United States Patent

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[73] Assignee **The United States of America as represented by the Secretary of the Army**

[54] **SMOKE GENERATOR**
9 Claims, 6 Drawing Figs.

[52] **U.S. Cl.** **244/136,** 40/213
[51] **Int. Cl.** **B64d 1/00**
[50] **Field of Search** 244/136; 40/213; 252/359, 305; 339/265.29, 265.37, 14, 263.17, 263.13

[56] **References Cited**

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ABSTRACT: A smoke generator for engines exhausting hot gases including an exhaust duct having a plurality of smoke-producing fluid-injection means mounted internally and circumferentially the duct and a plurality of baffle means extending longitudinally the duct between said injection means to channel the smoke and minimize turbulence within the duct.

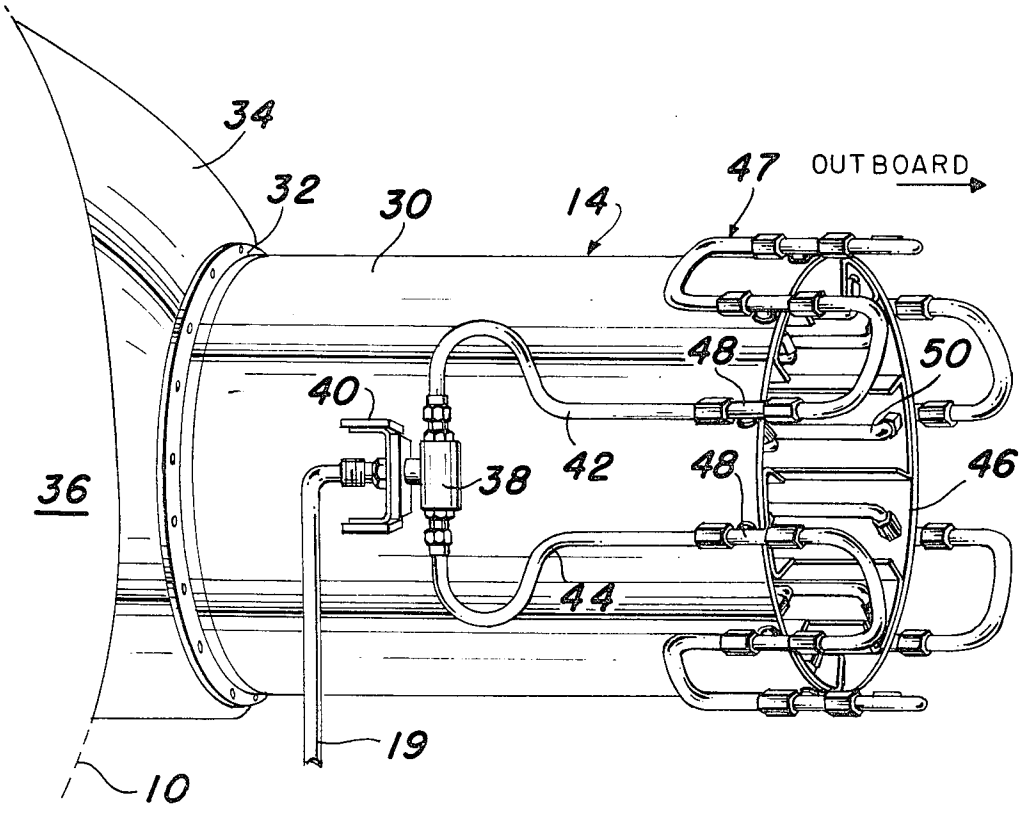
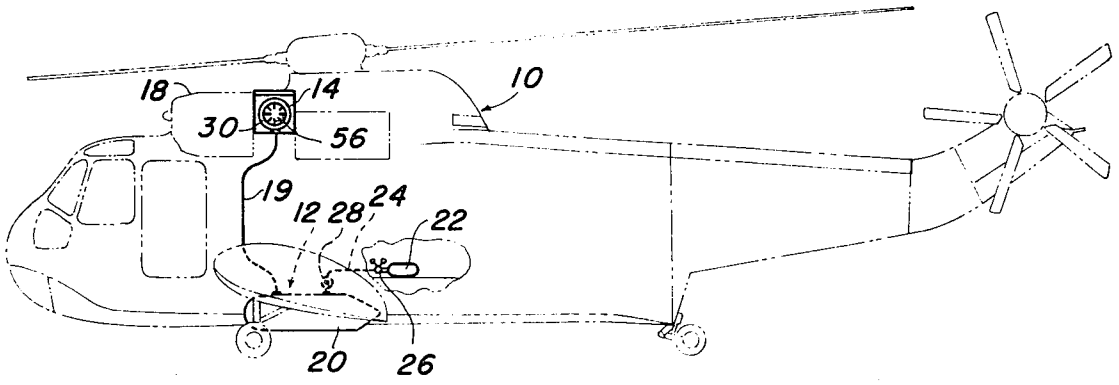


FIG. 1



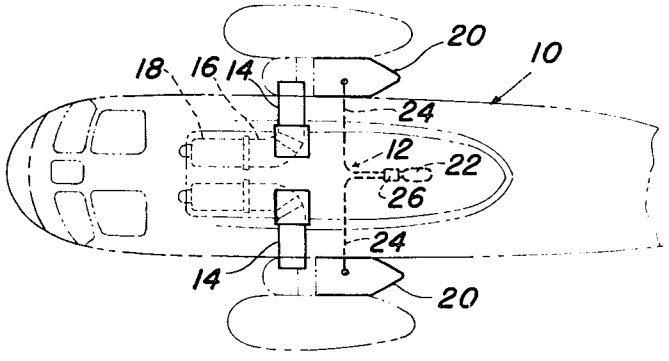


FIG. 2

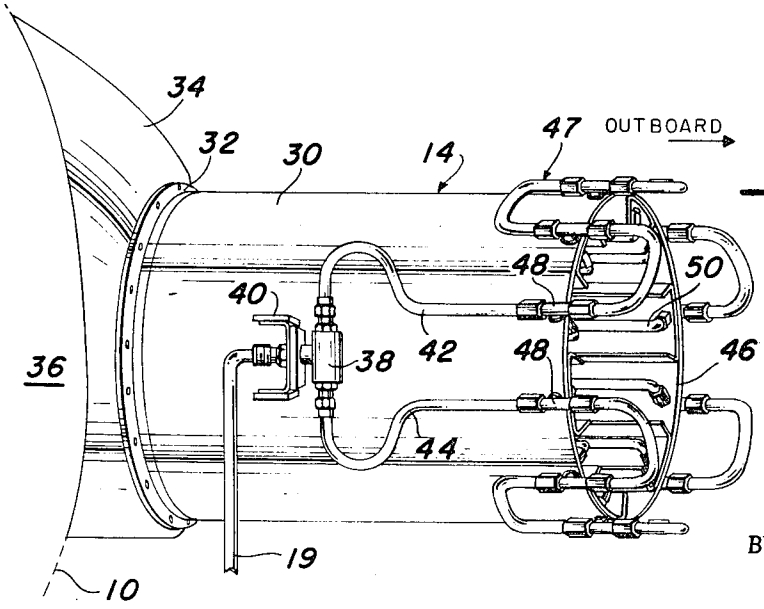


FIG. 3

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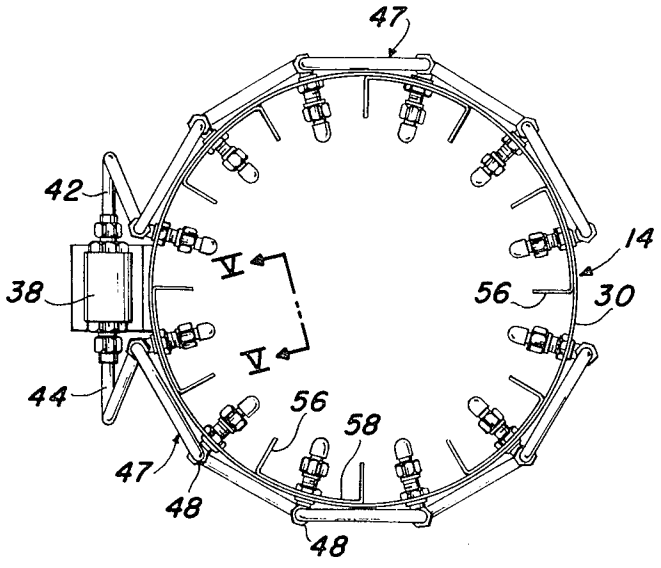

FIG. 4

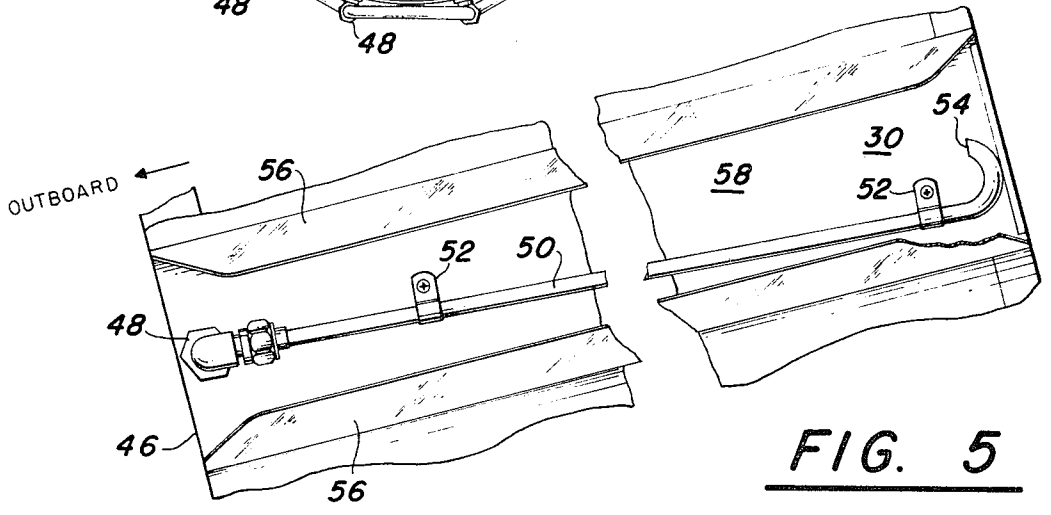

FIG. 5

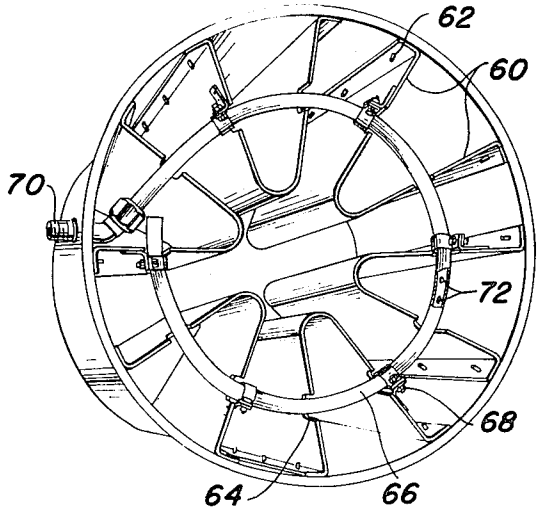

FIG. 6

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SMOKE GENERATOR

STATEMENT OF GOVERNMENT INTEREST

BACKGROUND OF THE INVENTION

This invention relates to a smoke generator and more particularly to a smoke generator for use on engines having a hot exhaust gas that will produce a larger volume and greater density of smoke.

The use of smoke-producing apparatus for various types of vehicles and for different types of applications has been long established. Land operated smoke generators, especially the ones that are stationary, do not present a problem because of the unlimited storage facilities of smoke-producing fluid and size is no limitation. However, smoke-producing apparatus for use in aircraft for military purposes present limitations in the supply of fluid that can be carried and the weight and size of the apparatus. Therefore, the importance of obtaining a larger and denser volume of smoke with a lightweight smoke generator is of paramount military importance.

The prior art smoke generators for the most part, such as Levey et al., U.S. Pat. No. 2,422,024, are concerned with exhaust flow emanating from diesel engines which have a small diameter exhaust pipe. A single nozzle ejects the smoke-producing fluid into the exhaust pipe and a limited volume of smoke is produced. In addition, the smoke travels in a random and turbulent flow through the exhaust pipe which could cause a back pressure on the engine before being discharged.

SUMMARY OF THE INVENTION

The novel smoke-generating system of this invention is for use on a prime mover developing hot exhaust gases that are used to vaporize the smoke-inducing medium. The system includes a generator unit that can utilize the exhaust duct of a reaction-type thrust engine or provide its own enlarged duct through which the hot exhaust gases from any other type of engine may be vented. The smoke-generating system provides a source of pressurized smoke-producing medium, such as a liquid, which is injected into the exhaust duct at a plurality of spaced stations around the inner periphery. An important feature is the employment of baffle means between the injection stations to provide separate channels through which the smoke flows without turbulence between channels. The baffle means are preferably plates, which may extend to the center of the duct, and provide additional hot surfaces within the exhaust duct for vaporizing the smoke-producing liquid. A unique arrangement of piping provides a preheat path as well as avoiding the formation of holes in the duct.

STATEMENT OF THE OBJECTS OF THE INVENTION

An important object of this invention is to provide a smoke-generating system which will produce a greater volume and higher density smoke flow.

Another important object is to provide a smoke generator which can be adapted to various types of engines and, a corollary object is to provide a generator of lightweight construction suitable for use on aircraft, such as helicopters.

Still another important object is to provide a smoke generator with baffle means that will produce nonturbulent flow.

A further object is to provide a smoke generator which will have a greater heated surface area for generating the smoke without adversely affecting engine performance.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation of a H–3 type helicopter illustrated in phantom with part of the fuselage broken away to show the general arrangement of the novel smoke generator assembly;

FIG. 2 is a top plan view of FIG. 1;

FIG. 3 is an enlarged perspective view of the smoke generator unit and piping arrangement;

FIG. 4 is an end elevation view of the exhaust end of the smoke generator of FIG. 3;

FIG. 5 is a longitudinal section taken along line V—V of FIG. 4; and

FIG. 6 is a perspective view of a modified smoke generator unit taken from an inboard position having a different arrangement of baffles and manifold.

Referring to the drawings where like reference numerals refer to similar parts throughout the figures, there is illustrated in FIGS. 1 and 2 a helicopter **10**, having a Navy designation H–3, shown in phantom lines being representative of one type of vehicle on which the novel smoke generator system **12** can be employed.

Smoke generator system **12** generally comprises a smoke generator unit **14** which may be connected directly or indirectly to a tailpipe **16** through which is discharged the hot gases of an engine **18**. This type helicopter has two engines, being Navy designated T–58 turbo jets, disposed in side-by-side relation, each engine having its own tailpipe and a novel smoke generator unit **14** associated therewith. It is obvious that the novel smoke-generating system of this invention may be utilized on other type engines and vehicles to meet prescribed operational requirements.

Each smoke generator **14**, the details of which will be later described with reference to FIGS. **3–6**, is fed a smoke-producing medium, such as a liquid, through a line **19** from a tank **20** located on a corresponding side of the aircraft. Both tanks **20** are pressurized by a common air pressure supply tank **22** through a pair of lines **24** and a pressure regulator **26** whereby the pressure in tank **22** of 1,800 p.s.i. is reduced to 18 p.s.i. found suitable in the described embodiment for transferring the smoke-producing liquid from tank **20** to smoke generator **14**. A control valve **28** is provided in line **24** to control the regulated pressure to the supply tanks and incorporates means of relieving the tank pressure by an overboard vent to permit immediate shutoff of the smoke for any reason.

The smoke-generating medium must meet certain requirements, for example, it must produce a smoke of adequate opacity; require no special handling or storage precautions; be relatively inexpensive; be stable for extended periods; and have a sufficiently high flash point to avoid ignition. The following liquids are available that meet these criteria,

Diesel fuel—Navy spec MIL–F–16884

Lubricating oil—Navy spec MIL–L–6081

Light turbine oil—Navy spec MIL–L–17672

Various mixtures of the above-described liquids were tried on the T–58 engine having an exhaust gas temperature of about 900° F. The best results were obtained using a 40–60 percent proportion of diesel fuel with the remainder being either the lubricating oil or the light turbine oil.

An import feature of the smoke generator system is the absence of filters or critical orifices so that all smoke-generating fluids can be used successively even though they may be grossly contaminated with water, rust, metal particles, etc.

Smoke generator unit **14** to which the fluid is piped for generating the smoke is shown in detail in FIGS. **3–5**, inclusive. The generator comprises a cylindrical duct **30** which in the illustrated embodiment is secured by flange **32** to a transition duct **34** mounted to helicopter nacelle **36**. In this manner the weight of the smoke generator is supported by the aircraft structure and not directly by engine tailpipe **16**, although it could be so supported if required in any other installation. In some installations the engine tailpipe can be utilized as the duct for the smoke generator and the necessary piping mounted thereto without the need for drilling holes through the tailpipe.

Supply line **19** from tank **20** leads to a T-connection **38** (FIG. 3) mounted by bracket **40** to the outside of duct **30** at an inboard position. From T-connection **38** the piping extends longitudinally in an outboard direction in the branches **42** and **44** positioned in close proximity to the outside surface of the

duct to the mouth **46** thereof to provide a preheating of the smoke-producing fluid. At the mouth of the duct each pipe branch extends annularly and in an opposite direction around the duct periphery in a serpentine manner forming a manifold section **47**. Intermediate portions of manifold piping section **47** are provided with a plurality of T-pipe connections **48** which support the piping to the duct adjacent the mouth and also provide lead-in piping to a plurality of corresponding injection stations within the duct for discharging the fluid in a manner to be described presently. In the embodiment described 12 injection stations are utilized but it is obvious that the number of stations may vary with the type and size of the tailpipe and the engine.

Connected to each T-connection **48** within the duct is a straight pipe **50** extending inboard from the duct mouth and supported to the inside of the ducts by brackets **52**. Each pipe **50** terminates in a semicircular curved nozzle end **54** being pointed in an outboard direction toward the duct mouth so as to discharge the smoke-producing fluid in the exhaust gas flow and against the hot duct surfaces to be vaporized. As previously described, it is important that the characteristics of the smoke-producing fluid be such that it will be heated by the exhaust gases to the extent it will boil off and vaporize without reaching the flash point that would cause ignition and a serious fire problem.

Another important feature of the invention is the provisions for channelizing the smoke created at each nozzle station to prevent interference and eddy currents between adjacent injection stations and thus to maximize the volume of smoke being emitted from the generator unit. In the preferred embodiment of FIGS. **3–5** the channelizing is performed by baffles **56** made of a blank of sheet metal and fabricated in pairs by forming the metal blank into a U-shaped configuration, each leg being a baffle and extending longitudinally from duct mouth **46** to the nozzles **54**. By this construction the baffles increase the structural rigidity of the duct against any bending moment without restraining expansion or contraction of the duct by the large temperature differential. The base **58** of the U-shaped metal is curved to conform to the duct to which it is welded or otherwise secured centrally each alternate station. Pipe **50** may be canted between its respective baffles so that nozzle **54** is centrally positioned.

In order to increase the smoke output from a given size generator it is necessary to increase the amount of heated surface area within the generator and to simultaneously increase the flow of fluid on the heated surfaces to a point of maximum efficiency. In the modification shown in FIG. **6** the height of baffles **60** are increased to extend for a major dimension of the duct radius but with the ends free to allow for expansion and contraction. In this modification each pair of baffles **60** are constructed of an inverted U-shaped sheet metal bank with the sides being the baffles, radially tapered toward the duct center. The free ends of the blank are provided with flanges which are secured to the duct interior by screws **62** at alternate injection stations. The inboard edge of each baffle is notched at **64** to accommodate a circular manifold pipe **66** extending around the duct medially the baffles and secured thereto by brackets **68**. The inlet end **70** of the manifold extends through the duct to be connected to the piping from supply tank **20**. A plurality of drilled openings **72** are provided in manifold **66** between the baffles for the injection of the smoke-producing liquid on the duct and baffle surfaces. It should be noted that the increase in the heated surface is limited to a value which will not produce an unacceptable pressure drop across the generator that would affect engine performance.

The smoke-generating system provides a means for producing a high volume of opaque and dense smoke using inexpensive smoke-generating liquids that can be in a contaminated condition. The volume of smoke can be tailored by varying the number of nozzles, the pressure of the fluid and the surface area of the baffles. The baffles function in addition to providing the necessary heated surfaces to vaporize the smoke producing liquid and channelizing the smoke to prevent turbulence in the smoke flow and the building up of a back pressure on the engine. In addition, the baffles provide longitudinal rigidity to bending moments on the duct without restricting its expansion and contraction.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. In combination with an aircraft having a reaction-type thrust engine and an exhaust duct, a smoke generator comprising:

a plurality of nozzles mounted within and circumferentially spaced around the inner peripheral surface of the exhaust duct at the inlet thereof;

a source of smoke-producing fluid;

piping means for connecting the fluid source to said nozzles;

a plurality of radially projecting baffle plates mounted to the inner duct surface and extending longitudinally and in parallel relation within the exhaust duct and between said nozzles;

whereby the fluid injected on the hot duct surfaces will generate smoke which flows aft longitudinally the exhaust duct, the smoke flow from each nozzle being channelled between the respective baffle plates to minimize turbulence therebetween.

2. The combination of claim **1**, wherein the exhaust duct is mounted to the engine tailpipe as an extension thereof.

3. A smoke generator for use with an engine producing hot exhaust gases comprising:

a duct for exhausting said hot gases;

a source of smoke-producing fluid;

a plurality of fluid injection means mounted within and circumferentially spaced around the exhaust duct;

piping means for connecting the fluid source to said injection means;

a plurality of baffle means extending longitudinally within the exhaust duct in a parallel relation and disposed between said injection means; said baffle plates being plates mounted to the inner duct surface in a uniform disposition thereabout and extending radially into the exhaust duct toward the axis thereof;

whereby injection of the fluid on the hot surfaces within the duct will generate smoke which flows aft longitudinally the duct, the smoke flow from each injection means being channelled between said respective baffle means to minimize turbulence therebetween.

4. The smoke generator of claim **3**, wherein said baffle plates extend radially inwardly a major portion of the radius of said exhaust duct and terminate short of said duct center.

5. The smoke generator of claim **3**, wherein said baffle plates are fabricated from a sheet of metal into a U-shaped cross section with each leg being a baffle.

6. The smoke generator of claim **3**, wherein said piping extends aft longitudinally along the outside to the exhaust end of said duct and then reverses direction to extend forward longitudinally inside said tail pipe to the injection means.

7. The smoke generator of claim **6**, wherein the piping means includes a manifold portion which extends in a serpentine manner around the mouth of the exhaust duct and connects the outside portion of the piping to the inside portion of the piping.

8. The smoke generator of claim **3**, wherein said exhaust duct is mounted to as an extension of an aircraft engine tailpipe.

9. The smoke generator of claim **3**, wherein each baffle means comprises a U-shaped configuration having leg portions, the free ends of the leg portions being secured to the inner duct surface.

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