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PREHEATED FUEL INJECTION DEVICE FOR INTERNAL-COMBUSTION ENGINES

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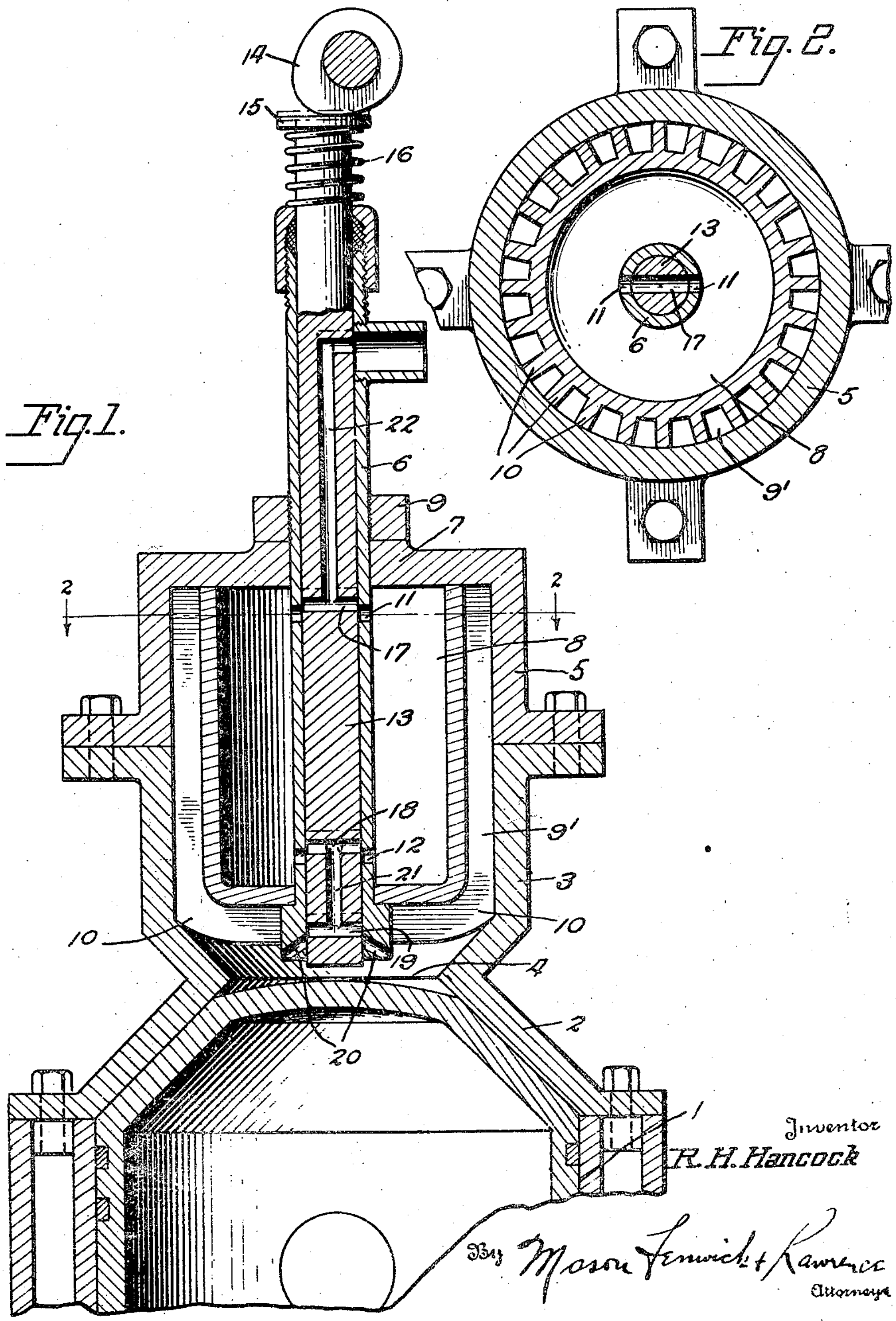
Fig. 1. Fig. 2.

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## PREHEATED FUEL INJECTION DEVICE FOR INTERNAL-COMBUSTION ENGINES

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6 Claims. (Cl. 123—32)

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This invention relates to internal combustion engines of that type in which fuel is spontaneously ignited in the combustion chamber by being injected into a body of highly compressed air. More particularly, the type of engine in contemplation is one in which the combustion continues through an appreciable extent of the working stroke of the piston.

One of the objects of the invention is to provide an engine of the class described, in which a confined body of liquid fuel, sufficient for a plurality of charges is maintained under pressure, fuel being admitted under pressure to one part of said body in the form of successive portions, each equal to a single charge, equal portions from another part of said body being simultaneously discharged through displacement by the admitted portions, the confined body of liquid fuel being subjected to heat developed in the engine by which the part of said body from which charges are released is heated above the vaporization point of the least volatile constituents of the fuel, said body being maintained under pressure sufficiently high to inhibit the vaporization of any part thereof until released to the combustion chamber, into which it issues as a dry gas.

Another object of the invention is to provide a fuel injector comprising a fuel chamber filled with a body of liquid fuel sufficient for a plurality of charges, with means for simultaneously admitting a charge under pressure into said chamber at one point, and by displacement forcing out an equal charge at a remote point, said chamber being subjected to a temperature above the vaporization point of all fractions of the liquid fuel, the time of travel of said fuel through said chamber from its point of admission to its point of discharge being sufficient to raise the temperature of that portion of the fuel body from which charges are released above the vaporization point of all of its constituents and the body of fuel in said chamber being maintained at a sufficient high pressure to inhibit vaporization of any part thereof until released from said chamber, so that when released it instantly expands into a dry gas.

A further object of the invention is to provide a fuel injector as above described, positioned within and surrounded by a compressed air chamber communicating with the combustion chamber of the internal combustion engine, charged with highly compressed air at each compression stroke of the engine piston and so sized as to contain a major portion of the air compressed by said

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piston, the discharge ports of said fuel chamber being adjacent the mouth of said compressed air chamber whereby during the entire period of admission of the fuel to the combustion chamber as a dry gas, it is mixed with a continuous supply of expanded air from said compressed air chamber, ensuring thorough and complete mixing and complete combustion of the fuel charge.

Other objects of the invention will appear as the following description of a preferred and practical embodiment thereof proceeds.

This application is a continuation-in-part of my abandoned application Ser. No. 476,873, filed February 23, 1943.

In the accompanying drawing:

Figure 1 is a longitudinal diametrical section through an internal combustion engine cylinder and fuel injecting and preheating apparatus embodying the principles of the invention;

Figure 2 is a cross-section taken along the line 2—2 of Figure 1.

Referring now in detail to the drawing, the engine cylinder 1 is provided with a head 2, formed with a casing 3, constituting the outer wall of a compressed air chamber which communicates with the clearance space within the cylinder by a restricted mouth 4. The casing 3 may be in two parts, as shown, the outer part 5 being bolted to the inner part.

An injector tube 6 extends through the outer end wall 7 of the casing 3, having its inner end terminating adjacent the mouth 4 of said casing. A cylindrical fuel receptacle 8 surrounds the major portion of the injector tube 6, having its bottom wall secured axially to the injector tube, the upper end of said fuel receptacle abutting the inner face of the end wall 7 of the casing 3 in fluid-tight manner. The nut 9 screwed to the injector tube 6 and bearing against the outer face of the casing 3, enables the fuel receptacle to be drawn tight against the end wall 7 of the casing. The fuel receptacle defines with the casing 5 a compressed air chamber 9′ surrounding the fuel receptacle. The outside wall of the fuel receptacle is provided with fins 10, extending into the compressed air chamber, forming an extended surface by which heat is transferred from the compressed air in the compressed air chamber to the liquid fuel within the fuel receptacle.

The compressed air chamber is designed to contain the major portion of the air compressed by the engine piston. In the proportionate dimensions shown, it contains about nine-tenths of it.

The injector tube 6 has ports 11, communicating with the fuel chamber within the fuel receptacle adjacent its outer end, and other ports 12 communicating with the fuel chamber adjacent its inner end. It also has the divergent nozzles 20 at its inner end, opening into the clearance space adjacent the mouth of the casing 3. A plunger valve 13 reciprocates within the injector tube 6. It is actuated by an engine driven cam 14 bearing upon its outer end 15. A spring 16 retained between the end of the injector tube and the valve urges the latter to closed position.

The valve 13 has a longitudinal inlet bore 22 communicating at one end with a source of liquid fuel under pressure, and at the opposite end it opens into a passage 17 adapted to register with the inlet ports 11 to the fuel chamber. At its inner end the valve 13 has a passage 18, positioned to register with the outlet ports 12, when the inlet passage 17 registers with the inlet ports 11. The valve also has a passage 19, adapted to register with the divergent nozzles 20, when the passage 18 is in registry with the outlet ports 12. A longitudinal bore 21 connects the passages 18 and 19. In the closed position of the valve, passages 17, 18 and 19, occupy the respective dotted line positions shown in Figure 1, all communication between the fuel chamber and the source of fuel on the one hand, and the nozzles 20 on the other, being then cut off. In operation, the heated compressed air within the air compression chamber will be transmitted through the fins 10 and the wall of the fuel receptacle to the fuel which fills the fuel chamber. This heat will be augmented by heat of combustion conducted through the contiguous metal parts of the engine to the fuel in the fuel chamber. The available heat is amply sufficient to produce a temperature above the vaporization point of all of the fractions of the liquid fuel.

However, assuming that the engine turns up only 1500 R. P. M., and that the charge of fuel must be injected and burned through a time interval corresponding to an angular displacement of about 35° crankshaft revolution, this allows only .004 second for this complete operation to be performed. This allows far too short an exposure of a single charge to the available heat to raise the temperature of the charge above the vaporization point of its least volatile fractions. Therefore, in those engines in which only a single charge at a time is brought into heat exchanging relation to the available heat, only the more volatile fractions will be vaporized, so that the charge will not flash into a dry gas at the instant of release, but will still contain some of the less volatile constituents in atomized and not vaporized state.

In the subject invention, although the fuel may enter the fuel chamber relatively cool, the fact that the fuel chamber holds enough fuel for a plurality of charges, permits the charges after admission to said chamber to travel gradually toward the discharge zone, acquiring heat all the while, so that the temperature of the liquid fuel in said chamber in said discharge zone will have become raised above the vaporization point of its least volatile constituents.

In the subject invention, it is assumed that pressure in the fuel chamber will be maintained at such high value as to inhibit any vaporization of fuel within said chamber. This assumption is predicated upon the conditions that the fuel chamber is always full, that the source pressure is at the requisite high value, and that the charge displaced is of equal volume to the charge admitted and forced out by the pressure of the admitted charge. Under such conditions, the released charge of fuel having a temperature high enough to vaporize all of its constituents flashes into jets of dry gas across the mouth of the compressed air chamber.

When the valve 13 is moved to bring the passages 17 and 18 simultaneously into communication with the fuel chamber, a charge of relatively cool liquid fuel under the requisite pressure is forced in and an equal charge under the same pressure heated above the vaporization point of its least volatile constituents, is simultaneously forced out. Since the bulk of the compressed air is back of the zone of emission of the divergent jets of dry fuel gas, and since the valve operation is timed to deliver a charge beginning at the top dead center of the piston and continuing until the crankshaft has rotated through an angle such as 30° to 35°, the combustion zone is continuously traversed by the expanding air from the compressed air chamber throughout the period of injection, intimately mixing with the jets of expanding dry fuel gas and progressively supplying oxygen for complete combustion throughout the entire injection period.

After the injection has been cut off, the air will still be expanding from the compressed air chamber while the piston continues its recessive movement and until the scavenging phase of the cycle commences. Thus no combustion will ever occur in the compressed air chamber and substantially no products of combustion can enter said chamber, so that pure air with its full quota of oxygen is always presented to the burning gaseous fuel.

Since the degree of heat imparted to the liquid fuel depends upon the time it takes a charge to travel from its point of admission to the fuel chamber to its point of discharge therefrom, and this in turn is depended upon the capacity of said chamber, the design of the preheated apparatus enables the liquid fuel at the point of discharge to be heated to a temperature well above its auto-admission point when ejected as a dry gas. This eliminates any ignition lag, assuring instantaneous ignition, and instantaneous combustion in the ample volume of air from the air chamber being forced through the issuing jets. With instantaneous ignition and complete combustion, no detonation or shock explosion can occur because no cumulative charge of fuel is at any time available for detonation.

What I claim as my invention is:

1. In an internal combustion engine of the type wherein ignition is spontaneously effected in an atmosphere of highly compressed air, a charge forming device comprising means forming a liquid fuel chamber having a capacity to hold a sufficient body of liquid fuel for a plurality of charges, and normally full of liquid fuel, having a liquid fuel inlet at the top and a liquid fuel outlet at the bottom, means about said liquid fuel chamber forming an air compression chamber having a mouth communicating with the compression space within the engine cylinder, said liquid fuel outlet opening at the mouth, said compressed air chamber being of larger capacity than the clearance space within the engine cylinder when the engine piston is at the compression end of its stroke, at least the lower part of said fuel body in said liquid fuel chamber being maintained at a temperature above the vaporizing point of the least volatile constituent of said liquid fuel by the

heat of the compressed air in said compressed air chamber and heat of the explosion transmitted through the walls of said liquid fuel chamber, means for maintaining the liquid fuel body in said liquid fuel chamber under sufficiently high pressure to prevent evaporation within said liquid fuel chamber, said means being constructed to simultaneously admit a charge into said liquid fuel inlet against the pressure maintained in said chamber and release an equal charge from said liquid fuel outlet, whereby the charge upon release expands instantly into a dry gas at the mouth of said compressed air chamber.

2. In an internal combustion engine as claimed in claim 1, said fuel outlet comprising downwardly divergent nozzles.

3. Method of operating an internal combustion engine of the type wherein ignition is spontaneously effected in an atmosphere of highly compressed air, comprising compressing the major portion of the air into a chamber communicating with the engine clearance space, maintaining a confined body of liquid fuel sufficient for a plurality of charges, in heat exchanging relation to the compressed air in said chamber and to the heat of explosion, so that the heat absorbed by said liquid fuel body is sufficient to raise the temperature of the liquid fuel in at least the lower part of said liquid fuel body above the vaporizing point of all the constituents of said liquid fuel, maintaining said liquid fuel body under sufficient pressure to prevent vaporization in said confined liquid fuel body, and, at the top of the compression stroke of said engine, simultaneously admitting a charge of liquid fuel from a supply to the upper part of said liquid fuel body against the pressure at which said liquid fuel body is maintained and releasing an equal charge from said body in the zone which demarks said chamber from said clearance space whereby the released charge flashes into a dry gas in said zone, traversed by expanding air from said chamber as the engine piston recedes.

4. Method of operating an internal combustion engine of the type wherein ignition is spontaneously effected in an atmosphere of highly compressed air, comprising compressing the major portion of the air into a chamber communicating with the engine clearance space, maintaining a confined body of liquid fuel sufficient for a plurality of charges, in heat exchanging relation to the compressed air in said chamber and to the heat of explosion, so that the heat absorbed by said liquid fuel body is sufficient to raise the temperature of the liquid fuel in at least the lower part of said liquid fuel body above the vaporizing point of all the constituents of said liquid fuel, maintaining said liquid fuel body under sufficient pressure to prevent vaporization in said confined liquid fuel body, and, at the top of the compression stroke of said engine, simultaneously admitting a charge of liquid fuel from a supply to the upper part of said liquid fuel body against the pressure at which said liquid fuel body is maintained and releasing an equal charge from said body in the zone which demarks said chamber from said clearance space whereby the released charge flashes into a dry gas in said zone, traversed continuously for the duration of the injection period by expanding air from said chamber as the engine piston recedes.

5. In an internal combustion engine as claimed in claim 1, the common wall of said compressed air chamber and liquid fuel chamber being formed with external longitudinal fins extending to the outer wall of said compressed air chamber dividing the latter into a plurality of longitudinal channels.

6. In an internal combustion engine of the type wherein ignition is spontaneously effected in an atmosphere of highly compressed air, a charge forming device comprising a liquid fuel chamber having a capacity to hold a sufficient body of liquid fuel for a plurality of charges, adapted to be maintained full of liquid fuel, means for maintaining at least the lower part of said liquid fuel body in said chamber at a temperature above the vaporizing point of the least volatile constituents of said liquid fuel, means for maintaining the liquid fuel body in said chamber at constant pressure sufficiently high to prevent vaporization of any part of the fuel within said chamber, said means comprising a single positively actuated valve having an inlet port communicating with a source of liquid fuel under requisite pressure and with the upper part of said liquid fuel chamber, and a port communicating with the lower part of said liquid fuel chamber and with the compression space of said internal combustion engine, said ports being so arranged as upon operation of said valve, to simultaneously admit a charge to the upper part of said chamber and to release an equal charge from the lower part of said chamber under the pressure maintained in said chamber, whereby the charge upon release expands instantly into a dry gas.

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