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TIMED FUEL INJECTION SYSTEM

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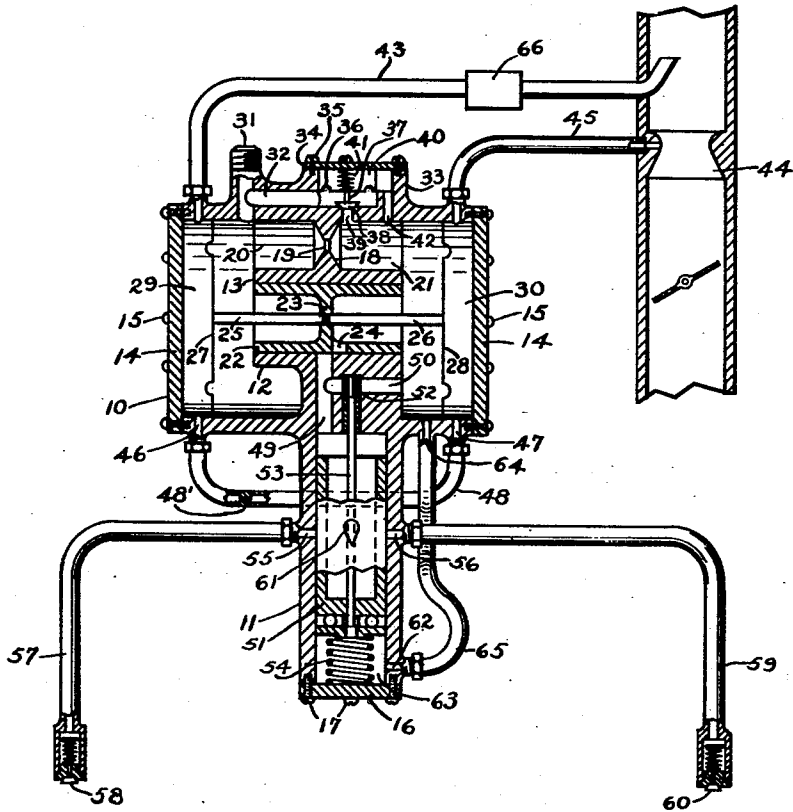


Fig. 1

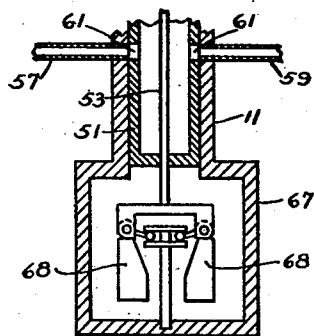


Fig. 2

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TIMED FUEL INJECTION SYSTEM

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The present invention relates to new and useful improvements in internal combustion engines, and more particularly to such improvements in timed fuel injection system for said engines.

It is an object of the present invention to provide means wherein corrections in metering suction can be made to compensate for changes in air density.

Another object of the present invention is the provision of means for fuel charge enrichment during high power operation.

A still further object of the present invention is the provision of means for correcting metering suction that will compensate for changes in air density, thus making metering suction vary as the square of mass flow.

With the above and other objects in view the invention consists of certain novel details of construction and combination of parts hereinafter fully described and claimed, it being understood that various modifications may be resorted to without departing from the spirit and scope of the invention and the appended claims.

Figure 1 is a sectional view of one form of the device made in accordance with the present invention.

Figure 2 illustrates a modification of the depending portion and showing a governor for controlling the valve stem in response to speed variations.

Referring to the drawings the numeral 10 represents a housing having a depending cylindrical portion 11 and within the housing 10 are portions 12 and 13 all being integral with the housing. The ends of the housing are provided with closure plates 14 that are secured to the housing by bolts 15, the end of the depending portion 11 or valve body also being provided with a closure plate 16 that is secured thereto by bolts 17. The portion 13 of the housing is provided with a tapering wall 18 midway the ends, and centrally of the wall 18 there is an orifice 19 that serves as a metering jet. The wall 18 divides the portion 13 into chambers 20 and 21. Interposed between the walls of portions 12 and 13 is a valve 22 having a wall 23 midway its ends and provided with an orifice or bleed port 24. Connected to the wall 23 is one end of rods 25 and 26, the opposite end of rod 25 carrying a diaphragm 27, the opposite end of rod 26 carrying a diaphragm 28, the diaphragms being in spaced relation from the ends of portions 12 and 13 and in spaced relation from the ends of the closure plates 14, thus forming chambers 29 and 30. The housing 10 is provided with a threaded fuel inlet 31 that communicates with a channel 32 and the chamber 20. The body 10 has an an-

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nular shoulder 33, the end of which is closed by a plate 34 that is secured to the shoulder 33 by bolts 35. Within the shoulder 33 is a diaphragm 36 that is connected to one end of a valve stem 37, the opposite end of the stem carrying a valve 38 that engages a valve seat of a bore 39 in the housing 10, the bore communicating with the chamber 21 and channel 32. The diaphragm 36 is in spaced relation from the plate 34 thus forming a chamber 40, and interposed between the plate 34 and the diaphragm 36 is a spring 41 that holds the valve 38 in the valve seat. A bleed opening 42 is also provided in the housing and this opening communicates with chamber 21 and chamber 40.

The chamber 29 communicates with a throttle body through an impact tube 43, having a suitable metering device 44; and chamber 30, with the low pressure point of a venturi 45 by a conduit 46. Chambers 29 and 30 are provided with bleed openings 46 and 47 respectively and they are connected by a conduit 48, having a restricted portion 49.

The portion 12, of the housing 10 is provided with a channel or chamber 49 having a portion in the depending portion 11 that communicates with a horizontal channel 50. Within the depending portion 11 there is mounted a rotary valve 51 that is driven by a pump 52 which is driven by the engine. The rotary valve 51 is driven at one half engine speed for a four stroke cycle engine, and at engine speed for a two stroke cycle engine. Pump 52 is connected to the rotary valve 51 by a shaft 53. The rotary valve 51 is balanced in the depending portion 11 by a spring 54. The depending portion 11 is provided with horizontal bores 55 and 56 that are diametrically opposite to each other, bore 55 being in communication with a conduit 57 that is provided at its lower end with a spring controlled valve 58. Bore 56 is likewise in communication with a conduit 59, the lower end of the conduit being provided with a spring controlled valve 60. The wall of the rotary valve 51 is provided with a timing bore or bores 61 adapted for alignment with bores 55 and 56. Adjacent the lower end of the depending portion 11 is a horizontal bore 62 that communicates with the spring chamber 63. Housing 10 is provided with a bore 64 that communicates with chamber 21, and this chamber is in communication with chamber 63 through conduit 65.

If desired a governor 67 as illustrated in Figure 2 may be mounted on the end of shaft 53. As shown in Figure 2 the depending portion 11 has its lower end 67 enlarged to allow free movement of the pivoted weights 68.

In the operation of the device fuel under pressure enters the inlet 31 and into chamber 20 and

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then passes through metering orifice or jet 19 into chamber 21.

The pressure in inlet 31 is limited at the high end by what diaphragms 27 and 28 will take before danger of rupturing. The low limit will be determined by the pressure necessary in passage 50 high enough to control cavitation at pump 52. This is a function of design and a specific figure cannot be given.

The low limit in chamber 20 or at inlet 31 must be low limit in chamber 21 plus maximum head, which is maximum pressure differential across jet 19. This is equal to maximum metering suction which is difference in pressure in chambers 29 and 30. With a Venturi impact tube arrangement as shown the metering suction will not exceed 100 inches of H₂O or about 3½ lbs. Therefore for maximum output with good design 5 lbs. pressure at 31 would be sufficient inlet pressure, although 15 or more lbs. would probably be better. For part throttle and idle the requirement for pressure would be considerably less than at full throttle.

The amount of fuel delivered from nozzles 58 and 60 will be a function of nozzle opening pressure and the pressure in lines 57 and 59 respectively. The pressure in line 57 or 59 is increased to the pressure in chamber 49 when port 61 and port 55 or 56 are in communication. They are timed to deliver fuel during correct part of cycle by positively timing and driving valve 51. Through pump 52 the port 61 in valve 51 is made to give increasing area exposure to port 55 as the valve 51 is moved down against spring 54. Therefore as the load on the engine is increased the need for fuel is increased and the pressure in 49 will have to be increased. Also, as the speed increases the period of time that ports 55 and 61 are in communication is shortened and therefore it will be necessary to increase the pressure in 49 in order to deliver the required amount of fuel out to the nozzles. This is accomplished by varying the pressure in chamber 49 to give the required amount of fuel to the engine. The pressure in chamber 49 is determined by the discharge through nozzle 58 and the quantity of fuel from the pump 52 and area of port 24 which is open.

With port 24 closed the pump 52 will build up pressure in chamber 49 since it is designed to have a capacity greater than that required by the engine at full throttle. When the pressure in chamber 49 starts to go above pressure required to give the engine the fuel it needs at that moment, valve 24 will open to the point of maintaining the required pressure by by-passing the excess fuel from the pump 52 back into chamber 21 which feeds the inlet to the pump. Therefore the amount of fuel delivered by the nozzles will be the amount taken from chamber 21 by pump 52 less amount returned by port 24. The amount of fuel flowing into chamber 21 will be equal to fuel being delivered to the engine. The fuel entering chamber 21 is measured by orifice 19 since the amount of fuel flowing varies as the square root of metering head, and since the pressure in chamber 20 is held relatively constant by the engine pump. The pressure in chamber 21 will be reduced by the pump 52 to the point where metering head is equal to metering suction. Metering head is the pressure drop across orifice 19 and metering suction is the difference between pressures in chambers 29 and 30.

Since metering suction is for all practical pur-

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poses equal to the square root of mass air flow and metering head is equal to the square root of fuel flow, the fuel air ratio will be a constant for all air flows. But, since in the high power range an increase in fuel air ratio is needed the enrichment valve 38, its diaphragm 36 and spring 41 are added. Diaphragm action is such that as metering head increases it will reach a point where it will overbalance spring 41 and valve 38 will open allowing an additional supply of fuel to flow into chamber 21.

The pressure in chamber 49 is many times higher than in chamber 63 therefore there will be leakage into chamber 63. This has to have an outlet (62) or the pressure in 63 would build up to that in chamber 49 and valve 51 would not operate. Pipe 65 could be run back to the fuel tank instead of into chamber 21 but then all metered fuel would not be delivered to the engine. Passage 65 will have very little effect on the position of valve 51 and almost none on the operation.

The element 66 is for altitude and temperature compensation and is used on several conventional aircraft carburetors. It may consist, for example and as shown in U. S. Patent No. 2,410,733 of a calibrated needle operable by a bellows to vary the metering suction in response to barometric and temperature changes. The calibration is made very effective through use of a correct orifice 48' in the pipe 48. Without this orifice, any variation in the compensator 66 could not affect the pressure in chamber 29 because it then would be a static pressure in the absence of flow from 29 to chamber 30.

While the form of mechanism herein shown and described constitutes a preferred form of embodiment of the present invention, it is to be understood that other forms might be adopted, all coming within the scope of the claims, which follow.

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 is claimed is:

1. Fuel supply system for internal combustion engines having an intake manifold with a venturi followed by a throttle comprising a pressure controlled casing having chambers in its ends bounded by internal diaphragms connected to operate a bleed valve by the differential pressure in said chambers, one of said chambers being connected by an impact tube to said manifold at a point ahead of the venturi, the inner faces of said diaphragms forming a portion of the walls for a fuel supply chamber and a fuel intake chamber, there being a restricted orifice between said chambers and a by-pass valve between said chambers operated in response to a reduction in pressure in said intake chamber to open and permit fluid to by-pass said orifice from said supply chamber to said intake chamber, a positive displacement pump driven by said internal combustion engine for delivering fuel from said intake chamber to the engine through a multiple injection system, said bleed valve controlling an orifice between the delivery side of said pump and said intake chamber to return excess fuel to said intake chamber in response to differential pressure in said end chambers and in said supply and intake chambers.

2. Fuel supply system for internal combustion engines having an intake manifold with a ven-

turi followed by a throttle comprising a pressure controlled casing having chambers in its ends bounded by internal diaphragms connected to operate a bleed valve by the differential pressure in said chambers, one of said chambers being connected to the manifold ahead of the throttle, the inner faces of said diaphragms forming a portion of the walls for a fuel supply chamber and a fuel intake chamber, there being a restricted orifice between said chambers and a by-pass valve between said chambers operated in response to a reduction in pressure in said intake chamber to open and permit fluid to by-pass said orifice from said supply chamber to said intake chamber, a positive displacement pump driven by said internal combustion engine for delivering fuel from said intake chamber to an outlet chamber, a distributor valve in said outlet chamber connected for rotation by said pump, said valve being axially adjustable by pressure in said outlet chamber acting against a control spring and the pressure in said intake chamber.

3. Fuel supply system for internal combustion engines having an intake manifold with a venturi followed by a throttle comprising a pressure controlled casing having chambers in its ends bounded by internal diaphragms connected to operate a bleed valve by the differential pressure in said chambers, one of said chambers being connected to the manifold ahead of the throttle, the inner faces of said diaphragms forming a portion of the walls for a fuel supply chamber and a fuel intake chamber, there being a restricted orifice between said chambers and a by-pass valve between said chambers operated in response to a reduction in pressure in said intake chamber to open and permit fluid to by-pass said orifice from said supply chamber to said intake chamber, a positive displacement pump driven by said internal combustion engine for delivering fuel from said intake chamber to the engine through a variable injection system, said bleed valve controlling an orifice between the delivery side of said pump and said intake chamber to return excess fuel to said intake chamber in response to differential pressure in said end chambers and in said supply and intake chambers, said end chambers being connected by a conduit.

4. Fuel supply system for internal combustion engines having an intake manifold with a venturi followed by a throttle comprising a pressure controlled casing having chambers in its ends bounded by internal diaphragms connected to operate a bleed valve by the differential pressure in said chambers, one of said chambers being connected to the manifold ahead of the throttle, the inner faces of said diaphragms forming a portion of the walls for a fuel supply chamber and a fuel intake chamber, there being a restricted orifice between said chambers and a by-pass valve between said chambers operated in response to a reduction in pressure in said intake chamber to open and permit fluid to by-pass said orifice from said supply chamber to said intake chamber, a positive displacement pump driven by said internal combustion engine for delivering fuel from said intake chamber to an outlet chamber, a distributor valve in said outlet chamber connected for rotation by said pump, said distributor valve having a stem extension, a speed responsive governor mounted in said extension for additionally controlling the axial adjustment of said valve in response to the speed of operation.

5. Fuel supply system for internal combustion engines having an intake manifold with a venturi followed by a throttle comprising a pressure controlled casing having chambers in its ends bounded by internal diaphragms connected to operate a bleed valve by the differential pressure in said chambers, one of said chambers being connected to the manifold ahead of the throttle, the inner faces of said diaphragms forming a portion of the walls for a fuel supply chamber and a fuel intake chamber, there being a restricted orifice between said chambers and a by-pass valve between said chambers operated in response to a reduction in pressure in said intake chamber to open and permit fluid to by-pass said orifice from said supply chamber to said intake chamber, a positive displacement pump driven by said internal combustion engine for delivering fuel from said intake chamber to an outlet chamber, a distributor valve in said outlet chamber connected for rotation by said pump, said valve axially adjustable in response to speed variation and a governor mounted for rotation with said valve to control said adjustment.

6. In combination with a throttle tube having impact and Venturi tubes connected thereto, a closed casing having movable walls adjacent its ends forming impact and Venturi chambers, a stationary wall between said movable walls forming therewith fuel receiving and discharging chambers, a metering orifice extending through said stationary wall, a valve slidable in said stationary wall and having portions engaging the movable walls for operation by the latter, said casing having a fuel discharge passage containing a rotary timing valve and having two intersecting supply passages, a rotary pump in one of said supply passages, said slidable valve having a port in communication with said discharging chamber and shiftable into communication with the other supply passage, and means connected into said discharge passage to convey away the fuel metered through said timing valve.

7. In the combination defined in claim 6, said timing valve being cylindrical and hollow with one end exposed to the discharge fuel and also being slidable axially, yieldable means at the other end of said timing valve substantially balancing the pressure exerted by the discharged fuel, and said port opening laterally through the cylindrical wall of said timing valve.

8. In the combination defined in claim 6, means forming a separate connection between said fuel receiving and discharging chambers for automatically supplying additional fuel when it is required.

9. In the combination defined in claim 6, a compensator associated with said impact tube, and means having a restricting orifice interconnecting said impact and Venturi chambers.

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