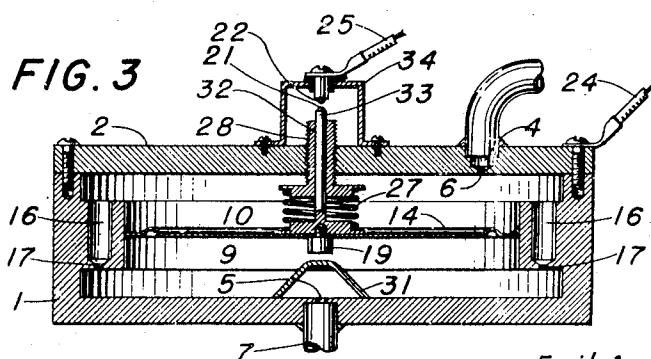
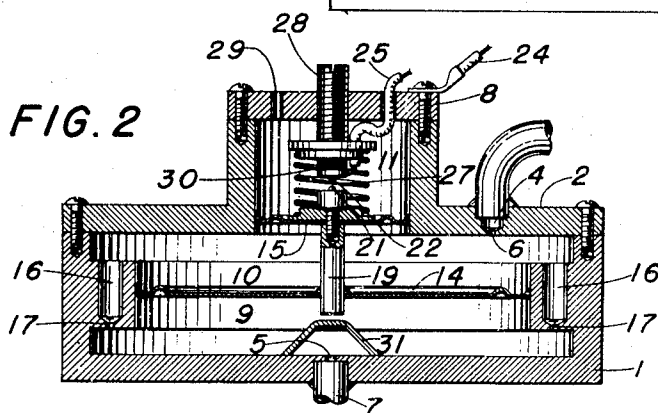
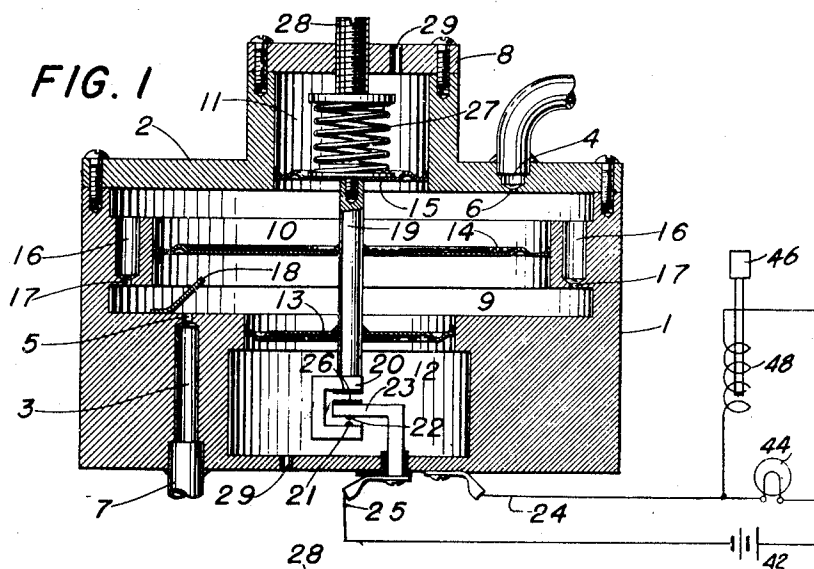


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MEANS TO INDICATE THE PRESENCE OF
VAPOR IN FLUID CONDUIT SYSTEMS
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MEANS TO INDICATE THE PRESENCE OF
VAPOR IN FLUID CONDUIT SYSTEMS

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This invention relates to an improved method for detecting the existence of the formation of vapor in fluid conduit systems and an improved indicator for accomplishing the same.

In order to simplify the specification and claims which are to follow, the broad term "vapor" shall be used generally hereinafter to indicate any compressible fluid such as gas, air, or any other substance having a density lower than that of the incompressible liquid in a fluid conduit system.

The efficiency of operation of all fluid conduit systems and particularly those systems adapted for metering fluid for an internal combustion engine, depends to a significant extent upon the condition of the fluid within the said system, e. g., whether or not the fluids are in comparatively liquid state as opposed to a combined liquid and vapor state. It is well known that existing fluid conduit systems do not function as efficiently nor as accurately when a combined liquid-vapor condition exists within the system. In less actual instances of operations, it has been demonstrated that the depreciation in performance of an internal combustion engine due to the presence of vapors often causes partial or complete failure of engine operation. In an effort to provide, in the fluid conduit system, some means for prevention of failure of various parts of the system, due to these causes, which means would in turn reflect favorably upon the operation of the system, common practice includes certain auxiliary, booster, or emergency pumps, or other known devices, which are intended to reduce or eliminate the formation of vapors. For a number of reasons, it is undesirable to operate these pumps or other devices continuously. Accordingly, the common practice is to operate or begin the operation of these devices manually, only after the presence of vapor in the system is detected by the operator, based upon the functioning of the engine. Such a procedure is undesirable inasmuch as it requires a conscious effort on the part of the operator and because the outward indication of the vapor function—its effect on the system—is often times difficult to diagnose (requiring an extensive knowledge of the particular system), and also because it is undesirable to permit the vapor formation to develop to the extent where actual mal-functioning is experienced, especially in the case of an internal combustion engine for an aircraft.

An object of this invention is to provide an improved indicator for the detection of the partial formation of vapor in fluid conduit systems.

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A further object of this invention is to provide a method for the detection of the partial formation of vapor in fluid conduit systems.

Other objects and advantages of this invention will become apparent as the discussion proceeds and is considered in connection with the claims and accompanying drawings wherein like characters of reference designate like parts in the several views and wherein:

Fig. I is a cross sectional view of the device embodying this invention.

Fig. II shows a cross sectional view of a modification embodied in this invention.

Fig. III shows a cross sectional view of a further modification embodied in this invention.

Referring now to the drawings, wherein for the purpose of illustration, is shown, an embodiment of this invention, numeral 1 of Fig. I designates a casing or housing having a covering 2 affixed to the top of the housing in any suitable manner. A fluid inlet passage 3 is provided in the bottom or base and a fluid outlet passage 4 in the top of said housing, as shown. Orifices 5 and 6 of suitable size are provided in the said fluid passages 3 and 4. Communicating with the inlet passage 3, and affixed thereto in any suitable manner, such as by a thread joint, is a conduit 7 adapted to allow passage of fluid or fluid and vapor from a main conduit line (not shown), carrying fluid under pressure, to the inlet 3. It is to be noted that the housing 1 is placed above the main conduit.

Within the said casing 1 of the modification shown by Fig. I are four expansion chambers 9, 10, 11, and 12 separated by three diaphragms 13, 14, and 15, as shown, rigidly affixed at their outer circumference to the casing 2, as by welding or in any other suitable manner.

Communication between chambers 9 and 10 is provided by a plurality of passages 16 having an orifice 17 in each of the said passages. A baffle 18 is provided, as shown, within the chamber 9 over the opening of the inlet 3 to deflect the flow of fluid away from the passages 16 nearest the said inlet 3.

A shaft 19 is mounted on the three diaphragms 13, 14, and 15, and carries on its lower extremity in the chamber 12, a suitable electrically responsive U-shaped element 20 having a contact point 21 on the inside of the U, as shown, grounded to the body of the housing adapted to close a circuit by contact with an electrical contact point 22 supported by an insulated arm 23, when the shaft 19 is moved upward. Leads 24 and 25 are connected to the housing 1 and the arm 23, respec-

tively, and operate a suitable electronic signal or control which may take the form of a simple battery circuit comprising, as shown, the leads 24—25, a battery 42, a lamp 44 and a solenoid coil 48 which is adapted to operate a valve or an electrical switch shown diagrammatically at 46. Suitable insulating material 26 is provided, as shown, between the portion of the U-shaped element 20 and the arm 23 to prevent closing of the electrical contact when the shaft 19 is moved downward.

The upper extremity of the shaft 19 carries a biased spring 27 in the expansion chamber 11, adapted to counteract the differential pressure existing across the diaphragm 14 during the flow of fluid from the chamber 9 to the chamber 10, and to provide a positive assurance of separation of contact points 21 and 22 during non-operation. An adjustable tension screw 28 threadedly engages cover 8 and bears on spring 27 to give control of the compression on said spring. Ports 29 are provided in the chambers 11 and 12 to permit breathing of the chambers.

In the modification of this invention shown in Fig. II the function is the same as that shown in Fig. I, and the structure differs only in that the expansion chamber 12 and diaphragm 13 are omitted and the electrical contacts 21 and 22 are modified and located within the spring 27 in the expansion chamber 11. The contact point 21 is grounded to the housing 2 and a suitable insulation 30 is provided to separate the contact point 22 from the grounding effect of the housing 2. A wire or open bridge 31 is provided over the inlet passage 3 to limit the downward movement of the shaft 19 and still permit the unrestricted passage of fluid and vapor into the chamber 9.

In the modification of this invention shown in Fig. III the function is the same as the modification shown in Fig. II and the structure differs only from that modification in that the expansion chamber 11 and diaphragm 15 are omitted. The spring 27 is located in the chamber 10 and is rigidly affixed to the diaphragm 14. The shaft 19 is affixed to the spring 27 and the diaphragm 14 by any suitable means, as shown. The adjusting screw 28 is provided with an opening 32 adapted to slidably receive, under pressure seal, a plunger 33. The lower end of the said plunger 33 is rigidly affixed to the shaft 19 in any suitable manner. A contact point 21 is provided at the upper end of the plunger 33 and is grounded to the housing 2 through the said plunger. A housing 34 carrying a second contact point 22, suitably insulated, is provided to protect the contact points from dirt, etc. The circuits in modifications shown in Figs. II and III as in the modification shown in Fig. I are closed by grounding the insulated contact 22 against the grounded contact 21.

During normal operation in the presence of fluid flow in the main conduit, there will be a certain amount of fluid flow into the inlet passage 3 and thence through the chamber 9 into the chamber 10 and into the outlet 4. Inasmuch as the flow into the chamber 10 from chamber 9 is controlled by orifices 17, a slight pressure differential will normally exist across the diaphragm 14 which is compensated for by the spring 27. Transient variations in the fluid pressure in the main conduit will have an inappreciable effect on the pressure in the chamber 9 due to the dampening effect of the orifice 5, and accordingly the differential pressure across the diaphragm 14 will not be markedly affected, since this is also to a large extent a function of the orifice 6.

It is a known hydraulic phenomenon that for a given pressure the volume rate of flow of a liquid through an orifice is considerably less than that of a gas. The exact magnitude of the differences in rate of flow for any given liquid and gas is a function of the size of the orifice and the pressure differential existing across it. Also, it is known that the critical velocity of flow through a given orifice is considerably lower for a liquid than for a gas. The relative sensitivity of the indicator can be increased or decreased by altering the ratio of the size of orifices 5 and 17 to orifice 6. For example by proper selection of the orifice 6, normal flow of liquid through said orifice 6, for the average pressure differential existing across it, can be made to flow, if desired, at or near a critical velocity condition. Inasmuch as the greatest pressure differential will at all times exist across orifice 6, it can be made to be the only restriction which is flowing in the critical region.

Now, at the time vapor begins to form in the main conduit, it will be carried past the juncture of conduits 7 and the main conduit. Due to the form of this juncture, (not shown) and due to the fact that the vapor of lower density than the fluid, will lie above the fluid, and due to the fact that the indicator housing 1 is located above the level of the conduits 7 and main conduit vapor, (under the same pressure as the liquid will be carried up into the inlet passage 3 and thence into the expansible chambers 9 and 10. Inasmuch as the vapor in passing through the orifice 5 will be flowing into the chamber 9 which is a lower pressure than existing in the conduit 7, it will effect neither the volume nor the pressure of the chamber 9. Inasmuch as the orifice 6 permits the passage of fluid at or near a critical velocity and is the main control of flow through the indicator, the drop in pressure across orifices 17 can be made small. As vapor passes through the said orifices 17, however, the volume-rate of flow will increase somewhat and produce a momentary slight decrease in the volume of fluid in chamber 9, which in turn will affect the differential across diaphragm 14 and thereby create a downward movement of the shaft 19; however this is not the effect which determines the operation of the indicator as embodied in this invention but if present will not create an undesirable closing of the electrical circuit because the downward action on the diaphragm will be absorbed by the insulation 26.

As vapor passes through the orifice 6, however, there will exist a very marked increase in rate of volume flow through that orifice due to the fact that the differential across this orifice is high. This will result in an immediate pronounced reduction of pressure in the expansive chamber 10 only, due to the reduction in volume of fluid in this chamber. Under the set of circumstances which will then exist, when the first flow of vapor takes place through the orifice 6, i. e. when all but a small portion of the fluid contained in the chamber 10 consists of a relatively incompressible fluid, the release of vapor through the orifice 6 will cause the pressure in chamber 10 to reach a value nearly that of the pressure in conduit 4. The result will be a pressure in chamber 10 considerably less than that in chamber 9 forcing the diaphragm and consequently the shaft 19 upward thereby closing the contacts 21 and 22.

With closure of the contact points, the electrical circuit can be made to start the operation

of those known devices in the fuel and/or fuel metering system which are included to alleviate the formation of vapor and which do not operate continuously, or such other devices whose continuous operating characteristics differ from the characteristics desired during the presence of vapor.

It is to be understood that the form of this invention, herewith shown and described, is to be taken as a preferred example of the same, and that various changes in the shape, size, and arrangement of the parts may be resorted to without departing from the spirit of this invention or the scope of the subjoined claims.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What I claim is:

1. A device for sensing vapor in a liquid comprising a pair of expansion chambers in a housing adapted to receive fluid under pressure, conduit means interconnecting said chambers adapted to direct successive fluid flow therethrough, discharge orifice means in the second of said chambers adapted to effect a change of pressure in that chamber with respect to pressure in the other chamber when entrained vapor in the fluid flows through the sensing device, and sensing means responsive to any change of pressure due to entrained vapor.

2. In a device for sensing vapor in a liquid the combination comprising a pair of chambers adapted to receive the fluid under pressure, conduit means interconnecting said chambers to direct successive fluid flow therethrough, discharge orifice means adapted to effect a change of pressure in the second of said chambers with respect to the pressure in the first chamber when entrained vapor in the liquid flows through the device, diaphragm means positioned between the chambers responsive to said change, and a sensing device responsive to said diaphragm.

3. A device for sensing vapor in a liquid comprising the combination of a pair of chambers in a housing adapted to receive the fluid under pressure, a movable partition wall common to both chambers, conduit means interconnecting said chambers adapted to direct successive fluid flow therethrough and discharge conduit means including an orifice communicating with the second chamber and effective to create a differential pressure between the second and first chambers when the fluid mixture of vapor and liquid flows through the device, said partition wall being movable in response to said differential pressure, and sensing means actuated by said wall.

4. A device as set forth in claim 3, wherein the movable partition wall is constructed in the form of a diaphragm.

5. A device as set forth in claim 3 wherein the conduit means interconnecting the chambers comprises a series of parallel conduits provided with orifices of predetermined metering characteristics.

6. A device for indicating the presence of a mixture of vapor and liquid in a fluid conduit comprising a housing connected to said conduit for fluid flow therefrom, a pair of chambers in

said housing adapted to receive the fluid under pressure in sequential flow, a flexible diaphragm forming a common wall between said chambers, conduit means provided with restrictive orifices interposed between the two chambers adapted to create a pressure differential therebetween when the fluid is in motion, an inlet passage in said housing connected to one of the chambers, a discharge passage provided with a restrictive orifice connected to the other chamber adapted to discharge liquid at or near its critical velocity and to thereby create a greater pressure differential between said chambers when a mixture of vapor and liquid passes through said last named orifice and means responsive to the movement of the diaphragm under said greater pressure differential adapted to indicate the presence of said mixture.

7. A device for indicating the presence of a mixture of vapor and liquid in a fluid conduit comprising a housing connected to said conduit for fluid flow therefrom, a pair of chambers positioned in said housing adapted to receive liquid under pressure, a flexible diaphragm forming a common wall between the two chambers, conduit means provided with restrictive orifices connecting said chambers for successive fluid flow therebetween, said conduit means adapted to create a differential pressure between said chambers across said diaphragm, the pressure in the said second chamber being less than that in the first chamber to thus actuate said diaphragm away from neutral position, resilient means positioned in said housing adapted to counteract the differential pressure to return the diaphragm to neutral position, means to limit the movement of the diaphragm when the differential pressure decreases, an inlet passage to the first chamber, an outlet passage from the second chamber adapted to pass liquid substantially at the critical velocity thereof and to pass vapor below the critical velocity thereof whereby the pressure differential between the two chambers is increased when vapor alone flows through said last named orifice and means actuated by the diaphragm under the last named condition to indicate the presence of the vapor.

8. A device for sensing the presence of vapor in a liquid system, comprising a casing defining a pair of chambers and a communicating passage for liquid under pressure, said chambers having a common yieldable partition, an inlet orifice for one of said chambers, an outlet orifice for the other of said chambers calibrated at approximately the critical velocity of said liquid, whereby the relative pressure in said chambers varies upon the flow of vapor through said outlet orifice, and sensing means responsive to pressure differentials between said chambers when there is vapor in the liquid system.

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