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COMPRESSION IGNITION ENGINE

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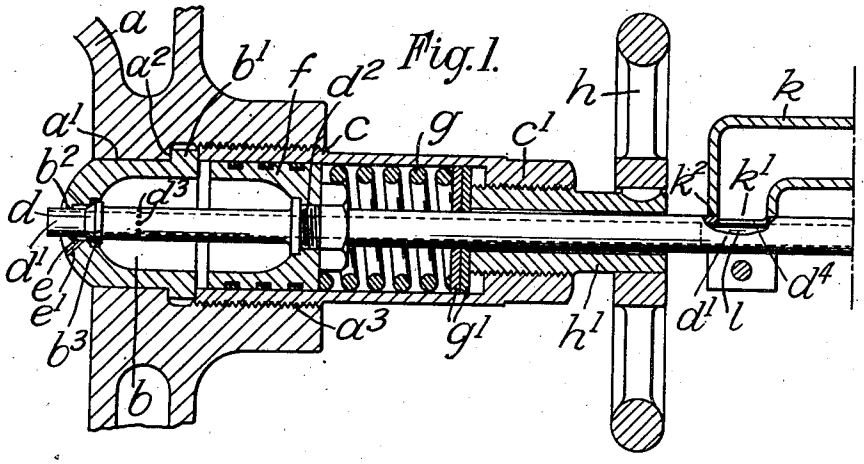


Fig.1.

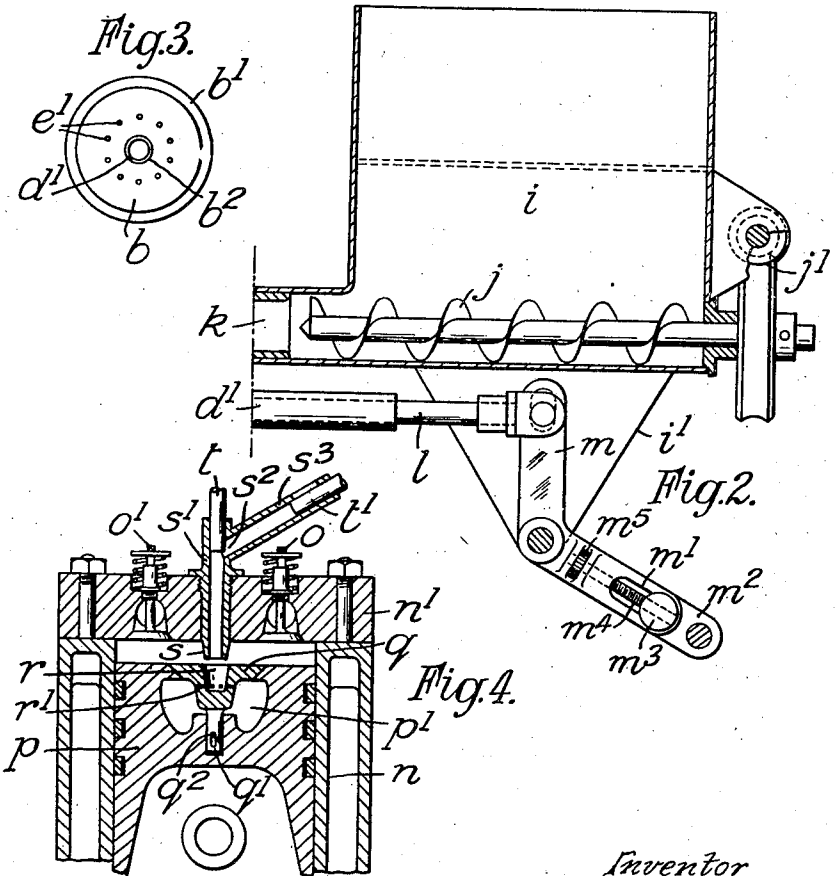


Fig.2.

Fig.3.

Fig.4.

Inventor
David Joseph Smith
By Geo C. Shoemaker
ATTORNEY

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COMPRESSION IGNITION ENGINE

David Joseph Smith, Dartmouth, England, assignor of one-half to Donald Stuart Kennedy, Andover, Hampshire, England

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9 Claims. (Cl. 123—23)

This invention relates to internal combustion engines, and more particularly to that type known as compression ignition engines.

In compression ignition engines using pulverized solid fuels, it is difficult to measure or control accurately the amount of such fuels injected into the working cylinder or combustion chamber; the present invention has for its main object to provide means for accurately and positively measuring and injecting the desired quantity of fuel in the form of a paste comprising pulverized solid fuel and liquid hydrocarbon fuel, in combination.

For the purpose of accomplishing this, a separate combustion chamber is provided in the upper part or head of the engine cylinder, or in the piston, this combustion chamber being normally sealed from the working cylinder or main combustion chamber, for example by a valve, and the fuel is fed into this separate combustion chamber by a plunger of adjustable stroke, the atomizing of the fuel in admixture with air being performed in the separate combustion chamber by the compression stroke of the piston and the pressure due to combustion being passed freely to the working cylinder or main combustion chamber, for example by the opening of the valve normally sealing the separate combustion chamber.

The invention is hereinafter described with reference to the accompanying drawing, in which—

Fig. 1 is a sectional elevation showing the engine cylinder head fitted with an attachment comprising the separate combustion chamber, sealing valve and fuel plunger.

Fig. 2 shows the fuel hopper and conveyor feeding the composite fuel to the measuring plunger.

Fig. 3 is an end view of the separate combustion chamber.

Fig. 4 is a sectional elevation showing an engine having the separate combustion chamber arranged in the piston.

Referring to Fig. 1, the cylinder head a of the engine is provided with a seating a^1 for the separate compression chamber b, which has an external flange or collar b^1 engaging with a shoulder a^2 at the outer end of the seating. The flange b^1 is held in place by a screw-threaded socket c engaging in a correspondingly screw-threaded hole a^3 in axial prolongation of the seating a^1. The inner end of the chamber b is bored at b^2 to receive the stem d^1 of a valve d which normally seats upon the inner edge of a counterbore b^3, thereby sealing off the interior of the chamber b from an annular space e around the valve stem d^1, from which space a plurality of inclined ducts e^1 extend through the inner wall of the chamber.

The valve d is controlled by a piston f slidable within the socket c and connected thereto by a screw-threaded portion d^2 of the valve stem, which is hollow throughout its length. The piston f is loaded by a coiled spring g, the compression of which is regulated by a hand wheel h keyed upon a hollow screw h^1 engaged in the screw-threaded outer end c^1 of the socket, a pair of thrust-washers g^1 being interposed between the screw h^1 and the end-coil of the spring. A plurality of holes d^3, formed radially through the valve stem and at about the middle of the chamber b, allow communication between the interior of the hollow stem and the separate combustion chamber for the introduction of the required amount of fuel at each cycle.

The fuel, comprising a pulverized solid such as coal dust and a liquid hydrocarbon such as fuel oil residues, mixed together in the form of a paste, is contained in a hopper i, shown in Fig. 2; from this hopper it is fed by a worm conveyor j, located at the bottom of the hopper and driven through speed-reduction gear j^1 from a source of power (not shown), to an elbow fitting k through the vertical branch k^1 of which the hollow stem d^1 extends by way of a diametrical passage k^2. A slot d^4 is formed in this portion of the valve stem to allow the fuel paste to enter the interior of the valve stem, along which it is propelled by means of a rod or plunger l reciprocated by a bell crank m mounted between a pair of vertical cheek plates i^1 below the bottom of the hopper. The stroke of the rod l is adjustable, for example by a slotted connection m^1 of the bell crank m to its driving means m^2, the connecting pin m^3 being adjusted along the slot according to the length of stroke required; as shown the pin m^3 is traversed by a screw m^4 rotatable by a milled head m^5 so as to shift the pin along the slots of the connection m^1. The timing of the fuel feed is preferably variable over the entire working cycle of the engine, so as to cover the use of fuels which require long exposure to the compressed air in order to insure ignition.

The reciprocating rod or plunger l can thus be caused to feed the fuel entering through the slot d^4 along the interior of the hollow stem d^1 and to any desired distance beyond the ring of holes d^3, short of the end of the valve stem;

the said distance will then represent the length of a column of fuel enclosed in the hollow stem and constituting approximately the charge for one working cycle. When a sufficient compression pressure is reached, the fuel is blown out through the holes d^3 into the separate combustion chamber b, where it ignites. The increased pressure due to combustion forces back the spring loaded piston f, which moves the valve d off its seat, allowing an increased passage between the two combustion chambers by the holes d^3 and the inclined ducts e^1. When the charge of fuel is blown out through the holes d^3, its escape along the valve stem is prevented by the plunger l, which is stationary at this moment; by reason of the movement of the valve stem, a further small quantity of fuel may be arranged to be forced out by the plunger, the whole charge being atomized in the separate combustion chamber b and the combustion products passed through the inclined ducts e^1 into the main combustion chamber.

By means of the hand wheel h it is possible to vary the compression of the engine at which the atomization of the fuel takes place, and to effect such variation even while the engine is operating, so as to give the required conditions with various fuels by regulating the loading or compression of the spring g; in combination with this compression-varying device, there may be furnished an escape for any ash or other unconsumed particles of the fuel by providing in the wall of the socket c a row of holes or slots normally covered by the piston f but unsealed by the backward movement of the piston at the moment of maximum combustion pressure. The uncovering of the holes or slots in the wall would cause a rapid drop of pressure in the combustion chamber b, the escaping gases carrying out the fuel particles or ash to exhaust, but this drop of pressure would immediately allow the piston f to return and so prevent any large loss of the working fluid.

In the construction illustrated in Fig. 1, which represents the application of the invention to an existing engine, the socket c, in which the fuel valve d and spring-loaded piston f are mounted, is of such length that the fuel plunger l has its reciprocating movement limited to the outer end of the hollow valve stem d^1; the normal sealing of the separate combustion chamber b from the working cylinder or main combustion chamber until the moment of maximum compression is therefore effected by the column or charge of fuel pushed beyond the holes d^3, the plunger l being assumed to rest at the inward end of the feed stroke so as to support the fuel and prevent it from being forced back along the stem. Alternatively, the plunger l may be moved back after the feed stroke, leaving the column or charge of fuel only to seal off the separate combustion chamber.

In a more convenient arrangement, such as an engine cylinder head designed expressly for this method of operation, the fuel plunger may be arranged to rest over the atomizing holes d^3 at the inner end of its stroke, thus sealing off the separate combustion chamber and preventing the fuel from being blown through the holes until the said plunger is moved back by its driving means in order to uncover the holes at the moment of highest compression.

Referring to Fig. 4, the engine comprises a cylinder n with a detachable head n^1 in which the inlet and exhaust valves oo^1 are mounted; the piston p includes an axially disposed cavity p^1 forming the separate combustion chamber, which is normally sealed off from the main combustion chamber of the engine by a valve q having its stem q^1 guided in the body of the piston. The stroke of the valve is limited by a stop q^2 engaging a slotted portion of the stem, so that the valve cannot be thrown out of position. A cup r is formed in the head of the valve, which communicates by atomizing holes r^1 with the cavity p^1 or separate combustion chamber.

At the center of the cylinder head n^1, there is fitted a nozzle s which enters the cup r at the moment when the piston reaches its upper dead center; the relative dimensions of the cup and nozzle are such that they do not come into direct contact, even though the valve q should lift to the extent limited by the stop q^2. The nozzle s projects from a socket s^1 screwed into the cylinder head, a fuel plunger t being arranged to operate in the upper part of the socket; a lateral port or slot s^2 in this upper part communicates with a branch s^3 along which the fuel paste is fed by a pilot plunger t^1, the paste being stored in a hopper or the like from which it flows into the branch s^3 during the return movement of the plunger t^1. The plungers tt^1 are operated by any suitable mechanism, the length of their strokes being variable by a governor or manually according to the load upon the engine.

The required charge of fuel is delivered by the plunger t at the end of the exhaust stroke of the piston p; the charge then remains in the cup r during the suction and compression strokes, while the valve o is held upon its seat by the compression pressure which drives the fuel through the atomizing holes r^1 into the separate combustion chamber p^1. Upon ignition of the charge by the heat of compression, the increase of pressure in the chamber p^1 lifts the valve o, allowing the combustion to proceed in the working cylinder, after which exhaust takes place in the customary manner and the cycle is repeated.

What I claim is:

1. In a compression ignition engine having a main combustion chamber in which air is compressed by movement of a piston, the combination of an auxiliary combustion chamber in proximity to said main combustion chamber, a valve normally shutting off communication between said chambers, a plunger for feeding a charge of fuel in paste form to said auxiliary combustion chamber, said plunger being positioned to prevent back flow of said charge of fuel, and means for atomizing said charge of fuel in said auxiliary combustion chamber by compressed air from said main combustion chamber, said valve being opened by the increased pressure due to combustion of said atomized fuel in said auxiliary combustion chamber.

2. In a compression ignition engine having a main combustion chamber in which air is compressed by movement of a piston, the combination of an auxiliary combustion chamber in proximity to said main combustion chamber, a valve normally shutting off communication between said chambers, a hollow stem slidingly supporting said valve, one end of said stem being open to said main combustion chamber, a portion of said hollow stem within said auxiliary combustion chamber having apertures in its wall, and a plunger slidable within said hollow stem for feeding a charge of fuel, in paste form along the interior of said hollow stem and at least partly beyond said apertures, said plunger being positioned to prevent back flow of said charge of fuel, the com-

pression pressure in said main combustion chamber blowing said charge of fuel through said apertures for atomization and ignition in said auxiliary combustion chamber, and the increased pressure due to the combustion of said charge of fuel opening said valve for passage of said increased pressure into said main combustion chamber.

3. In a compression ignition engine having a main combustion chamber in which air is compressed by movement of a piston, the combination of an auxiliary combustion chamber within said piston, a valve normally shutting off said auxiliary combustion chamber from said main combustion chamber, a hollow stem for said valve, a portion of said hollow stem within said auxiliary combustion chamber having apertures in its wall, and a plunger of adjustable strokes for feeding a charge of fuel in paste form along the interior of said hollow stem, said plunger being positioned to prevent back flow of said charge of fuel, the compression pressure in said main combustion chamber blowing said charge of fuel through said apertures for atomization and ignition in said auxiliary combustion chamber, and the increased pressure due to combustion of said charge of fuel opening said valve for passage of said increased pressure into said main combustion chamber.

4. In a compression ignition engine having a main combustion chamber and an ante-chamber with an orifice for fuel injection into said ante-chamber, a plunger for feeding fuel in paste form to said injection orifice, said plunger being so positioned that said injection orifice is sealed by said fuel until the compression pressure approximates to maximum value, and said fuel being blown through said orifice and atomized by said pressure, and controlled means for passing the increased pressure due to combustion of said fuel to said main combustion chamber.

5. In a compression ignition engine having a main combustion chamber in which air is compressed by movement of a piston, the combination of an auxiliary combustion chamber in proximity to said main combustion chamber, a valve normally shutting off communication between said chambers, a hollow stem slidingly supporting said valve, a plunger for feeding a charge of fuel in paste form along said hollow stem to said auxiliary combustion chamber, said plunger being positioned to prevent back flow of said charge of fuel, a piston secured to said hollow stem for operating said valve, a spring controlling said valve-operating piston, and means for atomizing said charge of fuel in said auxiliary combustion chamber by compressed air from said main combustion chamber, said valve-operating piston being exposed to the pressure in said auxiliary combustion chamber and adapted to overcome the said controlling spring and open said valve under the increased pressure due to combustion of said atomized fuel in said auxiliary combustion chamber.

6. In a compression ignition engine having a main combustion chamber in which air is compressed by movement of a piston, the combination of an auxiliary combustion chamber in proximity to said main combustion chamber, a valve normally shutting off communication between said chambers, a hollow stem slidingly supporting said valve, said hollow stem having apertures at a position within said auxiliary combustion chamber and a port in its wall at a point remote from said auxiliary combustion chamber, a plunger slidable within said hollow stem, over said port and toward said apertures, and a reservoir of fuel in paste form in communication with said port, the movement of said plunger being adjustable for feeding a measured charge of fuel received through said port along said hollow stem to said apertures, said plunger being positioned to prevent back flow of said fuel charge in said hollow stem, and said fuel charge being atomized through said apertures by compressed air entering said hollow stem from said main combustion chamber.

7. In a compression ignition engine having a main combustion chamber in which air is compressed by movement of a piston, the combination of an auxiliary combustion chamber in proximity to said main combustion chamber, a valve normally shutting off communication between said chambers, a hollow stem slidingly supporting said valve, one end of said stem being open to said main combustion chamber, a valve-operating piston secured to said hollow stem and slidably mounted in said auxiliary combustion chamber, a spring controlling said valve-operating piston, means for regulating the strength of said spring while the engine is operating, a portion of said hollow stem within said auxiliary combustion chamber having apertures in its wall, and a plunger for feeding a charge of fuel in paste form along the interior of said hollow stem and thereby sealing said apertures, said plunger being positioned to prevent back flow of said charge of fuel, the compression pressure in said main combustion chamber blowing said charge of fuel through said apertures for atomization and ignition in said auxiliary combustion chamber, and the increased pressure due to the combustion of said charge of fuel forcing said valve-operating piston against said controlling spring to open said valve for passage of said increased pressure into said main combustion chamber.

8. In a compression ignition engine having a main combustion chamber in which air is compressed by movement of a piston, the combination of an auxiliary combustion chamber within said piston, a valve normally shutting off said auxiliary combustion chamber from said main combustion chamber, a cup formed in the head of said valve, a portion of said cup within said auxiliary combustion chamber having apertures in its wall, a nozzle mounted in said main combustion chamber, said nozzle being enveloped by said cup at a dead-center position of said piston, and a plunger for feeding a charge of fuel in paste form through said nozzle into said cup approximately at said dead-center position of said piston, said plunger being positioned to prevent back flow of said charge of fuel, the compression pressure in said main combustion chamber blowing said charge of fuel through said apertures for atomization and ignition in said auxiliary combustion chamber, and the increased pressure due to combustion of said charge of fuel opening said valve for passage of said increased pressure into said main combustion chamber.

9. In a compression ignition chamber having a main combustion chamber in which air is compressed by movement of a piston, the combination of an auxiliary combustion chamber within said piston, a valve normally shutting off said auxiliary combustion chamber from said main combustion chamber, a cup formed in the head of said valve, a portion of said cup within said auxiliary combustion chamber having apertures in its wall, a nozzle mounted in said main combustion chamber, said nozzle being enveloped by said cup at a dead-center position of said piston, a plunger slidable within said nozzle and adapted to seal its

exit, and a pilot plunger for feeding a charge of fuel in paste form to said nozzle during partial withdrawal of the first-mentioned plunger, said first-mentioned plunger then advancing to feed said charge of fuel through said nozzle into said cup approximately at said dead-center position of said piston and to prevent back flow of said charge of fuel, the compression pressure in said main combustion chamber blowing said charge of fuel through said apertures for atomization and ignition in said auxiliary combustion chamber, and the increased pressure due to combustion of said charge of fuel opening said valve for passage of said increased pressure into said main combustion chamber.

DAVID JOSEPH SMITH.