

Oct. 23, 1956

W. L. TENNEY ET AL
AEROSOL GENERATOR

2,768,031

Filed April 27, 1951

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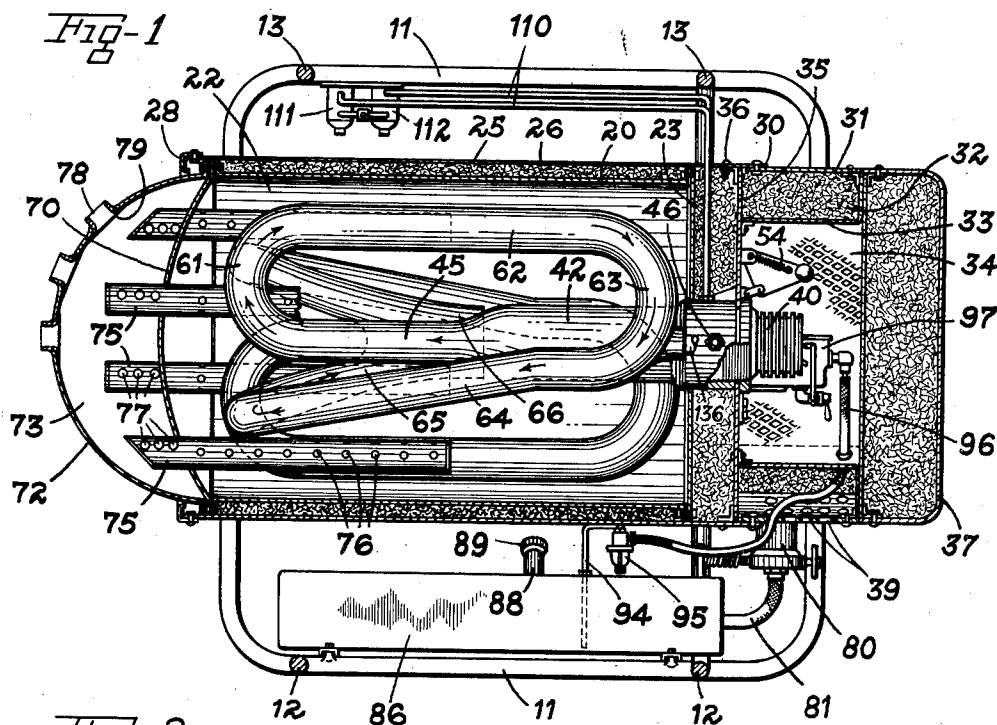


Fig-2

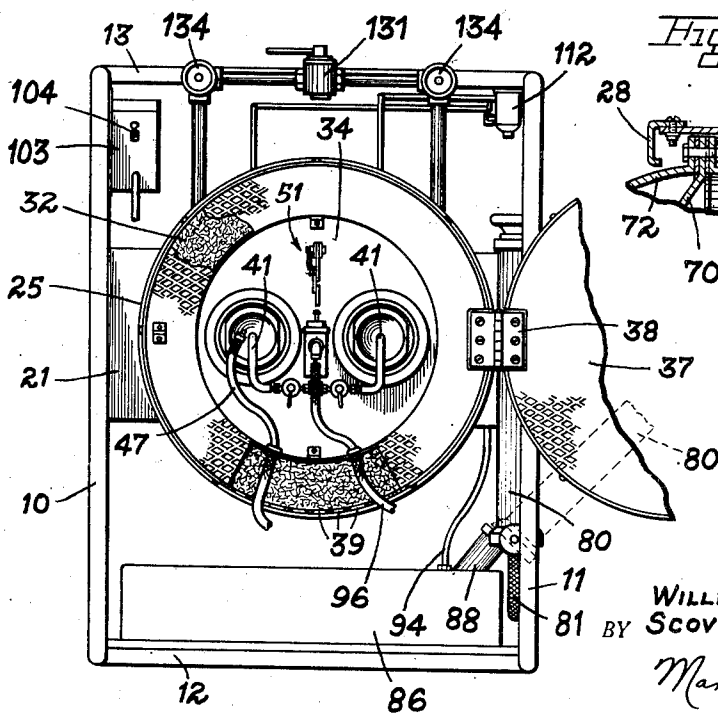
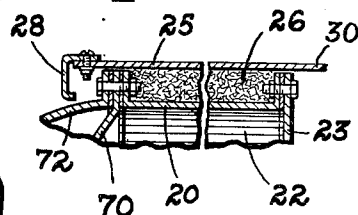


Fig-3



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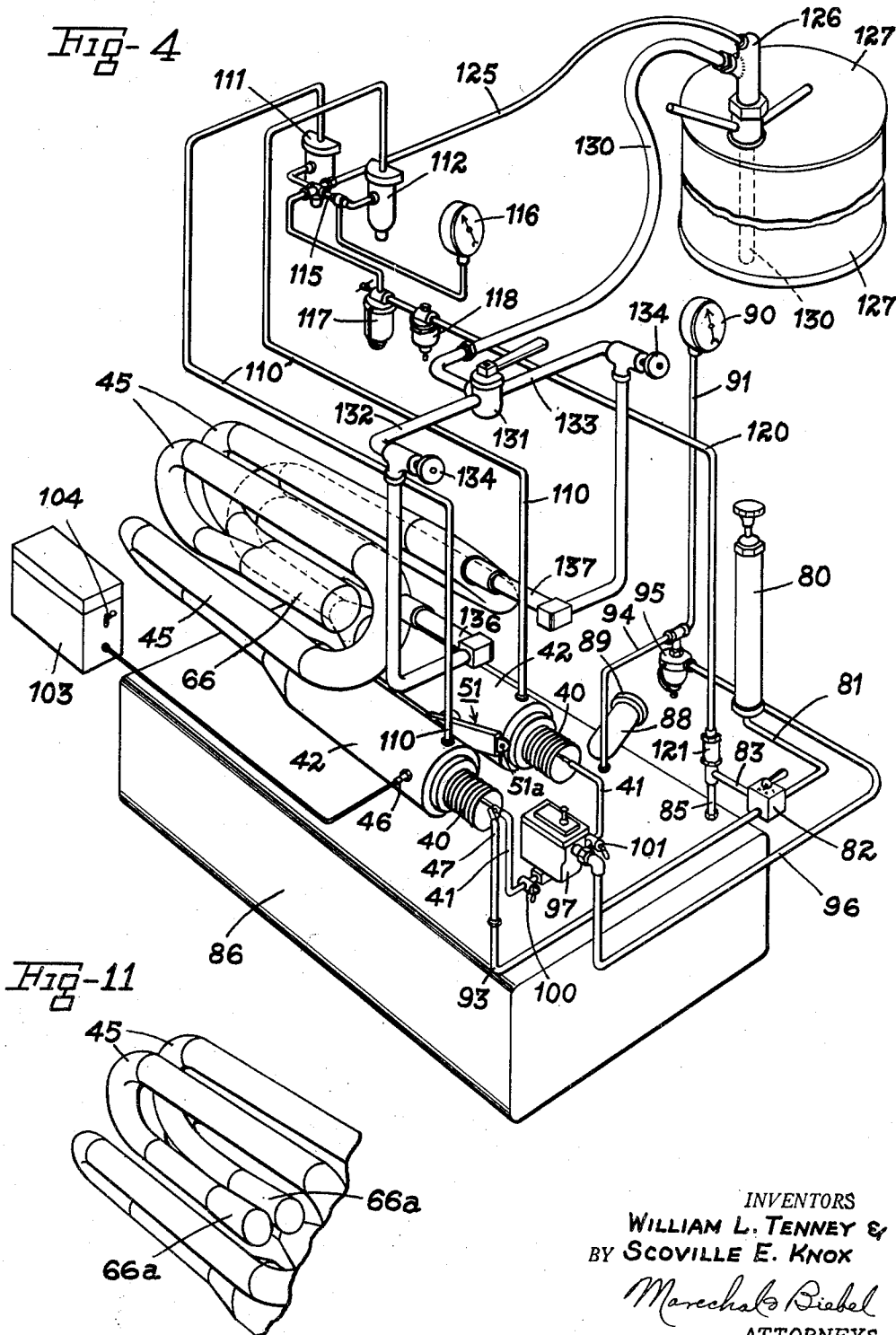
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Fig-5

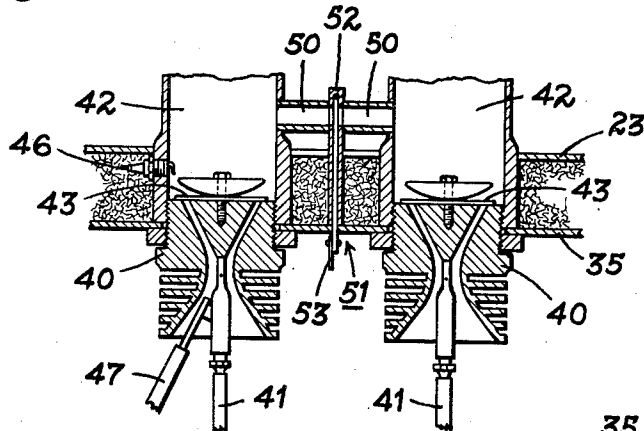


Fig-6

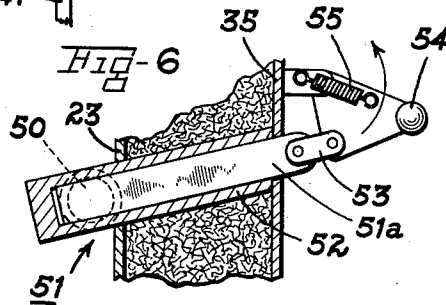


Fig-7

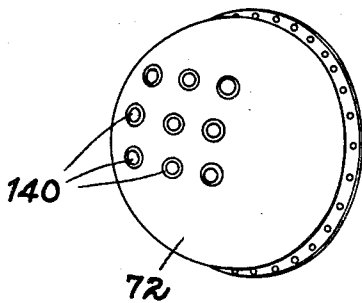


Fig-9

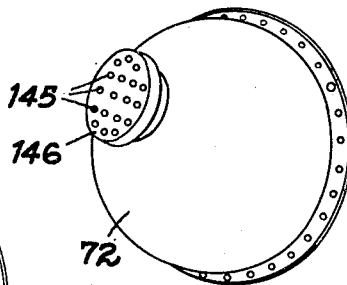


Fig-8

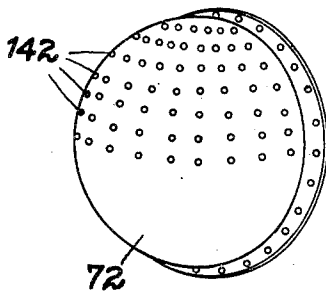
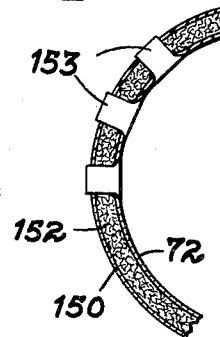


Fig-10



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2,768,031

AEROSOL GENERATOR

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Application April 27, 1951, Serial No. 223,254

14 Claims. (Cl. 299—86)

This invention relates to aerosol generators and more particularly to such devices operated by means of resonant intermittent combustion engines.

In accordance with the present invention a resonant intermittent combustion engine or engine system is utilized for creating an aerosol. Such an engine system develops heat and high velocity, pulsating gas flow, and by the introduction of a desired formulation at the proper points in the system that formulation is atomized, partially or fully vaporized, and ejected to the atmosphere where it condenses to form the desired aerosol. A highly efficient and quiet operation is obtained with combined cooling of the engine and coordinated heating of the formulation by properly enclosing and insulating the system and with the formulation being introduced thereinto in such a way that the heat of the engine is transferred to it, with the desired cooling effect on the engine, and with the entire system being enclosed to reduce noise and heat loss.

It is also desirable in such a system to be able to produce the aerosol at widely different flow rates depending upon the particular purpose for which it is to be used, while retaining good operating efficiencies. In accordance with the present invention a plurality of resonant intermittent combustion engines are utilized in the same system, the engines being mounted in side by side relation and preferably having a single exhaust outlet. Since engines of this type are not inherently self-starting, means are provided for starting one such engine and thereafter the adjacent engine can be started and placed in operation from the first. The engines may then be continued in joint operation or one engine may be started and operated alone, thus providing for wide variation in the rate of aerosol production. Further, the muffling or baffling of the discharge of such an engine to reduce the noise level without objectionably interfering with the delivery of the aerosol is important and is accomplished satisfactorily in the present invention.

It is accordingly the principal object of the invention to provide an aerosol producing device employing a resonant intermittent combustion engine which is quiet and efficient in operation, compact and readily portable, and which may be operated at widely differing rates of output for the dispersing of different types of aerosols.

It is a further object to provide such a device embodying a plurality of resonant intermittent combustion engines only one of which need be started by hand, that engine serving thereafter to initiate the operation of the other engine or engines and to maintain the other such engine or engines in coordinated firing relation with the first engine.

It is also an object to provide for enclosing and insulating such an engine system to retain the heat of the engine and make it available for heating the formulation and further to effect reduction of the noise level produced by the device.

It is also an object to provide for properly baffling or muffling the discharge outlet of the engine while at the

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same time improving the efficiency of operation of the system but without undesirable increase in its size.

Other objects and advantages will be apparent from the following description, the accompanying drawings, and the appended claims.

In the drawings:

Fig. 1 is a vertical sectional view of the device showing an arrangement of the engines within the casing with the exhaust resonator tubes of the engines extending both above and below the combustion chambers thereof;

Fig. 2 is an end elevational view of the device with the access door being shown in the open position;

Fig. 3 is a fragmentary detail view showing the construction of the casing and the enclosing of the insulating material;

Fig. 4 is a somewhat schematic view in perspective showing the essential parts of the system including the fuel and formulation supply and the starting means, the engines in this case having their exhaust tubes extending primarily above the combustion chamber portions thereof;

Fig. 5 is a detail horizontal sectional view through the combustion chamber zones of the two engines showing the valve for establishing communication between the engines;

Fig. 6 is a detail view of the slide valve and its operating mechanism for controlling such communication;

Figs. 7 to 9 are perspective views showing different forms of delivery outlets from the rear or discharge end of the device;

Fig. 10 is a further modified form of outlet in which the outer casing is provided with insulating material; and

Fig. 11 is a partial view in perspective showing a dual engine assembly with separate discharge outlets from their respective exhaust tubes.

Referring to the drawings which illustrate preferred embodiments of the invention, the device is mounted upon a pair of side frame members 10, 11 which stand vertically and which are spaced apart by bracing members 12, 13. The side members are preferably tubular in construction and of sufficient extent to form a protective guard for the entire device as well as a base upon which it is supported.

The engine is enclosed in major part within a casing 20 of heat resistant metal such as stainless steel or Inconel the main body of which is cylindrical in shape and supported by brackets 21 carried on the side frames 10 and 11, defining an internal chamber 22 which may be referred to as a primary muffler chamber and in which the major portions of the engine tubes are wholly contained. The plate 23 closes the front of the casing and serves as a mounting or support for the engines which thus have the major portions of their combustion chambers and all of their exhaust resonator tubes within the muffler chamber. The entire casing 20 is enclosed within and spaced from an outer cover or shell 25, the spacing between being filled by insulating material 26. Such material is both heat and sound insulating and may be glass fiber or the like, the outer cylindrical cover being either steel or sheet aluminum. The rearward end of the cover carries a finishing ring 23 which has a clearance from the end of the casing as shown in Fig. 3.

The cover member 25 extends forwardly beyond the casing 20 as shown at 30 and intake housing 31 is secured thereto, this housing also having a body of similar insulating material 32 held in place by an open mesh annular screen 33 leaving an open inlet chamber or manifold 34 the inner end of which is closed by plate 35. The outer cover 25 is secured in place by being bolted as shown at 36 to this plate 35, and the space between outer plate 35 and inner plate 23 is filled with insulation. A cover 37 similarly double walled and insulated is mounted on a hinge 38 and adapted to swing to open position as

shown in Fig. 2 when access to the engines is desired for starting or control thereof, the insulation serving to reduce objectionable noise from the inlet ends of the engines during operation. The bottom wall of the chamber is provided with perforations 39 through which the fuel lines and combustion air are introduced for engine operation and this space is preferably filled with steel wool serving both as an air cleaner and a silencer.

The engines are preferably two in number and are mounted in side by side relation on the front end plate 23 of the engine chamber 22. Each engine as shown in Fig. 5, has an inlet head 40 into which the fuel is introduced by means of fuel line 41. Each engine embodies also a combustion chamber 42 within which there is mounted the inlet valve 43 which operates automatically under the resonant intermittent combustion action of the system. At the end of the combustion chamber, each engine has an elongated exhaust tube 45 which is curved back and forth upon itself, as shown, the entire system so formed being resonant in gases. One of the engines, the left-hand one shown in Figs. 1 and 5, in addition has a spark plug 46 and a tube 47 for the supply of air under pressure for starting. Such engines are described in more detail in applicant's copending applications, Serial No. 174,498, filed July 18, 1950, now Patent No. 2,715,390, Serial No. 111,308, filed August 19, 1949, and Serial No. 202,668, filed December 26, 1950, now Patent No. 2,738,334.

To provide for the starting of the right-hand engine after the left-hand engine is operating, a short connecting passage 50 is provided in direct communication with the combustion chambers of each engine and extending generally at right angles thereto. A controllable valve generally designed as 51 in the form of a valve plate 51a is mounted for sliding in a casing 52 to open or close the passage 50 and is connected through link 53 to a hand lever 54 which has a toggle spring 55 tending to retain the plate in either of two positions. In the position shown in Fig. 6 the lever is down and the plate 51 closes the passage 50 between the two engines. Upon raising handle 54 the valve plate 51a is withdrawn and communication between the two engines is established.

The exhaust resonator tubes 45 of the two engines are relatively long and are preferably curved back upon themselves a number of times within the muffler or engine chamber 22, in order to make the device more compact and also to confine in a limited space the heat developed during operation. As shown in Fig. 1 the exhaust tube 45 from the nearest engine extends rearwardly, then curves upwardly as shown at 61, forwardly at 62, then downwardly at 63, rearwardly at 64 and forwardly again at 65 to a common outlet fitting indicated partially in dotted lines at 66. The tube of the other engine is curved in a corresponding pattern but extends primarily below the plane of the combustion chambers of the engine and likewise opens into the common discharge fitting 66.

In the schematic arrangement shown in Fig. 4 the discharge tubes of both engines extend above the plane of the combustion chambers thereof but have the same relative configuration and similarly open into the same common discharge fitting. In both cases the outlet from such discharge fitting opens forwardly or toward the right, i. e., away from the rear of the casing through which the mixture of combustion gases and formulation is to be discharged.

The rear end of the muffler chamber is preferably formed with a belled wall 70 secured around its periphery to the end of the casing 20, and spaced therefrom there is an outer wall 72 forming a secondary discharge or muffler chamber 73. Openings or passages are provided through the wall 70 by means of a plurality of tubes 75 mounted thereon and having a series of apertures 76 within the primary muffler chamber 22 and a corresponding series of apertures 77 within the secondary discharge chamber 73, the ends of such tubes being closed.

The rear cover plate 72 likewise has a number of open-

ings therethrough provided with short nozzles 78 having streamlined entrances 79 by means of which they are secured in place on such plate.

It will be evident by reference to the arrangement shown in Fig. 1 that the engine discharge from the common fitting 66 is directed forwardly and that the discharged mixture of combustion gases and formulation must therefore reverse its direction of flow and in so doing flow past the curved tubes of the engine. It then enters the apertures 76 in the tube 75 none of which is directly in line with nor closely adjacent the outlet 66, and is discharged from apertures 77 into the secondary baffling or muffling discharge chamber 73. Thereafter it flows out of the nozzles 78, none of which is in direct alignment with the openings from the chamber 22 so that a disconnected discharge path is provided which baffles and reduces the noise of operation. With this arrangement the temperatures within both the primary and secondary muffler chambers are kept sufficiently high to prevent premature condensation of the material within the chamber. The partially vaporized formulation from the outlet 66 is further vaporized by exposure to heat from the engine tube members within the muffled chamber. At the same time this further vaporization tends to cool the engine tubes and surrounding structure, in order to maintain them at a desirable temperature.

Referring to the schematic showing in Fig. 4 the means is shown for supplying the fuel and starting air to the engines as well as for introducing the formulation. As described only the left-hand engine is manually started and for this purpose a hand pump 80 is pivotally mounted within the frame and arranged to be tilted outwardly to the position shown in dotted lines in Fig. 2 for operation. Its discharge is connected to an air line 81 leading to a three-way valve 82. Before starting, this valve is turned to supply air through line 83, and line 85 to the fuel tank 86 located beneath the casing and directly upon the base of the supporting frame. The fuel tank has a filling opening 88 projecting upwardly at one side thereof and is equipped with a pressure cap 89.

After some pressure has been developed within the tank as indicated on gage 90 connected into the tank by means of line 91, fuel flows from the tank through tube 94, strainer 95 and fuel line 96 to a float chamber 97. Valve 82 is then turned to connect the pump through line 93 with the starting air tube 47. Additional operation of the pump causes air to be blown through the starting tube 47 which draws fuel from the float chamber through shut off cock 100 which has been opened, thereby supplying fuel through the fuel inlet tube 41 into only the left-hand or first engine. The spark plug is energized from a battery operated vibrator type spark coil indicated at 103, controlled by toggle switch 104, all as more fully described in said copending applications.

The valve 51 meanwhile is closed so that the combustion chamber 42 of the first engine is closed off from the combustion chamber of the second engine in order to permit independent starting and operation. Immediately upon the starting of the first engine, the valve control 54 may if desired be raised to the upper position, opening communication with the chamber of the right-hand engine through passage 50 and if the fuel shut off cock 101 for that engine has been opened, it likewise will begin operation, the valve 51 remaining in open position throughout and the engines thus operating in maintained coordinated resonant firing relation with each other.

The system operates effectively where the two engines have separate exhaust tubes 45 each having its own separate discharge outlet 66a, as indicated in Fig. 11. However the provision of the common exhaust as shown in Fig. 4 in combination with the connecting passage 50 has been found to contribute to the ease and reliability of starting of the second engine and its operation in coordinated and resonant relation with the first. The engines operate at

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substantially the same frequency but in different phase relation, that is, firing alternately or approximately 180° out of phase, and thus their operation may be considered as being isochronous without being synchronous. The opening of the connection 50 contributes to the starting of the pulsating flow of gases in the second engine, and also contributes to initiating combustion in the second engine by virtue of the flow of high temperature combustion gases from the first to the second engine. The back and forth flow of the combustion gases through the connection after the second engine is started aids in maintaining the operation of the two engines in coordinated firing relation.

As soon as either or both of the engines are in operation, pressure is supplied from the respective combustion chambers through pickup lines 110 to pressurizing valves 111, 112 such as described in said copending applications, the function of which is to establish a source of continuing pressure higher than the mean combustion chamber pressure. Such higher pressure is supplied through lines 115 and measured on gage 116, being transmitted through filter 117 and pressure regulator 118, and through line 120 from which it travels through the check valve 121 to provide and maintain a desired operating pressure within the fuel tank to cause the continuing delivery of fuel to the engines. Thus as soon as one of the engines is in operation, the operation of the spark plug as well as the hand pump may be discontinued and the engine will develop its own pressure source for fuel supply.

A branch connection 125 from the source of higher pressure extends through a fitting 126 and is transmitted into the container 127 which may be in the form of a drum holding the formulation, such for example as a heavy oil with or without additional suspended or dissolved materials as may be desired for producing a particular type of aerosol. The engine thus develops a pressure within the drum, forcing the formulation out through line 130 and it is thus delivered to a three-way valve 131 by means of which it may be quickly turned on and off as desired to control the supply to either or both engines. Separate pipes 132, 133 each controlled by a manual valve 134 provide for delivery of the formulation separately and at a desired rate through nozzle pipes 136, 137 directly into the exhaust tubes 45 of the engines preferably well ahead of the discharge outlet thereof. The formulation is finely atomized by the action of the high velocity pulsating gas flow within the exhaust tubes and heat is transferred from the high temperature gases to the atomized particles, intermixture of the particles with the heated gases being aided by the violent pulsating nature of the gas flow. In a typical device in which the exhaust tubes were 84 inches in length, the pipes for introducing the formulation were 40 inches upstream or ahead of the exhaust outlet. In this connection it is usually found more desirable to arrange the curved portions of the exhaust tubes, and particularly the part into which the formulation is introduced, at a level the same as or below that of the main combustion chamber portion thereof, thus avoiding any dripping or return flow of the formulation into the combustion chamber after the engine has been stopped.

Not only may the rate of flow to a single engine be varied by means of the control valve 134, but the capacity of the system may be increased by the use of the second engine when a larger rate of flow is desired. In this way when a small rate of aerosol production is desired, only one engine is utilized and a high efficiency of operation is obtained by maintaining an adequate rate of flow of the formulation. In the absence of the provision for the selected use of a number of engines, low efficiency of operation and inefficient utilization of the formulation would be involved except at high operating capacity.

Figs. 7, 8 and 9 show modified forms of the end plate construction 72, the arrangement of Fig. 7 embodying nine openings 140 of substantial size. In the form shown

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in Fig. 8 a much larger number of smaller diameter openings 142 is shown and in Fig. 9 an auxiliary projecting member 145 having perforations 146 is mounted upon one portion of the end wall 72.

Likewise the end wall 72 may have an outer shell 150 spaced therefrom with the space between being filled with insulating material 152 through which the tubular nozzle members 153 extend. Such insulation additionally serves to reduce objectionable noise in the operation of the device and prevent loss of heat.

As a specific example a device of the present invention employs two jet engines each having a combustion chamber 4 inches in diameter and 11 inches in length up to the reducing section and with the exhaust resonator tube thereof having a length of 84 inches and a diameter of 2 inches, the internal dimensions of the primary discharge chamber 22 being about 15½ inches in diameter and having a length from the front plate 23 to the center of wall 70 of 28½ inches. Operating continuously these engines resulted in the attainment of a "dry" aerosol stable operating condition at the rate of 90 to 100 gallons of formulation per hour, the consumption of gasoline when operating at this rate by the two engines being 7 gallons per hour. The engines are also capable of operating on diesel and other types of fuel instead of gasoline and with various types of formulation material.

While the forms of apparatus herein described constitute preferred embodiments of the invention, it is to be understood that the invention is not limited to these precise forms of apparatus, and that changes may be made therein without departing from the scope of the invention which is defined in the appended claims.

What is claimed is:

1. An aerosol generating device comprising a casing, heat and sound insulating means enclosing the main body of said casing, a resonant intermittent combustion engine having its major portion including at least a part of its combustion chamber and the entire extent of its exhaust resonator tube within said casing, a discharge passage in the rear wall of said casing in spaced and disconnected relation with said discharge outlet from said exhaust resonator tube, and means for introducing a formulation into said exhaust resonator tube of said engine for discharge through said outlet and for deflected flow through the interior of said casing in heat transferring relation with the engine therein before delivery from said outlet passage.

2. An aerosol generating device comprising a supporting frame, an enclosing casing mounted on said frame, a resonant intermittent combustion engine mounted on a wall of said casing, said casing having a rear enclosing wall, said engine having an exhaust resonator tube with a discharge outlet having its opening spaced from said rear wall, a discharge passage extending through said rear wall in disconnected relation with said discharge outlet, and means for introducing a formulation into said exhaust resonator tube of said engine for delivery thereof from said exhaust tube into said casing and thence in heat transferring relation with the outer surface of said exhaust resonator tube before delivery outward through said passage.

3. An aerosol generating device comprising a supporting frame, an enclosing casing mounted on said frame forming a muffler chamber, a resonant intermittent combustion engine a major portion of which is mounted entirely within said muffler chamber, said casing having a rear enclosing wall, said engine having an exhaust resonator tube in said chamber with a discharge outlet having its opening spaced from said rear wall, a plurality of discharge passages extending through said rear wall, and means for introducing a formulation into said exhaust resonator tube of said engine for delivery thereof from said exhaust resonator tube and outward flow through said passages.

4. An aerosol generating device comprising a support-

ing frame, an enclosing casing mounted on said frame forming a muffler chamber, means defining a separate inlet chamber, a resonant intermittent combustion engine having its inlet in said inlet chamber and a combustion chamber and exhaust resonator tube in said muffler chamber, means for insulating said muffler and inlet chambers, a door providing access to said inlet chamber, said casing having a rear enclosing wall, a passage extending through said rear wall and spaced from the discharge outlet of said exhaust resonator tube, and means for introducing a formulation into said exhaust resonator tube for discharge therefrom and outward flow thereof through said passage.

5. An aerosol generating device comprising an outer enclosing casing, insulating material enclosing said casing and forming a muffler chamber, a pair of resonant intermittent combustion engines having a major portion thereof within said muffler chamber, means for operating said engines singly and together, separate means for introducing a formulation into each of said engines for discharge thereof from the exhaust end of said engines, and means for discharging said formulation from the interior of said casing in a finely divided state.

6. An aerosol generating device comprising an outer enclosing casing, insulating material enclosing said casing and forming a muffler chamber, a pair of resonant intermittent combustion engines having a major portion thereof within said muffler chamber, means for operating said engines singly and together, separate means for introducing a formulation into each of said engines for discharge thereof from the exhaust end of said engines, and means for discharging said formulation from the interior of said casing including a pair of spaced apart walls, and separate means forming disconnected passages through each of said walls.

7. An aerosol generating device comprising an outer enclosing casing defining a primary muffler chamber, insulating material enclosing said casing, a pair of resonant intermittent combustion engines in heat transferring relation within said muffler chamber, means for operating said engines singly and together, separate means for introducing a formulation into each of said engines for discharge thereof from the exhaust end of said engines, means for discharging said formulation from the interior of said casing including a rear wall enclosing said primary muffler chamber, an outer plate defining a secondary muffler chamber, and separate means forming a plurality of disconnected spaced apart passages through said respective walls.

8. An aerosol generating device comprising an outer enclosing casing, insulating material enclosing said casing and forming a muffler chamber, a pair of resonant intermittent combustion engines within said muffler chamber, means for operating said engines singly and together, separate means for introducing a formulation into each of said engines for discharge thereof from the exhaust end of said engines, and means for discharging said formulation from the interior of said casing including a pair of spaced apart walls, separate means forming disconnected passages through each of said walls, and additional insulating means on one of said walls for reducing heat loss from said muffler chamber.

9. An aerosol generating device comprising a supporting frame, an enclosing casing mounted on said frame forming a muffler chamber, a resonant intermittent combustion engine having a major portion thereof entirely within said muffler chamber, said casing having a rear enclosing wall, said engine having an exhaust resonator tube with a discharge outlet having its opening spaced from said rear wall, a discharge passage extending through said rear wall, means for introducing a formulation into said exhaust resonator tube of said engine for delivery thereof from said tube and outward flow through said passage, said engine having an inlet for fuel and air, a closure for said inlet defining an inlet chamber, said closure incorporating insulating means to reduce ob-

jectionable noise from said inlet during the operation of said engine.

10. In a device of the character described, an engine system comprising a plurality of resonant intermittent combustion engines each forming a system resonant in gases and having a combustion chamber, an exhaust resonator tube, an intake valve and a fuel supply, means connected with a first said engine for starting that engine, a connection between the combustion chambers of a pair of said engines, a common discharge outlet for the exhaust resonator tubes of said engines, and a valve member in said connection closable to provide for maintaining resonance in the resonant system of said first engine and for the starting of said first engine and openable while said first engine is in operation providing for the starting of the other said engine and maintaining said other engine in coordinated firing relation with said first engine.

11. In a device of the character described, a resonant intermittent combustion engine system comprising a pair of engines arranged adjacent each other, each said engine including an intake valve, a combustion chamber and an elongated exhaust resonator tube forming a system resonant in gases, the discharge ends of said exhaust resonator tubes being connected to a common discharge outlet, a connecting passage extending from one of said combustion chambers to the other, and controllable means for closing said passage to maintain resonance in the system of one of said engines to enable the starting of one of said engines independently of the other said engine and for thereafter opening said passage to automatically start the other of said engines.

12. In a device of the character described, a resonant intermittent combustion engine system comprising a pair of engines arranged adjacent each other, an insulated casing forming a muffler chamber enclosing the major portion of both said engines, each said engine including an intake valve, a combustion chamber and an elongated exhaust resonator tube forming a system resonant in gases, the discharge ends of said exhaust resonator tubes being connected to a common discharge outlet, a connecting passage extending from one of said combustion chambers to the other, controllable means for closing said passage to enable the starting of one of said engines and for thereafter opening said passage to automatically start the other of said engines and to maintain said other engine in coordinated firing relation with the first said engine, and means for introducing a formulation selectively into one or both of said exhaust resonator tubes for discharge thereof in finely dispersed form from said outlet.

13. In a device of the character described, a resonant intermittent combustion engine comprising a pair of engines arranged adjacent each other, an insulated casing forming a muffler chamber enclosing the major portion of both said engines, each said engine including an intake valve, a combustion chamber and an elongated exhaust resonator tube forming a system resonant in gases, the discharge ends of said exhaust resonator tubes being connected to a common discharge outlet, a connecting passage extending from one of said combustion chambers to the other, controllable means for closing said passage to enable the starting of one of said engines and for thereafter opening said passage to automatically start the other of said engines, and means for introducing a formulation into said exhaust resonator tubes for discharge thereof in finely dispersed form into said casing surrounding said tubes and for discharge therefrom.

14. In a device of the character described, a resonant intermittent combustion engine system comprising a pair of engines arranged adjacent each other, each said engine including an intake valve, a combustion chamber and an elongated exhaust resonator tube forming a system resonant in gases, the discharge ends of said exhaust resonator tubes being connected to a common discharge outlet opening in a forward direction, a connecting passage extending from one of said combustion chambers to

the other, controllable means for closing said passage to enable the starting of one of said engines and for there-
after opening said passage to automatically start the other
of said engines and to maintain said other engine in co-
ordinated firing relation with said one engine, means for
introducing a formulation into said exhaust resonator
tubes for discharge thereof in finely divided form from
said outlet, a casing enclosing engine system and said
outlet, and means forming a rearwardly facing discharge
passage in said casing for discharge of said formulation
from the rear thereof.

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