

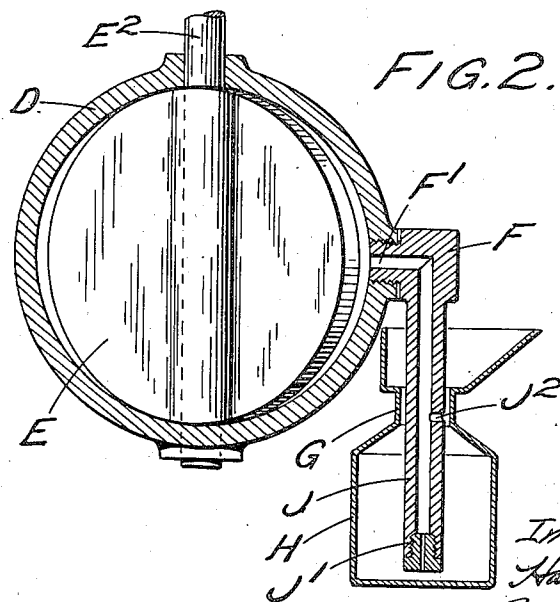
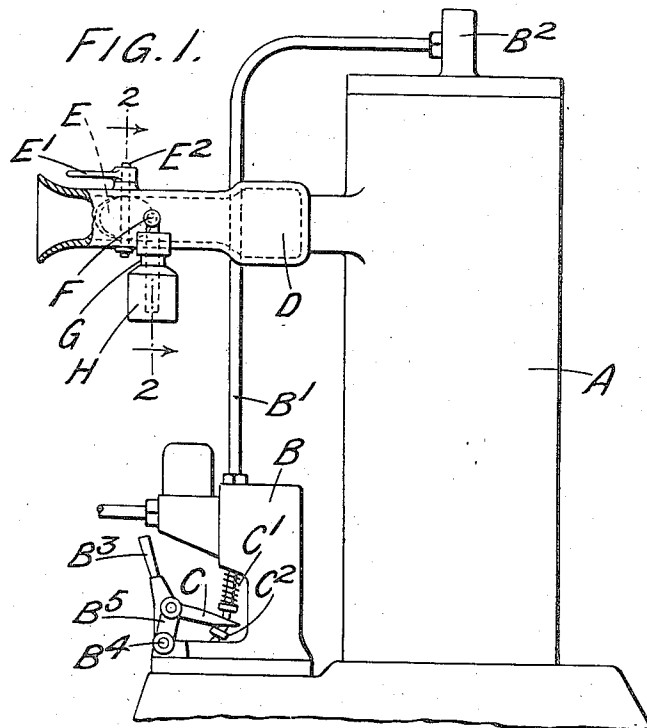
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INTERNAL COMBUSTION ENGINE OF THE COMPRESSION IGNITION TYPE

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INTERNAL COMBUSTION ENGINE OF THE COMPRESSION IGNITION TYPE

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This invention relates to internal combustion engines of the compression ignition type in which means are provided for delivering to the engine for starting purposes a fuel having a self-ignition temperature substantially lower than that of the fuel normally employed whereby the starting of such engines from cold, which, if a normal fuel is employed is often difficult particularly in small engines owing to excessive cooling of the charge during compression, is facilitated.

The object of the present invention is to provide an improved engine of the above general type in which the apparatus, whereby the delivery of starting fuel to the engine is effected, will be of simple form and yet will enable starting from cold to be readily effected with little risk of such mal-operation as might cause undesirably high pressures to be produced in the internal combustion engine cylinder or cylinders.

According to the present invention an internal combustion engine of the compression ignition type has an air inlet passage the quantity of air drawn through which can be varied, and means for supplying to the engine during the suction period for starting purposes a fuel and air mixture which is adapted to be ignited by the heat of compression, the arrangement being such that this mixture can only be delivered to the engine when the supply of air through the inlet passage is reduced or cut off.

The arrangement is preferably such that when the starting mixture is being supplied to the engine, the density of the gaseous charge in the cylinder or cylinders at the end of each suction stroke is substantially below that for normal running with liquid fuel injection so that risk of excessive pressures being produced in the cylinder or cylinders during the starting period is reduced.

The invention may be carried into practice in various ways but one construction according to this invention is illustrated somewhat diagrammatically by way of example in the accompanying drawing, in which

Figure 1 is an elevation of an engine cylinder and fuel supply apparatus according to this invention, and

Figure 2 is a cross-section on an enlarged scale on the line 2—2 of Figure 1 showing the apparatus for supplying fuel for starting purposes.

Figure 1 shows diagrammatically one cylinder A of an engine which may be either of the single or multiple-cylinder type having liquid fuel injection apparatus comprising, for example, a fuel pump B which delivers fuel through a pipe B¹ to a sprayer indicated at B² in the cylinder head. Mechanism is provided for varying the supply of fuel delivered by such fuel supply apparatus in known manner. For example a lever B³ may act through a shaft B⁴ and crank B⁵ on a wedge-shaped member C interposed between the stem C¹ of the by-pass valve of the fuel pump and the tappet C² for operating this valve whereby the period of opening of this valve can be controlled to vary the quantity of fuel injected on each pump delivery stroke.

Either a separate air inlet passage D may be provided for each cylinder or, in the case of a multi-cylinder engine, a number of cylinders may communicate through an induction manifold with a common air inlet passage. In either case the air inlet passage or each air inlet passage D is controlled by a throttle valve E for example of the butterfly type as shown adapted to be manually controlled by a lever E¹ on the spindle E² thereof whereby the quantity of air drawn through the passage D can be controlled.

Arranged in the wall of the air inlet passage D is a plug member F provided with a passage F¹ through which starting fuel is adapted to flow from a starting fuel supply apparatus G, the passage in the member F being disposed at a point where, as the throttle valve E approaches its closed position, the passage F¹ will be subjected to a depression so that fuel will tend to be drawn through it. Thus the passage F¹ conveniently opens into the air inlet passage D at a point slightly nearer the cylinder A than the point at which the throttle valve E when in its fully closed position meets the wall of the passage D.

The apparatus G whereby starting fuel is delivered to the passage F¹ may vary but is

preferably so constructed and arranged that a larger quantity of starting fuel will be delivered during the initial rotation of the engine than subsequently. Thus as shown in Figure 2, the starting fuel may be drawn from a small reservoir H by a pipe J forming a downward extension of the plug F. The pipe J has an inlet opening or jet J¹ at its lower end and an upper inlet opening J² in its wall at a point where, when the starting fuel reservoir H is filled preparatory to starting, it will be covered by the fuel, so that on starting fuel only will be drawn through the pipe J and passage F¹ into the air inlet passage D, but when the fuel in the reservoir H has sunk to a level below that of the opening J² air will be drawn through the opening and starting fuel only through the jet J¹ whereby the quantity of fuel delivered to the engine air inlet passage is reduced. With this arrangement the starting fuel reservoir H is only of sufficient size to accommodate fuel for one start and is adapted to be refilled for each start and to be allowed to run dry before the throttle valve E is fully opened.

Other arrangements may, however, be employed wherein the starting fuel reservoir is of such size as to accommodate enough starting fuel for two or more starts or wherein means are not provided for automatically reducing the quantity of starting fuel supplied during the subsequent stages of the starting operation.

With arrangements such as those shown in the drawings wherein the starting fuel is admitted to the air inlet passage D at a point which lies adjacent to the edge of the throttle valve when this valve is in its fully closed position, starting fuel in any appreciable quantity is only drawn in when a considerable depression exists in the air inlet pipe or manifold so that it is not possible for a full charge of fuel and air mixture to be drawn in during the starting period whereby risk of excessive pressures being produced in the cylinder or cylinders due to the explosion of such a full charge of fuel and air mixture is reduced.

With arrangements such as those above described the starting of the engine from cold is effected in the following manner.

The fuel pump or pumps are rendered inoperative by actuation of the lever B³ and the throttle valve E is moved to its nearly closed position. The engine is then turned over, for example by an electric starting motor. This will cause a strong depression to be exerted on the starting fuel inlet passage F¹ during the suction period, whereby fuel will be drawn through this passage and will mix with the air entering through the small throttle valve opening. Owing, however, to the nearly closed position of the throttle valve E, the density of the charge thus drawn into

the cylinder or cylinders will, at the end of the suction stroke, be considerably below that of the normal air charge which would be drawn in when the throttle valve is fully open.

The starting charge thus drawn in will then be compressed and the starting fuel, being of a kind which has a low self-ignition temperature as compared with fuels normally used in compression ignition engines, will ignite and the engine will start. When the engine has commenced to run on the starting fuel the throttle valve E may be opened somewhat and the main fuel injection apparatus adjusted, for example, by means of the handle B³ to permit a small quantity of normal fuel to be injected. The starting fuel mixture will then act as an igniting charge for the main fuel until the engine has become heated to a temperature at which it will run in the normal manner without the starting fuel, when the throttle valve can be fully opened. This opening of the throttle valve removes substantially completely the depression from the starting fuel passage F¹ so that no more starting fuel is drawn there-through and the engine continues to run as a normal compression ignition engine with liquid fuel injection.

As stated above the starting fuel reservoir may be made of such dimensions as to enable several starts to be made therefrom but preferably is of only sufficient size to accommodate fuel for one start, this reservoir being allowed to run dry when starting before the air throttle valve E is fully opened.

The fuel employed for starting purposes may vary but suitable starting fuels are, for example, ethyl ether, amyl nitrite and amyl nitrate. These fuels may be used either alone or mixed with some other liquid such as normal fuel oil.

It is to be understood that the invention is not limited to the starting fuel being delivered to the main air inlet passage but that it may be supplied through a separate passage if desired and other details of construction may be varied without departing from this invention.

What I claim as my invention and desire to secure by Letters Patent is:

1. An internal combustion engine of the liquid fuel injection compression ignition type including in combination an air inlet passage, a throttle valve controlling the quantity of air which can flow through such passage, a fuel jet in the air inlet passage disposed intermediate the throttle valve and the engine so that a depression will be exerted on the jet sufficient to cause fuel to flow therethrough only when the throttle valve is partially closed so as to reduce the quantity of air flowing through the air inlet passage below that for normal operation with liquid fuel injection, and a starting fuel

reservoir communicating with the fuel jet so that when the throttle valve is closed to a sufficient extent a fuel and air mixture can be delivered to the engine during the suction period and ignited by the heat of compression for starting purposes.

2. An internal combustion engine of the liquid fuel injection compression ignition type including in combination an air inlet passage, a throttle valve controlling the quantity of air which can flow through such passage, a fuel jet in the air inlet passage disposed intermediate the throttle valve and the engine so that a depression will be exerted thereon sufficient to cause fuel to flow there-through only when the throttle is partially closed so as to reduce the quantity of air delivered to the engine below that for normal operation with liquid fuel injection, and means for supplying fuel for starting purposes in varying quantity to the fuel jet.

3. An internal combustion engine of the liquid fuel injection compression ignition type including in combination an air inlet passage, a throttle valve controlling the quantity of air which can flow through such passage, a fuel jet in the air inlet passage disposed intermediate the throttle valve and the engine so that a depression sufficient to cause the fuel to be drawn through the jet will only be exerted thereon when the throttle is partially closed so as to reduce the quantity of air supplied to the engine below that for normal operation with liquid fuel injection, a starting fuel reservoir communicating with the jet and of such size as to accommodate only sufficient fuel for one start and means whereby a larger quantity of fuel will automatically be delivered to the jet during the initial than during the subsequent stages of the starting period.

4. An internal combustion engine of the liquid fuel injection compression ignition type including in combination an air inlet passage, means for varying the quantity of air drawn through such passage, means for supplying to the engine during the suction period for starting purposes a combustible fuel and air mixture which is adapted to be ignited by the heat of compression, means whereby this mixture will be delivered to the engine only when the quantity of air supplied through the inlet passage is reduced below that for normal operation with liquid fuel injection, the means for supplying starting fuel comprising a starting fuel reservoir and a pipe which dips into the fuel and is provided with lower and upper inlet openings both of which are adapted to be covered by the fuel when the reservoir is filled, the upper opening being uncovered after the initial stages of the starting period owing to the withdrawal of fuel from the reservoir.

5. An internal combustion engine of the liquid fuel injection compression ignition

type including in combination an air inlet passage, a throttle valve controlling the quantity of air which can flow through such passage, a fuel jet so disposed in the air inlet passage in relation to the throttle valve that a depression sufficient to cause fuel to be drawn through the jet is exerted thereon only when the throttle valve is partially closed so as to reduce the quantity of air supplied through the air inlet passage below that for normal operation with liquid fuel injection, and means for supplying fuel to the fuel jet comprising a starting fuel reservoir and a pipe leading to the jet and dipping into the fuel in the reservoir this pipe being provided with lower and upper inlet openings both of which are adapted to be covered by the fuel when the reservoir is filled, the upper opening being uncovered after the initial stages of the starting period owing to the withdrawal of fuel from the reservoir.

6. An internal combustion engine of the liquid fuel injection compression ignition type including in combination an air inlet passage, a throttle valve controlling the quantity of air which can flow through such passage, a fuel jet so disposed in the air inlet passage in relation to the throttle valve that a depression sufficient to cause fuel to be drawn therethrough is exerted on the jet only when the throttle valve is partially closed so as to reduce the quantity of air supplied through the air inlet passage below that for normal operation with liquid fuel injection, and means for supplying fuel to the fuel jet comprising a starting fuel reservoir of sufficient size only to supply fuel for one start, and a pipe leading to the jet and dipping into the fuel in the reservoir this pipe being provided with lower and upper inlet openings both of which are adapted to be covered by the fuel when the reservoir is filled, the upper opening being uncovered after the initial stages of the starting period owing to the withdrawal of the fuel from the reservoir.

7. An internal combustion engine of the liquid fuel injection compression ignition type including in combination an air inlet passage, a throttle valve controlling the quantity of air which can flow through such passage, a fuel supply means communicating with the air inlet passage intermediate the throttle valve and the engine so that a depression will be exerted on the fuel supply means sufficient to cause fuel to flow there-through only when the throttle valve is partially closed so as to reduce the quantity of air flowing through the air inlet passage below that for normal operation with liquid fuel injection, whereby a fuel and air mixture can be delivered to the engine during the suction period and ignited by the heat of compression for starting purposes.

8. An internal combustion engine of the

liquid fuel injection compression ignition type including in combination an air inlet passage, means for varying the quantity of air drawn through such passage, and means
5 controlled by manipulation of said first named means to reduce the flow of air to less than that required for normal operation with liquid fuel injection for supplying to the engine during the suction period for starting
10 purposes a combustible fuel and air mixture of varying proportions which is adapted to be ignited by the heat of compression.

9. In an internal combustion engine of the liquid fuel injection compression ignition
15 type adapted to operate under normal running conditions with fuel having a comparatively high self-ignition temperature, the combination with an air inlet passage, of means for varying the quantity of air drawn
20 through such passage, and means controlled by manipulation of said first named means to reduce the flow of air to less than that required for normal operation for supplying to the engine during the suction period for
25 starting purposes a mixture of air and combustible fuel of relatively low self-ignition temperature which is adapted to be ignited by the heat of compression.

10. In an internal combustion engine of the liquid fuel injection compression ignition
30 type adapted to operate under normal running conditions with fuel having a comparatively high self-ignition temperature, the combination with an air inlet passage, of means for varying the quantity of air drawn
35 through such passage, and means communicating with said inlet passage intermediate said first named means and the engine for supplying fuel of relatively low self-ignition temperature to said inlet passage when
40 the supply of air is reduced by the operation of said first named means below that for normal operation of the engine to provide a combustible fuel and air mixture for starting
45 purposes which is adapted to be ignited by the heat of compression.

In testimony whereof I have signed my name to this specification.

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HARRY RALPH RICARDO.

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