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C. A. BONVILLIAN ET AL
 APPARATUS FOR THE PRODUCTION AND DISTRIBUTION OF
 SMOKE, FOG, OR VAPOR CLOUDS

2,581,353

Original Filed June 26, 1943

3 Sheets-Sheet 1.

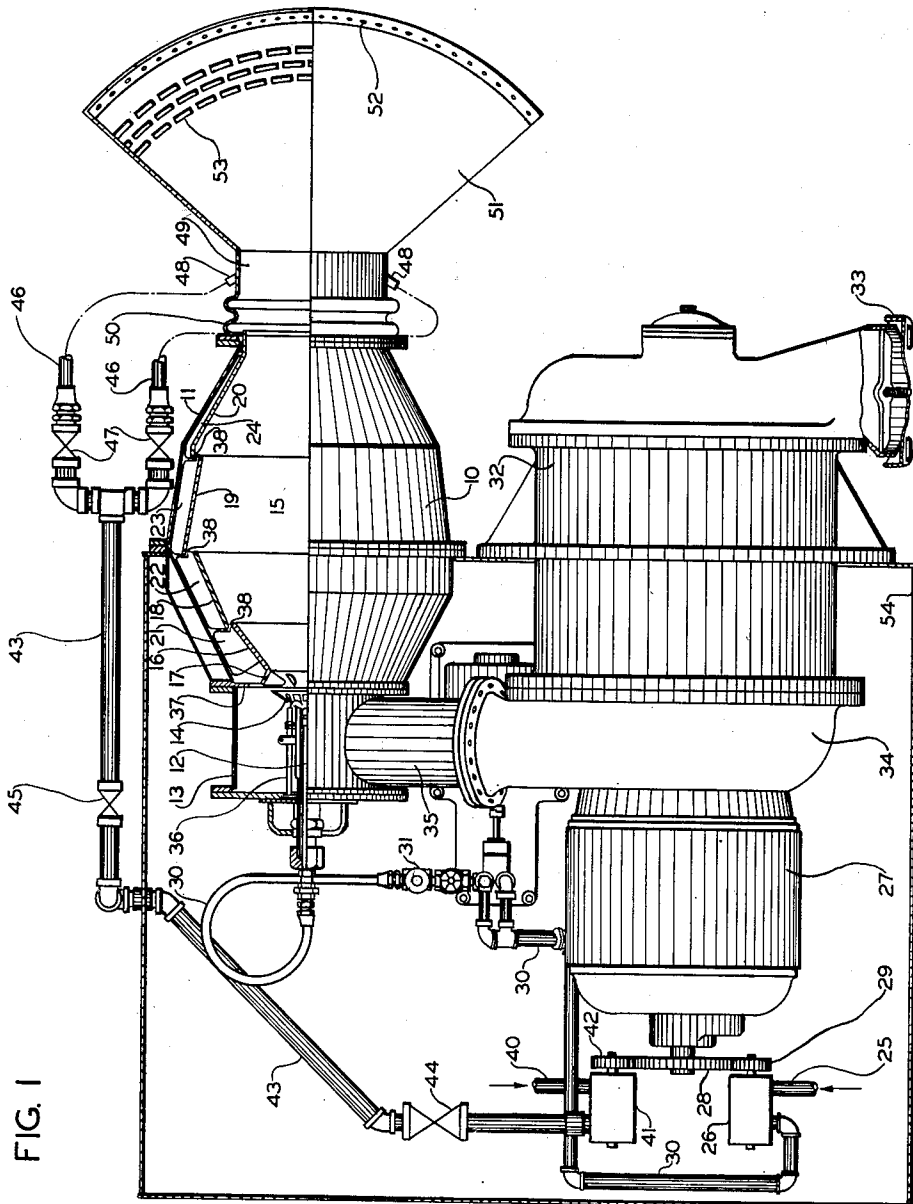


FIG. 1

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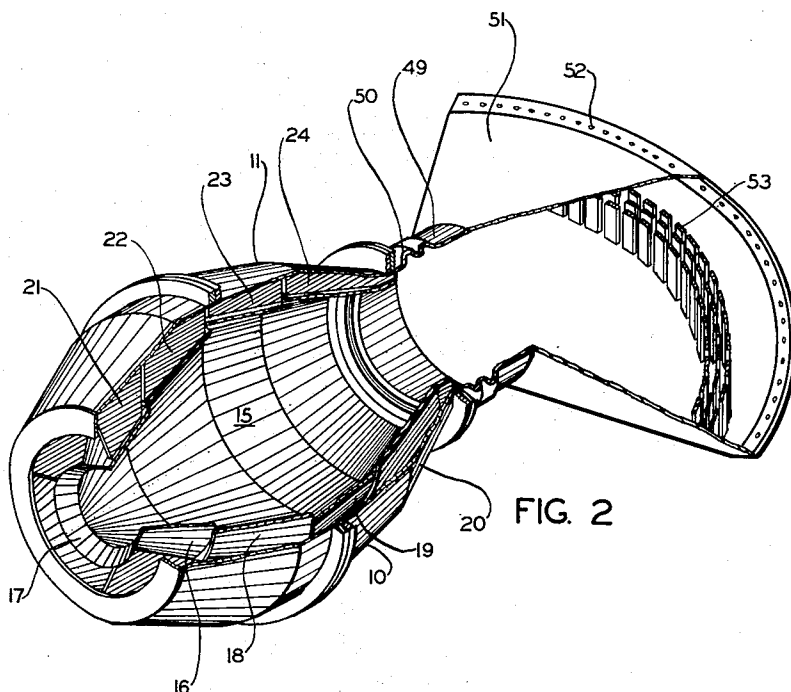


FIG. 2

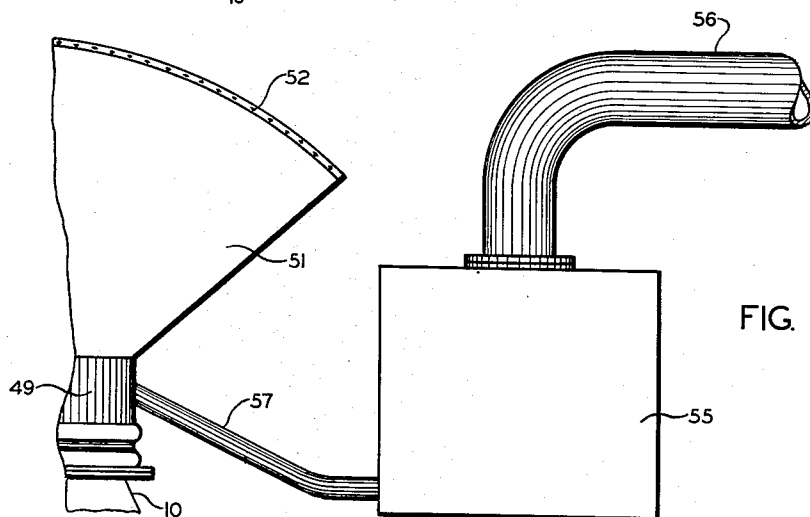


FIG. 3

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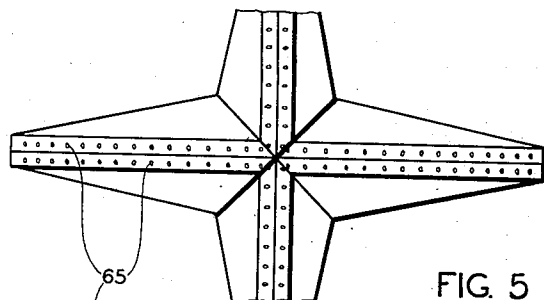


FIG. 5

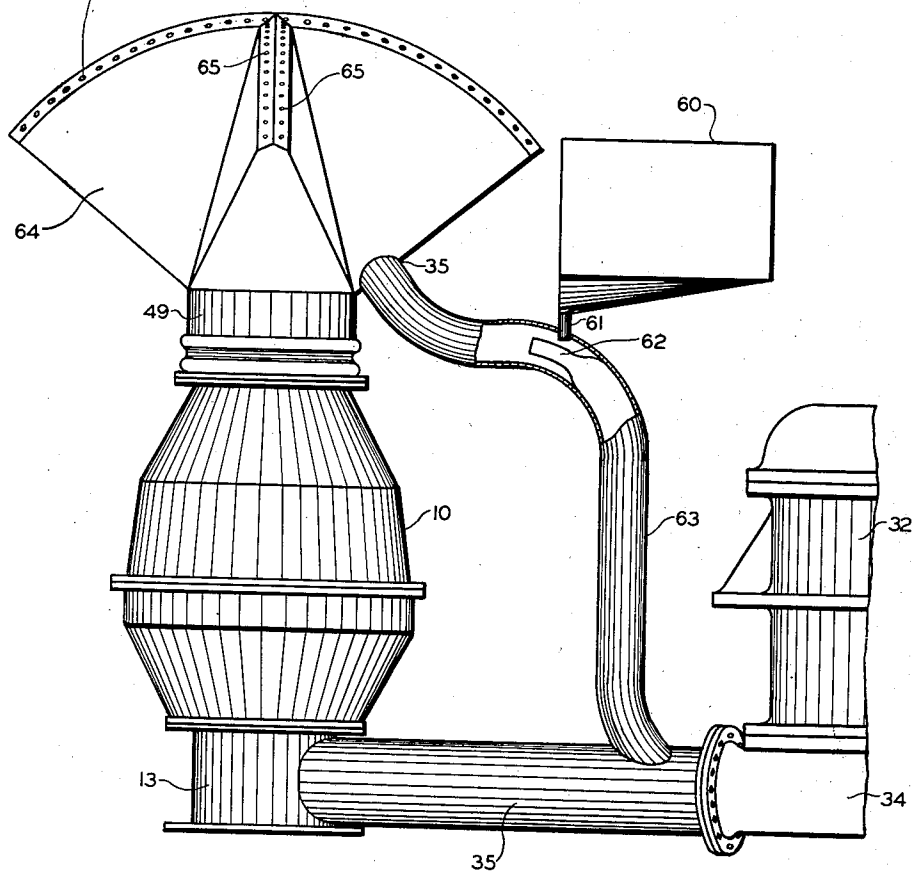


FIG. 4

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UNITED STATES PATENT OFFICE

2,581,353

APPARATUS FOR THE PRODUCTION AND DISTRIBUTION OF SMOKE, FOG, OR VAPOR CLOUDS

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Original application June 26, 1943, Serial No. 492,360. Divided and this application August 29, 1949, Serial No. 113,016. In Great Britain June 26, 1943

10 Claims. (Cl. 158—4)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

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This invention relates to the production of smoke, fog, or vapor clouds for any purpose, such as camouflage, the dispersal of finely divided particles, the dissemination of heat scattering materials to form protective coatings, the poisoning of parasites and the destruction of fungi.

Hitherto smoke makers or fog generators generally have been of the boiler or the internal combustion engine exhaust type. In the boiler type, which requires a furnace and burner as well as the boiler-like device, the smoke producing substance mingles with water or steam, passes through a coil or reservoir in which the smoke or fog making material and water are vaporized and in some instances superheated, and is thereafter emitted from apertures at the end of the coil or at the top of the reservoir. The steam which is produced in the coil and superheated if desired, serves a two fold purpose: it assists in the dispersal of vaporized smoke agent, and it simultaneously prevents carbonization or overheating of the smoke producing substance. In the combustion engine exhaust type, the use of water or steam is unnecessary because the gases in the exhaust conduit seldom, if ever, reach a temperature at which carbonization or decomposition of the smoke producing substance occurs. The products of combustion also act to disperse the vapor or smoke particles and, at the same time, minimize the possibilities of igniting the smoke producing agent in the event it is inflammable.

The present invention provides a novel smoke maker or fog generator for producing smoke or generating fog, which intrinsically possesses a higher efficiency than the types heretofore mentioned and which also possesses the additional advantages of greater compactness, lighter weight, portability, and more nearly instantaneous smoke or fog production, but do not require the use of water or steam, in consequence of which danger of freezing is eliminated. Additionally, satisfactory dispersion of the smoke making particles is obtained, ignition thereof is precluded, and firebrick or other refractories are not required.

Apparatus embodying the invention consists essentially of a furnace fitted with appurtenances to obtain satisfactory dispersion of the smoke or fog making particles and to preclude ignition of the smoke making substance, and accessories for delivering the fuel and smoke making substance to the furnace. A furnace suitable for the purpose is disclosed in our application Serial No. 479,010, filed March 13, 1943, (now Patent No.

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2,500,925), which is a continuation-in-part of our application Serial No. 455,254, filed August 18, 1942, which has been abandoned. In accordance with the invention, the substance employed to create the smoke or fog, the insecticide vapor or other chemical cloud, it introduced into contact with the stream of gases produced in the furnace, the smoke or fog making material is vaporized if in the liquid or solid state, either by the hot gases or by contact with adjacent metal surfaces of the furnace which have become heated by the gases, or both, and is mixed with the gases and is ejected at high velocities, on the order of the velocity of sound, through exit nozzles, orifices or apertures, hereinafter referred to as apertures, of a suitable distributing device. Relatively high air pressure is employed in the furnace wind box to serve the functions of furnishing oxygen for combustion, the force required to intermix the smoke or fog making substance with the products of combustion, the distribution of the mixture to the individual apertures of the distributing device, the maintenance through these apertures of the velocity of the magnitude mentioned, and the aspersion of air by the gas-vapor issuing therefrom.

Perfection of the device will depend upon the optimum proportioning of parts to assure maximum advantages from all of these variables. The spacing and the arrangement of the apertures of the distributing device, as well as their free areas, are important considerations. Substances, whether liquid or solid, or in any other state of aggregation, may be employed as the smoke producing or fog generating substances, although almost equally satisfactory results can be secured through the use of the same oil as that used for fuel for the furnace. One such oil which is useful for the purpose is a lubricating oil known as "Diol." In the event "Diol" is employed, both as the vaporizing substance and the fuel, a reduction in the accessories of the apparatus will result because of the elimination of one of the pumps which otherwise would be required, although an electric heater may be necessary since "Diol" is relatively viscous. Moreover, the furnace utilized in the apparatus of the invention and disclosed in the applications previously mentioned, is adaptable to the boiler type of fog generator by employing cylindrical or streamlined tubes which contain the smoke making agent intermixed with water, steam or other substance or without any dilution whatever, to form the walls of the combustion chamber of the furnace.

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The invention will be understood from the following description when considered in connection with the accompanying drawings forming a part thereof and in which:

Fig. 1 is a more or less diagrammatic plan view of apparatus embodying the invention;

Fig. 2 is an isometric view, partly in section, of the furnace and the mixing and distributing devices shown in Fig. 1;

Fig. 3 is a detailed view in elevation, showing another arrangement for delivering the smoke or fog making substance in pulverized form to the mixing device of the furnace;

Fig. 4 is a more or less diagrammatic plan view showing a further arrangement for delivering the smoke or fog making substance in pulverized form to the distributor, and

Fig. 5 is an elevational view of the discharge end of the distributor.

Like characters of reference refer to the same or to similar parts throughout the several views.

Referring to Figs. 1 and 2 of the drawing, reference character 10 designates the furnace which comprises an outer metallic casing 11, a burner 12, and means within the casing providing the boundary of the combustion chamber for the furnace and arranged so that secondary air is supplied to the periphery of the burning fuel and gas stream at spaced intervals. The burner 12 is located at one end portion of the furnace and is surrounded by a cylindrical wind box 13, from which air is supplied to the burner through louvers 14 or through and around these louvers. The furnace casing 11 flares outwardly from the burner end for a short distance and continues with a relatively short cylindrical portion and thereafter converges toward the outlet end of the furnace in two stages, the second of which converges somewhat more abruptly than the first. The combustion chamber 15 is approximately ellipsoidal in shape and is formed by a plurality of metallic bands which are disposed adjacent to each other and in spaced relationship with the casing 11. The burner end of the combustion chamber has a band 16 of hollow frusto-conical form which diverges from the burner end of the chamber and is provided with an outwardly and upwardly flaring flange 17 at its smaller end. A second band 18, also of hollow frusto-conical form and diverging from the burner end of the chamber but to a somewhat less degree than the band 16, is disposed adjacent the outlet end of band 16. A third band 19, somewhat wider than band 18 and having a slight inclination of its wall toward the outlet end of the furnace, is disposed adjacent band 18. A fourth band 20, which converges more sharply toward the outlet end of the furnace is disposed between the band 19 and the furnace outlet. Band 20 as shown, has short cylindrical portions at each end thereof. The several bands composing the combustion chamber are dimensioned so that the inlet end of each of the second, third and fourth bands is of somewhat greater diameter than the next preceding band in the direction of flow of the gases through the chamber, to provide annular openings between the bands through which secondary air is delivered to the combustion chamber from the annular space between the bands and the casing. Each band 16, 18, 19 and 20 is provided with spaced, radially extending and longitudinally disposed fins designated 21, 22, 23 and 24 respectively, which serve as heat radiating means and also as means to position the bands properly within the casing 11 through en-

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agement of the outer ends of the fins with the inner wall of the casing, and with relation to each other through engagement of the fins of one band with the end of the next adjacent band, as shown. The bands are urged toward each other and toward the outlet end of the furnace, and expansions and contractions of the bands are provided for, by devices not shown in the drawings, but which are disclosed in our aforesaid Patent No. 2,500,925.

Fuel for the burner 12 is supplied through a line 25 to a pump 26, which is operated by an electric motor 27 through gears 28 and 29, and the fuel is forced by the pump through a line 30 controlled by a solenoid operated valve 31, to the burner 12. Air for the wind box 13 is drawn into a compressor 32 through its inlet 33, and is delivered through outlet conduit 34 and conduit 35 to the wind box 13. The compressor is driven by the electric motor 27. Ignition of the fuel delivered by the burner 12 is effected in the combustion chamber 15 by an electric ignition device 36. Air from the wind box 13 also flows through openings 37 into the annular space between the bands forming the combustion chamber and the casing 11, and is delivered to the combustion chamber through the annular openings 38 between adjacent ends of these bands as previously described.

In the form of the invention shown in Figs. 1 and 2, a substance other than the fuel for the furnace, is employed to produce the smoke or fog, the insecticide vapor or other chemical cloud. This substance is introduced through a line 40 to a pump 41 which is driven by the electric motor 27 through gears 28 and 42, and is delivered by the pump through line 43 controlled by a solenoid operated control valve 44 and a manual valve 45 to two branch lines 46, each of which is controlled by a valve 47. Each branch line delivers the substance to an atomizer 48 through which it is projected into a tubular section cylindrical spool piece 49 which is connected to the outlet end of the furnace 10 by an expansion joint 50, which permits a limited amount of angular movement of the distributing member with respect to the axis of the furnace. The combustion gases flowing from the furnace 10 through the spool piece 49 possess reasonable homogeneity of constituents and temperatures, and vaporize the substance injected into the spool piece through the atomizers 48. The mixture of the smoke or fog producing substance and the combustion gases is delivered to a distributing member 51 which is substantially dove-tailed in shape and is of gradually decreasing area of flow from the spool piece to its arcuate discharge end. The distributing member has a plurality of discharge apertures 52 and is provided with means to assist in the mixing of the combustion gases with the smoke or fog producing substance and also to assist in the vaporization of the substance. As shown, such means consists of a lattice comprising a plurality of spaced arcuate rows of spaced baffles 53, with the baffles in each row disposed in staggered relationship with the baffles in the adjacent row or rows. This lattice is adjacent the discharge end of the distributing member 51 but is in spaced relationship to the apertures 52.

Any suitable form of casing or housing may be employed for apparatus embodying the invention. As shown, the casing 54 encloses all of the apparatus excepting for part of the furnace and the distributing member 51, part of the line 43 and

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the branch lines 46, and the inlet end of the compressor 32.

The operation will be apparent from the foregoing description. Liquid fuel is delivered to the burner 12 through line 30 by fuel pump 26, air is forced into the wind box 13 by the compressor 32, and the smoke or fog producing substance is delivered to the spool piece through nozzles 48 by pump 41. Secondary air is supplied to the periphery of the fuel and gas stream in the combustion chamber through the annular openings 38 between the bands forming the combustion chamber. The secondary air is directed into the combustion chamber substantially in the form of frusto-conical sheets with the bases of the cones disposed toward the burner end of the combustion chamber. In consequence, the flame is compressed and assumes a conical shape, combustion is completed quickly and in a short path of flow of the fuel, the gases of combustion are diluted, a relatively high degree of homogeneity with respect both to the temperature and constituents of the gas mixture is obtained, and the heat release per unit column reaches high figures. The secondary air cools the outer casing and the bands forming the combustion chamber, thus assuring long life of the furnace. The smoke or fog making substance mixes with the combustion gases leaving the furnace and is vaporized, and the mixture flows through the distributing member 51 and between the baffles 53 and from the distributing member through the discharge apertures 52. The distributing member functions not only to effect mixture of the substance and the combustion gases and to disseminate the mixture in the desired manner, but it also enables the expanding mixture flowing through the distributing member to be cooled rapidly and the vapor pressure of the mixture to be quickly lowered through the flow of currents of air over the exterior surfaces of the distributing member. However, the mixture is cooled primarily by expansion through the apertures of the distributing member.

The form of the invention illustrated in Fig. 3 is particularly well adapted to the use of a pulverized substance for producing smoke or fog or for other purposes, as distinguished from liquid or gaseous substances. Referring to Fig. 3, the pulverized substance is delivered to a reservoir or bin 55 which is maintained under pressure by air delivered from the compressor 32 through the air line 56, and the pulverized substance is forced through delivery line 57 and is discharged into the spool piece 49 tangentially thereto, as indicated by the tangential connection of the discharge end of the delivery line 57 with the spool piece. The operation of this form of the invention is substantially the same as that described in connection with the form of the invention shown in Figs. 1 and 2.

The form illustrated in Fig. 4 is also particularly well adapted for the use of a pulverized substance for producing the smoke or fog. In Fig. 4, the pulverized substance is delivered to a reservoir 60 from which it is withdrawn through an outlet 61 by the aspirating action of a nozzle 62 in an air line 63, the inlet end of which connects with the air conduit 35 through which air is delivered from the compressor 32 to the wind box 13 of the furnace 10. The pulverized substance thus withdrawn from the reservoir or bin 60 is delivered by the air current through line 63 to the inlet end of the distributing device 64. The operation of this form of apparatus is substantially the same as that described in connec-

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tion with the form of the invention shown in Figs. 1 and 2.

The distributing device 64 shown in Figs. 4 and 5, differs from the distributing device 51 shown in Figs. 1, 2 and 3, in that the device 64 consists essentially of two dove tails, one arranged at right angles to, and intersecting with, the other. Each discharge arm of the distributing device is provided with a double row of discharge apertures 65 which are similar to the discharge apertures 52.

Any suitable form of distributing device may be employed. For example, the distributor may have any desired number of discharge arms such as the arms shown in Figs. 4 and 5, or it may be star-shaped, or it may be arranged to provide a series of interconnected annular rings with air spaces between the rings. The design and general form of the distributing member largely will be controlled by the number and sizes of the discharge apertures which are necessary for the desired capacity of the apparatus. The higher the capacity, the greater the number of apertures required, and the larger the quantity of ambient air which is necessary to accomplish cooling of the mixture flowing through the distributing device. In other words, the design of the distributing member is dictated by the functions to be performed and previously described, and is arranged to permit maximum indirect contact of the mixture with ambient air.

In the event a single substance or mixture of materials is used both for fuel for the furnace and for smoke or fog making, the pump 41 may be eliminated.

If desired, the entire apparatus may be mounted on trunnions so that the position of the furnace and its accessories can be varied and the angle of ejection of the smoke or fog changed to permit egress at the desired angle. For this purpose, a flexible joint should be employed between the outlet of the compressor and the wind box of the furnace. Should it be desired to maintain the furnace, the compressor and the accessories in a fixed position, the distributing member may be moved by utilizing a flexible or Sylphon-like connection in lieu of the rigid spool piece 49. Distributing members arranged to project at an angle from the spool piece may also be employed if desired.

As used in the claims, "apparatus for producing or distributing vapor clouds" includes apparatus for producing smoke, fog, or vapor clouds, for any purpose, such as, but not limited to, the purposes mentioned hereinabove. Also in the claims, the expression "vapor cloud producing substance" includes within its scope, any substance for the production of smoke, fog, or vapor clouds for any purpose, including, but not limited to, the purposes mentioned hereinbefore.

The invention disclosed herein may be manufactured and used by or for the Government of the United States for government purposes without the payment of any royalty thereon.

This application is a division of our application Serial No. 492,360, filed June 26, 1943, for Method and Apparatus for the Production of Smoke, Fog or Vapor Clouds, which has been abandoned.

It will be understood that changes may be made in the form, location and relative arrangement of the several parts of the furnace and related equipment or devices disclosed herein, and changes may be made in the steps or in the sequence of steps of the method disclosed, without departing from the principles of the invention.

Accordingly, the invention is not to be limited excepting by the scope of the appended claims.

What is claimed is:

1. Apparatus for producing vapor clouds comprising a combustion chamber including a convergent outlet section, means for delivering fuel to said chamber, means for delivering compressed air to said chamber, an outlet unit for said chamber including a tubular section connected to said outlet section at its reduced end and a gas distributor connected to said tubular section, and means for injecting vapor cloud producing substance into said tubular section whereby said substance mixes with the products of combustion issuing from said combustion chamber.

2. Apparatus for producing vapor clouds comprising a combustion chamber including a convergent outlet section, means for delivering fuel to said chamber, means for delivering compressed air to said chamber, an outlet unit for said chamber including a tubular section connected to said outlet section at its reduced end and a gas distributor connected to said tubular section, and means for injecting vapor cloud producing substance into said tubular section whereby said substance mixes with the products of combustion issuing from said combustion chamber, said vapor cloud injection means including peripheral inlet nozzles placed around said tubular section, a source of supply for said substance and pressure means for forcing said substance through said peripheral nozzles.

3. Apparatus for distributing vapor clouds from a mixture of gases produced in a combustion chamber and a vapor cloud producing substance, comprising a closed member having an inlet communicating with the outlet end of the combustion chamber, an arcuate shaped discharge end spaced from the inlet and having a plurality of closely spaced apertures therein, and a plurality of spaced baffles in the member between the inlet and the discharge area and disposed in an arcuate row approximately parallel to and adjacent the arcuate discharge end of the member.

4. Apparatus for distributing vapor clouds from a mixture of gases produced in a combustion chamber and a vapor cloud producing substance, comprising a closed member having an inlet communicating with the outlet end of the combustion chamber, an arcuate shaped discharged end spaced from the inlet and having a plurality of closely spaced apertures therein, and a plurality of spaced rows of spaced baffles in the member between the inlet and the discharge area, the rows being arcuate and approximately parallel to and adjacent the arcuate discharge end of the member, the baffles in adjacent rows being staggered with respect to each other.

5. Apparatus for distributing vapor clouds from a mixture of gases produced in a combustion chamber and a vapor cloud producing substance, comprising a closed member having an inlet communicating with the outlet end of the combustion chamber, an arcuate shaped discharge end spaced from the inlet and having a plurality of closely spaced apertures therein, the cross-section of the member in the direction of flow of the gases being of gradually diminishing area from the inlet to the discharge end, and a plurality of spaced baffles in the member between the inlet and the discharge area and disposed in an arcuate row approximately parallel to and adjacent the arcuate discharge end of the member.

6. Apparatus for distributing vapor clouds

from a mixture of gases produced in a combustion chamber and a vapor cloud producing substance, comprising a closed member having a substantially circular inlet opening communicating with the outlet end of the combustion chamber, an arcuate shaped discharge end spaced from the inlet and having a plurality of closely spaced apertures therein, the chord of the arc of the discharge end being longer than the diameter of the inlet opening, the side walls of said member flaring outwardly from the inlet opening to the ends of the discharge end, the cross-section of the member in the direction of flow of the gases being of gradually diminishing area from the inlet to the discharge end, and a plurality of spaced baffles in the member between the inlet and the discharge area and disposed in an arcuate row approximately parallel to and adjacent the arcuate discharge end of the member.

7. Apparatus for distributing vapor clouds from a mixture of gases produced in a combustion chamber and a vapor cloud producing substance, comprising a closed member having an inlet opening, a tubular member connecting the inlet opening and the outlet end of the combustion chamber, an arcuate shaped discharge end spaced from the inlet and having a plurality of closely spaced apertures therein, and a plurality of spaced baffles in the member between the inlet and the discharge area and disposed in an arcuate row approximately parallel to and adjacent the arcuate discharge end of the member, the tubular member having a connection through which the vapor cloud producing substance is introduced into contact with the gases from the combustion chamber.

8. Apparatus for distributing vapor clouds from a mixture of gases produced in a combustion chamber and a vapor cloud producing substance, comprising a closed member having an inlet communicating with the outlet end of the combustion chamber, a curved discharge end spaced from the inlet and having a plurality of closely spaced apertures therein, and a plurality of spaced baffles in the member between the inlet and the discharge end and disposed adjacent to and across the discharge end of the member.

9. Apparatus for distributing vapor clouds from a mixture of gases produced in a combustion chamber and a vapor cloud producing substance, comprising a closed member having an inlet communicating with the outlet end of the combustion chamber, a discharge end spaced from the inlet and having a plurality of closely spaced apertures therein, the side walls of the member flaring outwardly from the inlet to the ends of the outlet end, the cross-section of the member in the direction of flow of the gases being of gradually diminishing area from the inlet to the discharge end, and a plurality of spaced baffles in the member between the inlet and the discharge end and disposed adjacent to and across the discharge end of the member.

10. Apparatus for distributing vapor clouds from a mixture of gases produced in a combustion chamber and a vapor cloud producing substance, comprising a closed member having an inlet communicating with the outlet end of the combustion chamber, the member having intersecting arms, each arm having a discharge end spaced from the inlet and having a plurality of closely spaced apertures therein, each discharge end being longer than the diameter of the inlet, and the cross-section of each arm in the direction of flow of the gases being of gradually di-

minishing area from the inlet to the discharge end.

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