high pressure gland G at one end of the cylinder, while the other end of the cylinder is connected with a long tube T of small bore. The length of the tube T is such that the volume of the liquid contained in the tube is of the order of say ten times the volume swept out by the plunger P. The other end of the tube T is closed as shown at A. The cylinder C and tube T are completely filled with a liquid, or semi-liquid such e.g. as oil, grease, molasses, jelly, or any kind of compound that is either liquid, or becomes liquid under very high pressures, all air being first expelled. This long tube T, which may be formed by several interconnected parts, may be coiled round the cylinder or coiled separately and fitted in any convenient position. The bore of the tube T is of the order of a fraction of a millimetre to a few millimetres diameter according to the damping required. The plunger may be formed with an enlarged head inside the cylinder so that it will not pull out accidentally. If such a head be provided, it will act also as a guide for the plunger during the working stroke and also as a dash pot at the end of the stroke to take up any rebound, if the liquid spring is used as a shock absorber.

In this example, if the plunger P is connected to a member oscillating relatively to another member connected to the cylinder, the resulting pulsations will produce longitudinal waves in the small bore tube T which will reflect themselves many times all along the tube and thus will dissipate energy in the form of heat. At the same time there will be resilience between the oscillating parts due to the elasticity of the liquid contained in the tube and the cylinder. Such a device will be suitable for any applications where a moderate amount of damping is required.

According to another example of the invention as shown in Figure 2, instead of closing the loose end of the long tube T, I connect the tube to each end of the cylinder C containing the plunger P having a piston P_1 as at B and C. In this case, the waves produced in the tube T by the pulsations of the plunger produce a higher loss of energy and thus a more pronounced damping effect is obtained, because the liquid acquires a displacement at both ends of the tube on each side of the piston P_1.

In cases where it is desirable to maintain a steady mean position of the plunger P in the cylinder C under the main load, I connect a secondary tube S to the liquid tube T and to a reservoir R of high pressure liquid. The pressure in this reservoir R is maintained at the mean pressure in the liquid spring under the static load by a high pressure pump H. This secondary tube S is of small bore and sufficient length as to offer great reactance (in the tubes T and S friction may be regarded as analogous to electrical resistance, elasticity to capacity and inertia to inductance) to the passage of the liquid when oscillations of high frequency are acting on the plunger. The reservoir R is shown in the form of a small capacity strong vessel, also completely filled with liquid, into which the high pressure pump H pumps the liquid so as to maintain the pressure constant. Any leakages that may occur in the liquid spring connected to this pressure reservoir are thus made up automatically. This pump may be worked either intermittently by hand or continuously by the engine of a vehicle on which the springs are fitted. If there is no engine—for instance in the case of a rail coach—the pump can be worked from the axles of the wheels or by the oscillations of the liquid springs themselves. Such a pump could pick up the leakages from the glands of the liquid spring and pump them back into the liquid spring or supply fresh liquid from a small tank under static pressure or from a low pressure pump.

Such an arrangement of pump and feeding lines, as just described, is illustrated in Figure 1 of the Specification of my Patent No. 128,592.

According to another example of the invention (not illustrated), I use supplementary damping devices, in the form of perforated valves, interposed between the cylinder ends and the tube ends, so as to allow free passage of liquid into the tube in one way, but restricted passage the other way, for the purpose of retarding the return stroke of the plunger to a slower pace, when the load is removed.

I may use one or several such valves at intervals along the wave tube, allowing freer passage one way and more restricted the other way, as illustrated in Figure 4 of the Specification of my Patent No. 128,592.

One advantage of this invention is that the wave tube, with the resilient liquid, can be situated at any convenient place on a vehicle or implement which is to be sprung and thus the size of the cylinder plunger and piston are reduced to a minimum, the bulk of the liquid being contained in the wave tube. Another point of importance is that small bore metallic tubes can stand very high internal pressures, are self cleaning and, in case of rupture under excessive pressure, there is no dangerous explosion, throwing fragments at high velocity, as will be the case with liquids occupying a compact volume as in a cylinder or a capacity.

Another point in favour of the invention is that damping is obtained mainly through friction of liquid in a very long tube, instead of through throttling liquid through very narrow passages of short lengths, as is usually done in damping devices. Such narrow passages can be blocked quite easily, while the bore of the long tube allows a relatively much larger opening for the passage of the liquid.

The long wave tube used in the present invention provides a very efficient cooling radiating surface, which enables such a liquid spring to work under continuous oscillations for an indefinite period of time, without unduly heating the liquid.

For cases where a high rate of damping is required, for instance in applications as shock absorbers to rapid firing guns, to large aircraft or suspension for vehicles running over bad roads, the amount of heat generated is quite substantial and unless it is radiated efficiently the liquid will overheat and expand. This, in turn, will increase the initial pressure and alter considerably the mean position of the plunger under the static load. The present invention provides ample cooling for the liquid due to the very large surface of radiation of the tube relatively to the liquid contained.

The ratio of the volume of liquid in the tube to the maximum volume swept out by the plunger is selected according to the coefficient of elasticity. With ten times the volume in the tube as the displacement in the cylinder, a pressure of about 1,500 atmospheres will be reached with ordinary kinds of mineral oils or jelly. This ratio may be varied considerably according to the characteristics required and the liquids used.

According to this invention, it will be appreciated that the damping of the oscillations in the liquid spring is due mainly to the viscosity of the liquid, e.g. oil in the tube or tubes. As the viscosity increases to very high values under high pressures, the damping effect is quite substantial, despite the relatively moderate speed of liquid displacement in the tube or tubes, when the plunger in the liquid spring oscillates.

What I claim is:—

1. A liquid spring comprising a cylinder in which slides a plunger or piston, the cylinder being in open communication with at least one tube of considerable length and which is of relatively small internal diameter compared with the diameter of the cylinder, the total liquid capacity of the cylinder being substantially smaller than that of the tube, the arrangement being such that the damping effect is obtained mainly by wave transmissions through the liquid in the tube.

2. A liquid spring as claimed in Claim 1 in which the tube is connected at one end to the lower end of the cylinder, and at the other is closed.

3. A liquid spring as claimed in Claim 1 or 2 in which the plunger or piston carries a head to prevent said plunger or piston being pulled out of the cylinder.

4. A liquid spring as claimed in Claim 1 in which the plunger is in the form of a piston and piston rod, the tube being connected at one end to the lower end of the cylinder and at the other end to the upper end of the cylinder.

5. A liquid spring as claimed in Claim 4 in which the tube has connected thereto a secondary tube which itself is connected to a liquid reservoir supplied with liquid under pressure by a high pressure pump.

6. Liquid springs substantially as hereinbefore described with reference to the accompanying drawings.

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PROVISIONAL SPECIFICATION

Improvements in Liquid Springs

I, GEORGE CONSTANTINESCO, British Subject, of Oxen House, Torver, Coniston, Lancashire, do hereby declare the nature of this invention to be as follows:—

This invention relates to resilient devices in which use is made of the elasticity of liquids under very high pressures.

In the Specifications of my prior Letters Patent Nos. 105.053 and 125,604 I have described such liquid springs in which the resilience is obtained by the compression of a liquid contained in a strong cylinder or capacity; e.g. in the Specification 125,604 I have described the use of a tube to transfer the liquid from a cylinder in which a plunger works to a cylindrical capacity to act as a radiator for cooling the liquid heated by the loss of energy due to various damping devices on its way to and from the capacity containing the resilient liquid. However, in such an arrangement only a portion of the total liquid enclosed in the system is circulating through the tube during the damping process: the bulk of the resilient liquid contained in the capacity does not participate in damping during the motion of the plunger. Moreover, the use of such a capacity for the liquid spring introduces the risk of explosion under the very high pressures required.

According to the present invention a liquid spring comprises a cylinder in which can slide a piston, the cylinder being in open communication with a tube of considerable length and which is of comparatively small internal diameter compared with the diameter of the cylinder, the total liquid capacity of the cylinder being substantially smaller than that of the tube, the arrangement being such that the damping effect is obtained mainly by wave transmissions through the liquid in the tube.

In liquid springs as foreseen by this invention, the necessity of containing the resilient liquid in a vessel likely to explode is eliminated and thus higher pressures can be used with safety. At the same time damping is obtained as effectively as desired by using small bore tubes of great length.

To illustrate the invention in its simplest form I use a plunger or piston working into a cylinder of sufficient displacement to produce the required stroke for the spring under the maximum load. The plunger works through a high pressure gland at one end of the cylinder while the other end of the cylinder is connected with a long tube of small bore. The length of the tube is such that the volume of the liquid contained in the tube is of the order of say ten times the volume swept out by the plunger. The other end of the tube is closed. The whole is filled with a liquid, or semi-liquid such e.g. as oil, grease, molasses, jelly, or any kind of compound that is either liquid, or becomes liquid under very high pressures, all air being first expelled. This long tube may be coiled round the cylinder or coiled separately and fitted in any convenient position. The bore of the tube is of the order of a fraction of a millimetre to a few millimetres diameter according to the damping required. The plunger has an enlarged head inside the cylinder so that it will not pull out accidentally. The enlarged head acts also as a guide during the working stroke and also as a dash pot at the end of the stroke to take up any rebound if the liquid spring is used as a shock absorber.

In this example, if the plunger is connected to a member oscillating relatively to another member connected to the cylinder the resulting pulsations will produce longitudinal waves in the small bore tube which will reflect themselves many times all along the tube and thus will dissipate energy in the form of heat. At the same time there will be resilience between the oscillating parts due to the elasticity of the liquid contained in the tube and the cylinder. Such a device will be suitable for any applications where a moderate amount of damping is required.

According to another example of the invention, instead of closing the loose end of the long tube, as in the above example, I connect each end of the tube to each end of the cylinder containing the plunger with its piston. In this case the waves produced in the tube by the pulsations of the plunger produce a higher loss of energy and thus a more pronounced damping effect is obtained because the liquid acquires a displacement at both ends of the tube on each side of the piston.

According to another example of the invention I use supplementary damping devices in the form of valves interposed between the cylinder ends and the tube ends so as to allow free passage of liquid into the tube in one way but restricted the other way for the purpose of retarding the return stroke of the plunger to a slower pace when the load is removed.

I may use one or several such valves at intervals along the wave tube allowing freer passage one way and more restricted the other way.

One advantage of this invention is that the wave tube with the resilient liquid can be situated at any convenient place on a vehicle or implement which is to be sprung and thus the size of the cylinder plunger and piston are reduced to a minimum, the bulk of the liquid being contained in the wave tube. Another point of importance is that small bore metallic tubes can stand very high internal pressures, are self cleaning and in case of rupture under excessive pressure there is no dangerous explosion throwing fragments at high velocity as will be the case with liquids occupying a compact volume as in a cylinder or a capacity.

Another point in favour of the invention is that damping is obtained mainly through friction of liquid in a very long tube instead of through throttling liquid through very narrow passages of short lengths as usually is done in damping devices. Such narrow passages can be blocked quite easily while the bore of the long tube allows a relatively much larger opening for the passage of the liquid.

The long wave tube used in the present invention provides a very efficient cooling radiating surface which enables such a liquid spring to work under continuous oscillations for an indefienite period of time without unduly heating the liquid.

For cases where a high rate of damping is required, for instance in applications as shock absorbers to rapid firing guns, to large aircraft or suspension for vehicles running over bad roads, the amount of heat generated is quite substantial and unless it is radiated efficiently the liquid will overheat and expand. This in turn will increase the initial pressure and alter considerably the mean position of the plunger under the static load. The present invention provides ample cooling for the liquid due to the very large surface of radiation of the tube relatively to the liquid contained.

The ratio of the volume of liquid in the tube to the maximum volume swept out by the plunger is selected in dependance on the coefficient of elasticity. With ten times the volume in the tube as the displacement in the cylinder a pressure of about 1,500 atmospheres will be reached with ordinary kinds of mineral oils or jelly. This ratio may be varied considerably according to the characteristics required and the liquids used.

In another form of the invention, especially applicable to all cases where the maintenance of a steady mean position of the plunger in the cylinder under the mean load is desired, I connect a secondary tube to the liquid to a reservoir of high pressure liquid through a non return valve. The pressure in this reservoir is maintained at the mean pressure in the liquid spring under the static load. This filled secondary tube is of very small bore offering great reactance (in the tube, friction may be regarded as analogous to electrical resistance, elasticity to capacity and inertia to inductance) to the passage of the liquid when oscillations of high frequency are acting on the plunger. The reservoir may be in the shape of a small capacity strong vessel into which a high pressure pump is pumping the liquid so as to maintain the pressure constant. Any leakages that may occur in the liquid springs connected to this pressure reservoir are thus made up automatically. This pump may be worked either intermittently by hand or continuously by the engine of the vehicle on which the springs are fitted. If there is no engine—for instance in the case of a rail coach—the pump can be worked from the axles of the wheels or by the oscillations of the liquid springs themselves. Such a pump could pick up the leakages from the glands of the liquid spring and pump them back into the liquid spring or supply fresh liquid from a small tank under static pressure or from a low pressure pump.

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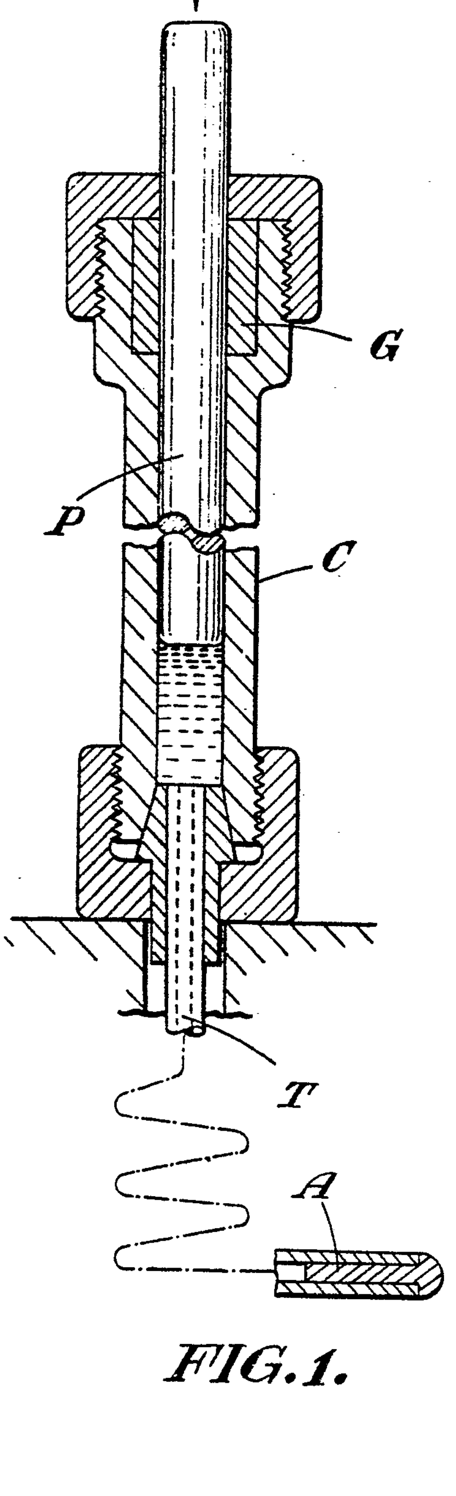
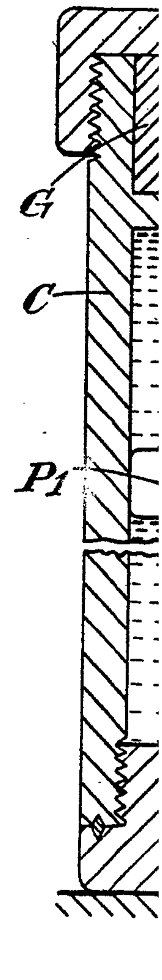


FIG.1.



679,155 COMPLETE SPECIFICATION
2 SHEETS *This drawing is a reproduction of the Original on a reduced scale.*
SHEETS 1 & 2

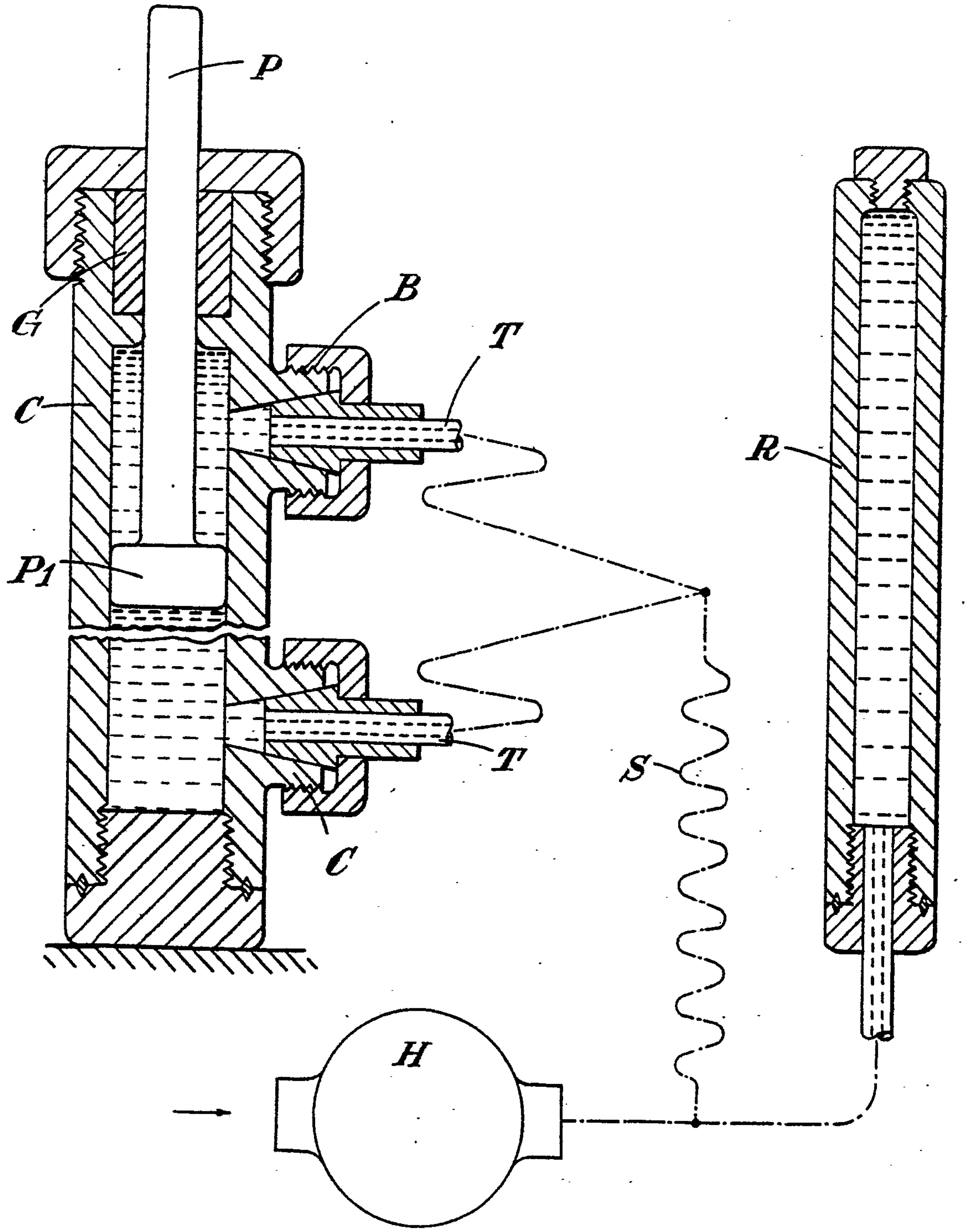


FIG. 2.

679,155 COMPLETE SPECIFICATION
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This drawing is a reproduction of the Original on a reduced scale.
SHEETS 1 & 2

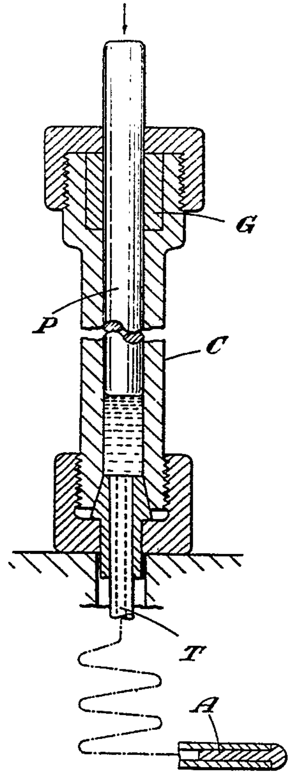

FIG.1.

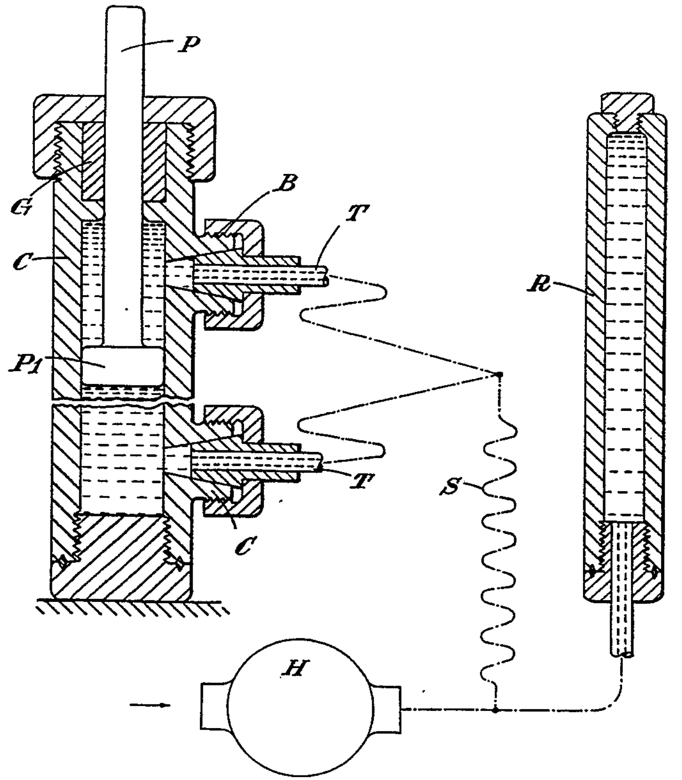

FIG.2.