Aug. 18, 1959 J. N. MORRIS 2,899,953

FUEL SUPPLYING SYSTEM FOR SPARK-IGNITION FUEL INJECTION INTERNAL COMBUSTION ENGINES

Filed Dec. 18, 1956 2 Sheets-Sheet 1

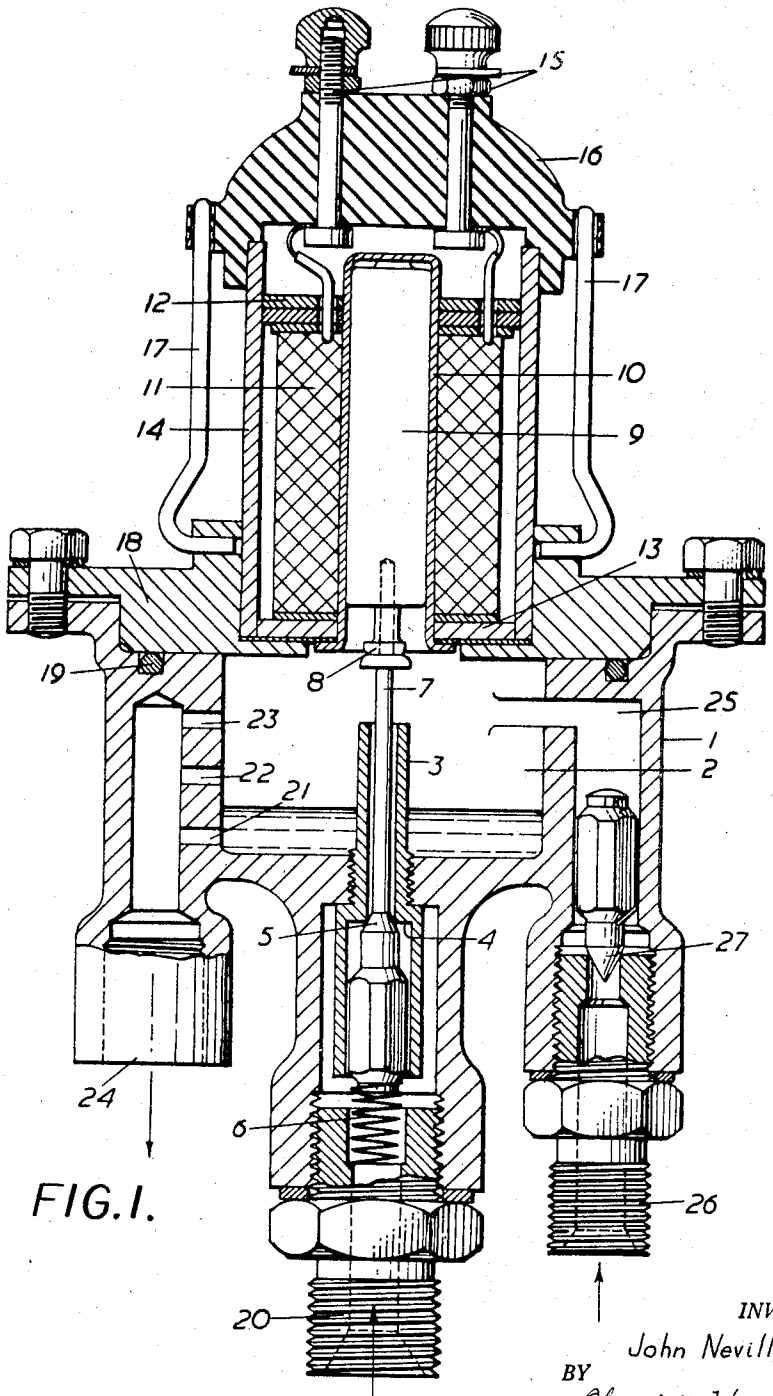


FIG. 1.

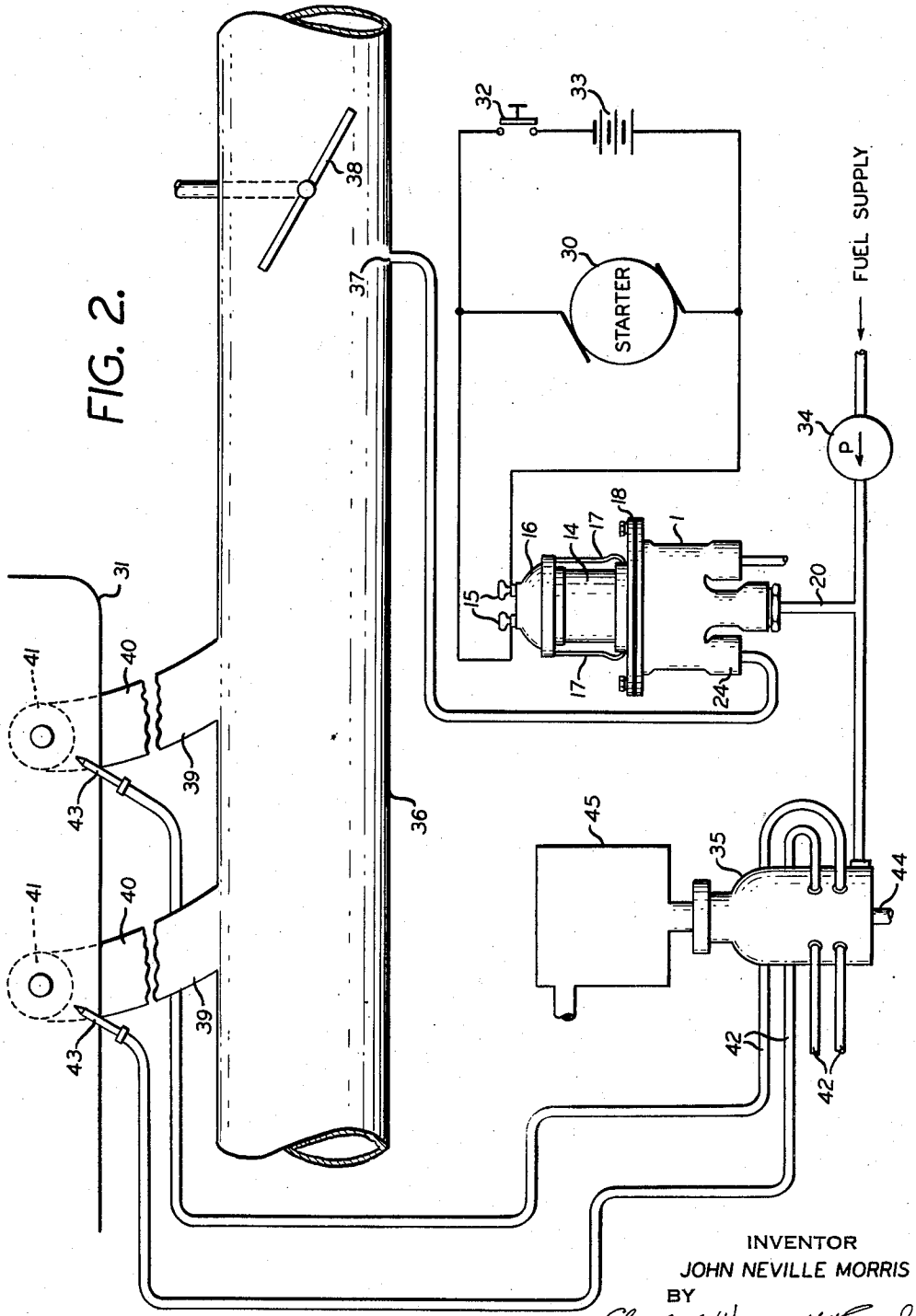
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FIG. 2.



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United States Patent Office 2,899,953
Patented Aug. 18, 1959

2,899,953

FUEL SUPPLYING SYSTEM FOR SPARK-IGNITION FUEL INJECTION INTERNAL COMBUSTION ENGINES

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Application December 18 1956, Serial No. 629,120

Claims priority, application Great Britain December 22, 1955

11 Claims. (Cl. 123—179)

This invention relates to a fuel supplying system for spark-ignition internal combustion engines operating with liquid fuel and having the fuel supplied thereto by injection equipment.

Engines in which the fuel is supplied to the cylinders by injection either into the air induction tract or directly into the cylinders need a considerably increased supply of fuel per cycle during the initial starting phase at low temperatures. It has been established that the extent of this increase, under extreme conditions of low temperature, is between four and five times the normal full-load fuel requirement per cycle. For various reasons it would be inconvenient to arrange for the injection pump which normally supplies the fuel to be capable of providing temporarily the requisite degree of enrichment needed for cold-starting of the engine, and in the initial period of its running from a cold condition.

An object of the present invention is to provide improved means for effecting an augmented fuel delivery as required by a spark-ignition fuel injection engine during cold operating conditions. To this end, the invention comprises the provision, in combination with the usual injection equipment, of fuel metering means coupled with the engine for metering out a quantity of fuel which varies in proportion to the cranking time of the engine, and means coupling the metering means with the engine cylinders for adding said metered quantity of fuel to the normal fuel supply, whereby the fuel mixture supplied to the cylinders is enriched during starting for an interval determined by the difficulty encountered in starting. More specifically the invention comprises a cold-starting or auxiliary fuel supplying device having a chamber for receiving an auxiliary supply of fuel, a control inlet valve for metering the quantity of fuel supplied to the chamber, and means for operatively coupling the valve to the starting system of the engine for concurrent operation therewith, the chamber being provided with outlet means for supplying the fuel therein to the engine cylinders at a rate proportioned to the quantity of fuel in said chamber. In this way it is possible to insure a degree of enrichment which, both in its extent and duration, suffices to accommodate the varying demands of the engine as reflected by the length of time for which it proves necessary to maintain the starter motor in operation.

If desired, a thermo-sensitive control may be employed to preclude operation of the cold-starting device whenever the general temperature of the engine exceeds a preselected level at the time when the engine is to be started or restarted. However, apart from its slight effect upon fuel consumption, the omission of such an overriding control is unharmful, even under high-temperature conditions, because usually it is then only necessary to operate the starter motor for a very brief period, and consequently the relatively small degree of enrichment effected is perforce of equally short duration.

In its preferred form the cold-starting device is incorporated in the housing of the engine throttle valve, but

it is more convenient here to describe the device schematically as constituting a separate unit. The invention will be better understood after reading the following detailed description with reference to the accompanying drawing wherein:

Figure 1 is a sectional elevation of an auxiliary fuel supplying device constructed in accordance with the invention, and

Figure 2 is a diagrammatic representation of the auxiliary fuel supplying device as coupled to a typical engine installation.

Referring to Figure 1 of the drawing the auxiliary device comprises a main body **1** enclosing a chamber **2** through the base of which a tubular member **3** extends upwardly within the chamber. Outside the latter the tubular member **3** is arranged to form a seating **4** for a coaxial spring-loaded needle valve **5** which is normally held closed by its spring **6**. A mushroom-headed thrust pin **7**, slidable with clearance within the tubular member **3** and protruding from it, engages, at its lower end, the needle valve **5**. Resting centrally upon the head of the thrust pin **7** is a button **8** which is fixed to the lower end of a vertically disposed solenoid plunger **9**. This plunger operates within a non-magnetic barrel **10**, which is closed at the top and open at the bottom. The solenoid **11**, which is provided with end plates **12**, **13** and a coaxial shroud **14** of iron or steel to concentrate the flux, is energized through terminals **15** mounted in an insulating cap **16** fitted on the shroud **14**. Attachment wires **17** are employed to secure this cap to a cover plate **18**, which is bolted to the main body **1** with a packing ring **19** interposed.

The solenoid **11** is intended to be connected as shown in Figure 2 in parallel with the starter motor **30** of the engine **31**. Consequently, when the starter motor is operated by closing the switch **32** and thereby completing the circuit to the battery **33**, the solenoid **11** is energized concurrently and its plunger **9** as seen in Figure 1 is drawn downwards, causing the thrust pin **7** to open the needle valve **5** against the action of its spring **6**. This valve remains open only so long as the starter motor is in use.

The opening of the auxiliary fuel-control needle valve **5** admits liquid fuel from an inlet connection **20**, to the chamber **2** by way of the annular clearance between the thrust pin **7** and the tubular member **3**, this auxiliary supply of fuel being conveniently derived from the usual feed pump **34** (see Figure 2) which supplies the fuel injection pump **35**.

Referring again to Figure 1, the auxiliary fuel chamber **2** has a plurality of spill outlets **21**, **22**, **23** located at different levels in the form of vertically spaced openings in the walls thereof, and the spillage from these is delivered to a discharge orifice **24**. As seen in Figure 2, the orifice **24** is adapted to be coupled to the engine in the induction tract **36** at the point **37** adjacent to the edge of the engine throttle valve. This supplementary fuel is, therefore, admixed with the air at the main air intake to the induction manifold, and is distributed to the various engine cylinders in the same manner as in the case of a normally carburetted engine.

Now referring to Figure 2, a multicylinder, spark-ignition engine, part of the cylinder block of which is indicated at **31**, has branch pipes **39** (only two of which are illustrated) leading from the intake manifold **36** to the respective inlet ports **40** each of which is controlled by the usual poppet valve **41**. The variable-delivery, liquid-fuel injection pump **35**, having a suction line connected to the pump **34** and discharge lines **42**, supplies (in the required firing order) each of the injection nozzles **43** fitted to the respective inlet ports **40**. The injection pump **35** is provided with a driving spindle **44** which is connected to the engine in any well known manner. Similarly the

control mechanism for the injection pump 35 represented by the housing 45 may be coupled to sense an operating characteristic of the engine in known manner.

In the event of it proving necessary to maintain the starter motor in circuit for a rather long period so that the level within the auxiliary fuel chamber 2 rises considerably, an increasing number of the spill outlets 21, 22, 23 will become operative and there will furthermore ensue, after starting of the engine, a correspondingly longer period during which the fuel lodged in that chamber will continue to be spilled through the bottom outlet 21. The condition is thus fulfilled that the colder the environment, and therefore the longer the period of cranking necessary to ensure the initial start, the greater will be the rate of auxiliary fuel supply to the throttle edge, and at the same time, the longer will be the period over which such fuel supply will persits after the initial start is achieved. This arrangement has been found to meet the cold-starting requirements of fuel-injected engines in a satisfactory manner, since it is, generally speaking, only necessary to provide a relatively brief period of initial firing before the supply of fuel from the injectors, either unenriched or slightly enriched, is sufficient to ensure continued running.

The upper part of the auxiliary fuel chamber 2 is in communication through a duct 25, with an atmospheric air inlet 26 controlled by a gravity-loaded needle valve 27. This provides uni-directional communication with the atmosphere. When the engine is being turned by the starter motor, and also when it is running, a small flow of air is induced into the auxiliary fuel chamber 2 owing to the needle valve 27 being lifted off its seating by the pressure differential then existing, this air passing through the spill outlets 21, 22, 23 and being conveyed to the throttle edge. If, however, a lengthy period elapses before starting is achieved and fuel should enter the auxiliary fuel chamber 2 at a faster rate than that at which it is being removed by the totality of the spill outlets, the possibility of its eventual discharge through the air inlet 26 will effectively be precluded by the air-control needle valve 27 becoming seated.

A limitation to the rate at which the fuel is supplied to the auxiliary fuel chamber 2, when the engine is being started, is conveniently afforded by appropriate choice of the diameter of the thrust pin 7 in relation to the bore of the surrounding tubular member 3 at the downstream side of the seating 4 of the auxiliary fuel-control needle valve 5. The rate at which the fuel enters the auxiliary fuel chamber is also, of course, contingent upon the pressure provided by the fuel feed pump which may, however, be regarded as substantially constant in a given installation.

As an alternative to having two or more spill outlets at different levels in the auxiliary fuel chamber 2, the same effect could be achieved with an equivalent single slot-like spill outlet extending upwardly.

Having described the invention in detail with reference to a preferred embodiment thereof it should be apparent that numerous modifications and changes may be made therein.

What I claim is:

1. A fuel supplying system for spark-ignition internal combustion engines which are provided with a starting system, said fuel system including means for supplying liquid fuel to the combustion chambers of the engine by injection, and having provision for cold-starting comprising in combination fuel metering means coupled with said engine for metering out a quantity of fuel which varies in proportion to the cranking time of the engine, and means coupling said metering means with said combustion chambers for adding said metered quantity of fuel to the normal supply provided by said injection means, whereby the fuel mixture supplied to said combustion chambers is enriched during starting for an interval determined by the difficulty encountered in starting.

2. A fuel supplying system according to claim 1, wherein said fuel metering means comprises a fuel control valve and means operatively coupling said valve to said starting system.

3. A fuel supplying system according to claim 2, wherein said starting system comprises an electric starting motor, and wherein said means operatively coupling said valve to the starting system comprises means coupled with said starting motor for concurrent operation therewith.

4. A fuel supplying system according to claim 1 wherein said starting system comprises an electric starting motor and a starting circuit therefor; and wherein said fuel metering means comprises a fuel control valve, and solenoid operating means for said valve energized from said starting circuit for concurrent operation with said motor.

5. An auxiliary fuel supplying device for use in cold-starting of spark-ignition internal combustion engines provided with liquid fuel injection equipment and a starting system, comprising a chamber for receiving an auxiliary supply of said fuel, said chamber having at least one outlet for supplying said fuel to the engine cylinders, a control inlet valve coupled with said chamber for metering the quantity of fuel supplied to said chamber, and means for operatively coupling said valve to said starting system for concurrent operation therewith, whereby the fuel mixture supplied to said cylinders is enriched during starting for an interval determined by the difficulty encountered in starting.

6. An auxiliary fuel supplying device for use in cold-starting of spark-ignition internal combustion engines provided with liquid fuel injection equipment and a starting system, comprising a chamber for receiving an auxiliary supply of said fuel, said chamber being provided with outlet means for supplying said fuel to the engine cylinders at a rate proportioned to the quantity of fuel in said chamber, a control inlet valve coupled with said chamber for metering the quantity of fuel supplied to said chamber, and means for operatively coupling said valve to said starting system for concurrent operation therewith, whereby the fuel mixture supplied to said cylinders is enriched during starting to an extent and for an interval determined by the difficulty encountered in starting.

7. An auxiliary fuel supplying device according to claim 6, wherein said starting system comprises an electric starting motor and a starting circuit therefor; and wherein said means for coupling said valve to the starting system comprises a solenoid operatively controlling said valve, and means for coupling said solenoid to said starting circuit.

8. An auxiliary fuel supplying device according to claim 6, wherein said valve comprises spring means for biasing it to a normally closed position, a valve seat formed in a tubular member which extends upwardly within said chamber, and a thrust pin slidably disposed within said tubular member for opening said valve.

9. An auxiliary fuel supplying device according to claim 6, wherein said chamber is provided with means for establishing uni-directional communication between the upper part thereof and the atmosphere for admitting air thereto while preventing the outward flow of fuel therefrom.

10. An auxiliary fuel supplying device according to claim 6, wherein said outlet means for the chamber comprise a plurality of vertically spaced openings in the side walls thereof.

11. An auxiliary fuel supplying device for use in cold-starting of spark-ignition internal combustion engines provided with liquid fuel injection equipment and a starting system, comprising a chamber for receiving an auxiliary supply of fuel, a control inlet valve coupled with said chamber for admitting said fuel to said chamber when said valve is open, means for operatively coupling said valve to said starting system for opening said valve while

said engine is being cranked to supply said chamber with a quantity of fuel which is determined by the cranking time, and an outlet for said chamber for supplying the quantity of fuel which has been admitted to the chamber to the cylinders of the engine at a slower rate than the rate of admission, whereby the fuel mixture supplied to said engine will be enriched during starting and for a period thereafter as determined by the cranking time of the engine.

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