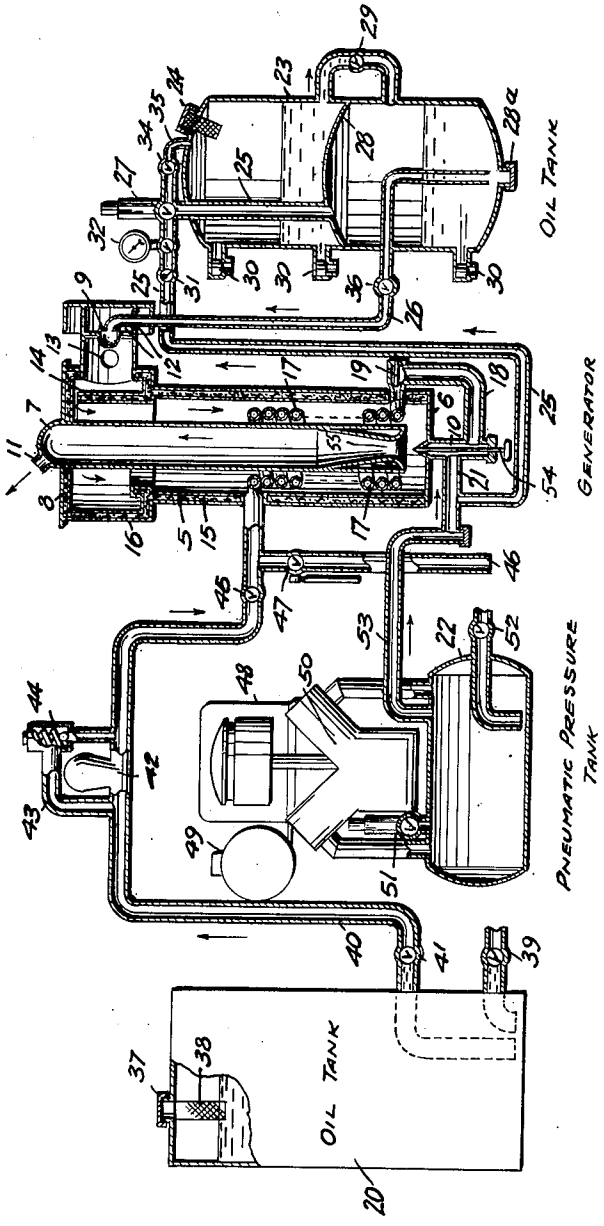
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AEROSOL GENERATOR

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AEROSOL GENERATOR

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The invention described herein may be manufactured and used by or for the Government, for governmental purposes, without the payment to us of any royalty thereon.

This invention relates particularly to a method and apparatus for producing a white smoke-like aerosol of an oil.

The production of aerosol fog or smoke in large quantities, known militarily as a screening or blanketing smoke, has the purpose of preventing aimed bombing by enemy aircraft and of hiding ground targets from aerial observation.

A number of different methods and apparatus for forming oil smokes and fogs have been tried. They include mainly: (1) incomplete combustion of a smoke producing oil; (2) vaporizing a fog oil in a boiler by indirect heat exchange; (3) spraying a fog-producing oil against a heated surface for evaporation; and (4) vaporizing of a fog-producing oil with steam. The first method was one of the earliest and had the disadvantage of giving a grey or black smoke of low obscuring power with high oil consumption. Of all the prior methods, the one involving vaporization with steam in an apparatus known as a mechanical smoke generator was the most successful. In the mechanical smoke generator, water is pumped through a steam generating coil, a stream of relatively cooler oil is dispersed by an injector into the steam leaving the coil, and the oil-steam mixture is further heated in a coil from which a resulting vapor mixture is emitted through orifices into the air. Although the mechanical generator efficiently makes a good smoke, it is somewhat cumbersome with a large amount of machinery requiring attention and experience in operation, is slow in starting, and requires the carrying of large amounts of equipment and material, including a pump capable of delivering liquid at pressures up to 140 lbs. gage and pure soft water.

An object of this invention is to provide a method and apparatus for generating an oil fog or smoke aerosol using hot combustion or flue gas to vaporize a spray of fog-forming oil with such improvements in design as to make the apparatus light in weight, simple in manufacture and operation, quick in starting and efficient, also, to give other advantages as the need arises.

A characterizing feature of a type of smoke generator designed to accomplish the objects of this invention resides in atomization of a fog-producing oil by gas under pressure, as in an airbrush similar to that used in paint spraying, into the bottom of a vertical vaporization and

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exhaust duct that is externally heated so that the atomized oil is rapidly vaporized in a steam of hot flue gas passing through the duct. Compressed gas used for the atomization is easily supplied by a small air compressor unit or compressed gas tank and provides the following additional valuable effects: (1) induced draft on the oil burner producing the flue gas to hasten starting; (2) a required suitable high velocity in the exhaust duct to prevent ignition of the fog oil spray or its vapors and carbonization: (3) sufficient pressure in the exhaust duct to give a high vapor emission velocity from the exhaust duct so as to obtain optimum fog particle size; and (4) improved vaporization temperature control to reduce cracking and decomposition of the fog oil. Besides giving these desired effects, the use of a compressed gas may be made advantageously with modification of the apparatus for feeding the fog-producing oil, fuel, or any other liquid in the system with the elimination of pumps and other moving mechanical parts.

A smoke generator designed according to the principles of the present invention is practically independent of climatic conditions and may dispense with the use of water, which adds to the transportation problem and gives great difficulty of freezing in cold climates.

For showing how the objects and advantages mentioned, also, others which wil become apparent, are attained, the invention will be described in detail with reference to the accompanying drawing, in which is illustrated diagrammatically a flow plan view of one practical embodiment of the aerosol or smoke generator unit.

The aerosol unit illustrated comprises 3 subassemblies: (1) an aerosol generator connected to a fuel oil tank, (2) a fog oil tank, and (3) a gasoline driven air compressor and fog oil pump.

Briefly, the aerosol generator comprises, in general, an outer shell or body 5 having a bottom closure 6, an inner shell or exhaust duct 7 suspended within and spaced from said outer shell 5, a top closure 8 for the outer shell surrounding said inner shell 7, a fuel oil burner 9 disposed near the top of the outer shell 5 for producing hot combustion gases passed in a stream between the inner shell 7 and the outer shell 5 thence exhausted through the inner shell 7, and atomizing means 10 extending through the bottom closure 6 of the outer shell 5 for centrally spraying a fog-producing oil into the

combustion gases as they enter the bottom opening of the inner shell 7.

The outlet 11 of the inner shell or exhaust tube 7 is one or more small vent holes or emission slots for discharging fog oil vapors mixed with gases in constricted streams at high velocity with reduction in pressure to atmospheric air surrounding the apparatus.

Primary air is admitted to the combustion zone of burner 9 through an opening 12, and a hole 13 is provided for insertion of a lighting tube or igniter, which may be an electrical igniter or simply a match to start the burning of fuel oil injected from burner nozzle 9. A baffle wall 14, or similar shield between the burner 9 and the exhaust tube 7, is desirable to prevent direct impingement of hot flame from the burner on the exhaust tube. The baffle or shield may completely or partly surround the exhaust tube 7 to avoid hot spots on the exhaust tube and should be spaced from the exhaust tube 7 to provide a passageway for hot flue gas to the annular space between the exhaust tube 7 and the outer shell 5 down to the inlet at the bottom of the exhaust tube 7 for effecting even heat distribution around the exhaust tube 7.

For conservation of heat, the outer shell 5 of the generator may be covered with insulation 15 and with an outer jacket 16.

In order to improve atomization of a normally viscous fog oil and accommodate for various climatic conditions, a preheating coil or heat exchange means 17 is located in the lower part of the annular space between outer shell 5 and the exhaust tube 7 for preheating the fog oil. The fog oil passed through the preheating coil 17 abstracts heat by indirect heat exchange from the hot flue gas in the down draft stream after the hot flue gas has imparted some of its heat to contents in the upper part of exhaust tube 7 by indirect heat exchange. The outlet end of preheating coil 17 may be connected to atomizer 10 by pipe 18 through an automatic, thermostatic, or simply a manually controlled valve 19. A suitable thermostatic valve for this purpose is responsive to high temperatures, e. g., about 400–500° F., so that the valve gradually opens with increasing oil temperature to deliver the heated oil under pressure to the atomizer 10 through pipe 18. The valve opening can be limited to a degree at which a good white smoke is produced. Preheated fog oil is thus supplied to the atomizer 10 from supply tank 20 and compressed air or other compressed gas suitably unreactive with the fog oil under conditions existing in the exhaust tube 17 is supplied from any available source to atomizer 10 through pipe 21 as from compressed air tank 22.

The fuel oil tank 23 may simply be provided with a cap 24, an air supply line 25, an oil line 26 to the burner 9, a safety pressure relief valve 27, and a clean-out drain plug 28a. For smoother operation, the tank 23 is divided into two compartments by a central partition 28. A substantially constant head of oil is maintained in the lower compartment by manipulating the divider valve 29, which controls the flow from the upper compartment. A series of pet cocks 30 at different levels of the tank may be used for draining and testing for liquid levels. The air inlet line 25 may be provided with a check valve 31, a pressure gauge 32, the pressure relief valve 27, and the hand valve 34 on the bypass 35 to the upper compartment. The oil is sent from the lower compartment of tank 23 under air or gas pressure to the burner nozzle 9 through pipe 26 controlled by the outlet valve 36.

Although one oil tank is sufficient for supplying an oil to be used both in the burner for making the hot combustion gases and in the atomizer as a fog oil, particularly if the unit is to be made light in weight and is to be used for small scale operations, for units which are to be carried on a truck and used for large scale operations, it is technically advantageous and more economical to have a separate tank for special fog oil with a lower grade fuel oil in a fuel oil tank for burning.

The fog oil tank 20 may simply comprise a filler cap 37 with a screen 38, a drain valve 39, and an outlet line 40 to the generator.

For controlling the flow of fog oil from tank 20, the pipe 40 may be provided with a valve 41, a pump 42, a pump by-pass 43 with a pressure regulator 44, a pump outlet valve 45, and a vent line 46 with valve 47. The supply line 40 from the fog oil tank passes the fog oil to the heat exchange coil 17, from which the heated oil is finally passed to the atomizer 10.

A commercial type of gasoline engine driven air compressor may be assembled with the unit for supplying compressed air. As conventionally shown in the drawing, the air compressor comprises a gasoline engine 48 with gasoline supply tank 49, compressor 50, safety pressure relief valve 51, air tank 22, tank discharge valve 52, and distributing line 53. An air strainer may be placed in the compressed air supply or distributing line for removing dirt or other contaminants. The distributing line 53 is joined to pipe 25 which conducts compressed air to the fuel oil tank 23 and also is connected to line 21 leading to the atomizer 10. The pump 42 may be driven by the air compressor engine 48.

The atomizer 10 may simply comprise a nozzle with inlets for the fog oil and compressed air or gas and having a needle valve 54 for adjusting the atomizer. The nozzle is positioned to spray the oil centrally and vertically into the exhaust tube 7.

For operation, compressed air or an equivalent compressed gas, such as, nitrogen or carbon dioxide, is supplied to one or more oil tanks from which fog oil and/or fuel oil are obtained. Air is admitted from injector 10 as soon as burner 9 is lit to provide induced draft for the burner. When temperatures are sufficiently high for vaporization of fog oil sprayed into the exhaust tube 7, valve 19 is gradually opened so that the fog oil preheated to about 400–500° F. in coil 17 becomes sprayed into the exhaust tube 7 where the spray becomes mixed with hot flue gas which has passed over the preheating coil 17. The oil flow through the coil 17 is regulated by valves 45 and 19, and the hot oil is supplied to the atomizer simultaneously with compressed air from line 21. The oil spray is vaporized in the exhaust tube 7, and the oil vapors mixed with the flue gas and air are emitted through discharge opening 11 to the atmosphere, where the oil vapors become condensed to produce a white smoke-like cloud.

The exhaust tube 7 is preferably constructed of a suitable heat resisting material, e. g. ceramic or steel alloy, light in weight, and formed to provide a Venturi jet effect with the atomizer 10 for increasing the velocity of the gases into the exhaust tube to obtain more favorable particle size, better heat transfer between the atomized oil and

hot flue gas, and, also, to make the velocity of the gases greater than the rate of flame propagation so that the burner flame is extinguished where the hot flue gas enters the exhaust tube 7.

The atomizer 10 in coaxial alignment with the exhaust tube 7 injects the atomized fog oil centrally through the Venturi throat 55 of the exhaust tube 7, and the flue gas is induced to flow by the jet effect of the sprayed fog oil and compressed gas into the throat 55. The atomized oil becomes vaporized almost instantaneously after entering the exhaust tube in what may be considered as a vaporizing zone and does not substantially contact the heated wall of the exhaust tube 7. For satisfactory operation, the temperatures and proportions of the fog oil and compressed air passed from the atomizer and of the flue gas entering the vaporizing zone in exhaust tube 7 should be such that the oil is not subjected to decomposition prior to vaporization in the vaporizing zone. There may be some cooling effect when the gases and spray jet through the Venturi throat 55 becomes rapidly expanded but there is not sufficient reduction in temperature to prevent rapid vaporization of the atomized oil. The atomizer may be constructed to have an automatic valve control in conjunction with a thermal element in a preheating coil so that the atomizer operates to spray the fog oil when the fog oil temperature in the preheating coil 17 reaches a desired point, such as about 250° C.

It has been determined that a particle size of about 0.6 micron diameter provides optimum screening power. The approximate particle size of the dispersed oil can be determined by observing the color of the sun viewed through the smoke. Favorable particle size is obtained when the sun color ranges from a deep orange to red.

In producing the oil fogs with the generator of this invention, a jet of oil vapors is discharged into the atmosphere to undergo rapid condensation. The generator operates at highest efficiency in producing a white smoke-like fog, the efficiency being measured by the amount of oil used to substantially obscure an object.

Various fog-producing oils may be used, but in selecting the oil, consideration is given to the availability and the ease of handling, tendencies of the smoke to be toxic or injurious to equipment, and the property of the oil with respect to vaporization, carboniization, pour points, and the stability or persistency of the aerosol dispersion.

Of the oils considered, petroleum oils were selected as the most suitable. Oleic acid gives a persistent fog but with rancid odor. Fuel oils do not give a very persistent smoke. Petroleum oils having characteristics of light lubricating oils with mid-boiling points of about 750–800° F. at atmospheric pressure prove satisfactory.

A petroleum oil known as Diol 55 was efficiently used. It is a distilled lubricating oil cut with a minimum flash point of about 385° F., a low pour point, a substantially negligible carbon residue, and a mid-boiling point of about 780° F. Analysis of condensed vapor samples and odor of smoke from this oil indicates that very little cracking takes place in the exhaust tube. The vaporization of the sprayed oil is almost instantaneous, and any small amount of cracking which may take place occurs where the atomized oil strikes the hot side walls of the exhaust tube does not affect the efficiency of the generator. Flue gas analysis shows that very little oxygen in excess air supplied to the burner and in the air used for atomization undergoes combustion in the exhaust tube.

Although the generator operates satisfactorily without the use of water or steam with advantages that are readily appreciated, it may be modified easily to introduce a small amount of steam through an adjustable restriction into the oil fog preheating coil by having a small amount of water fed through a steam coil. By using steam, the vaporization pressure of the fog oil may be reduced, and accordingly, the characteristics of the fog oil may be more varied. A pressure regulator maintained at a set pressure difference across an adjustable valve may be placed in the water feed line to the steam coil so that the water flow to the steam coil is constant regardless of variations in the steam coil pressure.

For the purpose of illustration without limiting the invention, data on a model unit developed in accordance with this invention is given as follows:

Capacity rate	50 gal. fog oil per hr.
Fog-oil tank capacity	110 gal.
Burner nozzle, gal. per hr.	3.5.
Air pressure, lbs. per sq. in.	69.
Fog-oil pressure, lbs. per sq in.	59.
Fog oil temperature, °C.	251.
Color of sun	Orange.

The sub-assemblies were bolted together with shock absorbing rubber pads to reduce vibration. The unit has a total weight of 1,250 pounds without charge and fits a QM 1-ton trailer.

Results from testing the model unit showed that the generator can be started in less than 1 minute. The fuel and fog oil could be fed to the generator with any available compressed gas supply at about 60 lbs. per square inch. The operation of the generator was independent of climatic conditions except that in extremely cold weather, it was desirable to cut the fog oil in viscosity. Ignition of the fog oil vapors in the exhaust tube was avoided.

The described generator unit is adapted to be operated with relatively low tank pressures for flow of fog oil, fuel oil, and even water, if desired, and thus may be provided compressed air or gas, such as nitrogen or carbon dioxide, in cylinders to entirely eliminate moving parts such as pumps, engines, and blowers, or the necessary pressure is readily obtained with a small air compressor unit in the field. The reduction and elimination of moving parts beneficially eliminates mechanical difficulties and reduces the total weight to be carried. For a portable generator, the liquid and gas supply tanks may be equipped with hand pumps which are capable of producing pressures of the order of 60 pounds per sq. in.

The type of generator described, produces screening smokes which are thick voluminous clouds of high obscuring power. Although the oil aerosol formed is strictly speaking a fog produced by vaporization of an oil and condensation of the vapors into very fine droplets; in military parlance it is known as a smoke. Though relatively high temperatures of the order of cracking temperatures of the fog oils are necessary to vaporize the high boiling temperature range oils which form persistent oil fogs, with the type of apparatus described, the vaporization of the fog oils is obtained without substantial cracking, even with little or no steam used for lowering the vaporizing temperature.

Organic dyes, particularly those soluble in the

fog oils, may be added to the fog oils to obtain a colored smoke. The generator has a high efficiency with respect to utilization of heating value of the fuel oil and with respect to the obscuring power obtained from a given quantity of fog oil.

It is to be understood that, though the invention has been described with reference to certain specific embodiments that other modifications come within the spirit and scope thereof.

We claim:

1. In an apparatus for producing an aerosol having a source of vaporizable fluid and a source of flue gases, the improvement comprising a vertically disposed, tubular member having a top closure and a bottom closure, an inner tubular member positioned within and spaced from said first mentioned tubular member, the space between said tubular members being in communication with said source of flue gases, one end of said inner tubular member extending through said top closure, the other end of said inner tubular member having a Venturi-shaped inlet, and a nozzle extending through said bottom closure at a point beneath said inlet and being in communication with said source of vaporizable fluid.

2. In an aerosol generator, the combination comprising an outer tubular member, a closure at each end of said outer tubular member, an inner tubular member positioned within and spaced from said outer tubular member and having one of its ends extending through one end closure and its other end being Venturi-shaped and positioned adjacent to the other end closure, means for supplying vaporizable fluid through

said other end closure, and means for supplying flue gases to the space between said tubular members.

3. In an aerosol generator, the combination comprising an outer tubular member, a closure at each end of said outer tubular member, an inner tubular member positioned within and spaced from said outer tubular member and having one of its ends extending through one end closure and its other end being positioned adjacent to the other end closure, means for supplying vaporizable fluid through said other end closure, said means for supplying vaporizable fluid including a conduit which is in part positioned within the space between said tubular members, and means for supplying flue gases to the space between said tubular members.

4. In an aerosol generator, the combination defined in claim 3 wherein said conduit is coiled about said inner tubular member.

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