May 8, 1951 R. P. GENDREAU 2,551,836

REGULATOR

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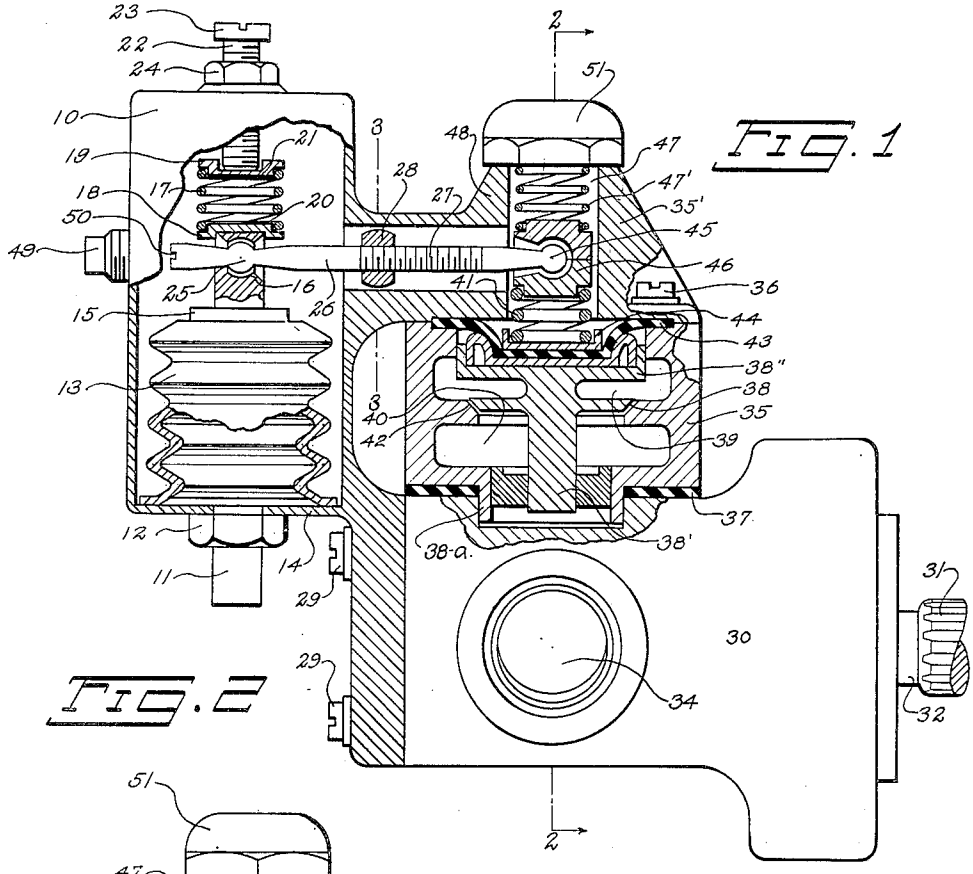

FIG. 1

FIG. 2

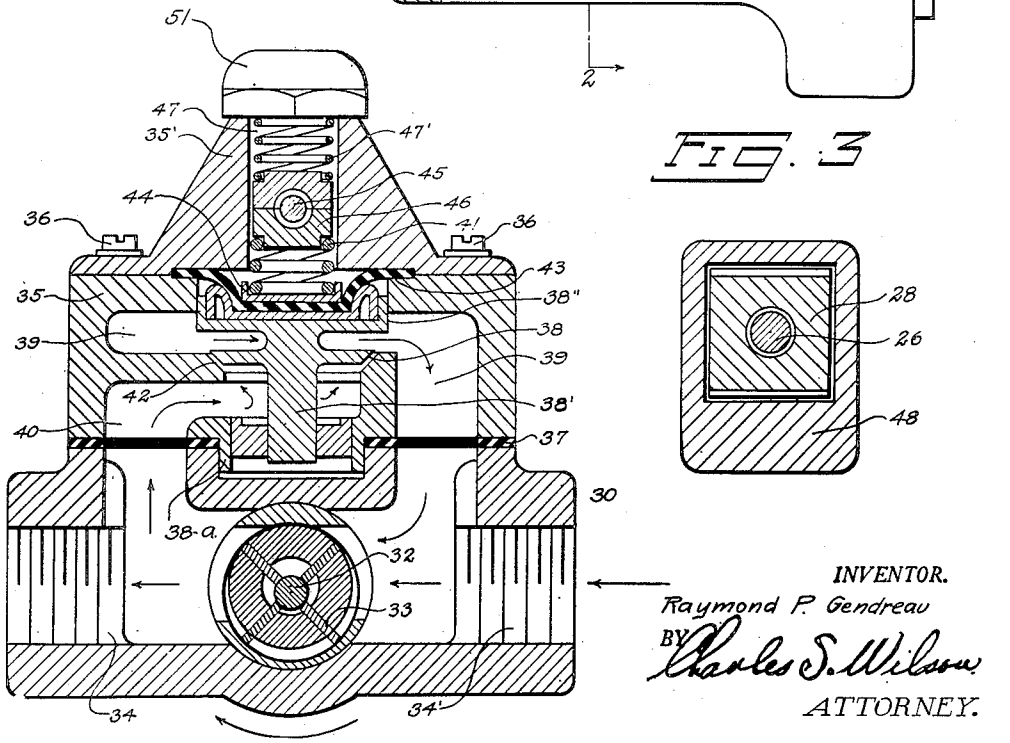

FIG. 3

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REGULATOR

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9 Claims. (Cl. 103—42)

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This invention relates to regulators for use in conjunction with the water injection systems of internal combustion engines and contemplates means for controlling the supply of water or equivalent fluids to the intake conduits or intake manifold of the engine or the like, for blending with the air-fuel mixtures.

In substantially all the prior regulating systems the volume of water directly or indirectly injected into the engine has been controlled by fuel pressure, but for one reason or another this control has been unsatisfactory. For example, it has frequently been found that variations of the fuel pressure do not coincide with or correspond to variations in the manifold pressure. In other cases, the variation of fuel pressure is insufficient to regulate the volume of water necessary to meet the requirements of the engine at different throttle settings. In many of these prior water regulators, a diaphragm is employed, fuel being directly admitted to one side of the diaphragm and water on the other side thereof. Since it is well known that various types of fuel vary chemically, introduction of these different fuels in the prior water regulating systems has often resulted in diaphragm failures and consequent intermingling of the fuel with the water. In such cases, if the water is exhausted or not in use, the fuel passes through the diaphragm and into the engine through the water system, thus making the mixture too rich and slowing up the engine operation.

The present invention proposes a water regulator for internal combustion engines wherein the fuel pressure performs no function in the control of the volume of the water thus avoiding the defects and failures above described which inevitably flow from the use of fuel pressure to regulate the volume of water.

Among its other objects the instant invention has in view a water regulator so constructed and arranged that the volume of water is controlled by and from the manifold pressure and a constant but adjustable ratio is maintained between the manifold pressure on the one hand and the quantity of water on the other, the latter being independent of the fuel pressure.

With the above and other objects in view, as will be apparent, this invention consists in the construction, combination and arrangement of parts all as hereinafter more fully described, claimed and illustrated in the accompanying drawings, wherein:

Fig. 1 is a side view of a regulator constructed according to the present invention showing parts

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of the outer housing thereof broken away to disclose in section the interior arrangement of parts including the means by which the manifold pressure is communicated to the valve controlling the volume of water;

Fig. 2 is a section taken along the line 2—2 of Fig. 1, indicating the directional flow of the water, the rotation of the impeller of the pump and illustrating with more particularity the regulation of the volume of water discharged by the pump by the opening and closing of the valve of the regulator; and

Fig. 3 is an enlarged transverse section taken along the line 3—3 of Fig. 1, to illustrate the fulcrum of the control rod.

One use for the present water regulator is in the construction of aircraft where it is obviously desirable and important that the pilot have at his command all the speed, power and maneuverability of which his plane is capable. To that end it is further desirable to provide a fixed ratio of operation or effectiveness between the manifold pressure of the engine and the volume of water feeding into the water injection system.

Water injection ordinarily is not constantly used in the operation of aircraft engines, since it is only required when power in excess of the normal output of the engine is needed, or where it may be substituted for that portion of the fuel used as a coolant in normal operation. When excessive power is used it is only used for short intervals and is always accompanied by, or is the result of pronounced increases in manifold pressure. One of the objects of the present invention, therefore, is the provision of means whereby the manifold pressure regulates and controls the volume of water feeding from the water system into the engine fuel intake.

As previously pointed out substantially all of the prior systems have "tied in" the water control to the fuel pressure with unsatisfactory results as noted. According to the present invention, therefore, there is no direct connection or interdependence, between the volume of water passing into the engine system and the fuel pressure thereof. On the contrary the arrangement of parts according to the instant invention is such that there is provided complete independence of the fuel pressure so far as the quantity of water delivered to the system is concerned; and a direct relationship is afforded between the manifold pressure and the water, whereby as the manifold pressure increases the volume of water correspondingly increases. Conversely, if the

manifold pressure falls, then the flow of water likewise decreases.

To that end there is contemplated any conventional water tank or reservoir connected to a pumping unit, with the water running from the reservoir or container through the water pump to be delivered under pressure to the engine fuel system. As an integral part of the pump unit or operating in conjunction therewith is provided a housing to contain the structure whereby variations of the manifold pressure correspondingly increase or decrease the volume of water fed into the engine fuel system. This includes a bellows operable from the manifold pressure which in turn actuates a rod or lever fulcrumed between the bellows and a by-pass valve coacting with the pump. This valve is so coordinated with the pump that as its opening decreases, the supply of water discharged by the pump is increased and reversely when the valve opening is increased the quantity of discharged water is decreased. Thus there exists a definite ratio between the volume of water and the manifold pressure, and the former is regulated by the latter. Since it is desirable that an increase of manifold pressure be accompanied by a greater flow of water and conversely that a smaller volume of water be concomitant with a reduction of manifold pressure, the utility of the instant invention is apparent.

The regulator contemplated herein is primarily adapted for use as a regulator for the water injection system of a combat aircraft though it will become manifest that it has general application and use. It includes a casing or housing **10** into which the manifold pressure is transmitted through the tubular fitting or pipe **11**, fastened to the casing **10** by the nut **12** or other suitable fastening means. Within the hollow casing **10** is the bellows **13**, the open end of which is connected or otherwise bonded to the end wall **14** of the casing, whereby the manifold pressure becomes effective within the bellows **13**. Manifestly, as the manifold pressure varies, the bellows **13** correspondingly expand or compress. At its other or upper end the bellows **13** are closed by and secured to the plate **15** which also serves as a base or mounting support for the spherical or universal socket **16**. According to this arrangement of elements, it will be readily understood that if the manifold pressure increases, the bellows **13** within the casing **10** will expand, thus moving the socket **16** vertically upward and further away from the end wall **14** of the casing. Reversely, if the manifold pressure decreases or falls, the bellows **13** compress or deflate and the universal socket **16** moves vertically downward toward the end wall **14** of the casing **10**.

As shown in Fig. 1, the bellows **13** and the socket **16** are normally urged downwardly by means of the compression coil spring **17**, the ends of which seat or nest on the flanges **18**, **19** of the opposed collars or annular rings **20**, **21**, the central portion of each collar being received within the coacting end of the spring. The end of a bolt **22** threaded through the upper end wall of the casing is seated in a recess in the ring **21** so that the adjustment or variation of the tension of the spring **17**, may be accomplished by turning the bolt **22** in the appropriate direction. As shown in Fig. 1, this adjustment may be accomplished without recourse to the interior of the housing or casing **10** since the head **23** of the bolt **22** is outside of the casing **10** and may be fixed by the lock nut **24** mounted on the bolt **22** adjacent the upper end wall of the casing **10**.

A lever or rod **26** is moved or actuated through the movement of the bellows **13** by being connected to the socket **16** by the ball **25** integral with or fixed to the extremity of the lever or rod. This lever or rod **26** projects horizontally beyond the confines of the casing **10** and medially of its length is threaded as at **27**. A nut **28** is mounted on the threaded intermediate portion **27** of the rod or lever **26** to act as a central fulcrum therefor, as will be apparent. It is the movement of this rod or lever **26** about the nut **28** as a fulcrum that controls the volume of water in relation to the manifold pressure as will be described hereinafter.

Adjacent the housing **10** and fastened thereto by means of the bolts **29** is a conventional water pump **30** having a spline gear **31** and shaft **32** adapted to rotate the impeller **33** of the pump whereby the water is received from the pump inlet **34'** and forced or expelled under pressure through the opposed pump outlet **34**.

As shown in Fig. 2 the water pump **30** forms a base or support on which is mounted an upper hollow housing **35** which accommodates the control valve whereby the volume or flow of water from the outlet **34** is increased or decreased. The housing **35** is mounted on the pump **30** by means of the bolts **36** located on the perimeter of the housing **35** and passing through the rubber gasket **37** into the pump housing **30**.

The valve seat **42** divides the housing **35** into an upper chamber **39** which communicates with the inlet port **34'** of the pump and a lower chamber **40** which communicates with the outlet port **34** of the pump, the impeller **33** being disposed between these two ports **34—34'**. The valve opening in the seat **42** permits communication between these chambers **39** and **40** and the degree of valve opening determines the volume of water permitted to pass under pressure from chamber **40** to chamber **39** and thus recirculate through the impeller **33**. Thus if the valve opening is fully open, a large percentage of the water passing the impeller **33** is forced upwardly through the chamber **40**, the valve opening and into the chamber **39** to return to the intake side of the impeller **33**. A part of the water admitted to the pump **30** through the intake port **34'** may be thus bypassed and recirculated through the pump and not be discharged through the outlet port **34**. If the valve opening is completely closed there is none of this recirculation or by-passing of water and the entire water intake is discharged through the outlet port **34** for ultimate delivery to the fuel intake of the engine.

The opening in the seat **42** is closed or its effective size is regulated by the valve **38** having a stem **38'** upon one side and a cup **38''** on the opposite side. The stem **38'** of the valve reciprocates in a guide **38a** which is a fixed structure situated generally between the pump casing and the housing **35** below the valve seat **42**. The cup **38''** is located above the valve **38** and is therefore disposed above the valve seat **42**. A flexible diaphragm **43** is disposed above and extends into the cup **38''** where it is held by a clamping plate **44** bearing upon that portion of the diaphragm **43** extending into the cup. This plate **44** is held in place by a spring **41** interposed between the outer extremity of the lever **26** and said clamping plate **44** for the purposes hereinafter set forth. The periphery or circumference of the diaphragm is fixedly clamped between the housing **35** and the cover **35'** of the said housing. The compression spring

41 acts upon the diaphragm 43 through the clamping plate 44 and through the cup 38'' on the valve 38 and tends to fully seat the valve 38 and completely close the valve opening in the seat 42 thereby stopping communication between the compartments 39 and 40.

At the outer end of the rod or lever 26 is a ball and socket arrangement similar to the socket 16 and ball 25 at the inner end of the rod 26. This arrangement comprises the ball 45 fixed to the end of the rod 26 to operate within the split universal socket 46. As is apparent from Fig. 1, the socket 46 is adapted to reciprocate vertically within the passage 47 of the cover 35' of the housing 35 in alignment with the valve stem 38' and is operatively connected with the ball and socket 25—16 in the casing 10 by the rod or lever 26 passing through the hollow transverse extension 48 of the casing. The rod 26 projects from each end of the extension 48 and is fulcrumed medially of its length by the threaded nut 28 located within the extension. Thus one end of the rod, viz. the ball and socket 25—16, rests within the housing 10 while its opposite end, viz. the ball and socket 45—46, rests within the passage 47. Above or beyond the split socket 46 is disposed a relatively light compression spring 47' which operates between the cap 51 of the cover 35' and the socket 46 to maintain the parts or halves of the latter in cooperative relation to engage the ball 45 therebetween. Thus the movement of the rod or lever 26 about the pivot or fulcrum 28 under the influence of the manifold pressure applied to the ball and socket 16—25 causes the ball and socket 45—46 to reciprocate oppositely in the passage 47 to thereby regulate the spring loading applied to the cup 38''.

It is to be noted that the fulcrum nut 28 is rectangular in cross-section and that opposed edges or sides thereof are convexed, as shown in Figs. 1 and 3. Since the nut 28 is so constructed, if the ball 25 moves downward, then the ball 45 will move upward and vice versa as the rod or lever 26 pivots or oscillates on and about the opposed convexed edges or sides of the nut 28. Furthermore, if it is desired to move the nut 28 from one position to another along the threaded portion 27 of the rod 26 this may be done by turning the rod 26, whereupon the nut 28, being held against rotation by the cooperation of its sides with the walls of the extension 48, will move along the threaded portion 27 of the rod 26.

The regulator herein described primarily regulates the valve opening available for the by-passing or recirculating of water by determining the position of the valve 38 with respect to said valve opening and seat. Thus as the manifold pressure increases, the bellows 13 expand swinging the rod or lever 26 about the nut 28 as a fulcrum to move the ball and socket connection 45—46 in a direction toward the valve 38. This movement increases the compression of the spring 41 which is applied to the valve 38 and tends to move it toward its seat. As the manifold pressure increases to a maximum determined by the adjustments to be described, the valve 38 ultimately becomes fully seated and completely closes the valve opening. In this manner as the manifold pressure increases to a maximum the size of the valve opening available for the recirculating passage of water from the chamber 40 to the chamber 39 progressively decreases until the passage of all water is cut off.

Reversely as the manifold pressure falls, the bellows progressively collapse swinging the lever or rod 26 in the opposite direction about the fulcrum 28 elevating the ball and socket joint 45—46. This movement of the outer end of the rod or lever 26 away from the valve cup 38'' relieves the tension of the spring 41 so that the valve may be lifted by the pressure of the water within the chamber 40. Hence, as the manifold pressure increases and decreases the proportionate amount of water permitted to by-pass the chamber 40 to the chamber 39 is correspondingly decreased and increased and since all water passing the impeller 33, and not recirculated to chamber 39 is discharged through the outlet port 34, the volume of water delivered by the outlet port 34 of the pump is increased and decreased accordingly.

To adjust the position of the fulcrum nut 28 on the rod 26 thereby altering the ratio of response between movement of the ball and socket 25—16 and of the ball and socket 45—46, the end of the rod or lever 26 projecting beyond the ball and socket 16—25 is provided with a screw slot 50 whereby the rod may be rotated. An access hole, closed by the removable plug 49, pierces the casing 10 in alignment with the lever 26 whereby a suitable tool may be inserted, after the removal of the plug, for the rotary manipulation of the rod.

The tension of the spring 17 may be determined or changed by the adjustment of the bolt 22 and once determined can be fixed by the lock nut 24. This adjustment of the tension of the spring 17 regulates the response of the bellows 13 to the manifold pressure. Likewise the cap 51 which bears against the spring 47 can be adjusted to regulate the tension of that spring.

Wherever the term "water" is used herein it is intended thereby to include not only water but any other suitable fluids or mixtures thereof.

What is claimed is:

1. The combination with a pump having inlet and outlet ports and an impeller situated between said ports to draw fluid from the inlet port and deliver it under pressure to the outlet port, of a housing associated with said pump having means of communication upon each side of the impeller with the fluid stream passing between said ports, a valve cooperating with said means of communication on the outlet side of the impeller to control the admission of fluid under pressure to said housing, said valve being subject to fluid pressure on the outlet side of the impeller tending to normally open said valve, a compression spring operating on said valve in opposition to said fluid pressure, a lever connected at one of its ends to said spring, and a source of variable pressure connected to the opposite end of said lever to operate it in response to pressure changes and thereby vary and regulate the compression of said spring and its operative effect on said valve in opposition to the fluid pressure.

2. The combination with a casing, of a conduit to communicate the manifold pressure of an internal combustion engine to said casing, a bellows within the casing to be extended or collapsed in response to variations in manifold pressure, a pump to discharge water under pressure for ultimate delivery to the intake manifold of said engine, a valve associated with the pump to vent at least part of the water discharged thereby and thus proportionately reduce the volume of water delivered to the intake manifold, a spring cooperating with said valve to move it against the wa-

ter pressure of the pump, and a centrally fulcrumed lever interposed between said bellows and said spring and operable by the former in its movements in response to variations in manifold pressure to regulate the tension of the spring aforesaid.

3. The combination with a pump to discharge water under pressure for ultimate delivery to the intake manifold of an internal combustion engine, of a valve for controlling the volume of water delivered by said pump by venting a part of the water under pressure prior to its delivery to the intake manifold, and means, responsive to variations in manifold pressure of the engine, for regulating the volume of water so vented comprising a lever, means operable by variations in manifold pressure to pivot said lever on its fulcrum, and a connection between said lever and said valve whereby the operative position of the latter varies in response to the movement of the lever.

4. A fluid regulator responsive to variations of pressure at an independent source of variable pressure to determine the flow of fluid in a conduit, comprising a fluid pump having an inlet and an outlet for delivering fluid under pressure, a valve controlled by-pass between the outlet and the inlet of said pump for regulating the delivery pressure to the conduit, and a lever arm connected at one end to the valve of the by-pass and at its other end to the independent pressure source to adjust said valve in response to variations in pressure at said source.

5. The combination with an independent source of variable pressure, of a fluid pump having an outlet conduit for the delivery of fluid under pressure, a regulator for controlling the pressure of the fluid in the said conduit, a bellows responsive to variations in pressure at the independent pressure source, and a lever arm interposed between and connected to the bellows and the regulator aforesaid whereby the operation of said bellows adjusts the regulator, said lever arm having an adjustable fulcrum for modifying the degree of adjustment of said regulator by said arm.

6. The combination with a pump to discharge fluid under pressure and a variable source of pressure, of means for regulating the volume of fluid discharged by the pump comprising a valve controlling the volume of discharged fluid, a spring including a socket supported thereby acting on the valve against the pressure of the fluid, a pressure actuated bellows responsive to variations in said pressure source, a second spring acting in opposition to the bellows having means for adjusting its opposing pressure, and a centrally fulcrumed lever interposed between the bellows and the socket to change the effectiveness of

the spring acting on the valve in accordance with the pressure variations at said source.

7. In a fluid regulator for discharging fluid under pressure, means for controlling the discharge pressure thereof from an independent source of pressure, comprising a spring loaded bellows responsive to variations in the pressure source including means for altering the load on said bellows, a valve operable to determine the rate of fluid discharge, a two section spring acting on said valve, a socket interposed between and in alignment with said spring sections, a lever connecting the said bellows with the said socket, and a fulcrum for the lever aforesaid adjustable to modify the movement transmitted to the valve.

8. In a fluid regulator, the combination with a valve, of spring means normally tending to operate said valve in one direction, a bellows operable by and from a variable pressure, and a centrally fulcrumed lever connecting the said bellows and the valve to vary the operating effect of the spring, the said fulcrum comprising a collar threadably engaged with the lever for longitudinal movement thereof, and means restricting rotation of the collar about the longitudinal axis of said lever whereupon rotation of the lever will change the position of the collar thereon.

9. The combination with the valve of a fluid regulator, of a compression spring to operate said valve in one direction, a bellows operable in response to variations of pressure at an independent pressure source, means of adjustment to modify the response of the bellows to pressure variations, a lever, having a medial fulcrum, interposed between said compression spring and said bellows whereby the movement of the bellows controls the operative compression of said spring, and means for adjusting the position of the fulcrum with respect to said lever.

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