S. P. AND H. A. COWARDIN.

FUEL INJECTOR FOR INTERNAL COMBUSTION ENGINES.

APPLICATION FILED OCT. 9, 1916. RENEWED APR. 4, 1918.

1,333,541.

Patented Mar. 9, 1920.

2 SHEETS—SHEET 1.

Fig. 1.

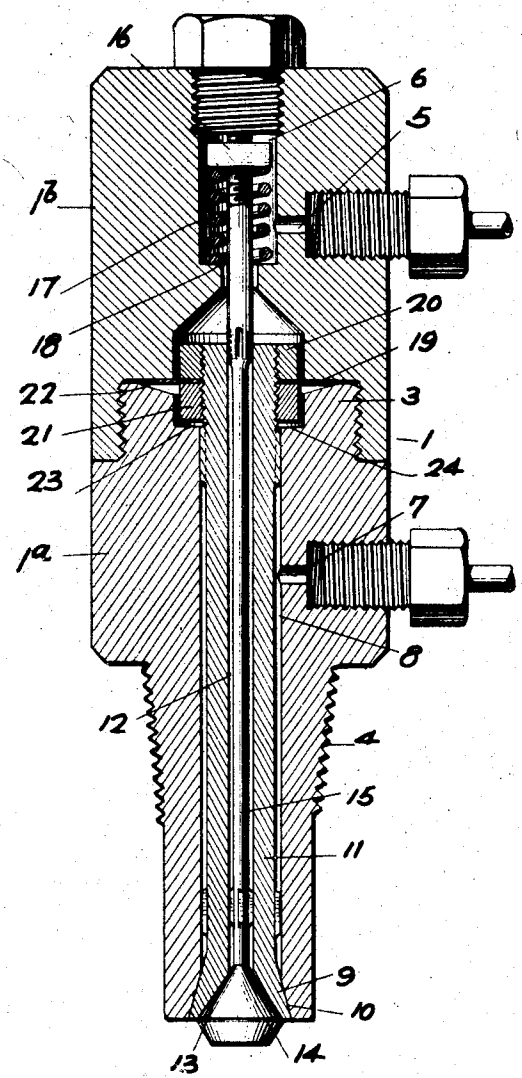


Fig. 2.

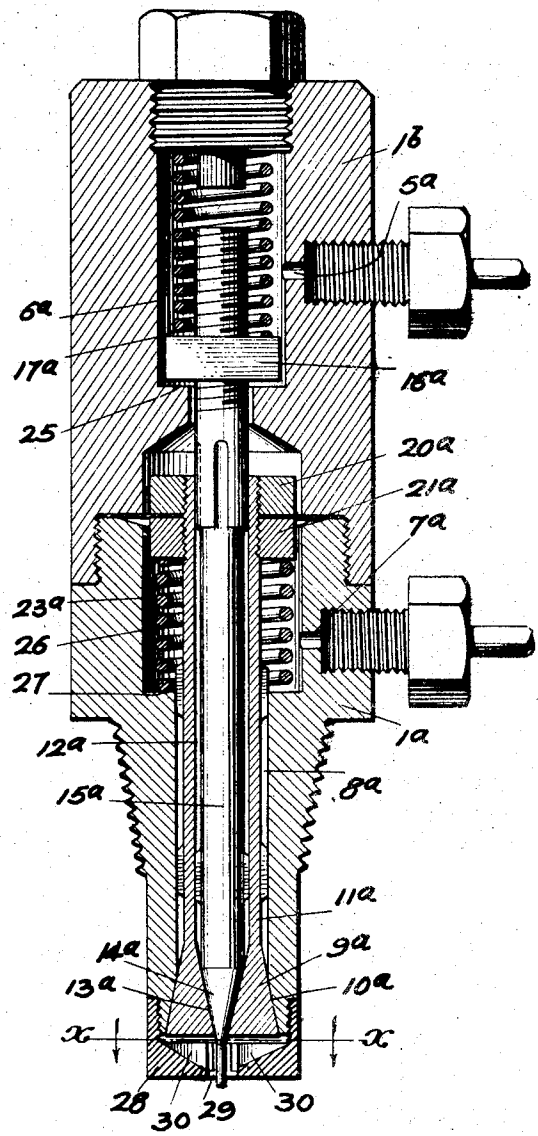
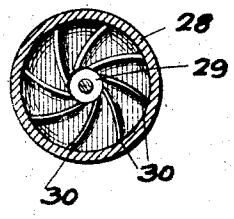


Fig. 2a



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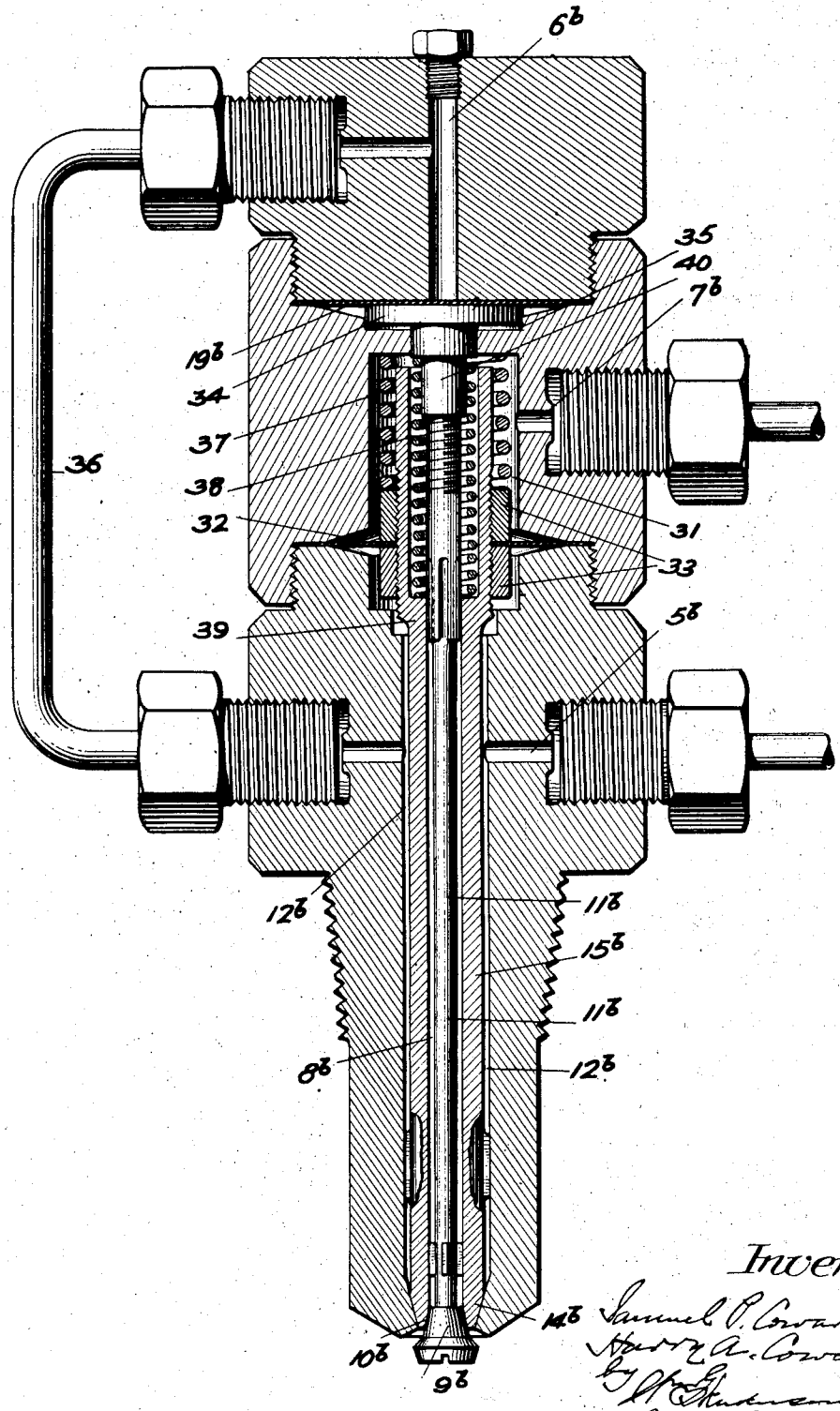
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2 SHEETS—SHEET 2.

Fig. 3.



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UNITED STATES PATENT OFFICE.

SAMUEL P. COWARDIN AND HARRY A. COWARDIN, OF RICHMOND, VIRGINIA.

FUEL-INJECTOR FOR INTERNAL-COMBUSTION ENGINES.

1,333,541. Specification of Letters Patent. Patented Mar. 9, 1920.

Application filed October 9, 1916, Serial No. 124,621. Renewed April 4, 1918. Serial No. 226,777.

To all whom it may concern:

Be it known that we, SAMUEL P. COWARDIN and HARRY A. COWARDIN, citizens of the United States, residing at Richmond, in the county of Henrico and State of Virginia, have invented certain new and useful Improvements in Fuel-Injectors for Internal-Combustion Engines; and we do declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to the letters and figures of reference marked thereon, which form a part of this specification.

This invention relates to improvements in fuel injectors for internal combustion engines, proposing a device which is applicable to engines operating on the Diesel cycle and adapted for the heavier and less volatile fuel oils. The present injector is of the broad or general type which includes air and oil valves functioning, in coöperation, to discharge the oil in an atomized or highly comminuted condition into the engine cylinder whereby it will form an explosive, or more strictly, combustible mixture with the air, admitted by the main air valve, and highly compressed by the engine piston at the moment of oil admission.

The primary object of the invention is to effect, so far as practicable, such a complete atomization of the liquid fuel by air under pressure projected through a stream or film of the fuel at the discharge end of the injector that a combustible mixture from the heavier oils may be produced capable of ignition in cylinders of low compression engines without the necessity of using preheating device, such as the "hot ball," or relying on the high temperature of compressed air, and without depending on a carbureter for making the combustible mixture before the charge enters the engine cylinder.

Other objects of the invention briefly stated, are to simplify the construction and operation of injectors of the type referred to, to establish certainty and reliability in the correlation of the operations of its air and oil valves, to insure certainty in the timing of the fuel injection and to effect thoroughness and uniformity in the atomization of the oil, whereby it will more readily and completely form a combustible mixture with the air under compression in the engine cylinder.

These objects are achieved according to the invention, by the utilization of the oil supplied to the injector for the control of the operation of the air valve and by a special arrangement of parts whereby the oil pressure effects the opening of the oil valve in conjunction with the opening of the air valve, the arrangement enabling, as is preferred, the correlation of the operations of said valves, whereby the oil valve is opened after and closed before the respective opening and closing of the air valve.

Three embodiments of the invention are shown, by way of example, in the accompanying drawings which comprise:

Figures 1, 2 and 3, each a vertical sectional view of one of the respective embodiments, that shown in Fig. 1 being, as now considered, preferred; and Fig. 2ª, a detail sectional view on the line *x*—*x* of Fig. 2.

The injector shown in Fig. 1 includes a casing 1, preferably made in two parts 1ª and 1ᵇ, the part 1ª having a screw-threaded boss 3 by which it is joined to the part 1ᵇ. The casing 1 is adapted for attachment to the engine cylinder in the same manner as an ordinary spark plug and accordingly its part 1ª is formed with attachment threads 4 for engagement in a threaded opening in the cylinder.

The casing is provided with an oil inlet 5 opening into an oil chamber 6 and with a compressed air inlet 7 opening into an air passage 8 which extends axially through the casing, piercing the inner end thereof. The escape of air from the passage 8 is controlled by a valve 9 which is formed to co-act with a seat 10 at the discharge end of the passage 8 and whose stem 11 extends wholly through said passage but is reduced to provide the necessary clearance. The oil chamber 6 is open to an oil passage 12 which, in the present embodiment, extends axially through the air valve stem 11 and air valve 9, piercing the end of the latter and terminating in an external seat 13 for coöperation with an oil valve 14. The stem 15 of the oil valve 14 extends through the oil passage 12 and projects into the oil chamber 6 wherein it is provided with an adjustable nut or collar 16 for engagement by a spring 17 which normally holds the

valve 14 to its seat, the spring 17 having a bearing against a shoulder 18 formed with the casing 1 internally of the chamber 6.

The air passage 8 and the oil chamber 6 are separated by a movable element which is influenced by the pressure of the air and oil in said respective passage and chamber and is connected to the air-valve stem 11 to control the operation of the air valve 9. As now preferred this movable separating element comprises a diaphragm 19 surrounding the stem 11 and clamped thereto by upper and lower nuts 20 and 21. The marginal portion of the diaphragm 19 is conveniently clamped between the boss 3 of the casing part 1^a and an adjacent annular shoulder 22 of the casing part 1^b. The air passage 8 terminates within the casing in an enlarged portion 23 which accommodates the nut 21 and extends to the diaphragm 19. The depth of said enlarged portion 23 is sufficient to allow of a slight downward play of the nut 21 in consequence of a downward deflection of the diaphragm and the width or diameter of said enlarged portion is such as to insure that the air pressure on the diaphragm shall be sufficient to hold the diaphragm in its normal plane and to maintain the closure of the air valve 9 until the proper moment for the operation of the injector. The enlarged portion 23 provides an annular shoulder 24 against which the nut 21 strikes when the diaphragm is deflected downward, the shoulder 24 thus limiting the downward movement of said diaphragm whose upward movement is limited by the engagement of the air valve 9 against its seat 10.

The oil inlet 5 and the air inlet 7 are connected respectively to an oil pump and an air compressor but these elements are not shown inasmuch as they are well known as the necessary accessories of an injector of the type to which the invention relates. The oil pump is timed to work with the engine and the air is maintained at a substantially constant degree of pressure which, as is known, must suitably exceed the maximum pressure developed by the engine piston of the air admitted into the engine cylinder through the main air valve (not shown) during the suction stroke.

As the engine piston nears the completion of its compression stroke the oil pump forces a charge of oil into the chamber 6 and oil passage 12, the maximum pressure of the oil pump being maintained for the period necessary to effect the injection of the right amount of fuel into the engine cylinder. The first effect of the charge of oil thus forced into the chamber 6 is to counteract the air pressure on the opposite side of the diaphragm 19 and to thus produce a downward or inward deflection of said diaphragm in consequence of which the valve 9 is opened to permit the escape of compressed air into the engine cylinder. The next and immediately succeeding effect of the oil pressure in the chamber 6 and passage 12 is to pop open the oil valve 14 whereby the oil will escape from said passage into the engine cylinder, the said valve thus functioning as a discharge valve for the oil pump.

The discharge mouths of the air and oil passages are in concentric juxtaposition and the relative inclination of the faces of the air and oil valves and their seats is such that an annular stream of compressed air is projected angularly through an annular stream or film of oil, effecting complete atomization of the oil whereby the latter will form an intimate combustible mixture with the air previously compressed in the engine cylinder. The thorough atomization of the oil in this manner is, of course, assisted by the heat developed during the compression stroke of the engine piston and constantly latent in the exposed portions of the air and oil valves.

When the piston of the oil pump commences to retract the oil pressure in the chamber 6 and passage 12 is relieved until it is insufficient to counteract the spring 17 at which moment the oil valve is closed. Thereafter the diminished air pressure in the passage 8 and the resiliency of the diaphragm 19 become effective to return said diaphragm to its normal position and thereby to close the air valve 9 against its seat 10 upon which the air pressure quickly increases to its normal degree.

The pressure of the spring 17 may be regulated, as desired, by suitable adjustments of the nut or collar 16 on the oil valve stem 15 but, in any event, will be selected with regard to the normal air pressure in the passage 8 and the operating pressure of the oil on the diaphragm 19 and valve 14 whereby said valve will not be forced open until after the oil pressure has effected a downward or inward deflection of the diaphragm and consequent opening of the air valve 9 but will be closed prior to the closing of said air valve.

The construction shown in Fig. 2 includes a casing made in sections 1^a and 1^b, an oil inlet 5^a, an oil chamber 6^a, an air inlet 7^a, an air passage 8^a, an air valve 9^a with its stem 11^a and seat 10^a, and a diaphragm 19^a secured to the stem 11^a by nuts 20^a and 21^a—all similar to the corresponding features of the construction shown in Fig. 1. A modification, however, is introduced in the relation of the air and oil valve. In this case the oil valve 14^a and its stem 15^a are arranged within an oil passage 12^a extending axially through the air valve stem as in the previous embodiment, but the seat 13^a for the oil valve is internal instead of external

and the oil valve must, therefore, be lifted from its seat instead of being popped therefrom. This necessitates a re-arrangement of the oil valve spring, here shown at 17^a, according to which said spring has its fixed bearing against the upper or outer end of the casing and presses the oil valve downward or inward. The spring 17^a exerts its thrust against a nut or collar 16^a adjustably mounted on the stem 15^a. The oil pressure, as in the previous embodiment, produces a downward or inward deflection of the diaphragm which effects the unseating of the air valve. Under the action of the spring 17^a the oil valve initially participates in the opening movement of the air valve but before such movement is completed the further movement of the oil valve is arrested by the engagement of the nut or collar 16^a against an annular shoulder 25 formed with the casing 1 within the oil chamber 6^a. This engagement of the nut or collar 16^a against the shoulder 25 is instrumental, in conjunction with the continued opening movement of the air valve to lift the oil valve from its seat 13^a whereby the oil will be injected into the engine cylinder and will be atomized by the air escaping past the air valve. When the pressure of oil in the chamber 6^a and oil passage 12^a is relieved the air valve commences to close and in the course of its closing movement the seat 13^a is brought against the oil valve which at such time is completely closed. The air valve then continues its closing movement and thereupon the air and oil valves move together as one until the movement of the air valve is arrested by its engagement upon its seat 10^a. If desired, a spring 26 may be provided to assist the closing of the air valve, said spring being arranged in an enlargement 23^a at the upper end of the air passage 8^a to bear against an annular shoulder 27 at the base of said enlargement and exert its thrust against the nut 21^a.

Fig. 2 and 2^a also illustrate a special form of air nozzle which may be employed with advantage for certain of the heavier fuels. This nozzle comprises a cap 28 which is threaded or otherwise secured upon the inner or lower end of the injector casing and has a central orifice 29 leading from a concentric recess whose diameter is slightly greater than the greatest diameter of the air valve seat 10^a. This recess is provided with an annular series of ribs 30 tangential to the orifice 29 and which provide channels to divide the air escaping past the valve 9^a into separate streams. By virtue of the tangential inclination of the ribs 30 the air streams have a whirling motion as they meet in and pass through the orifice 29 and they are, therefore, highly effective in atomizing the oil, also passing through said orifice and in establishing the thorough and uniform admixture of the atomized oil with the compressed air in the engine cylinder.

The ribs 30 may also be utilized to limit the opening movement of the air valve and, therefore, the shoulder 24 employed for this purpose in the embodiment of Fig. 1 is not required.

In the two embodiments above described the oil valve and its stem are arranged concentrically within the air valve and its stem. Fig. 3 shows a modification wherein the relation of the air and oil valves is reversed. In this case the oil passage 12^b supplied by an oil inlet 5^b is formed within the injector casing and has at its lower end an internal seat for an oil valve 14^b whose stem 15^b extends through said passage and into an air chamber 31 having a compressed air inlet 7^b. The air passage 8^b is formed axially within the oil valve stem 15^b and terminates in an external seat 10^b for coöperation with an air valve 9^b whose stem 11^b extends through the passage 8^b. The air chamber 31 is formed between an upper diaphragm 19^b and a lower diaphragm 32, the casing being made in sections having screw threaded joints to provide for the convenient and secure clamping of the marginal portions of these diaphragms. The diaphragm 32 surrounds the oil valve stem 15^b and is connected thereto by clamping nuts 33. The diaphragm 19^b acts on the air valve stem 11^b, preferably, through the medium of a spacing disk 34 arranged in a suitable clearance or recess 35. The portion of the casing above or at the outer side of the diaphragm 19^b is provided with an oil chamber 6^b which is supplied by a by-pass 36 from the oil passage 12^b.

The oil valve is held closed by the pressure of the air in the chamber 31 on the diaphragm 32, aided, if desired by a spring 37 having its bearing against the upper or outer end of said chamber and exerting its thrust against the upper nut 33. The air valve is held closed by a spring 38 arranged in a clearance or enlargement 39 at the upper end of the air passage 8^b and exerting its thrust against a nut or collar 40 adjustably mounted upon the upper or outer end of the air valve stem 11^b and bearing against the spacing disk 34.

When the oil pump charges the passage 12^b and chamber 6^b with oil, the first effect of the developed oil pressure is to produce a downward or inward deflection of the diaphragm 19^b and a consequent opening of the air valve whereby the air under compression in the chamber 31 escapes past the air valve into the engine cylinder. The air pressure in the chamber 31 being thus reduced the next and immediately succeeding effect of the developed oil pressure is to produce an upward or outward deflection of the diaphragm 32 and a consequent opening of the

oil valve. The film or stream of oil then forced into the engine cylinder meets, at an angle, the stream of compressed air and is completely atomized thereby. Upon the oil pressure being relieved by the action of the oil pump, the oil valve is first closed by the combined action of the air pressure and spring 37 in the air chamber 31 and immediately thereafter the air valve is closed by the combined action of the air pressure and the spring 38.

In each of the embodiments of the invention, the oil pressure directly effects the opening of the air valve and directly or indirectly effects the opening of the oil valve. The opening of the air valve before, and its closing after, the opening and closing of the oil valve secures a result of great advantage in that a thorough atomization of all the oil escaping past the oil valve is effected and any solid particles of oil which, upon the opening or closing of the oil valve might otherwise adhere to its exposed surfaces are completely broken down and consumed. Each embodiment of the invention is specially constructed to provide for this desired correlation of the operations of the oil and air valves consequent to the developed oil pressure.

Having fully described our invention, and set forth its merits, what we claim is:

1. A fuel oil injector for internal combustion engines having oil and air passages whose discharge ends are in juxtaposition, oil and air valves located at the discharge ends of said passages for controlling the respective passages, an oil chamber, an oil inlet supplying said oil chamber and oil passage, a movable element separating the oil chamber from the air passage and movable by oil pressure in said chamber, said element in its movement by oil pressure effecting the opening of the air valve and means whereby the oil pressure effects the opening of the oil valve in conjunction with the opening of the air valve.

2. A fuel oil injector for internal combustion engines having concentric stems provided respectively with oil and air valves and having oil and air passages controlled by said valves and in which said stems are mounted, one of said passages being formed in one of said stems, an oil chamber, an oil inlet supplying said oil chamber and oil passage, a movable element separating the oil chamber from the air passage and movable by oil pressure in said chamber, said element in its movement by oil pressure effecting the opening of the air valve and means whereby the oil pressure effects the opening of the oil valve in conjunction with the opening of the air valve.

3. A fuel oil injector for internal combustion engines having oil and air passages whose discharge ends are in juxtaposition, oil and air valves controlling the respective passages, an oil chamber, an oil inlet supplying said oil chamber and oil passage, a movable diaphragm separating the oil chamber from the air passage and movable by oil pressure in said chamber, said diaphragm being related to said air valve to open the same in its movement by oil pressure, and means whereby the oil pressure effects the opening of the oil valve in conjunction with the opening of the air valve.

4. A fuel oil injector for internal combustion engines having a casing formed with an air passage, piercing one end thereof, an air valve having its stem disposed in said passage and in turn formed with an oil passage, an oil chamber, a diaphragm connected to said air valve and separating said oil chamber from said air passage, said diaphragm being movable by oil pressure in said chamber to open said air valve, an oil valve having its stem disposed in said oil passage and projecting into said oil chamber and means, including a spring to maintain the closure of said oil valve, whereby the oil pressure effects the opening of the oil valve in conjunction with the opening of the air valve.

5. A fuel oil injector for internal combustion engines having a casing formed with an air passage piercing one end thereof and terminating in an external valve seat, an air valve coacting with said seat and having its stem disposed in said passage and in turn formed with an oil passage terminating in an external valve seat, an oil chamber, a diaphragm connected to said air valve and separating said oil chamber from said air passage, said diaphragm being movable by oil pressure in said chamber to open said air valve, an oil valve coöperating with the valve seat of said oil passage and having its stem disposed in said oil passage and projecting into said oil chamber and a spring in said oil chamber acting on said oil valve stem to hold the latter closed and tensioned whereby the oil pressure effects the opening of the oil valve in conjunction with the opening of the air valve.

6. A fuel oil injector for internal combustion engines having oil and air passages with their discharge ends in juxtaposition, oil and air valves located at the discharge ends of said passages for controlling said passages, an oil chamber, an oil inlet supplying said oil chamber and oil passage, and means operated by the pressure of oil in said oil chamber for opening said air valve.

7. A fuel oil injector for internal combustion engines having concentric oil and air passages, oil and air valves positioned adjacent each other at the discharge ends of said passages for controlling said passages and having their stems disposed in said respective passages, one of said passages being

formed in one of said valves, an oil chamber, an oil inlet supplying said oil chamber and oil passage, and means operated by the pressure of oil in said oil chamber for opening said air valve.

8. A fuel oil injector for internal combustion engines having concentric oil and air passages, oil and air valves controlling said passages and having their stems disposed in said respective passages, one of said passages being formed in one of said valves, an oil chamber, an oil inlet supplying said oil chamber and oil passage, and a diaphragm operated by the pressure of oil in said oil chamber for opening said air valve.

9. A fuel injector for internal combustion engines having fuel and air passages whose discharge ends are in juxtaposition, means located at the discharge ends of said passages for controlling the respective passages, and means for opening the air passage first and afterward the fuel passage in discharging fuel and air from the respective passages, and closing the fuel passage first and afterward the air passage in cutting off the discharge from the respective passages, the discharge ends of said passages and the controlling means being so positioned that a stream of air is projected through a stream of oil at the point of discharge of the separate streams from the passages.

10. A fuel injector for internal combustion engines having fuel and air passages whose discharge ends are in juxtaposition, fuel and air discharge controlling means, located at the discharge ends of said passages, controlling the respective passages, a fuel chamber, a movable element separating the fuel chamber from the air passage and coacting with one of the discharge controlling means in its closing operation, and means for opening the air passage first and afterward the fuel passage and subsequently closing the fuel passage and then the air passage.

11. A fuel injector for internal combustion engines having fuel and air passages whose discharge ends are in juxtaposition, fuel and air valves disposed concentrically with relation to each other and controlling the respective passages, and means for opening the air valve and afterward the fuel valve and subsequently closing the fuel valve and then the air valve.

12. A fuel injector for internal combustion engines having fuel and air passages whose discharge ends are in juxtaposition, fuel and air valves controlling the respective passages, a fuel chamber, an air chamber, a movable member separating the two chambers and co-acting with the air valve, means for opening the air valve first and fuel valve afterward in discharging air and fuel from the injector and closing the fuel valve first and air valve afterward in cutting off the discharge of fuel and air from the injector, said air and fuel valves being concentrically disposed and formed so that the fuel and air are projected one across the path of the other at the discharge end of the fuel and air passages.

13. A fuel injector for internal combustion engines having fuel and air passages whose discharge ends are in juxtaposition, fuel and air valves controlling the respective passages, a fuel chamber, an air chamber, means for opening the air valve first and fuel valve afterward in discharging air and fuel from the injector and closing the fuel valve first and air valve afterward in cutting off the discharge of fuel and air from the injector, said fuel and air valves being concentrically disposed and formed so that the fuel and air are projected one across the path of the other, and means for producing a whirl of the mixed air and fuel at the discharge end of the injector.

In testimony whereof we affix our signatures in presence of two witnesses.

SAMUEL P. COWARDIN.
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Witnesses:
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CHR. E. TALLEY.