

Jan. 17, 1956

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2,731,079

APPARATUS FOR ATOMIZING AND IGNITING SUBSTANCES

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2 Sheets-Sheet 1

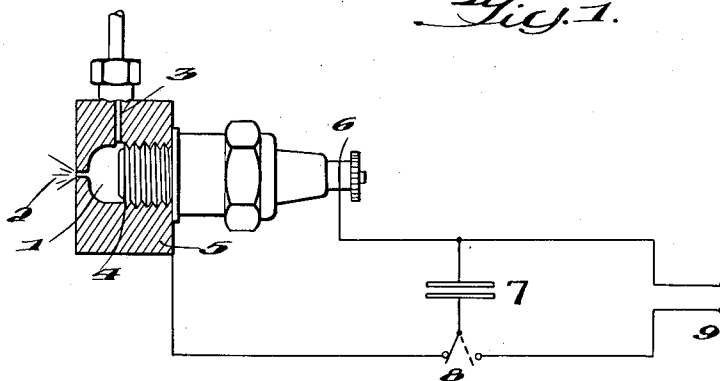


Fig. 2.

Fig. 4.

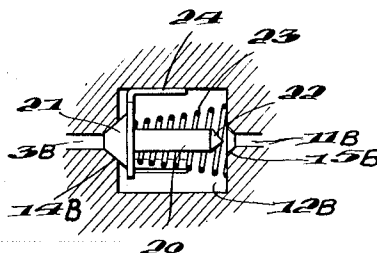
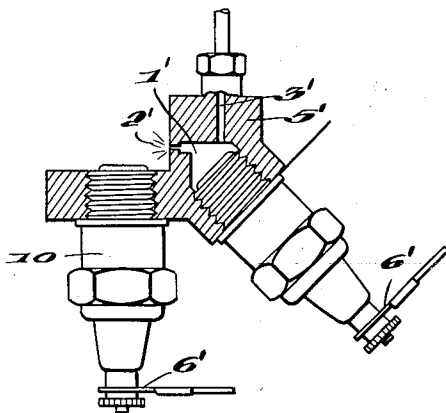
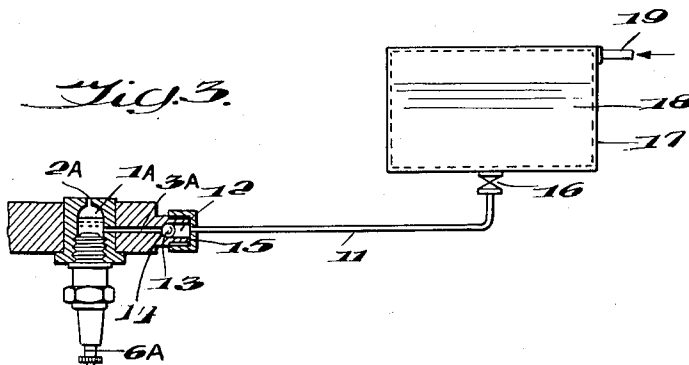


Fig. 3.



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Fig. 13.

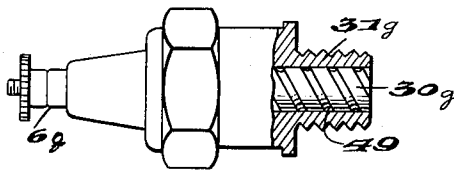


Fig. 5.

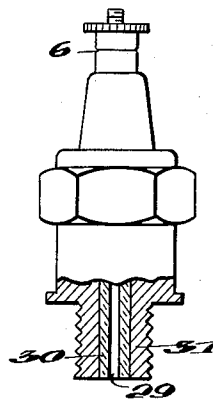


Fig. 6. Fig. 7. Fig. 8. Fig. 9. Fig. 10.

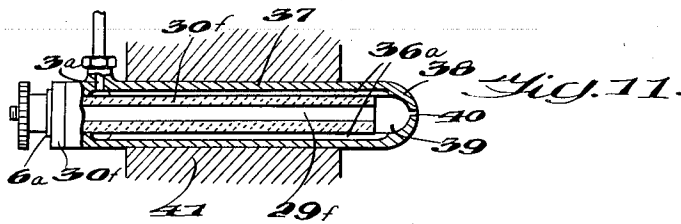
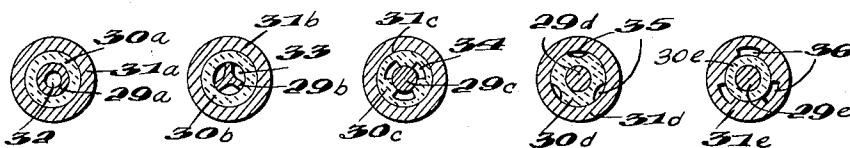
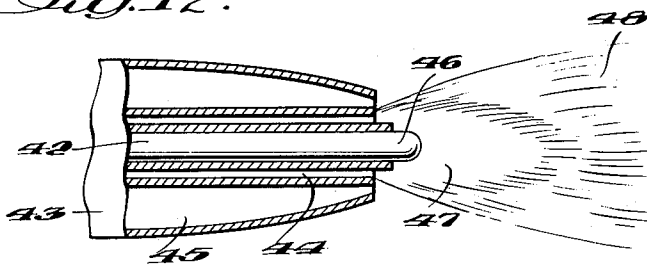


Fig. 12.



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APPARATUS FOR ATOMIZING AND IGNITING SUBSTANCES

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10 Claims. (Cl. 158—28)

The present invention relates to atomizing and igniting substances in a chamber having at least one hole, by means of an electric spark produced in the chamber. The energy of the spark drives the substance with great force out of the chamber through the holes, whereby it is atomized and ignited. This application is a continuation in part of an application entitled, "Process and Apparatus for Atomizing and for Igniting Substances," Serial No. 37,904, filed July 9, 1948, now abandoned.

Apparatus operating according to this principle in which a high tension spark (5000–30,000 volt) or a series of high tension sparks is used for atomizing and igniting combustibles are known. However, the known apparatus presents various objections. It is desirable for a good operation of the apparatus to use an electric discharge in which the electric energy is liberated in the form of a spark in the shortest possible time. The inductive or the inductive-capacitive discharge obtained in the usual high tension apparatus cannot satisfy this requirement.

Furthermore, it is known that production of sparks is impeded if the electrodes become fouled by carbon deposit or other similar deposit on the insulation between the electrodes. Also great care must be taken to be sure that all parts of the high tension devices are well insulated.

The object of the present invention is to overcome these difficulties in the known devices. In the present invention, the spark is obtained by a completely or substantially aperiodic discharge of a condenser across a spark bridge. Investigations carried out by the inventor have led to the discovery that, for a good atomization, accompanied by ignition, the tension at the spark gap need not be much higher than 3000 volts and, in many cases, may even be considerably lower.

The chamber from which the substance is atomized, hereinafter to be called spark chamber, is provided with a spark gap carrying device to be called a spark plug, the electrodes of which extend into the chamber. In the chamber wall, one or more holes, connecting the chamber with its surroundings, are provided through which the substance is atomized and which may be equipped or not with automatic or commanded closing devices. Furthermore, a duct from the supply of the substance to be atomized to the spark chamber has been provided through which the substance to be atomized can be fed to the spark chamber. The substance can be conveyed to the spark chamber in any suitable way. In the case of a suitable pump, by means of suitable pressure in the container, to which the spark chamber is connected by a duct, by placing the container in a higher position so that the liquid may reach the spark chamber under the influence of gravitation, or by other means or combination of means.

The invention also comprises filling and/or dosing devices for the substance to be atomized, actuated automatically by the operation of the spark chamber. These filling and/or dosing devices are advantageously placed in the vicinity of the spark chamber. They consist substantially of a conveniently shaped non-return valve placed in a widened part of the duct through which the liquid

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reaches the spark chamber. Under the influence of the pressure urging the substance through the duct to the chamber, the non-return valve shuts off the supply of liquid to the spark chamber. Generating of sparks causes the pressure in the spark chamber to rise to such a degree that the non-return valve is forced back, and in its extreme position, closes the orifice of the upstream section of the duct. Thus, the liquid in the supply duct is prevented from being forced back by the overpressure developed in the spark chamber. As soon as the pressure in the spark chamber has dropped sufficiently, the valve returns to its original position. During the latter movement, however, a predetermined quantity of liquid, exactly measured, enters the spark chamber, propelled partly by the head of the liquid, partly by the pump action of the valve, whereupon the process repeats itself.

It is advantageous to supply the fuel through the spark plug to the spark chamber, the spark plug being provided to this end with suitable ducts. These ducts may be either straight or screw-shaped. The latter shape has the advantage of opposing a high resistance to a backward flow of the liquid in the duct due to the rise of pressure in the spark chamber when a discharge takes place. As the emptying of the duct is hereby reduced in certain embodiments, especially those working with low discharge frequencies, the non-return valve may be dispensed with. If a non-return valve is used, its useful life is prolonged by using screw-shaped ducts. Thus, the sudden pressure rise provoking the impact of the valve against the orifice of the upstream section of the duct is restrained by the high resistance of the screw-shaped ducts.

In using fuels to be not only atomized but ignited as well, the spark chamber should be so dimensioned that, in addition to the substance to be ignited, a certain quantity of air, serving to start the ignition, should be present in the spark chamber. Satisfactory results have been obtained by using 2 per cent by volume of oil and filling the remainder of the chamber with air. Thus, for a small chamber, only a few drops of oil will be lying on the spark surface. The energy of the spark should be adapted to the conditions and to the properties of the fuel.

It will be readily understood that it is also possible to atomize the fuel from the spark chamber only, and to ignite the fuel thus atomized outside of the spark chamber by any suitable means. This may conveniently be effected by means of separate electric sparks.

Particularly favorable results are obtained in the embodiment wherein the main discharge of the condenser is initiated by a surface creepage discharge over the frontal surface of the spark plug between the electrodes. The discharging time of the condenser is extremely short, the electric energy manifesting itself almost as an explosion in the spark chamber. It will readily be understood that, even at relatively low tensions at the spark bridge which may be considerably less than 3000 volts, a discharge is obtained which will atomize the fuel and, if desired, ignite it with certainty. By using the condenser discharge, the duration of the spark is extremely short lasting for $\frac{1}{3,000,000}$ second. It has a very high temperature of about 3000° C. The force, energy, and rapidity of the spark is so great that it will cause the fuel oil, for example, to be very rapidly atomized and ignited as if it were an explosion. The explosion, combined with the heat created, will force the atomized fuel through the chamber orifice and outside in an ignited condition.

In order to promote the surface creepage discharge, the spark device may consist of electrodes separated by a solid material, on the frontal surface whereof the electrodes emerge. In all the cases referred to in connection with the drawings, the material will be semi-conductive, or, in the case of a non-conductor, may be provided on

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its frontal surface with a semi-conductive layer or will become semi-conductive in operation by deposits of carbon on the surface of the material. These alternatives can be used interchangeably as desired.

The process and apparatus according to the present invention, whereby a fuel is atomized and ignited, can be used advantageously to ignite other inflammable or explosive substances. Various embodiments can be given to this apparatus. It is, however, advantageous to combine the spark plug with the spark chamber to form one single unit which may be mounted and removed as such. It is also advantageous to feed the ignition fuel in the spark chamber through the spark plug as described above. The use of low tension makes possible the use of an insulating layer separating the electrodes of a very small thickness which, in many cases, need not be more than 1 mm. Thus, the apparatus may have a substantially cylindrical shape of very small cross section so that the apparatus may be lodged very easily, for example, even in existing burners, without necessitating important modifications of the burner. Such an ignition apparatus may be placed axially in the burner in such a way that the spark chamber, being the extremity of the apparatus, is located within the cold core of the burner flame, but does not protrude past said core. Thus, a rapid and certain ignition of the burner is ensured without unfavorably influencing the form of the flame cone, which is often the case with the usual ignition devices. At the same time, the life of the ignition device is greatly prolonged, as it does not come in contact with the hot part of the burner flame.

The invention will be further explained with reference to the drawings, representing several examples of embodiments. It will be understood that the invention is not limited to these examples, as other embodiments falling within the scope of the invention are possible.

Fig. 1 is an elevational view, partly in section and partly diagrammatic of the apparatus according to the invention with a possible arrangement of electrical connections;

Fig. 2 is an elevational view, partly in section of another embodiment in which a substance is atomized from a spark chamber and is ignited by a separate ignition device represented in the form of an electrical spark plug;

Fig. 3 is an elevational view, partly in section of an apparatus substantially as in Fig. 1, showing a filling and dosing device;

Fig. 4 is an elevational view in section of another dosing device;

Fig. 5 is an elevational view, partly in section, showing a possible embodiment of the spark bridge shaped as a spark plug;

Figs. 6, 7, 8, 9 and 10 are cross sections of the spark plug, showing various embodiments of ducts;

Fig. 11 is an elevational view, partly in section, of another embodiment of the spark plug, combined with the spark chamber;

Fig. 12 is a diagrammatic representation of a burner provided with the ignition device according to Fig. 11;

Fig. 13 represents still another embodiment of a spark plug with the outer shell partly broken away in order to show screw-shaped ducts of the type represented in Fig. 9.

In Fig. 1 the spark chamber 1 is formed partly by a hollow body 5, partly by the active extremity 4 of the spark bridge shaped as a spark plug. The spark chamber is provided with atomizing holes 2 and with a duct 3, to which the fuel supply duct is connected. The central electrode of the spark plug is electrically connected at 6 with a condenser 7 and with a current source 9 supplying direct or rectified alternating current. The outer electrode of the spark plug is connected over the mass of the body 5 and a switch 8 with the condenser 7 or the current source 9, dependent upon the position of the switch. It will be readily understood that the switch 8

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may also be inserted in the line, connecting the points 6, 7 and 9. In the dotted position of the switch 8, the condenser is charged, whereas the condenser discharges itself over the spark bridge when the switch is in the position indicated by the solid line. The self induction of the circuit being negligible permits an entirely or substantially aperiodic spark discharge.

Fig. 2 represents a similar device, differing, however, in that a second spark plug 10 is used to ignite the substance atomized from the spark chamber 1'. It will readily be understood that the respective position of the spark plug 10 and of the atomizing holes should be such that the substance atomized from the holes 2 meets the spark of the spark plug 10. Other parts in Fig. 2 corresponding to parts in Fig. 1 are indicated by primed numerals.

Fig. 3 represents again the embodiment according to Fig. 1, but now in combination with a dosing device which automatically and periodically supplies a predetermined quantity of fuel to the spark chamber. The substance to be atomized is supplied to the spark chamber 1A from the container 17 through a duct 11, propelled by compressed air admitted to the container by the duct 19. A cock 16 can be used to cut the duct 11 from the container 17. Between the container 17 and the spark chamber 1A, preferably as near as possible to the spark chamber, is placed a device for automatically measuring the quantity of liquid introduced during each cycle into the spark chamber. Said device consists substantially of a valve chamber 12, wherein a non-return valve 13, in this embodiment a ball valve, is located. In the position indicated in the drawing, the ball 13 closes the supply duct 3A to the spark chamber 1 so that there is no connection between the container 17 and the spark chamber 1A. The electric discharge in the spark chamber provokes a sudden increase of pressure forcing the ball 13 backward, which now closes the orifice 15 of the upstream duct 11. When the pressure in the spark chamber drops again below that existing in the duct 11, the ball 13 moves back again toward the seat 14 under influence of the pressure of the liquid. As the valve chamber 12 has a greater diameter than the ball 13, there is a direct connection between the upstream duct 11 and the duct 3A, the ball moves from position 15 to position 14 so that, during this period, liquid is admitted from the container 17 to the spark chamber 1A. The quantity of liquid supplied each time to the spark chamber 1A depends, among other factors, upon the pressure in the container 17, upon the diameter of the duct 14 and of the duct 3, upon the length of the stroke of the ball 13, and upon the difference in diameter between the ball and the valve chamber 12. All of these factors can be controlled so that it is possible to measure the quantity of liquid to the spark chamber with every stroke. Other parts in Fig. 3 corresponding to parts in Fig. 1 are indicated by the same numeral with the letter A added.

Best results will be obtained if the amount of oil supplied each time is only a few drops, approximately 2 per cent by volume of the chamber.

Fuel supplying devices such as that shown in Fig. 3 can be used with all of the spark plugs described herein.

Fig. 4 gives another embodiment of the non-return valve, here indicated at 20 and provided with two conical faces 21 and 22 closing the orifices 14B and 15B of the ducts 3B and 11B respectively. In the position represented in the drawing, the valve is forced onto the seat 14 by the spring 23. Several guide wings 24 center the valve in the valve chamber. The space between the guide wings allows the liquid to flow from the duct 11B through the valve chamber 12B to the duct 3B in the intermediate positions of the valve. It will be understood that various embodiments can be given to the valve and the valve chamber falling within the scope of this invention.

Fig. 5 represents an embodiment of the invention in the form of a spark plug. The spark plug consists sub-

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stantially of a central electrode 29 which can be connected to the electric conduit at 6, surrounded by a relatively thin insulating or semi-conductive layer 30, surrounded again by the outer electrode 31, the lower end of which may be provided with a screw-thread. As mentioned above, it may be advantageous to feed the substance to be atomized through the spark plug to the spark chamber. Some embodiments of a spark plug provided with supply ducts are shown in cross section in Figs. 6 to 10 inclusive.

Fig. 6 represents a spark plug with a central electrode 29a provided with a central bore 32 forming the duct. Other parts in Fig. 6 similar to corresponding parts in Fig. 5 are indicated by the same numeral with the letter *a* added.

According to Fig. 7, one or more ducts are formed by grooves 33 running along the central electrode 29b so that said ducts are limited on one side by the central electrode and on the other side by the spark bridge 30b. Other parts in Fig. 7 similar to parts in Fig. 5 are indicated with the same numeral with the letter *b* added.

Fig. 8 is a similar embodiment differing, however, in that the supply ducts 34 in this case are disposed on the inner face of the spark bridge 30c. Other parts in Fig. 8 similar to corresponding parts in Fig. 5 are indicated by the same numeral with the letter *c* added.

According to Fig. 9, the ducts 35 have been given the form of grooves disposed on the outer circumference of the spark bridge 30d. Other parts in Fig. 9 similar to corresponding parts in Fig. 5 are indicated by the same numeral with the letter *d* added.

Fig. 10 represents an embodiment in which the ducts 36 are disposed on the inner side of the outer electrode 31e. This embodiment presents the advantage that the spark bridge 30e is not submitted to tensile stresses due to the pressure developed in the spark chamber 1 and transmitted to the liquid filling the ducts, so that there is no danger of fracture. An advantage of the embodiments represented in Figs. 9 and 10 is that the liquid filling the ducts is not subject to electric tension as is the case in the embodiment according to Figs. 6, 7, and 8 and that the duct 11 need not be insulated. Other parts in Fig. 10 similar to corresponding parts in Fig. 5 are indicated by the same numeral with the letter *e* added.

An embodiment of a spark plug with screw-shaped ducts 49 is represented in Fig. 13. It is easily to be understood that ducts of the type shown in Figs. 7, 8, 9, and 10 can be advantageously given a similar disposition. Other parts in Figure 13 similar to corresponding parts in Figure 5 are indicated by the same numeral with the letter *g* added.

Fig. 11 shows, partly in cross section, partly in elevation, a spark plug having ducts as represented in Fig. 10, in which the extended end portion of the outer electrode constitutes the spark chamber. The straight central electrode 29f can be connected to the electric terminal at 6a. The central electrode is surrounded by a spark bridge 30f substantially having the shape of a thin hollow cylinder and consisting of an insulating and at least partly semi-conductive material. The outer electrode 37 likewise having substantially the form of a hollow cylinder is disposed around the spark bridge 30f, the foremost end 38 projecting from the frontal faces of the spark bridge and of the core electrode and forming the spark chamber 39, from which substances may be atomized through one or more holes 40. The outer electrode 37 is connected to mass 41 and by way of the latter to the electric circuit. The inside surface of the electrode 37 is provided with ducts 36a which are connected with the supply duct 3a. As a consequence of the low tensions used, it is possible to give to the device a small outer diameter, as the body 30f need have only a very reduced thickness. This allows the convenient use of the device as an ignition apparatus for burners.

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The fuel may be supplied by a device such as that shown in Fig. 3 and described above.

In operation, oil is supplied to chamber 39 in small doses, through ducts 36a in such a manner that sufficient air will remain in the chamber to support combustion.

Since use is made of a periodic condenser discharge at about 3,000 volts, the ignition spark is extremely short and is explosive in nature. Upon creation of the spark, a very strong flame explodes through orifice 40 and may be used for igniting combustibles in a burner or the like. After the discharge, air will penetrate again into chamber 39, as no oil or no gases will be present in the chamber after the explosion.

In Fig. 12, a section of such a burner has been represented in a very simplified way. 42 is the ignition device placed centrally in the burner 43. 44 is the fuel duct of the burner, whereas combustion air is supplied through 45. The burner is started by means of the ignition device 42, the foremost end 46 of which does not project beyond the cold core 47 of the flame 48 during the operation of the burner.

I claim:

1. A device for atomizing and igniting a liquid fuel substance and comprising means forming a pressurizing chamber having at least one narrow orifice connecting the interior of said chamber with the surrounding atmosphere and permitting entrance of atmospheric air into the chamber, means for supplying to the chamber the liquid fuel substance to be atomized and ignited, said chamber and said orifice being so proportioned and arranged as to allow the simultaneous presence of air and fuel substance, a substantially non-inductive spark bridge in said chamber and adjacent said fuel supplying means to contact a portion of said fuel, and a uni-directional capacitive voltage source, means connecting said voltage source directly to said spark bridge comprising a substantially non-inductive circuit to produce a substantially aperiodic spark discharge, whereby the fuel substance within the chamber is ignited, propelled through said orifice and atomized, said spark bridge comprising opposing electrodes separated by a continuous bridge of semi-conductive insulating material to form a fuel contacting creep spark supporting surface thereon, one of said electrodes comprising a central rod-like member and the other of said electrodes comprising a cylindrical member surrounding said rod-like member, the cylindrical member having an end portion extending beyond and spaced from the corresponding ends of said central member and of the insulation to form said chamber and said narrow orifice.

2. A device for atomizing and igniting a liquid fuel substance and comprising means forming a pressurizing chamber having at least one narrow orifice connecting the interior of said chamber with the surrounding atmosphere, and permitting entrance of atmospheric air into the chamber, means for supplying to the chamber the liquid fuel substance to be atomized and ignited, said chamber and orifice being so proportioned and arranged as to allow the simultaneous presence of air and said fuel substance, a substantially non-inductive spark bridge in said chamber and adjacent said fuel supplying means to contact a portion of said fuel, said spark bridge comprising two electrodes and means forming a semi-conductive fuel contacting spark creep surface disposed therebetween, a unidirectional capacitive voltage source, means connecting said voltage source directly to said spark bridge comprising a substantially non-inductive circuit to produce a substantially aperiodic spark discharge, whereby the ignition of the substance is started within the chamber to propel the ignited substance through said orifice.

3. A device according to claim 2 wherein one of said electrodes comprises a central rod-like member and the other of said electrodes comprises a cylindrical member surrounding said rod-like member.

4. A device according to claim 2 wherein said spark

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bridge has at least one duct passing substantially longitudinally through said spark bridge and forming a part of said means for supplying said liquid to be atomized.

5. A device according to claim 2 wherein said spark bridge has a helical duct passing substantially longitudinally through said spark bridge and forming a part of said means for supplying said liquid to be atomized.

6. A device according to claim 2 in which one of said electrodes comprises a central rod-like member and the other of said electrodes comprises a cylindrical member surrounding said rod-like member, the rod-like member having a central bore therethrough forming part of said means for supplying said liquid to the pressurizing chamber.

7. A device according to claim 2 in which one of said electrodes comprises a central, rod-like member and the other of said electrodes comprises a cylindrical member surrounding said rod-like member, said central electrode and the semi-conductive material being formed to provide at least one duct forming part of said means for supplying said liquid to be atomized.

8. A device according to claim 2 in which one of said electrodes comprises a central rod-like member and the other of said electrodes comprises a cylindrical member surrounding said rod-like member, said insulating mate-

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rial and said outer electrode being spaced to provide at least one duct forming part of said means for supplying said liquid to be atomized.

9. In a device according to claim 1, wherein the means for supplying to said chamber the substance to be atomized and ignited includes at least one duct provided between said central electrode and the insulating material for the passage of liquid to said chamber.

10. In a device according to claim 1, wherein the means for supplying to the spark chamber the substance to be atomized and ignited includes at least one duct provided between said insulating material and said outer electrode for the passage of liquid to said chamber.

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