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Haidvogel

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[54] **METHOD AND APPARATUS FOR SUPPLYING GASEOUS AND LIQUID FUELS TO A DUAL-FUEL ENGINE**

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[51] **Int. Cl.**.. **F02m 13/08**

[58] **Field of Search**.................. 123/120, 121, 27 G

[56] **References Cited**

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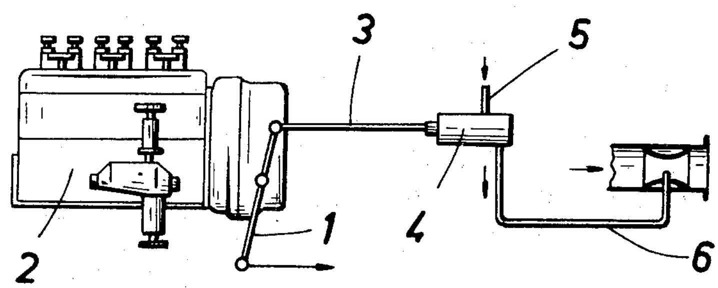
[57] **ABSTRACT**

Only liquid fuel is supplied to the engine under a no-load condition. Only liquid fuel at an increasing rate is supplied to said engine as the load thereon increases from said no-load condition through a lower partial load range. Liquid and gaseous fuels are supplied to said engine in a higher partial load range and under full load. The proportion of said gaseous fuel relative to said liquid fuel is increased during an increase of the load on said engine above said lower partial load range to about three-fourths of the full load on the engine.

5 Claims, 5 Drawing Figures



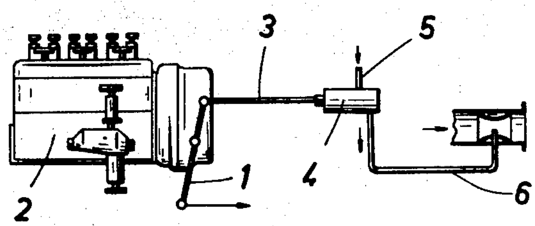


FIG.1

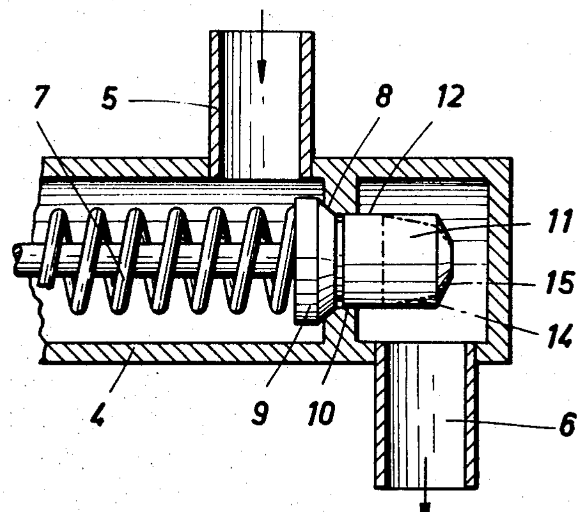


FIG.2

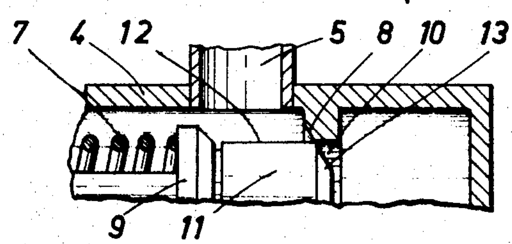


FIG.2a

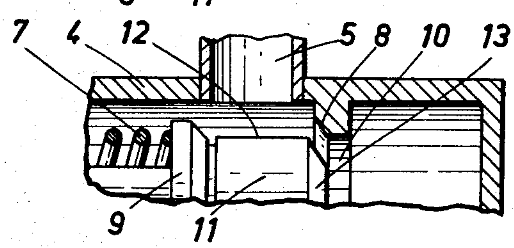


FIG.2b

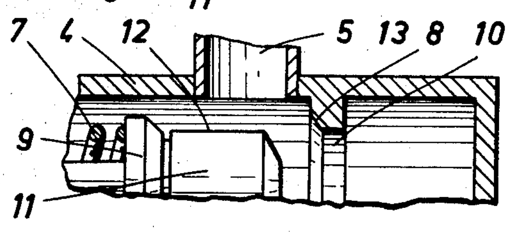


FIG.2c

METHOD AND APPARATUS FOR SUPPLYING GASEOUS AND LIQUID FUELS TO A DUAL-FUEL ENGINE

This invention relates to a method of controlling the mixing ratio in dual-fuel engines for vehicles, which engines are fed only with liquid fuel under no-load conditions. The invention relates also to apparatus for carrying out this method.

An apparatus is known in which the gas flow controller and the fuel injection pump are permanently coupled for simultaneous adjustment. A device is provided which is associated with the gas flow controller and which, when the adjusting member of the fuel injection pump is moved from a position correspnding to 70–80 percent of the full load of the engine to positions corresponding to an injection of larger amounts of fuel, will reduce the free area of flow in the gas flow controller or will maintain said free area of flow constant. The device consists of a throttling pin, which is carried by the valve member of the spring-loaded valve which constitutes the gas flow controller, and said pin protrudes into the passage bore and from the valve member is gradually tapered and subsequently formed with an enlarged or cylindrical portion. Because the gas flow controller and the adjusting member of the fuel injection pump are coupled, an increase of the load will initially result in an increase of the amount of liquid fuel which is injected as well as in an increase of the rate at which gaseous fuel is fed so that the mixing ratio remains approximately constant. When a position has been reached which corresponds to 70–80 percent of the full load on the engine, only the amount of liquid fuel which is injected is increased whereas the rate at which the gaseous fuel is fed is maintained constant or even reduced so that the mixing ratio in the upper load range is changed in favor of the liquid fuel. All other known methods of controlling the mixing ratio in dual-fuel engines for vehicles also involve an increasing supply of the gaseous fuel in the lower partial load range, beginning from a no-load condition.

It has now been found that an admixing of gaseous fuel in the lower partial load range results in an exhaust gas having an undesirable composition. This may be due to the fact that in the lower partial load range the gaseous fuel prevent a complete combustion.

It is an object of the invention to eliminate these disadvantages and provide a method which enables an improvement of the composition of the exhaust gas in the lower partial load range whereas other advantages of the dual-fuel process need not be sacrificed. That method should be carried out with fairly simple apparatus.

The above-mentioned object is accomplished by the method according to the invention in that during an initial increase of the load from a no-load condition only the amount of liquid fuel which is injected is increased, gaseous fuel is added only when a higher partial load range has been entered, and the gaseous fuel is added in a maximum proportion under about three-fourths of the full load on the engine. Hence, no gaseous fuel at all is added in the lowermost partial load range and only liquid fuel is supplied in said range. This operation surprisingly results in a much improved exhaust gas composition in said range. Tests have shown that particularly the proportion of unburnt hydrocarbons in the exhaust gas is much reduced. Because the proportion of the gaseous fuel reaches a maximum when about three-fourths of the full load on the engine have been reached and the porportion of gaseous fuel remains constant or is decreased under higher loads, an excessive pressure rise otherwise to be expected in the uppermost partial load range and under full load as a result of a further increase of the proportion of gaseous fuel will be avoided.

The gaseous fuel may be added at a rapidly increasing rate during an increase of the load above about two-thirds of the full load on the engine. This enables the provision of optimum conditions regarding the composition of the exhaust gas. Alternatively, the gaseous fuel may be admixed at a gradually increasing rate above approximately the first one-third of the full load on the engine. This practice results in a higher economy and a lower consumption of liquid fuel whereas the composition of the exhaust gas is not substantially deteriorated.

In the apparatus for carrying out the method, the gas flow controller and the adjusting member of the fuel injection pump are also coupled for simultaneous adjustment and the gas flow controller consists of a spring-loaded valve, which is closed in the no-load condition and comprises a valve pin, which is carried by the valve member and protrudes into the passage bore. The apparatus is characterized according to the invention in that the control pin comprises in known manner a cylindrical portion which adjoins the valve member and has a diameter which matches the passage bore, and a preferably conically tapered portion which adjoins said cylindrical portion, the cylindrical portion having a length which is at least as large as the stroke of the valve member from its no-load position to the position corresponding to approximately one-third of the full load on the engine. Because the cylindrical portion matches the passage bore of the gas flow controller that bore will remain closed as long as the cylindrical portion of the pin is disposed in the bore and there will be no supply of gaseous fuel during that time. In this way, the apparatus meets the requirement that the engine should be supplied only with liquid fuel in the lower partial load range. As soon as the tapered portion of the pin enters the passage bore, a supply of gas is enabled too and the real two-fuel operation begins.

An apparatus for carrying out the method according to the invention is shown in the drawing, in which

FIG. 1 is a diagrammatic view showing the entire apparatus,

FIG. 2 is a sectional view showing the gas flow controller and

FIGS. 2*a* to 2*c* show the gas flow controller in three other positions.

The adjusting member 1 of a conventional fuel injection pump 2 for supplying liquid fuel into a dual-fuel engine for vehicles consists of a lever, which by a linkage 3 is coupled to a gas flow controller 4 for simultaneous adjustment. Gas is supplied to the gas flow controller 4 through a conduit 5 from a suitable tank and through conduit 6 enters the induction manifold of the engine. The adjusting member 1 of the fuel injection pump 2 is indirectly connected to the accelerator pedal.

The gas flow controller 4 comprises a valve member 9, which is forced by a spring 7 against a valve seat member 8 and to which the linkage 3 is connected. The valve member 9 is provided with a valve pin 11, which protrudes into the passage bore 10 of the valve seat member 8 and which comprises a cylindrical portion 12 which adjoins the valve member and has a diameter matching the passage bore 10, and a conically tapered portion 13 adjoining the cylindrical portion 12.

The valve which is formed by the gas flow rate controller 4 is closed in the no-load position shown in FIG. 2 so that the vehicle engine is then supplied only with liquid fuel. Because the cylindrical portion 12 of the pin has a diameter which matches the diameter of the bore 10, the flow of gas will be blocked until the position shown in FIG. 2*a* is reached, which corresponds to about two-thirds of the full load on the engine. Under about three-fourths of the full load (FIG. 2*b*), the gas flow rate reaches a maximum and remains constant thereafter until the full-load position shown in FIG. 2*c* has been reached. From the position shown in FIG. 2*a* to the position shown in FIG. 2*b*, the rate at which gas flows through the bore 10 increases fairly rapidly owing to the conically tapered portion 13 of the valve pin.

The cylindrical portion 12 of the valve pin 11 might alternatively be succeeded by a conical portion 14 having an acute apex angle, and this conical portion might be succeeded by an end portion 15, such as is indicated by dash-dot lines in FIG. 2. With such a valve pin, the gaseous fuel will be admixed at a gradually increasing rate during an increase of the load above about one-third of the full load on the engine.

What is claimed is:

1. A method of controlling the supply of a normally gaseous and a normally liquid fuel to a dual-fuel engine for vehicles after it has been started, which comprises the steps of

1. supplying only the liquid fuel to the engine under a no-load condition;
2. continuing to supply the liquid fuel to the engine at an increasing rate as the engine load increases from the no-load condition to a full engine load,
   a. only the liquid fuel being supplied during a first, low load range;
3. also supplying the gaseous fuel to the engine at an increasing rate during a second, higher load range above the first load range and up to about three-fourths of of the full engine load; and
4. continuing to supply the gaseous fuel to the engine up to the full engine load.

2. The method of claim 1, wherein the gaseous fuel is supplied at a rapidly increasing rate during an increase of the engine load from about two-thirds to about three-fourths of the full engine load.

3. The method of claim 1, wherein the gaseous fuel is supplied at a gradually increasing rate during an increase of the engine load from about one-third to about three-fourths of the full engine load.

4. In an apparatus for supplying a normally gaseous and a normally liquid fuel to a dual-fuel engine for vehicles, which apparatus comprises a fuel injection pump operable to supply the liquid fuel to the engine, an adjusting member for controlling the rate of supply of the liquid fuel, a controller for controlling the gaseous fuel supply rate, the controller comprising means defining a gaseous fuel passage bore, a spring-biased valve member axially urged toward the bore to assume a closed position wherein the valve member adjoins the bore and shuts off the supply of the gaseous fuel through the bore, a valve pin carried by the valve member for protruding into the bore, and means operatively connecting the adjusting member to the valve member for moving the valve member away from the bore in response to a movement of the adjusting member corresponding to an increase of the engine load from a no-load condition, the improvement of the valve pin comprising a cylindrical portion adjoining the valve member and having a diameter matching the bore, the cylindrical valve pin portion having a length at least equal to the length of the stroke of the valve member from the no-load position to a position corresponding to about one-third of the full engine load, and a tapered portion adjoining the cylindrical portion.

5. In an apparatus for supplying a normally gaseous and a normally liquid fuel to a dual-fuel engine for vehicles, which comprises a fuel injection pump operable to supply the liquid fuel to the engine, an adjusting member for controlling the rate of supply of the liquid fuel, a controller for controlling the gaseous fuel supply rate, the controller comprising means defining a gaseous fuel passage bore, a valve pin arranged to be moved into and out of the bore, and means operatively connecting the adjusting member to the valve pin for the movement thereof, the improvement of the valve pin comprising a cylindrical portion having a diameter matching the bore, the means connecting the adjusting member and valve pin being arranged to move the cylindrical valve pin portion into the bore to shut off any flow of the gaseous fuel through the bore when the adjusting member is in a position corresponding to a no-load condition of the engine, and to move the cylindrical valve pin portion entirely out of the bore in response to a movement of the adjusting member corresponding to an increase of the engine load to at least about one-third of the full engine load, and a tapered portion adjoining the cylindrical valve pin portion.

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