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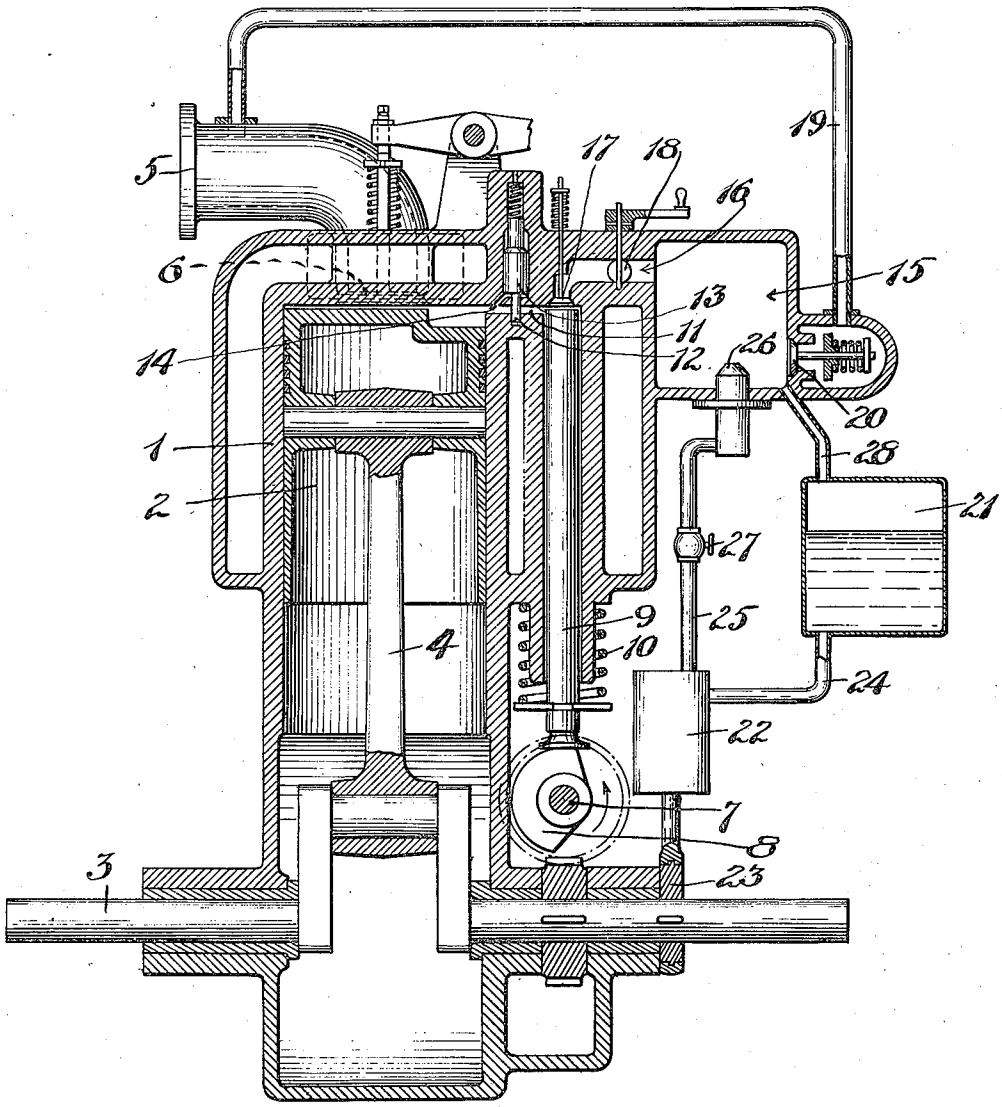
B. C. SMITH

INTERNAL COMBUSTION ENGINE

Filed May 5, 1923



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UNITED STATES PATENT OFFICE.

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INTERNAL-COMBUSTION ENGINE.

Application filed May 5, 1923. Serial No. 636,995.

To all whom it may concern:

Be it known that I, BENJAMIN C. SMITH, a citizen of the United States of America, residing at Westfield, New Jersey, have invented new and useful Improvements in an Internal-Combustion Engine, of which the following is a specification.

My invention relates to improvements in fuel burning engines of the internal combustion type. I shall show and describe my invention as applied to an engine in which compression alone is relied upon to effect the ignition of the fuel, as this type of engine has many advantages, in that it may successfully utilize low-grade hydrocarbon fuel such as heavy oil. My invention is particularly useful in connection with engines employing cylinders of relatively small bore. In such engines the actual volume of solid liquid fuel per charge is so very small that it cannot be accurately controlled or measured so that the best conditions will obtain under varying speed and load. To that end, I have conceived the idea of preparing the liquid fuel in advance of its construction into the combustion chamber in such a manner that it can be, in its prepared state, easily and accurately measured. I thereby attain a higher degree of efficiency than would otherwise be possible. In preparing the fuel in advance of its introduction into the combustion chamber, I provide means to break up the liquid into fine particles which are held in suspension in a special chamber until required in the combustion chamber. At the proper time, I cause a measured quantity of the contents of said chamber to be transferred into the combustion chamber, wherein it is mixed with atmospheric air in the proper proportion to produce an effective ignitible charge. Since the volume of this prepared fuel charge is relatively very much greater than it would be were said fuel in a solid liquid form as distinguished from a vaporized or atomized form, I am able to accurately measure the quantity of fuel that is transferred to form a single ignitible charge. Heretofore, in engines of the smaller sizes, effective control in this respect has been practically impossible of attainment, because where solid liquid fuel is fed to the combustion chamber an exceedingly small passage is required and a very delicate valve must be used. Because of the smallness of the passage and the delicacy of the valve, it has been found practically impossible to variably control the volume of fuel per charge in such a manner as to secure that degree of efficiency now demanded in such engines. By my present improvement, the passage through which the fuel is fed is relatively very large and cannot become clogged. The metering valve is also of the simplest possible type and is easy to maintain and operate. There is, therefore, no danger of stoppage in the fuel feed passage, and there is no delicate or difficult duty imposed upon the control valve itself.

In the accompanying drawing, I have shown in a single view, diagrammatic in character, a vertical section of a single cylinder of an engine of the four-cycle type and of the internal combustion variety, the same being constructed to embody my invention.

In the drawing, 1 represents the wall of the working cylinder. 2 represents the usual working piston which is connected to the usual crank shaft 3 by means of the usual connecting rod 4. 5 represents the usual exhaust pipe which is controlled by the usual exhaust valve 6, operated in any suitable manner to open on the exhaust stroke of the piston. Another similar pipe and valve are provided in each cylinder for the purpose of taking in atmospheric air on the suction stroke of the piston. This intake pipe and intake valve is not shown, since it would appear on the section removed in the single view shown in the drawings. Such intake pipes and intake valves are well understood in four-cycle engines, and since the same would correspond substantially in appearance to exhaust pipe 5 and exhaust valve 6, illustration seems unnecessary. 7 represents the usual cam shaft, which is driven from the main engine shaft 3 at one half speed relatively thereto, as is common practice. The intake and exhaust valves for the working cylinder are ordinarily operated by this cam shaft by means well understood in the art. There is also mounted on the cam shaft a cam 8, which operates a fuel feeding plunger or piston 9, which in this instance is moved in the feeding direction by the cam and in a reverse direction by a spring 10. The plunger or fuel feeding piston 9 reciprocates in a bore arranged along side of the working cylinder 1, and the upper end of said bore is in communication with the combustion chamber in the head of the working

cylinder through the medium of a passage 11. 12 is a valve for the passage 11, which valve may be operated in any well-known manner, but which, in the form shown, is operated automatically. As shown, the valve 12 is carried by a piston 13, spring pressed in a direction to cause valve 12 to normally close passage 11. 14 is a small passage leading from the combustion chamber into the space below the piston 13 so that when the compression in the combustion chamber is sufficiently high it will lift said piston, which serves to lift the valve 12 and open passage 11. 15 is a chamber preferably located along side of the working cylinder. 16 is a passage leading from the chamber 15 into the space above the plunger 9. 17 is a check valve in said passage. 18 is a manually controllable metering valve or throttle which, as shown, is a simple butterfly valve, so called. 19 is a pipe which may lead from the exhaust pipe 5 to the interior of the chamber 15. 20 is a check valve therefor, which permits air or gas to flow into the chamber as needed but checks its outflow. 21 conventionally represents a reservoir containing a supply of liquid fuel. 22 conventionally represents a suitable pumping means which is operated from an eccentric 23 on the main shaft 3. 24 is a pipe leading from the reservoir 21 to the pumping chamber 22. 25 is a pipe leading from the pumping chamber 22 to a suitable liquid fuel spraying device 26. 27 conventionally represents a regulating valve which may constitute one means to control the flow of liquid fuel from the pumping chamber 22 to the sprayer 26. 28 is a pipe leading from the bottom of the chamber 15 to the reservoir 21 so as to return to said reservoir any fuel that may be condensed in solid liquid form in the bottom of said chamber.

Operation: Referring to the drawing, it may be assumed that the piston 2 stands in its uppermost position, and that it is about to descend on the suction stroke. As it descends, the intake valve (not shown) opens to admit atmospheric air into the working cylinder 1. At this time the passage 11 is closed by valve 12. As the piston descends, the cam 8 moves away from the plunger 9, allowing the same to descend, creating thereby a vacuum in the chamber above the piston 9 so that a portion of the contents of chamber 15 will flow (due to pressure difference) through the passage 16 and into the space above the plunger 9. The fuel drawn into this space is in the form of a very heavily charged gas, in which the actual hydrocarbon fuel is merely in suspension in the form of a heavy mist. Obviously the quantity of fuel, in this attenuated state, that is drawn into the space above the plunger 9, may be accurately controlled by the simple butterfly valve 18. When the piston 2 ascends on the next stroke, it will compress the atmospheric air contained in the working cylinder and lift the valve 12 and open communication between the space above the plunger 9 and the combustion chamber. At the proper time, which is determined by the shape of cam 8, the fuel contained in the space above the piston 9 will be forced, by the ascending plunger 9, through the passage 11, into the combustion chamber, the check valve 17 being closed at such a time. This causes the measured fuel charge to be mixed with atmospheric air so as to form an ignitible charge suitable for the load demand. In the preferred construction, it is intended that the compression obtained shall be sufficient to cause the charge to ignite spontaneously. The expansion of the gases, upon ignition, drives the piston down in the usual manner on its working stroke. During this stroke, the plunger 9 may be held elevated by the cam 8. On the next up stroke, which is the exhaust stroke, the valve 6 is opened and the burned gases within the cylinder are permitted to flow out. This causes the pressure to drop, and the valve 12 closes. As soon as valve 12 closes, the plunger 9 drops and draws another charge of prepared fuel from chamber 15. It will be understood that the liquid fuel is being sprayed into the chamber 15 so as to maintain therein at all times an adequate supply in a finely divided state. It should be understood that the sprayer 20 may be of any suitable type which will serve to break up the solid liquid fuel into fine particles.

It will be seen that by my improvement I provide means to prepare the fuel in advance of mixing it with sufficient air to form a proper ignitible mixture so that the amount of fuel per charge may be accurately measured which, as I have indicated at the outset, is highly important in engines having cylinders of small bore and which measurement, in such engines, is impossible of accurate attainment when solid liquid fuel is employed.

It will be understood that the term "gas," in referring to the medium which holds the finely divided liquid fuel in suspension preparatory to its delivery to the fuel-feeding means, is used in its broadest sense, to include air or any other gaseous medium that will hold said finely divided fuel in a suspended state.

I have shown and described only one embodiment of my invention, and wish to have it understood that I fully appreciate that many changes may be made in the construction, arrangement, design and proportion of the various parts without departing from the spirit and scope thereof.

I claim:

1. In an internal combustion engine, a working cylinder having an air inlet and an

exhaust outlet, a fuel chamber for containing a quantity of gas heavily charged with finely divided liquid hydrocarbon in suspension, a gas inlet into said chamber, a check valve therein, means for heavily charging said gas in said chamber with said fuel in said state through another inlet, and means for measuring off and positively forcing a portion of said prepared fuel from said chamber into the combustion chamber of the cylinder at predetermined intervals to form with the air in the latter an ignitible charge.

2. In an internal combustion engine, a working cylinder having an air inlet and an exhaust outlet, a fuel chamber for containing a quantity of gas heavily charged with finely divided liquid hydrocarbon in suspension, a gas inlet into said chamber, a check valve therein, means for heavily charging said gas in said chamber with said fuel in said state through another inlet, and means for measuring off and positively forcing a portion of said prepared fuel from said chamber into the combustion chamber of the cylinder at predetermined intervals to form with the air in the latter an ignitible charge, and a measuring means between said first-mentioned chamber and said combustion chamber.

3. In an internal combustion engine, a working cylinder, a fuel chamber for containing a quantity of gas under pressure heavily charged with finely divided liquid hydrocarbon in suspension, a gas inlet into said chamber, a check valve therefor, means for heavily charging said gas with said fuel in said state through another inlet, a passage leading from the fuel chamber to the combustion chamber of the working cylinder, fuel feeding means communicating with said passage for receiving a portion of said heavily charged gas from the first mentioned chamber and forcing it into the working chamber of the cylinder, a check valve between said feeding means and said fuel chamber.

4. In an internal combustion engine, a working cylinder, a fuel chamber for containing a quantity of gas under pressure heavily charged with finely divided hydrocarbon in suspension, a gas inlet into said chamber, a check valve therefor, means for heavily charging said gas with said fuel in said state through another inlet, a passage leading from the fuel chamber to the combustion chamber of the working cylinder, fuel feeding means communicating with said passage for receiving a portion of said heavily charged gas from the gas chamber and forcing it into the working chamber of the cylinder, a check valve and a measuring valve between said feeding means and said fuel chamber.

5. In an internal combustion engine, a working cylinder, a fuel chamber for containing a quantity of gas under pressure heavily charged with finely divided hydrocarbon in suspension, a gas inlet into said chamber, a check valve therefor, means for heavily charging said gas with said fuel in said state through another inlet, a passage leading from the fuel chamber to the combustion chamber of the working cylinder, fuel feeding means communicating with said passage for receiving a portion of said heavily charged gas from the gas chamber and forcing it into the working chamber of the cylinder, a check valve and a measuring valve between said feeding means and said fuel chamber, said measuring valve being located between the check valve in said passage and said chamber.

6. In an internal combustion engine, a working cylinder, a fuel chamber for containing a quantity of gas under pressure heavily charged with finely divided hydrocarbon in suspension, a gas inlet into said chamber, a check valve therefor, means for heavily charging said gas with said fuel in said state through another inlet, a passage leading from the fuel chamber to the combustion chamber of the working cylinder, fuel feeding means communicating with said passage for receiving a portion of said heavily charged gas from the gas chamber and forcing it into the working chamber of the cylinder, a check valve and a measuring valve between said feeding means and said fuel chamber, and a valve between said fuel feeding means and the combustion chamber, said valve normally closing said passage and operable to open said passage when the piston in the working cylinder is near the top of its stroke.

7. In an internal combustion engine, a working cylinder, a fuel chamber for containing a quantity of gas under pressure heavily charged with finely divided hydrocarbon in suspension, a gas inlet into said chamber, a check valve therefor, means for heavily charging said gas with said fuel in said state through another inlet, a passage leading from the fuel chamber to the combustion chamber of the working cylinder, fuel feeding means communicating with said passage for receiving a portion of said heavily charged gas from the gas chamber and forcing it into the working chamber of the cylinder, a check valve and a measuring valve between said feeding means and said fuel chamber, and a valve between said fuel feeding means and the combustion chamber, said valve normally closing said passage and operable to open said passage when the piston in the working cylinder is near the top of its stroke, with means for utilizing the compression in the working cylinder to open said last mentioned valve.

8. In an engine of the four-cycle type, a working cylinder having a valved inlet and

a valved outlet, a working piston in said cylinder, a fuel chamber adjacent to said cylinder for containing a supply of prepared fuel in the form of gas heavily charged with finely divided liquid hydrocarbon in suspension, a passage leading from the fuel chamber to the combustion chamber in the working cylinder, a driven fuel feeding means operating to withdraw from the fuel chamber a portion of the prepared fuel therein and to force it into said combustion chamber, a check valve in said passage between said fuel chamber and feeding means, a normally closed valve in said passage between said feeding means and said combustion chamber, means for opening said last mentioned valve by compressed air in the working cylinder, a manually controllable measuring valve or throttle for the communicating passage.

9. In an engine of the four-cycle type, a working cylinder having a valved inlet and a valved outlet, a working piston in said cylinder, a fuel chamber adjacent to said cylinder for containing a supply of prepared fuel in the form of gas heavily charged with finely divided liquid hydrocarbon in suspension, a passage leading from the fuel chamber to the combustion chamber in the working cylinder, a driven fuel feeding means operating to withdraw from the fuel chamber a portion of the prepared fuel therein and to force it into said combustion chamber, a check valve in said passage between said fuel chamber and feeding means, a normally closed valve in said passage between said feeding means and said combustion chamber, means for opening said last mentioned valve by compressed air in the working cylinder, a manually controllable measuring valve for the communicating passage, means for spraying liquid fuel into the space within the feed chamber, and a regulating means therefor.

10. In an internal combustion engine, a working cylinder having an air inlet and an exhaust outlet, a fuel chamber for containing a quantity of gas heavily charged with finely divided liquid hydrocarbon in suspension, a gas inlet into said chamber, means for heavily charging said gas in said chamber with said fuel in said state through another inlet, and means for measuring off and positively forcing a portion of said prepared fuel from said chamber into the combustion chamber of the cylinder at predetermined intervals to form with the air in the latter an ignitible charge.

BENJAMIN C. SMITH.