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FUEL INJECTION SYSTEMS

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Fig.1

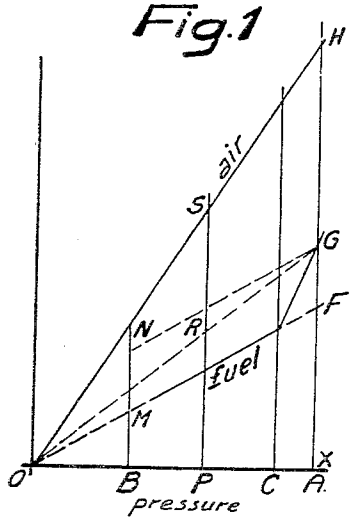


Fig.2

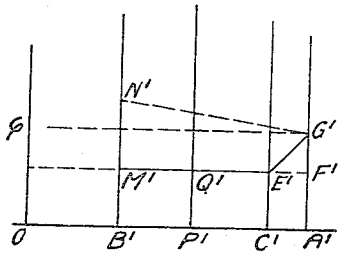


Fig.3

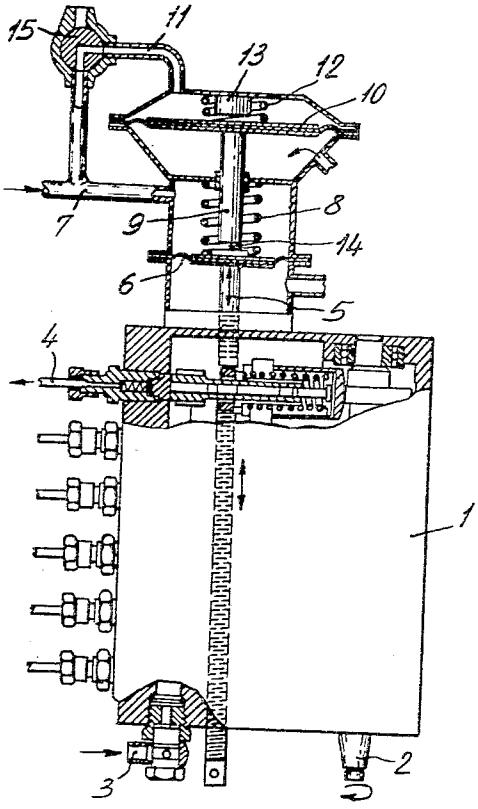
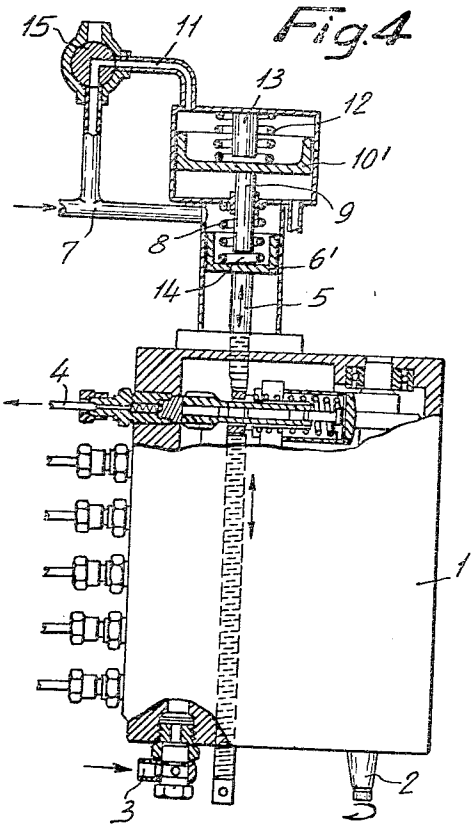


Fig.4



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FUEL INJECTION SYSTEMS

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7 Claims. (Cl. 123—140)

It is usual, in engines fed with fuel by injection, to use a volumetric fuel pump synchronised with the speed of rotation of the engine and so adjusted as to provide the quantity of fuel which is desirable to ensure the best combustion.

As a first approximation, it is desirable for the degree of richness, that is to say the ratio of the weight of fuel to the weight of air, of the air-fuel mixture to be independent of the speed of rotation of the engine and the pressure at which the air enters the valves which control the air delivery.

If the pump is strictly volumetric, the total quantity of fuel injected is proportional to the speed of the engine, as also is the weight of air introduced into the cylinders, and the speed consequently has no effect on the degree of richness; however, certain variations as a function of speed are desirable, and are usually obtained by modifying the characteristic curve of the pump. On the contrary, the quantity of air introduced into the cylinders depends on the inlet pressure. It is consequently necessary, if it is desired to keep the richness of the mixture constant, to control the volumetric pump so as to make the quantity of fuel injected directly proportional to the pressure.

Most of the present injection pumps are effectively based on this principle, and comprise a device which is sensitive to the induction pressure, which is intended to act on the volume of the pump so as to allow this volume to increase or decrease in proportion to the absolute pressure at which air is admitted to the cylinders. However, this constancy of the level or degree of richness is not altogether satisfactory; in fact, it is desirable, in order to keep down the fuel consumption, to reduce this level as long as the engine is not required to work at maximum torque for a given speed.

For this purpose, the adoption of a constant level of richness has already been recommended for low values of inlet pressure, this level then being increased up to the optimum value for higher values of inlet pressure.

The subject of the invention is a volumetric pump in which the air inlet pressure is made to act on the valves of a first device to modify the volume of the pump in accordance with this pressure, and also on a second device which has the purpose of acting on the volume of the pump only above a certain value of this pressure.

According to another characteristic of the invention, the action of the inlet pressure on the second device may, if desired, be replaced by the action of the atmosphere, in order to make this device come into action rapidly whatever the value of pressure at that instant.

These characteristics, together with some others, will be apparent from perusal of the following description, with reference to the annexed drawings, wherein:

Fig. 1 is a diagram of air and fuel delivery as a function of inlet pressure in a pump of the usual type and in a pump according to the invention;

Fig. 2 is a diagram of the level or degree of richness as a function of inlet pressure;

Fig. 3 is a diagrammatic representation of a volumetric pump according to the invention;

Fig. 4 is another type of embodiment of the pump.

In the diagram in Fig. 1, the abscissae are the absolute pressures, and the ordinates are the weights of air and fuel, the speed of rotation of the engine being supposed constant.

O corresponds to no-load conditions, the butterfly valve being ideally entirely closed; A corresponds to atmospheric pressure, that is about 1 kg./cm.^{2}, this corresponding to a wide-open butterfly valve, assuming no loss of pressure at the valves and an unsuper-charged engine. The straight line O—H represents the variation of the weight of air drawn in by the engine when the absolute induction pressure varies between zero (gas butterfly hermetically closed) and value 1 (gas butterfly wide open and no loss of pressure at the entry to the valves).

The straight line OG (or OF) represents the variation of the weight of fuel delivered by a pump of the usual type, in which the quantity of liquid delivered varies in proportion to the air induction pressure.

For any pressure P, the delivery of fuel (for the straight line OF) is PQ and the delivery of air PS. It can be seen that the ratio

$$\frac{PQ}{PS}$$

is constant, which is shown in Fig. 2 by the horizontal position of the richness curve

$$\varphi=\frac{PQ}{PS}=P'Q'$$

The variation of PQ, delivery of fuel, as a function of pressure is generally obtained by altering the position of the element which regulates the capacity of the fuel pump, the said elements being rigidly connected to a piston or a diaphragm subjected to inlet pressure.

However, as has been explained, an absolutely constant richness is not desirable. The object of the invention is to attain a variation of the ratio φ as a function of inlet pressure by means of a simple and practical device.

It has already been stated that at full load, that is to say at high inlet pressure, it is advantageous to attain the optimum richness which gives maximum power, while at reduced load it is preferable to reduce this richness for the sake of economy.

A known theory consists in replacing the straight line OG (or OF) by a broken line OEG which retains up to a carefully chosen point E a weak mixture suitable for low loads, and which progressively increases the richness in such a way as to obtain at the point G a high value of richness suitable for full load.

The pump according to the invention described below allows this increase of richness to be obtained automatically.

In Fig. 3 or Fig. 4 (in which the diaphragms are replaced by pistons), an injection pump comprising a driving shaft **2** synchronised with the crank shaft of the engine is schematically represented. It receives fuel at **3**, and delivers same to the injectors via pipes such as **4**. The rod **5** controls by means of its axial movements the variation of the capacity of the pump (or of its delivery per revolution); a diaphragm **6** is attached to this rod. Atmospheric pressure prevails below this diaphragm, and the pressure at the valves of the engine above, said pressure being transmitted via the pipe **7**. The spring **8** likewise applies weak pressure from above. The choice of stiffness of this spring **8** determines the overall richness, which is chosen to be low.

A rod **9** projects into the depression space above the diaphragm with minimum play in order to avoid large

leakages, but sliding freely it is coaxial with the rod **5**. It is attached to a diaphragm **10** which is subjected from below to atmospheric pressure and from above to the pressure at the valves transmitted via a branch **11** of the pipe **7**. A very flexible spring **12** acts on the upper part of this diaphragm, and a projection **13** determines its highest position. In this position, space **14** exists between the rod **9** and the diaphragm **6** allowing play, this play being greater than the possible stroke of the rod **5**.

The calibration of the spring **12** is such that the diaphragm reaches equilibrium for an absolute pressure corresponding to the ordinate CE. Below this pressure (that is to say at medium and light loads), the diaphragm **10** is drawn upwards and abuts against **13**. Play then exists at **14**, and the rod **5** is freely operated by its normal diaphragm **6**, a constant weak mixture then being obtained.

Above the said pressure the diaphragm **10** is pushed downwards and the rod **9** pushed against the diaphragm **6** with a pressure due to the pressure of the spring **12**, less the differences between atmospheric pressure and the pressure at the valves. This resultant pressure is added to that acting on the diaphragm **6**. In Fig. 1, the straight line EG represents the new deliveries in the region of heavy loads, and E'G' in Fig. 2 represents the corresponding degrees of richness.

There is thus attained a second element of control comparable to the first, but on a different scale, and only coming into action after a certain value of load has been reached. The accelerator pedal has no direct effect on this enrichment, but an indirect effect by means of the inlet pressure.

An advantageous additional arrangement consists in making the depression branch **11** pass through a plug cock **15** which can connect the branch **11** to the atmosphere without the pipe **7** being able to communicate with the atmosphere. This cock is fitted on the instrument panel, and fulfils the function of a choke. In effect, when the pipe **11** is connected to atmosphere, the diaphragm **10** is continuously unbalanced, and receives only the constant downward pressure of the spring **12**. It consequently increases the delivery of fuel by the constant quantity FG throughout the length of the curve, which becomes GN instead of GEM ($MN=GF$). Under these conditions, for a very low absolute pressure OB, at idling for example, the delivery of fuel is no longer BM but BN for the same quantity of air admitted; the richness B'N' is virtually doubled, which is suitable for starting off when cold (with injection).

Another interesting result is also obtained. It has been noted that there is a space **14** between the rod **9** and the diaphragm **6**. When the accelerator butterfly is progressively opened until the value OC is passed, the rod **9** comes gently into contact with **6**, and the richness varies in accordance with the broken line M'E'G'. But if the butterfly opens suddenly when immediate acceleration is required, the pressure suddenly increases, and the whole of the mechanism attached to the rod **9** strikes a hammer blow on the rod **5**, which has the effect of increasing the instantaneous richness above the value provided for and thus giving a transient over-richness favourable for acceleration. A minimum being laid down for the space **14**, the maximum value of the play will be chosen to obtain the desired value of this over-richness.

All that has been said regarding the device of Fig. 3 may be likewise repeated for the device represented in Fig. 4, it being remembered that the pistons **6'** and **10'** are substituted for the diaphragms **6** and **10**.

I claim:

1. An adjustable volumé volumetric injection pump, more particularly intended for feeding fuel to engines having an intake manifold, means for varying the volumetric output of the pump, a first biased pressure responsive means connected to said output varying means, a second biased pressure responsive means acting on said output varying means through a lost motion connection and means for applying intake pressure to said pressure responsive means, said lost motion connection causing said second pressure responsive means to act on said output varying means only when the intake pressure is beyond a predetermined range so that in one range of intake pressures said output varying means is subject only to the first of said pressure responsive means and in another range of intake pressures said output varying means is subject to both of said pressure responsive means.

2. A pump according to claim 1 in which each of said pressure responsive devices comprises movable piston means subjected on one side to intake pressure and on the other side to atmospheric pressure and a spring biasing said piston means against the remitting pressure differential and in which both pressure responsive means act on the output varying means in the same sense.

3. A pump according to claim 2 in which the biasing spring of said second pressure responsive means is stronger than that of the first.

4. A pump according to claim 2 in which said piston means comprise flexible diaphragms.

5. A pump according to claim 1 in which said second pressure responsive means is connected with the engine intake by a conduit and in which a valve is provided in said conduit to cut off intake pressure and connect said conduit to the atmosphere.

6. In an adjustable volume volumetric fuel injection pump for an internal combustion engine having an intake, means for varying the volumetric output of the pump, a first piston means connected to said output varying means, means for subjecting said piston means to the differential of intake and atmospheric pressures, means for biasing said piston means against said pressure differential, a second piston means acting on said first piston means through a lost motion connection, means for subjecting said second piston means to the differential of intake and atmospheric pressures and means for biasing said second piston means against said pressure differential, said lost motion connection permitting said first piston means to act on said output varying means in a predetermined pressure range and causing both of said piston means to act on said output varying means in another pressure range.

7. A pump according to claim 6 in which said two piston means are coaxial and in which said first piston means has a piston rod connected to said output varying means and said second piston means has a piston rod the end of which is spaced from said first piston means.

No references cited.