Nov. 6, 1956 W. J. CLIFFORD 2,769,500

FOAM-PRODUCING APPARATUS

Filed July 9, 1952

4 Sheets-Sheet 1

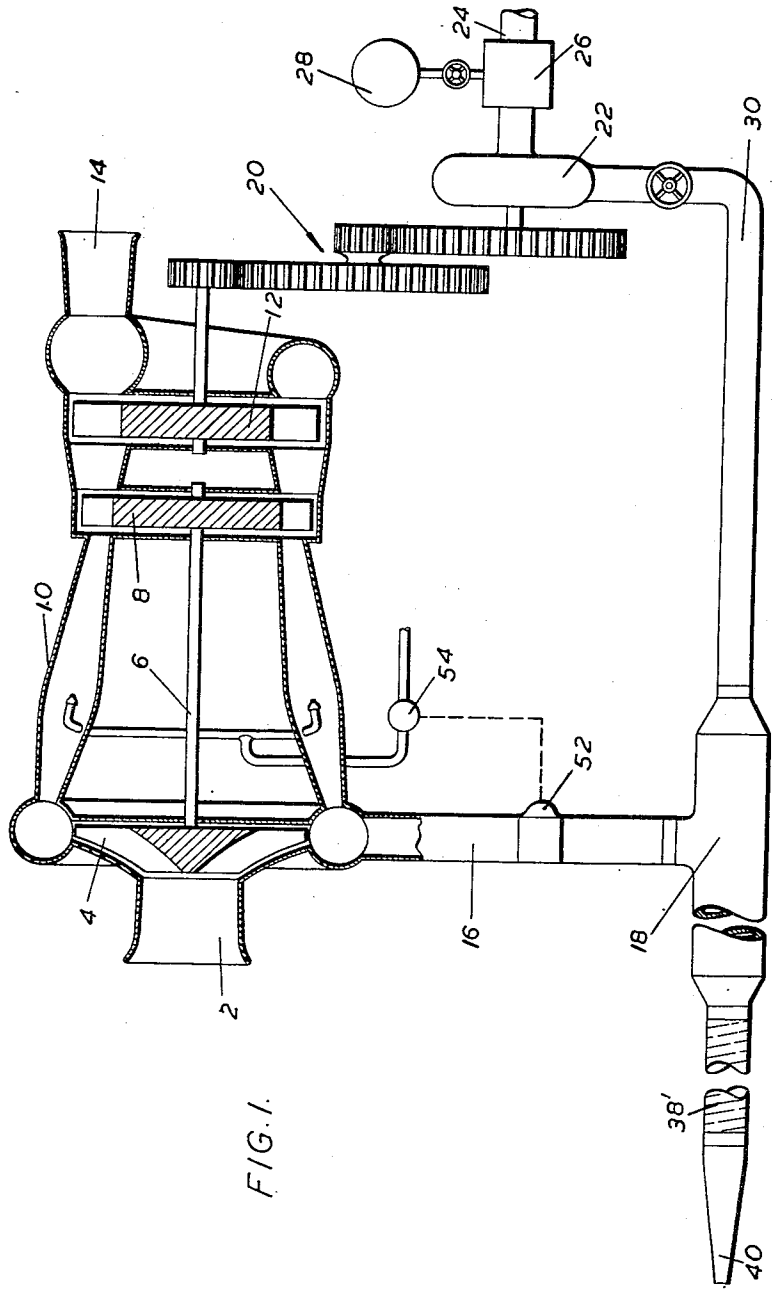


FIG. 1.

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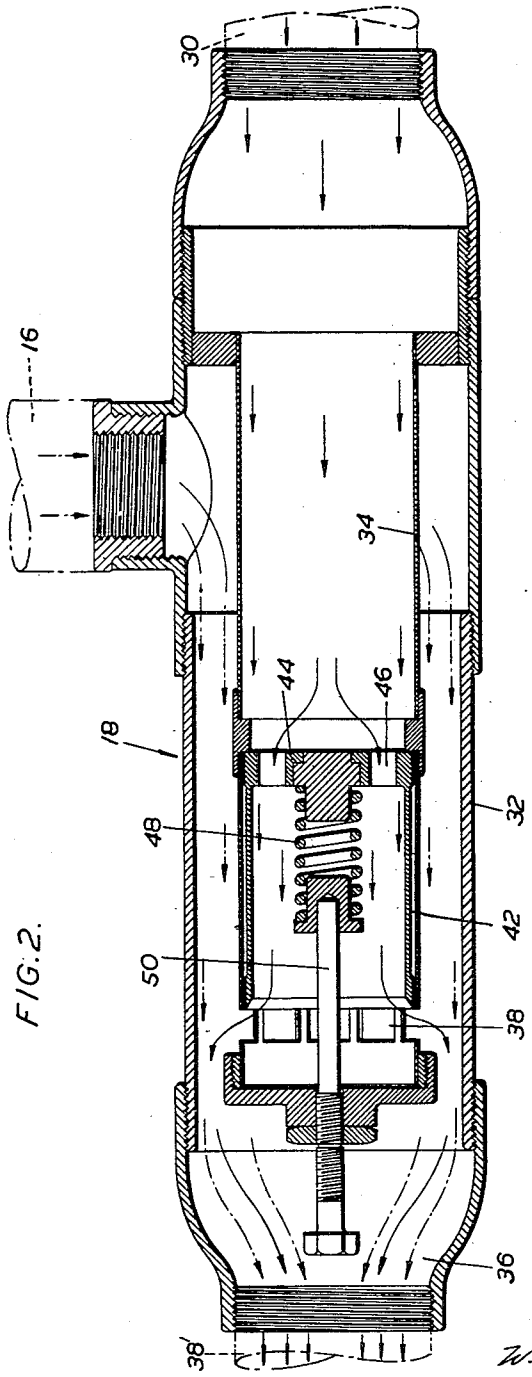


FIG. 2.

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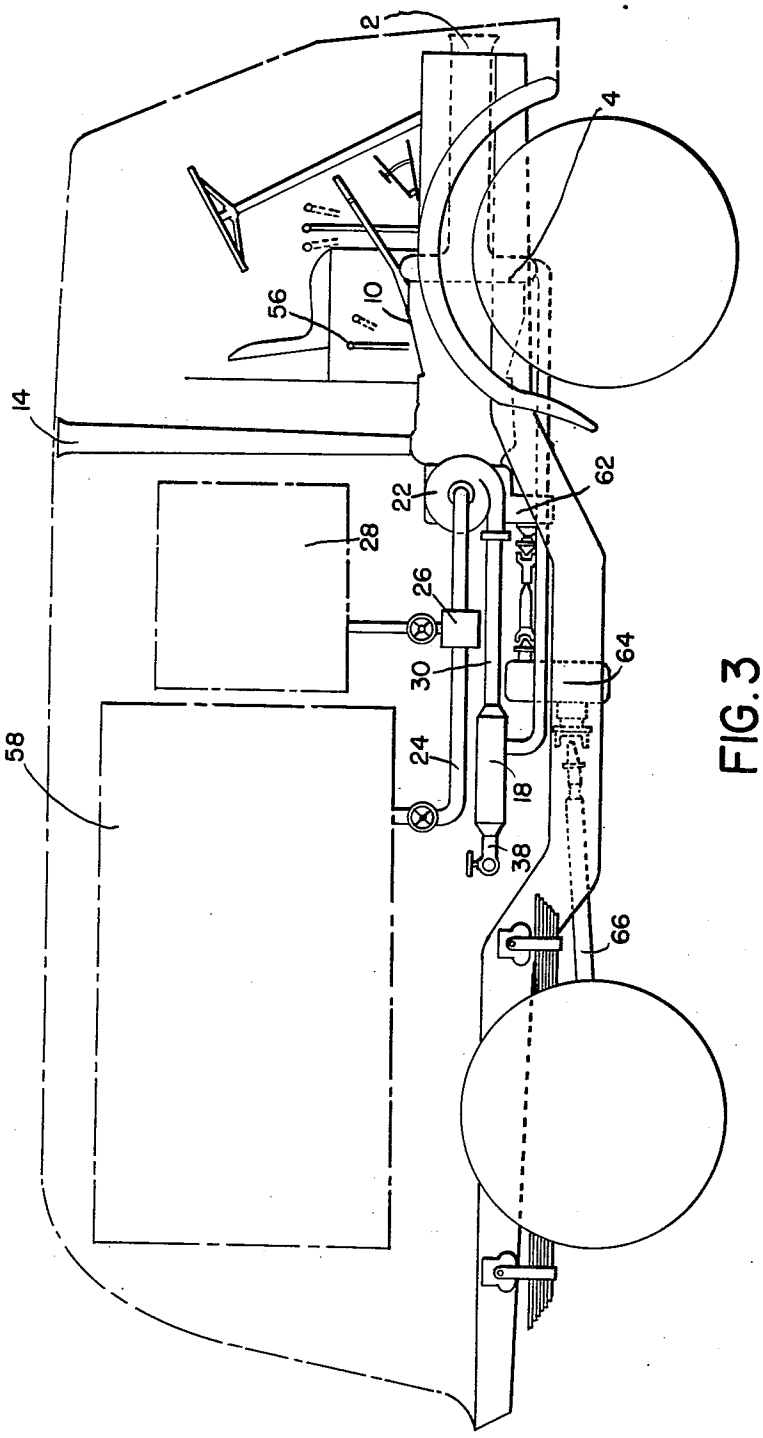


FIG. 3

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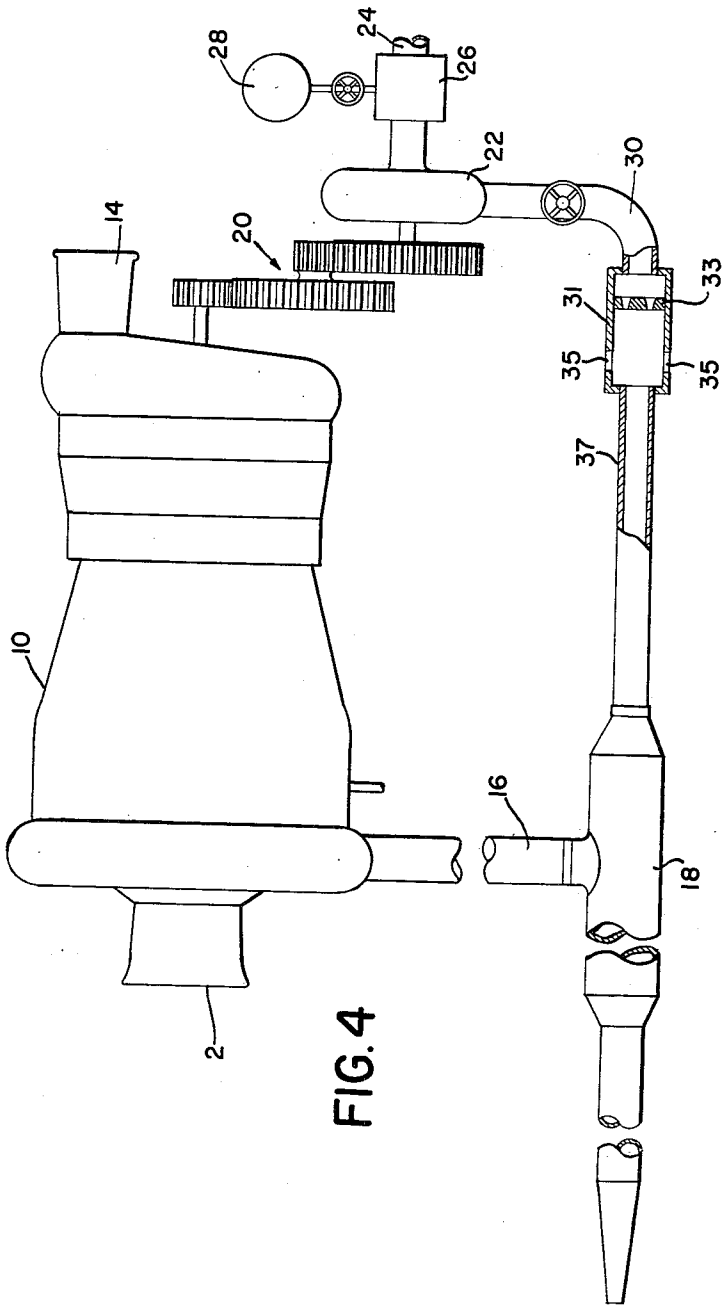


FIG. 4

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FOAM-PRODUCING APPARATUS

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Claims priority, application Great Britain July 11, 1951

6 Claims. (Cl. 169—15)

Fires breaking out in aircraft on landing are commonly attacked by foam produced by pumping a mixture of water and foam-stabilising agent through a foam generator in which the mixture entrains air. The expansion of the foam, that is to say the ratio of its volume to that of the liquid from which the foam is formed, is about 8.

It is desirable for the expansion of the foam to be higher, but this cannot readily be achieved in a generator which draws in air at atmospheric pressure by injector action. Various proposals have been made to form foam from liquid and air both under pressure, the air being either compressed continuously or drawn from a reservoir. However until now air compressors have been found to be bulky and heavy and the amount of air which can be stored under pressure too limited for these proposals to be much used.

It is an object of the present invention to produce high-expansion foam by means of apparatus which is light in weight and readily constructed.

It is a further object to make a novel use of the compressed air and power outputs of an internal-combustion gas-turbine engine.

According to the present invention air is delivered to a foam-mixing space from a compressor which delivers air for combustion of fuel in an internal-combustion gas-turbine engine which also drives a pump delivering liquid to the foam-mixing space. With this arrangement foam with an expansion considerably higher than previously available can be produced by equipment of substantially the same weight as that previously required to handle liquid at the same rate.

Preferably the liquid is water which entrains a small proportion of a foam-stabilising agent either upstream or downstream of the pump. Alternatively the liquid may be a ready-made mixture of water and foam stabiliser drawn from a reservoir, or the liquid may be simply water, in which case the foam stabiliser must be supplied separately to the foam-mixing space.

The air is bled off from a compressor delivering air for combustion. A suitable pressure for the air is 25 lbs. per square inch gauge, and for the water 50 lbs. per square inch gauge.

It will be apparent that the air is not necessarily pure atmospheric air, and in fact although the word "air" is used throughout the specification for convenience it is possible to use some other gas.

The accompanying drawings show one example of an apparatus constructed in accordance with the present invention. In these drawings:

Figure 1 is a diagram of the general layout of the apparatus;

Figure 2 is a longitudinal section on a considerably larger scale of a body in which liquid and air streams meet;

Figure 3 is a schematic view in elevation of a crash tender for air field use embodying the invention; and

Figure 4 is a schematic view illustrating a modified form of the invention in which a low expansion foam is first produced and then converted to a high expansion foam.

Air enters a gas-turbine engine through an inlet 2 and is compressed by a centrifugal compressor 4 which is mechanically connected by a shaft 6 to a turbine 8. Part of the air from the compressor 4 is delivered to combustion chambers 10 whence it passes through the turbine 8 and through a second turbine 12 to an outlet 14. A further part of the air from the compressor 4 passes down a pipe 16 to a body 18. The turbine 12 drives through gearing 20 a pump 22 which draws in water from a pipe 24. The water is mixed in an inductor 26 with a foam-stabilising agent supplied from a small reservoir 28. The liquid delivered by the pump 22 passes through a pipe 30 to the body 18, which contains a constant flow valve controlling the liquid.

As shown in Figure 2 the body 18 has an outer casing 32 and an inner cylinder 34. Air from the pipe 16 passes through the annular space between the casing and the cylinder to the outlet 36 from the body. Water from the pipe 30 passes axially through the inside of the cylinder 34 and then outwards through ports 38 to join the air flowing to the outlet 36. The outlet 36 is connected to a hose 38' terminating in a nozzle 40 and the hose serves as the foam-mixing space in which the air and liquid combine.

The flow of liquid is controlled by a sleeve 42, the downstream edge of which controls the ports 38. There is a wall 44 across the sleeve 42 and in the wall are orifices 46 through which the liquid flows. The sleeve is subjected to a predetermined force directed upstream by a compression spring 48 confined between the wall 44 and an adjustable rod 50. The sleeve 42 takes up a position in which the ports 38 are sufficiently obstructed for the flow of liquid through the orifices 46 to produce a pressure drop across the wall 44 balancing the force of the spring 48.

If in any apparatus a length of hose is not required between a delivery nozzle and the point at which the streams of air and liquid first meet then it is necessary to provide a foam-mixing space in some other form such as a short chamber containing baffles or packed with small solid bodies through which the mixture of air and liquid passes.

Since the viscosity of foam increases with decreasing liquid content some form of constant flow device in the liquid stream is very desirable in order to obtain stable operation. Control of the air stream is not so necessary for stable operation, but is desirable in order to obtain a predetermined and variable expansion for the foam. It will be apparent that the speeds of the compressor and water pump are determined by the power at which the gas-turbine engine is operating, and that these speeds will not always deliver both liquid and air at the pressures required for a particular output of foam. This is particularly so if a single engine supplies several foam-mixing spaces.

In the apparatus shown in Figure 1 the air stream passes a pressure-sensitive device indicated purely diagrammatically at 52. This device is connected to a valve 54 controlling the supply of fuel to the combustion chambers 10. In this way the speed of the turbine 8 and compressor 4 is controlled to maintain a definite but variable predetermined pressure in the pipe 16.

Alternatively a pressure reducing valve may be inserted in the pipe 16.

The present invention may be used in connection with a system in which water, a foam-stabilising agent and air are mixed in an injector to form foam which flows through a hose or the equivalent to an outlet, and gas is

introduced under pressure into the foam to become incorporated in the foam before the outlet and so increase the expansion of the foam. This method may be combined with the present invention by arranging that the liquid in the present invention on its way to the foam-mixing space passes through an injector in which it draws in air to become low-expansion foam which is converted to high-expansion foam in the foam-mixing space. Thus referring to Fig. 4 there is shown a system similar to that illustrated in Fig. 1 but in which an injector capable of producing low expansion foam is introduced between the pipe **30** and the body **18**. This injector may be of any suitable construction. It may, for example, comprise a chamber **31** into which the pipe **30** delivers a mixture of water and foam stabilizer under suitable pressure. Within the chamber **31** is an orifice plate **33** having a plurality of parallel jet orifices therethrough. On the downstream side of the plate **33** atmospheric air is drawn into the chamber **31** through openings **35**. The mixture of water, foam stabilizer, and air is then passed into and through a tubular extension **37** of the injector, the opposite end of this extension being connected with the body **18**. Within the latter the low expansion foam is converted to a high expansion foam by virtue of the air introduced through the pipe **16** into the body **18** under a suitable pressure, somewhat, though not greatly, in excess of that of the low expansion foam adjacent the pipe **16**. Body **18** may suitably be of the form illustrated in Fig. 2. The high expansion foam thus produced may be discharged through a hose and nozzle, as shown in Fig. 1, and delivered to the desired point.

In the apparatus shown in Figure 1 the gas-turbine engine includes separate turbines for drivng the air compressor and the power take-off. This type of engine has the advantage of great flexibility of operation, but it is also possible to use an engine in which a single turbine drives both the compressor and the take-off.

In a crash tender for airfield use the gas-turbine engine may be used for driving the road wheels, but preferably it is independent of the wheels, so that its full power is available for making foam when the tender is being manoeuvred. The mounting of the apparatus on a crash tender is illustrated in Fig. 3. Various parts are designated in this figure by the same numbers as are employed in Fig. 1. A control lever **56** serves to operate suitable clutch connections from the gas turbine engine **10** to the pump **22** and to the driving wheels of the crash tender. Conventional speed reducing gearing **62** and **64** may be provided in the transmission line from the gas turbine

engine **10** to the rear wheels of the tender which are driven from a transmission shaft **66**. The water supply for delivery to the line **24** is carried in a tank **58** mounted on the tender.

I claim:

1. A self-contained apparatus for producing foam comprising an internal-combustion gas-turbine engine including an air compressor, connections for delivering air from said compressor to a combustion chamber of said engine, means defining a foam-mixing space, means for conducting air from the high pressure side of said compressor to said foam-mixing space, a pump driven by said engine, means for storing a limited amount of liquid under low head, connections from said pump to said liquid storing means whereby said liquid is withdrawn by said pump from said storing means, and means for conducting liquid under relatively high pressure from the discharge side of said pump to said foam-mixing space.

2. Apparatus as claimed in claim 1 in which said means for conducting liquid to said foam-mixing space includes an injector provided with means by which said liquid draws in atmospheric air.

3. Apparatus as claimed in claim 1 in which said means for conducting liquid to said foam-mixing space includes means for maintaining a constant flow.

4. Apparatus as claimed in claim 3 in which said means for maintaining a constant flow comprises a cylinder through which liquid flows axially and then radially outwards through at least one port, a sleeve within the cylinder provided with a downstream edge arranged to control the ports and provided with a transverse wall having at least one orifice through which the liquid flows, and a spring urging the sleeve upstream with a predetermined force.

5. Apparatus as claimed in claim 1 in which said foam-mixing space is a length of hose.

6. Apparatus as claimed in claim 1 which is mounted on a self propelled vehicle, connections being provided from said internal combustion gas turbine engine to said vehicle for propelling the same.

References Cited in the file of this patent

UNITED STATES PATENTS

1,874,209	Schnabel	Aug. 30, 1932
2,201,040	Hansen-Ellehammer	May 14, 1940
2,218,294	Muller	Oct. 15, 1940
2,611,439	Faulkner	Sept. 23, 1952
2,630,183	Foutz	Mar. 3, 1953