July 29, 1930. S. P. COWARDIN ET AL 1,771,875

FUEL ATOMIZER

Filed April 3, 1924

Fig. I

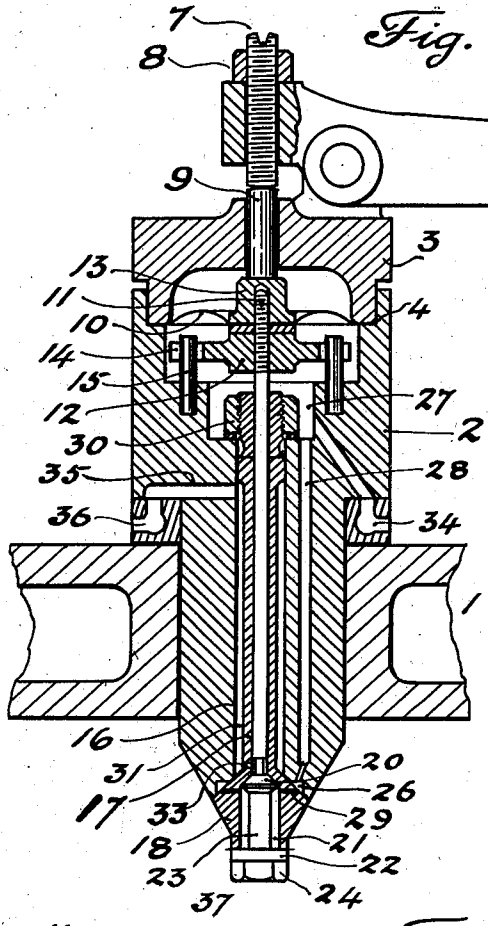
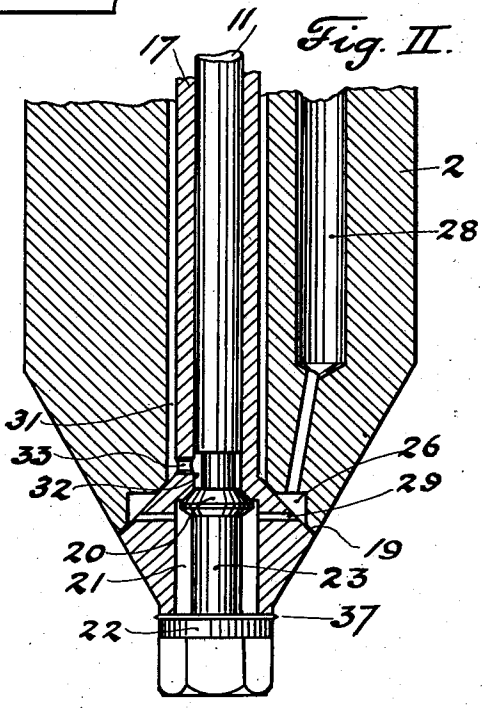


Fig. II.



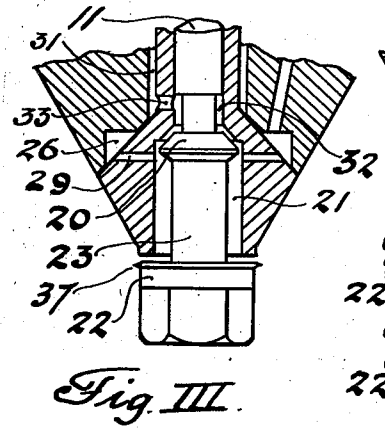
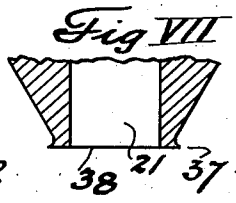


Fig. III.

Fig VII



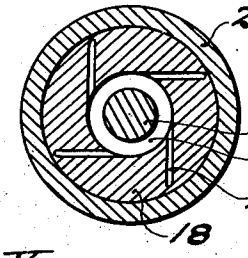


Fig. IV.

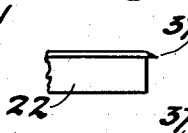


Fig. V.

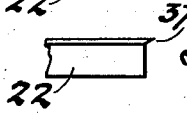


Fig. VI.

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UNITED STATES PATENT OFFICE

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FUEL ATOMIZER

Application filed April 3, 1924. Serial No. 703,972.

Our invention relates, in its mechanical aspect to fuel atomizers for internal combustion engines, heating furnaces, and for other purposes, in which oil and air under pressure are brought together and are so controlled that the oil is discharged in an atomized or highly comminuted state, and relates, in its method aspect, to the production of a fog-like fuel ingredient, specially intended as a combustible charge for explosive engines.

One object of our invention is to provide an atomizer of simple and substantial construction and of few working parts, so arranged and operated that the fuel shall be finely divided, and so that the loss of fuel—that is, fuel passed through the atomizer without being finely divided—shall be reduced to a minimum; and further so that the quantity of air required for atomization may be regulated and proportioned to the oil consumption and so that the atomized fuel discharged from the atomizer may be closely regulated to meet the demands of fractional changes of load. A further object of our invention is to control the direction of the discharge of atomized fuel from the atomizer.

In the conventional type of atomizer for atomizing liquid fuels with steam or with compressed air the liquid fuel is caused to issue from one orifice, while the steam or air is caused to issue under considerable pressure and at considerable velocity from another orifice, the stream of air or steam striking the stream of liquid fuel and reducing it to a more or less fine spray. In some of these atomizers there is loss of fuel, caused by the fuel dropping past the stream of air or steam before it can be thoroughly broken up; and in an attempt to minimize the fuel loss, an excess of air is used for atomization, which excess is an obstacle to regular ignition, and consequently to regular and satisfactory operation. The arrangement and construction of our atomizer enable us to closely regulate both the oil and the air, or other atomizing agent, while proportioning the volume of air used to the volume of oil; and they enable us to practically eliminate waste of oil from drips. Even with air at comparatively low pressure, the oil is finely and uniformly divided; and its discharge from the atomizer is under complete control.

In the drawings which accompany and form a part of this specification, and in which like numerals refer to like parts in the several views: Figure I is a vertical section of the atomizer shown in position in the head of an internal combustion engine cylinder; Figure II is an enlarged view of the lower end of the atomizer shown in Figure I; Figure III is a partial vertical section showing the control valves in an open position; Figure IV is a cross section on line *a*—*b* in Figure II; Figures V and VI are details, broken, showing variations in the shape of the discharge valve; and Figure VII is a detail, in vertical section, showing a variation in form of the discharge end of the atomizer.

Referring to Figure I:— 1 represents the cylinder head of an internal combustion engine (it may also be taken to represent the front plate of a furnace); 2 is the body of the atomizer secured in the head of the cylinder; 3 is a cap removably secured to the body 2, and forming with it the rebate 4. On the cap 3 is fulcrumed a tappet-lever 6, the head of which carries an adjustable hammer 7 with lock-nut 8. In the cap 3 is mounted the tappet-pin 9.

Securely clamped between the body of the atomizer and the cap 3 is a corrugated flexible diaphragm 10. This diaphragm may be of flexible material or of spring material. Passing through and secured about the center of the diaphragm 10 is a valve-stem 11, which is held in position relative to the diaphragm by the nut 12 and the lock-nut 13. The nut 12 is provided with slotted wings 14, engaging pins 15 set in the body of the atomizer, to hold the nut 12 from turning when the nut 13 is screwed down. The tappet-pin rests upon the lock-nut 13. Pressure upon this pin will depress the diaphragm 10 and the valve-stem 11. On the other hand: fluid pressure beneath the diaphragm 10 will tend to raise the valve-stem 11.

Held securely in the bore 16 of the atomizer body is the valve-stem sheath 17, which terminates at its lower end in the cone-shaped

foot 18. The outer conical face of this foot is a ground fit in the conical seat in the lower end of the atomizer body, at 19. The sheath 17 is locked in position by the nut 30. An annular chamber 31 is formed between the sheath 17 and the bore 16 in the body 2.

At the lower end of the valve-stem is the oil valve 20. which seats on a valve-seat formed in the inside of the foot of the sheath 17. Below the valve-seat is the atomizing chamber 21, which is closed by the discharge valve 22. This discharge valve may also be regarded as the air control valve, for it controls the admission of air to the mixing chamber 21, as well as the discharge of the atomized fuel therefrom. The discharge valve 22 and the oil valve 20 are connected by, and actuated by, the lower end 23 of the valve-stem 11. The nut 24 is a means for holding the valve-stem in place while it is being adjusted; and it may be used to hold the discharge valve disc in place on the valve-stem in cases where the said disc is made as a separate part for the purposes of renewal or repair. It will now be seen that fluid pressure under the diaphragm 10 will hold the valves 20 and 22 against their seats.

The assembling of the oil valve and discharge (also air regulating) valve on one and the same stem ensure in a very simple way the synchronous and proportional opening of these valves; both important considerations in the economical use of fuel, and in the regularity of ignition and combustion.

Formed within the cone-shaped seat 19 in the lower end of the atomizer body is an annular chamber 26, which is connected with the counterbore 27 in the upper part of the atomizer body by the duct 28; and which is also connected with the atomizing chamber 21 by the tangential tuyères or passages 29. See also Figure IV.

The diameter of the valve-stem is reduced at a point immediately above the valve 20 to form an annular chamber 32; and this chamber is connected with the oil chamber 31 by the passage 33.

Air under pressure is admitted to the counterbore 27 by the inlet 34, and passes down the duct 28 to the chamber 26. The air then enters the mixing chamber 21 at a high velocity by the tuyères 29, which are set tangentially to the mixing chamber. A whirling body of air is formed within the mixing chamber by the air entering at the tuyères. Oil is admitted to the channel 35 and the chamber 31 by the inlet 36; and it then passes by the passage 33 to the chamber 32 above the oil valve 20. When the said oil valve is opened by moving the valve-stem 11, the valve 22 is also opened. Air enters the atomizing or mixing chamber 21 by the tuyères 29, atomizing the oil which enters the mixing chamber 21 in the form of an annular film over the valve 20. When used on an internal combustion engine, in which case ignition and combustion must be intermittent, the valve-stem 11 is actuated by means of a tappet mechanism as shown at 6 and 9. Upon the valve-steam being actuated, the valve 22 opens, and immediately the pressure within the chamber 21 is momentarily relieved. At the same time the oil valve 20 opens, and a thin film of air enters the chamber 21 over the valve. This film of oil is immediately broken up by the high velocity streams of air entering tangentially to it by the tuyères 29; and the mixture of oil and air passes out of the open valve 22. Upon the pressure of the tappet being relieved, the air pressure under the diaphragm 10, which is larger in area than the combined areas of the two valves 20 and 22, closes the valves. It should be noted that while the discharge valve 22 is closed, the oil valve 20 is also closed; and furthermore the air does not flow into the mixing chamber and through it, since its only outlet is by the valve 22. But the moment the valve-stem is actuated to open the valves, the air within the mixing chamber is agitated; and into this agitated atmosphere there flows the thin film of oil. The fact that this film is in the form of a thin hollow cylinder, and the further fact that the agitated air strikes this film at a tangent, the mixture being further agitated during its passage through the mixing chamber, results in the production of a finely divided condition of the oil mixed with the air in the nature of a fog-like fuel ingredient, which mixture issues from the opening of the valve 22. The form in which the oil fog issues from the valve 22 depends upon the shape of the valve opening. In our atomizer for internal combustion engines we make the valve annular in shape as shown in the drawings. The oil fog then issues in the form of a sheet or veil radially to the valve. In furnace work we may use the same shape of valve; or we may use an orifice valve, the valve itself seating on the inside of the orifice, as in the case of the needle valve of any liquid supply.

Reference has been made to the tappet motion for operating the atomizer. Such a motion is required only where the veil of atomized oil is to be released intermittently. In cases where the fog is to be released continuously, as in most furnace work, a suitable form of adjusting screw or other device may be used in place of the tappet motion; the adjusting screw being caused to bear upon the valve-stem 11 to operate the valves 20 and 22. The question of seepage of oil past an oil valve is not only one of loss; but in the case of an internal combustion engine seepage into a cylinder results in loss of economy, irregularity in the richness of the mixture, and in some cases and under some conditions in preignition. An atomizer in which there is a seepage of oil is sometimes referred to as a

weeping atomizer. Weeping of our atomizer is prevented first by the fact that if oil leaked past the valve 20 it would also have to leak past the valve 22 before it could escape from the chamber 21, and also by the fact that we use a balanced pressure between oil and air, or an air pressure exceeding that of the oil. In either case the pressure of the air within the chamber 21 will prevent any seepage past the valve 20 even if that valve is in a leaky condition. The result of a higher air pressure than oil pressure would not be to drive the oil back into the passage 33 and passage 31, for in the case of an internal combustion engine the valve 22 is closed for a very brief space of time, and before the movement of the oil could be reserved the pressure in the chamber has been relieved by the opening of the valve 22, and both oil and air have been injected into the chamber 21, and the oil fog into the cylinder of the engine. The question of weeping is a serious matter in most atomizers, and particularly in those in which high oil and air pressures are used, and in which there is no balancing effect between the air and oil. Take an atomizer in which air pressures and oil pressures as high as eight hundred to a thousand pounds per square inch are used, and in which there is no balancing effect; the least irregularity of valve surfaces will allow seepage of oil. If we used such pressures in our atomizer, the oil would be held back by the air pressure when the valve was closed. Furthermore, if there was a tendency of the air at high pressure to leak past a discharge valve, this tendency would be more than balanced by the upward air pressure under the diaphragm 10. The balancing effect of the diaphragm 10 against the pressures on the oil and air valves results in a much reduced load on the valve operating mechanism, and on the means used for closing the valves. The diaphragm is better than would be a spiral spring under compression, for a spring would have to be of such a strength as to provide against any pressure of oil and air that might be used; whereas the air pressure acting on the diaphragm in proportional to that on the air valve.

It is known that in certain types of internal combustion engines and with certain types of atomizers, a large quantity of air at high pressure is employed to atomize the charge of oil. Reasons for the high air pressure are that the cylinder compression is high, that the oil must be blown into this high compression at considerable speed and also sufficiently atomized to ensure ignition, and that sometimes high velocity air is needed to scour the head of the piston to remove unburned oil. High velocity air and spray is a disadvantage in that it is very difficult if not practically impossible to fire it with an electric spark. The large volume of air per charge of oil is made necessary with that type of atomizer because volume is required to break up the oil and to drive the whole charge into the engine cylinder. Under conditions such as these, and with the types of atomizers referred to, there is used from sixteen to thirty times the volume of air we find it necessary to use in our atomizer for the same charge of oil. For this reason the fog discharged from our atomizer can be made much richer than the spray delivered from the types referred to above; and with our atomizer the refrigerating effect is very much less, for we use less air, and at a lower pressure.

The richness or leanness of a mixture also has a bearing on cylinder pressures. A good mixture will fire by auto-ignition in an atmosphere at as low a pressure as 120 lbs. per square inch. A lean mixture will not so fire with certainty. And if a charge is injected in advance of compression, and compression is low, and the charge is small because of reduced load, we will have a lean mixture, and we will have no ignition. But if we can make sure of a good mixture, and can inject this mixture into the cylinder and through a spark, and at so low a speed that the spark may ignite it, we shall have ignition. This we accomplish with our atomizer, even though the load be low and the final fog-like mixture formed by the finely atomized oil and the air injected into the cylinder is lean. For lean mixtures when ignition is effected only by the heat of compression, a high compression is required. Therefore in cases where large quantities of air are used for atomization or spraying, and at low loads, a high compression is required to ensure auto-ignition. And again must we add to the compression to overcome the effects of the refrigeration due to expanding a large volume of air from a high pressure. Though in such cases an increase in compression will improve the thermal efficiency of the engine, there is a limit to the net improvement, imposed by the cost of compressing the air and by the physical considerations to be met.

With our atomizer we obtain a quick discharge, and as rich a fog as desired, and in a finely divided state adapted to ensure ignition and complete combustion. This fog is injected into the cylinder at any pressure which will carry the charge into the compression space in the short time available; and it is fired either by the heat of compression or by the electric spark; and because we are able to inject into the cylinder a charge of the fog-like ingredients of certain and of predetermined quality, we are able to time ignition to a nicety to obtain the best results. At low loads and pressures we can fire with certainty by the electric spark; and this feature of our atomizer enables us to start a cold engine from a standstill, either forward or in reverse, without the aid of any compressed

air or other means for turning the engine over. A few cubic inches of air for atomization, a few charges of oil (frequently only one), and a spark, are what we require to start an engine. The reason for the variation of the number of charges of oil required is one of engine or of fuel conditions. After an engine has been standing for some time, the first shot in a cold cylinder may not fire as well as the second, and the resulting first explosion may not be sufficient, with oil and air adjusted for running, to turn the engine over to the next point of ignition.

To reverse a motor boat or similar engine we require no reverse gear. We have simply to cut off the fuel supply to allow the engine to come to rest; to shift the spark; to cut the fuel supply on again; and then to adjust the spark until we get the first explosion. This method of starting is described in another application filed July 14, 1924, Serial No. 725,931 co-pending herewith. After starting, and as soon as compression rises to 120 lbs. or thereabouts, we can cut off the spark and proceed to fire by the heat of compression. We have found that an air pressure of about 200 lbs. is enough to get a sufficiently rapid injection of oil fog into the cylinder when running, when the compression is from 120 to 150 lbs.; and we carry a small reserve of air at a somewhat higher pressure for use in starting the engine, the excess pressure being to provide against possible leakage of air from the tank. In the case of a thirty horse power boat engine we provide about thirty cubic inches of air tank capacity; and when starting from a stand-still the reduction of pressure in this tank is often not more than from one to three per cent. After starting, air for atomization is supplied by a small air pump or compressor driven from the engine shaft.

We have found that with the conventional type of orifice or valve-controlled outlet the direction of the discharge of the film of fog in a vertical direction is uncertain. The film is inclined to follow the surface with which it is in contact; or, on leaving a surface, it is inclined to follow an adjacent surface. This is particularly the case when the outside face of the opening or valve is a plain surface, cylindrical or otherwise. This is also the case with an oil film. When discharged from the valve opening, the film of oil fog, if not controlled, may shoot upward or downward, over surfaces of cylinder head, cylinder walls; injector or atomizer surfaces; and the tendency of the film to deviate from a direct path will be influenced and varied by differences in conditions and pressures within the cylinder. Where ignition is effected by the electric spark irregularity in the direction of the film discharge will result in irregular combustion and operation; and even when ignition is effected by the heat of compression or by other means this irregularity in the direction of the film discharge will cause trouble. We control and direct the discharge of the film of oil fog by providing a fin 37, as shown in Figures I, II, III, V, VI, and VII of the drawings, on the periphery of the valve 22 or valve seat 38, or adjacent to the opening. Whether the fin be made a part of the valve or of the valve seat; whether it be made a part of the wall of any form of opening; or whether it be supported independently of the valve or of the wall of the opening; the fin should terminate in an acute edge, and its outside diameter must be greater than the outside diameter of the adjacent parts of the structure. The film of oil fog follows the surface of the valve opening and the surface of the fin to its outermost edge, and this edge it will leave without materially altering its direction. The shape of the fin affects the direction of the discharge. A horizontal fin, as in Figure VI, will give an approximately horizontal film; and a fin shaped as in Figure V will give a slightly downward discharge.

When we desire to use electric ignition, the direction of discharge of our oil fog film being controlled, we are able to adjust the position of our spark to the best advantage. We find that when an engine is started cold, or when the engine is idling, it is best that the film be directed through the spark gap; that is to say, the spark is adjusted so that it may envelop the film. We practically synchronize the spark and injection; though we allow adjustment between the two, as we find that under different starting conditions or running conditions a slightly different adjustment may give the best results. Under normal operating conditions, after starting we cut the spark off and ignite by the heat of compression. Then too the controlled direction of the film results in improved operation.

In the drawings the discharge opening formed between the valve 22 and its seat is shown of annular form. It may be of other forms; each one that best suited to the use to which the atomizer is to be put. For instance, in furnace work, in which a closely directed discharge is not so important as in engine practice, the valve opening may be at the end of the atomizer instead of on the side as shown; in which case the valve is of the internal type (as in a needle valve) instead of the external type. In our furnace atomizers the discharge is continuous, and the opening and closing of the needle or outlet valve is controlled by a manually operated screw or similar mechanism. In some classes of furnace work we also use the film-directing fin, disposed about the outlet opening, and shaped so as to guide the film into the desired direction.

From the foregoing description it will be

seen that one aspect of our invention comprises a method of producing a fog-like ingredient for an explosive or combustible engine charge. And also that the steps of this method consist in introducing air under pressure into a chamber in a relatively smaller quantity than the quantity of oil, both measured by weight; in intermittently introducing fuel oil by pressure into such chamber in a relatively larger quantity than the quantity of the air, so measured; in intermittently opening the discharge end of such chamber, as when the oil is admitted into the inlet end, to cause the pressure on the air to put it into violent motion and by such motion to cause it to so atomize the oil that when thus mixed with the air a fog-like fuel ingredient will result.

And it will be understood also that by preference the air is introduced into such chamber from the air passage in a tangential direction with reference to the wall of the chamber so as to enhance or create a whirling motion of the air. And again, that by preference also the oil is admitted to said chamber in a film-like formation which, with such whirling motion of the air, results in the more perfect and almost infinitesimal breaking up of the oil so that when these minute particles are taken up by the air the aforesaid fog-like product results.

We have referred above to using about 200 pounds air pressure to effect injection when the compression is about 120 to 150 pounds. We desire to state further that we usually use an air pressure for the atomizer ranging from 120 to 400 pounds, which is sufficient, on the meeting of the oil and air in the mixing or atomizing chamber 21, the air entering such chamber through the tangential tuyères 29. These tangential streams of air act violently to break up and atomize the oil and to cause the fine particles to become suspended as it were, in the air. The pressure of the air and the oil, each at say 150 to 400 pounds per square inch, and the whirling course of the air, both entering the mixing or atomizing chamber 21, and the rapid passage of the oil and air past the discharge valve or disk 22 combine in their action to reduce the oil particles to such a state of entire atomization as is distinguishable only from a state of vapor or vaporization, which latter state does not occur until this fuel ingredient is subjected to the heat incident to combustion or that immediately preceding ignition. The best illustration we can give of the state of the fuel charge, as it issues from this atomizer and enters a cylinder, is that the charge constitutes a fog made up of the constituents of oil and air.

It is further to be understood that the fog produced by this atomizer is composed of a less quantity of air than of oil. This refers to the relative quantities as determined by weight. For instance, taking one cubic foot of free air per brake horse-power (which is conservatively high) and .6 of a pound of oil per brake horse-power per hour (which is about the amount used) the weight of such quantity of air will be about .075 pounds per brake horse-power per hour. This is on the assumption that we have free air at about 70 degrees F.

We claim:

1. An atomizer consisting of a body having an air inlet passage for air under pressure leading through the body, an atomizing chamber near the discharge end of the structure, tangential tuyères connecting the air passage with said chamber, an oil passage extending through the body for oil under pressure, a valve stem extending through the structure and adapted to be actuated from the outside, and two valves carried by said stem, one to open communication between the oil passage and the atomizing chamber and the other to permit the oil and air fog generated in the atomizing chamber to escape, such fog resulting from the action on the oil of the air whirling in the chamber from the effect of the tuyères and their arangement and from the pressure on the air and oil.

2. In an atomizer comprising an oil chamber and a mixing chamber, means in a condition for continuously delivering oil to the oil chamber, pressure means in a condition for constantly delivering air under pressure to said mixing chamber, and a provision for causing the air to whirl in said chamber, and a common means for admitting the oil to the mixing chamber and discharging the mixture of oil and air, now fog, from the mixing chamber.

3. In an atomizer comprising an oil chamber and a mixing chamber, pressure means in a condition for continuously delivering oil under pressure to the oil chamber, pressure means in a condition for constantly delivering air under pressure to said mixing chamber, and tangential tuyères for directing said air into said mixing chamber, and a common valve means for admitting the oil to the mixing chamber and discharging the mixture of oil and air, now fog, from the mixing chamber.

4. In an atomizer comprising a mixing chamber, means in a condition constantly delivering air to said mixing chamber tangentially, and means for periodically admitting oil in a thin sheet like form to said chamber across the path of the entering air, and for discharging the mixture of oil and air, now fog, from said chamber.

In testimony whereof we hereunto affix our signatures.

SAMUEL P. COWARDIN.
HARRY A. COWARDIN.