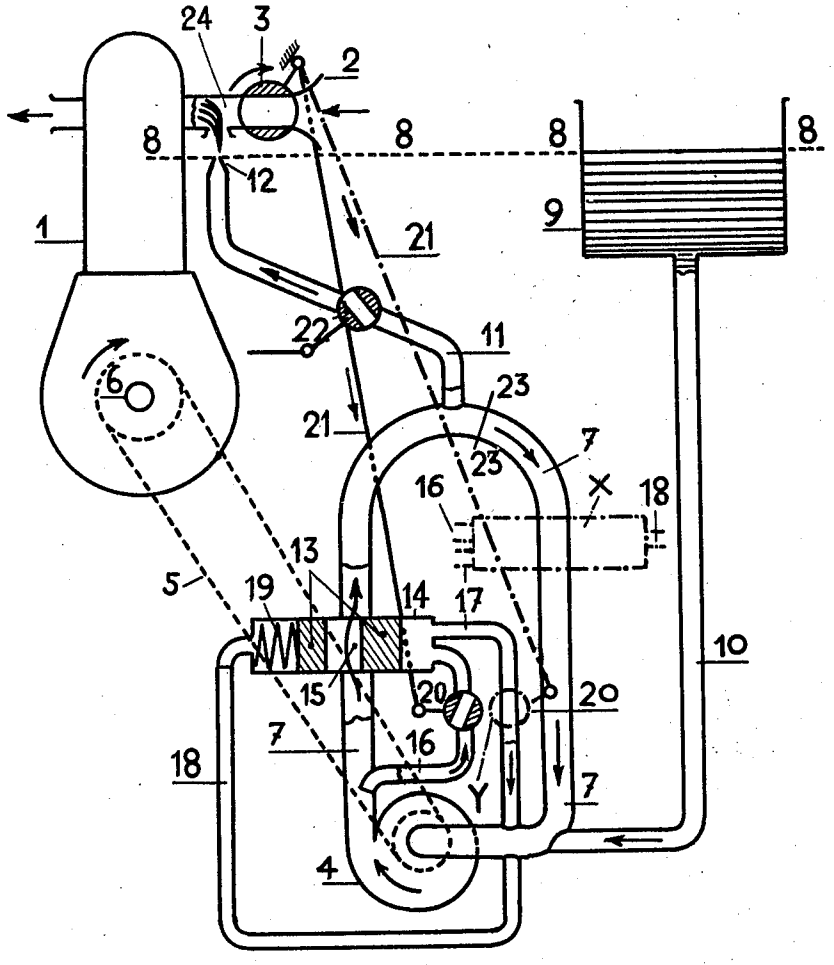
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METHOD AND APPARATUS FOR FEEDING LIQUID FUEL TO INTERNAL COMBUSTION ENGINES

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METHOD AND APPARATUS FOR FEEDING LIQUID FUEL TO INTERNAL-COMBUSTION ENGINES

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The present invention has for its object apparatus for feeding liquid fuel in a suitable and automatic manner to internal combustion engines.

This apparatus, applied to an internal combustion engine allows of obtaining a practically constant relation (for instance 1/10) between the weight of the liquid fuel and the weight of air contained in the engine cylinder at the end of the admission stroke, at all rates of speed of the engine, that is to say, at all speeds of rotation normally obtained at each of the possible positions of the throttle valve usually arranged in the admission conduit of the engine.

The annexed drawing diagrammatically illustrates the apparatus in combination with an internal combustion engine. The engine 1 is seen from the end and comprises four four-stroke cylinders, a crankshaft of the ordinary type and regulated inlet valves, with a single inlet 2 for admitting the gases provided with the usual throttle valve 3, the air being sucked in direct from the atmosphere by the engine, the law adopted for the feeding to the gaseous mixture being the law of constancy of the rate of feed (for instance 1/10).

The turbine of a centrifugal pump 4 is rotated by means of an endless chain 5 or by gear wheels or other equivalent means, driven from the crank-shaft 6 of the engine. A pipe 7 forms a communication between the outlet orifice and the inlet orifice of the centrifugal pump, thus forming with the pump an endless circuit.

The liquid fuel feeding the internal combustion engine is kept at a constant level 8 in a tank 9 by any known means and fills the whole of the foresaid circuit by means of a pipe 10 which is connected to the pipe 7 as near as possible to the inlet of the centrifugal pump.

A pipe 11 is soldered to the pipe 7 at preferably the highest point of the latter, this pipe 11 having at its upper end a nozzle 12 the outlet orifice of which is on the same level as the constant level 8, for the fuel. The jet of liquid fuel issuing from the nozzle 12 is directed into the intake pipe of the engine. The pressure prevailing at the exterior of the outlet orifice of the said nozzle is equal to the exterior pressure on the constant level 8 in the tank 9. In order to obtain this equality of pressure any known means can be used; for instance as shown in the drawing, the jet of liquid fuel enters into the admission conduit 24 of the engine through a tube of small diameter slightly removed from the orifice of the nozzle 12 consequently atmospheric pressure prevails both on the constant level of the liquid fuel in the tank and on the outlet orifice of the nozzle 12.

The delivery of the fuel from the nozzle 12 is practically therefore only due to the effect of the centrifugal force created, by the rotation of the centrifugal pump driven by the engine.

All the pipe circuits in the apparatus are situated below the constant level 8 so that they are always filled with the liquid fuel.

On the pipe 7, between the outlet of the centrifugal pump and the pipe 11, an automatic sliding-valve is arranged said valve being for example constructed in the following manner: a piston 13 of diameter greater than the diameter of the pipe 7 passes through the said pipe and can slide longitudinally in a cylinder 14; this piston is provided with an orifice or port 15 of suitable shape which by the movements of the piston 13 can more or less obstruct the passage of the liquid fuel circulating in the pipe 7. The shape and size of the orifice 15, is determined by trial or experiments; in the present case owing to the constancy of the rate of fuel supply the shape of the orifice is such that the size of the passage for the liquid fuel will be decreased as the speed of rotation of the engine increases; (the shape of the orifice depends on the law adopted for the supply). The sliding of the movable piston is effected by pressure created by the liquid fuel in the following manner:—one end of the cylinder 14 forms a closed chamber with which two pipes 16 and 17 are connected the pipe 16 is connected to the pipe 7, adjacent the outlet of the centrifugal pump; the pipe 17 is connected to pipe 7 adjacent the inlet of the centrifugal pump. The rotation of the centrifugal pump driven by the engine therefore

creates in the said chamber and consequently on the corresponding end of the piston a hydraulic pressure. The other end of the cylinder 14 also comprises a closed chamber with which a pipe 18 is in communication the other end of said pipe being connected to the inlet of the centrifugal pump. When the motor is stopped the centrifugal pump does not rotate and the movable piston is in hydraulic equilibrium. In the latter chamber a spring 19 serves to counterbalance the hydraulic pressure created on the other end of the piston.

On the pipe 16 is arranged a valve 20, the plug of which has an orifice of suitable shape determined by experiment, the plug of this valve 20 is connected with the plug of the valve 3, arranged on the inlet pipe of the explosion motor, by means of a rod 21 or the like connecting device in such a way that the minimum opening of the valve 20 corresponds to the maximum opening of the valve 3 and that inversely the minimum opening of the valve 3 corresponds to the maximum opening of the valve 20. To each definite position of the plug of valve 3 (which position is comprised between the maximum opening and the minimum opening) corresponds a definite position of the plug of valve 20 which allows the piston 13 to slide so as to maintain the rate of supply adopted in a practically perfect way for the whole range of engine speeds normally obtainable with the respective positions of the inlet valve.

The various members of the device can have shapes most suitable to their function, the drawing being essentially diagrammatic.

In order to provide a device giving the best results all possible care should be taken in the construction of the various members, to meet as far as possible the following conditions:—

(1) Each pipe circuit must, for an invariable position present to the flow of liquid fuel a coefficient of resistance which is as constant as possible for the various speeds of flow of the liquid fuel. As this condition is not sufficiently obtained with straight and smooth pipes there should be provided along the circuits and at the most suitable places, means effecting known losses of hydraulic charge in order to give the various speeds of flow a more marked character of constancy of coefficient; these means such as abrupt elbows, sudden changes of section or of direction of the piping etc. being sufficient to predominate in the general resistance of the circuit under consideration, these means are not illustrated in the drawing.

(2) To employ pipes of sufficiently large diameter and having speeds of flow high enough to prevent capillary flow and thus to have in the circuit flows governed by the Torricelli principle;

(3) To construct the centrifugal pump according to the known principles and to use it rationally in accordance with the known principles, so as to obtain between its outlet and its inlet total hydraulic pressure proportional to the square of its speed of rotation;

(4) To give to the hydraulic circuit passing through the pipes 16 and 17 a minimum hydraulic resistance sufficient for the maximum delivery of this circuit to be small in relation to the total delivery of the centrifugal pump;

(5) To give to the pipe 10 a slight hydraulic resistance.

After having previously set out by the known means (Pitot tube, gaseometer, meter, etc.) the curves representing the weights of air (or other utilizable gaseous fluids), absorbed by the engine in function of its speed of rotation, one may obtain with practically complete accuracy by a proper calculation for each of the constituent elements of the device the constant rate of supply previously decided on, that is, in the present case: one tenth.

If a cock 22 is inserted between the connection of the pipe 11 to the pipe 7 and the nozzle 12 a special constant rate of supply can be obtained for each definite position of the said cock (for instance, one position of the said cock may be arranged to give the general constant rate of 1/8; another position the general constant rate of 1/13; etc.); the maximum delivery of the nozzle should be small in relation to the delivery of the pipe 7. The cock 22 principally allows of giving 1st) great flexibility to the motor; 2nd) of obtaining corrections which may be necessitated by the variations of the different calorific powers of the various liquid fuels which may be employed; 3rd) of ensuring the corrections which may be necessitated by the variations of the atmospheric conditions notably at change of altitude, the control of the said cock being effected, for instance, by barometric variations or the like.

With regard to the constant level 8 it is to be remarked that the absolute constancy of the said level is rather difficult to obtain, especially when the device forms part of an engine in motion; conventionally the degree of constancy of the said level can be defined as the ratio between the absolute maximum distance of height which can exist between the actual level and the theoretical constant level passing through the orifice of the nozzle and the pressure gauge height furnished by the centrifugal pump for a given speed of rotation of the motor, 1,000 revolutions per minute for example (for a given pressure gauge height the said ratio is therefore so much less as the actual level is closer to the theoretical level passing through the orifice of the nozzle). Being given that the value of this ratio is not altered by multiplying its two terms by one factor it can be seen that very considerable difference of height

can be tolerated between the constant level and the nozzle by consequently increasing the pressure-gauge height furnished by the centrifugal pump at the considered speed of the internal combustion engine, 1,000 revolutions per minute for instance, this being effected by the high circumferential speeds of the turbine.

This property of insensibility of the device to differences of height of the level 8, as explained, allows the said level to be established, in the first place, by very rudimentary means, or again the average level of a comparatively distant supply tank can be taken as the level, this average level not necessarily coinciding with the level of the nozzle. This property of insensibility enables the device to be used without appreciable difficulty in a machine capable of assuming various positions in space, such for instance as an aeroplane. It is, however, expressly specified that the above described considerations relating to particular establishments of the level relate to special applications of the apparatus as for most general uses the constant level should coincide with the level of the orifice of the nozzle.

The operation of the apparatus is not altered by obstructing the pipe 7 on the line 23 and omitting the portion of the pipe 7 comprised between this line and the inlet of the centrifugal pump, this inlet being then in communication only with the three pipes 10, 17 and 18. The said portion of pipe is provided in order to comply as much as possible with the 4th of the conditions previously referred to and which should be observed for the construction of the device, it being preferable to form with the pipe an endless circuit as shown in the drawing.

The operation of the apparatus is not effected by shifting the position of the automatic sliding-valve to that shown in broken lines at X on the drawing instead of in the position illustrated in full lines. In this case the shape of the orifice or port in the piston 13 which shape is also to be determined by experiment, is such that the passage offered to the liquid fuel increases as the speed of the motor increases (this shape of the orifice depends on the law of supply adopted). All the previously described features of construction of the automatic sliding-valve are retained. Obviously the position X of the automatic sliding-valve can only be employed if the pipe 7 is complete as shown in the drawing. In the case of the omission of this portion 7 of the pipe as referred to the automatic sliding valve can only be placed in the position shown in full lines on the drawing; it is preferable however as before stated to arrange the pipe 7 with closed circuit as shown in the drawing.

The working of the apparatus is not altered by transporting the valve 20 from the position shown in full lines on the pipe 16 to the position Y illustrated in dotted lines; in this case, the orifice of the plug of this valve is also determined by experiment; the movement of the plug of valve 20 is combined with the movement of the plug of throttle 3 placed in the admission conduit of the engine as previously described but so that the minimum opening of the valve 20 corresponds to the minimum opening of the throttle 3 and that inversely the maximum opening of the valve 20 corresponds to the maximum opening of the throttle 3; each fixed position of the plug of valve 20 possesses the properties above described with reference to the initial position of this plug, that is to say as shown in full lines in the drawing.

The device is applicable to all types of internal combustion engines taking the air directly or indirectly from the atmosphere or using any poor gas which is to be enriched with liquid fuel; in fact one of the remarkable properties of the device is the facility with which the delivery of liquid fuel can be practically adapted to suit various compositions of the gaseous mixture as may be required. The law of constancy of the rate of the supply which is the most general in demand and for which reason has been considered herein, is not the only possible law; the laws of supply may be as numerous as the various conditions of use of the internal combustion engines.

It may be stated however that the best results are obtained with internal combustion engines having regulated inlet valves.

When the engine comprises several cylinders the admission conduit or conduits should be provided so that in one section of the admission conduit in which the jet of liquid fuel is introduced, such as the section 24, each admission to a cylinder must correspond to a like duration of feed of the nozzle when the motor rotates at uniform speed; this being the case the pipe 11 may comprise several nozzles all complying with the requirements above specified for a single nozzle. Should this be the case, the movements of the valves such as 3 are synchronized.

It is expressly specified that the pump 4 must be a centrifugal pump, this is essential for obtaining the results herein indicated.

What I claim as my invention and desire to secure by Letters Patent of the United States is:—

1. Apparatus for supplying liquid fuel to internal combustion engines comprising a centrifugal pump, a pipe forming an endless conduit with said pump, means actuated by the engine for driving said centrifugal pump, a branch pipe connected to said conduit, a nozzle at the free end of said branch pipe adapted to feed a jet of liquid fuel into the admission conduit of the engine, means for maintaining said endless conduit and said branch pipe filled with liquid fuel, means

governing in said endless conduit the flow of liquid fuel produced by said centrifugal pump, a throttle valve on said engine admission conduit, a valve operating to regulate said governing means, and a connection between said valves whereby said governing means adjusts the rate of supply of the liquid fuel to said nozzle in accordance with the varying positions of said throttle valve.

2. Apparatus for supplying liquid fuel to internal combustion engines comprising a pump casing a centrifugal pumping element within said casing, a pipe forming an endless conduit with said pump casing means actuated by the engine for driving said centrifugal pumping element, a branch pipe connected to said conduit, a nozzle at the free end of said branch pipe adapted to feed a jet of liquid fuel into the admission conduit of the engine, means for maintaining said endless conduit and said branch pipe filled with liquid fuel, said means comprising a constant-level tank the constant level of which is at the same level as said nozzle, means governing in said endless conduit the flow of liquid fuel produced by said centrifugal pump element, a throttle valve on said engine admission conduit, a valve operating to regulate said governing means, a connection between said valves whereby said governing means adjusts the rate of supply of the liquid fuel to said nozzle in accordance with the varying positions of said throttle valve, and a cock in said branch pipe for obtaining a particular constant rate of supply of the liquid fuel to said nozzle in accordance with given positions of said cock.

3. Apparatus for supplying liquid fuel to internal combustion engines comprising a pump casing, a centrifugal pumping element within said casing, a pipe forming an endless conduit with said pump casing, means actuated by the engine for driving said centrifugal pumping element, a branch pipe connected to said conduit, a nozzle at the free end of said branch pipe adapted to feed a jet of liquid fuel into the admission conduit of the engine, a transversally sliding valve in said endless conduit adapted to more or less close the cross sectional area of said conduit, pipe circuits connecting said endless conduit to the casing of said sliding valve whereby the valve is operated by the flow of liquid fuel produced by said centrifugal pumping element, means for maintaining said endless conduit said branch pipe and said pipe circuits filled with liquid fuel, a throttle valve on said engine admission conduit, a valve in said pipe circuit and a connection between said throttle valve and said last mentioned valve whereby said sliding valve is adjusted so that the supply of liquid fuel to said nozzle is in accordance with the varying positions of the throttle valve.

4. Apparatus for supplying liquid fuel to internal combustion engines comprising a centrifugal pump, a pipe forming an endless conduit with said pump, means actuated by the engine for driving said centrifugal pump, a branch pipe connected to said conduit, a nozzle at the free end of said branch pipe adapted to feed a jet of liquid fuel into the admission conduit of the engine, a constant level liquid fuel tank for maintaining said endless conduit and said branch pipe filled with liquid fuel, the level of the liquid in said tank being the same, as that of the orifice of said jet, means governing in said endless conduit the flow of liquid fuel produced by said centrifugal pump, a throttle valve on said engine admission conduit, a valve operating to regulate said governing means, and a connection between said valves whereby said governing means adjusts the rate of supply of the liquid fuel to said nozzle in accordance with the varying positions of said throttle valve.

In witness whereof I have signed this specification.

MARCEL JOSEPH ACHILLE REBILLET.