Feb. 18, 1969 J. R. WINSLOW 3,428,131

METHOD AND APPARATUS FOR GENERATING FIRE-FIGHTING FOAM

Filed Aug. 16, 1966 Sheet 1 of 5

FIG. 1

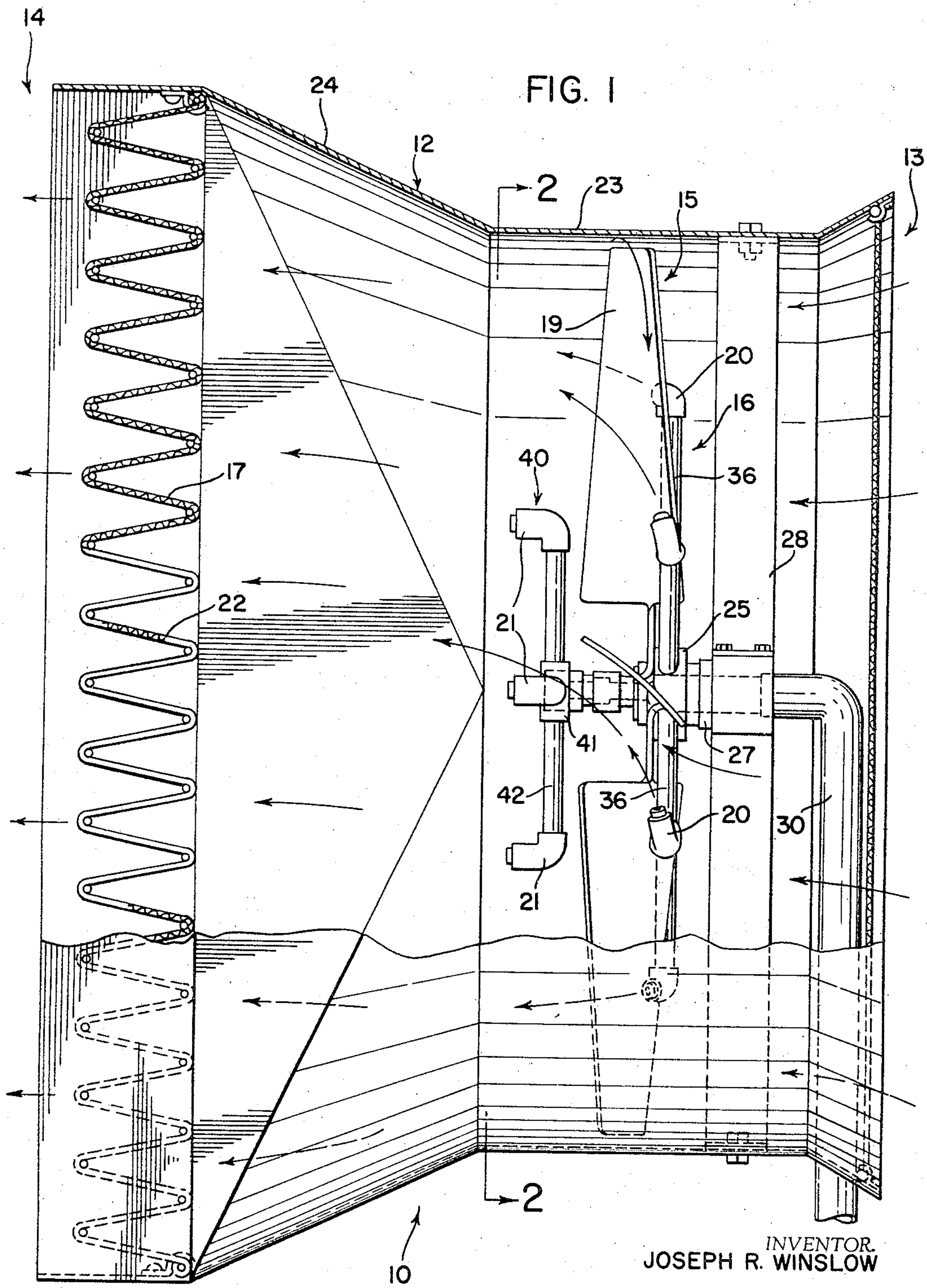

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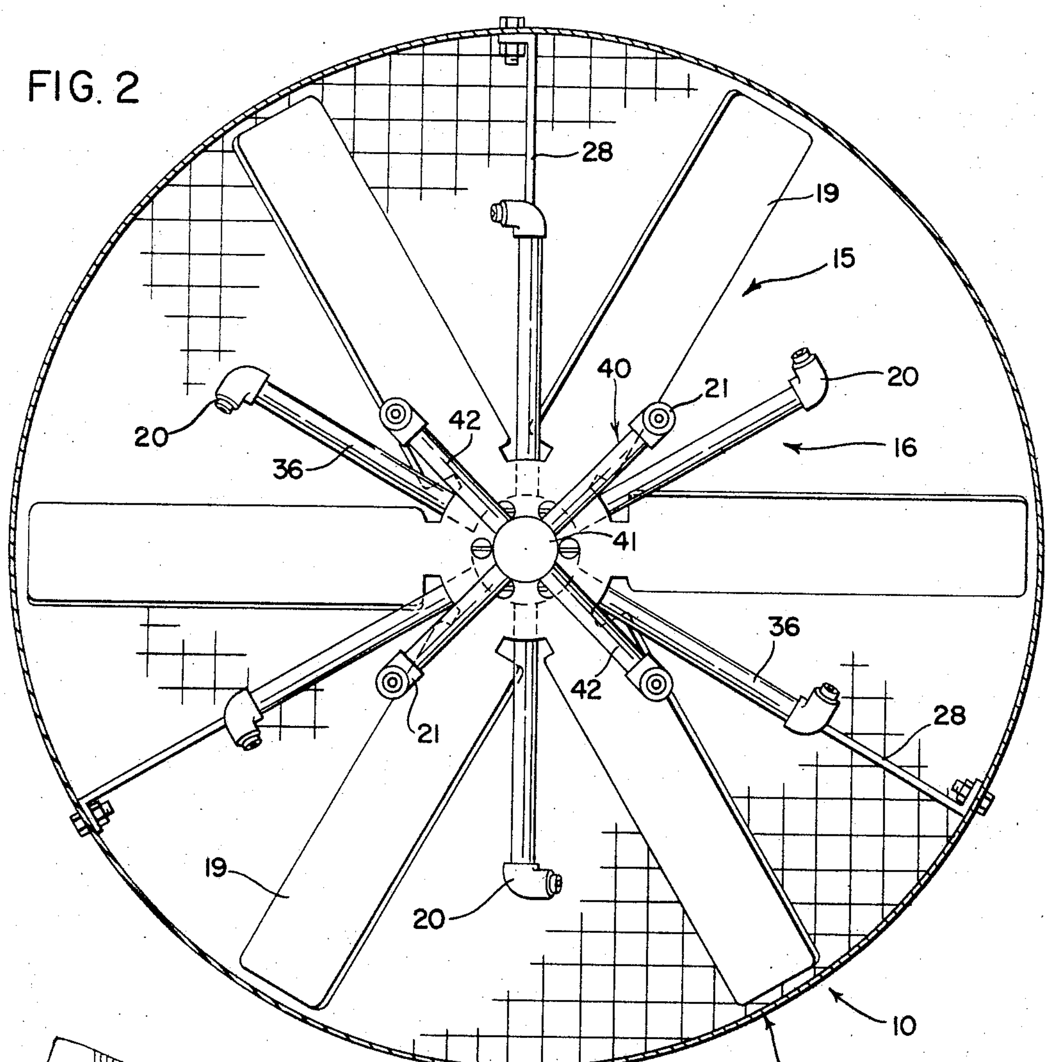
FIG. 2



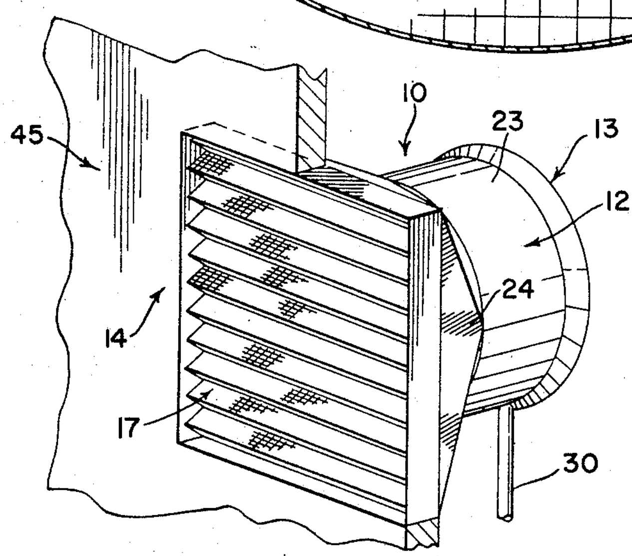


FIG. 3

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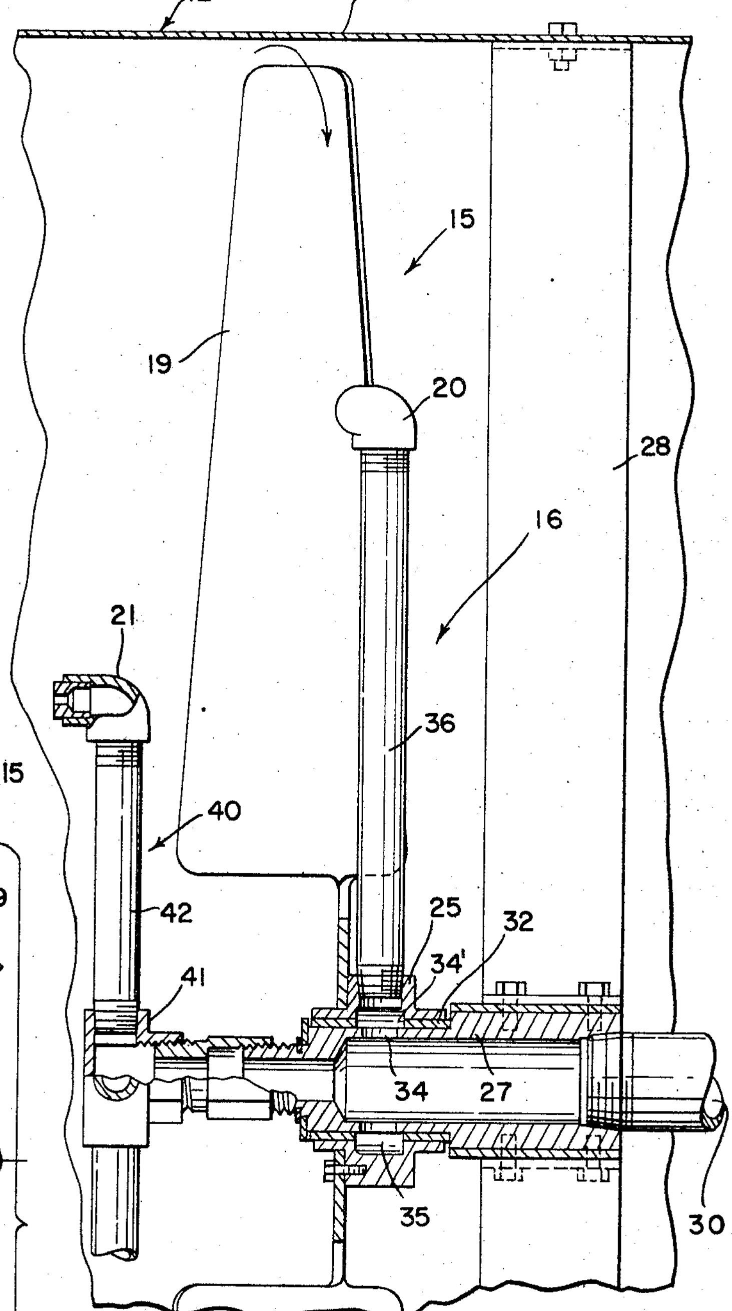
FIG. 4



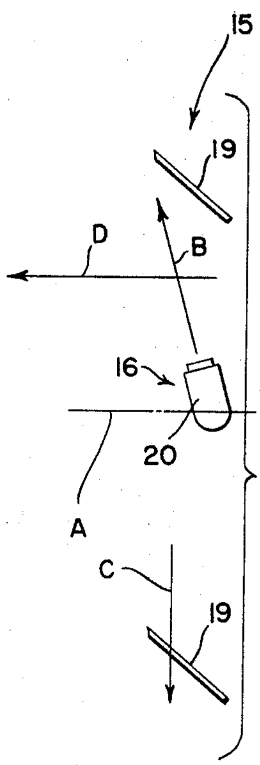


FIG. 5

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FIG. 6

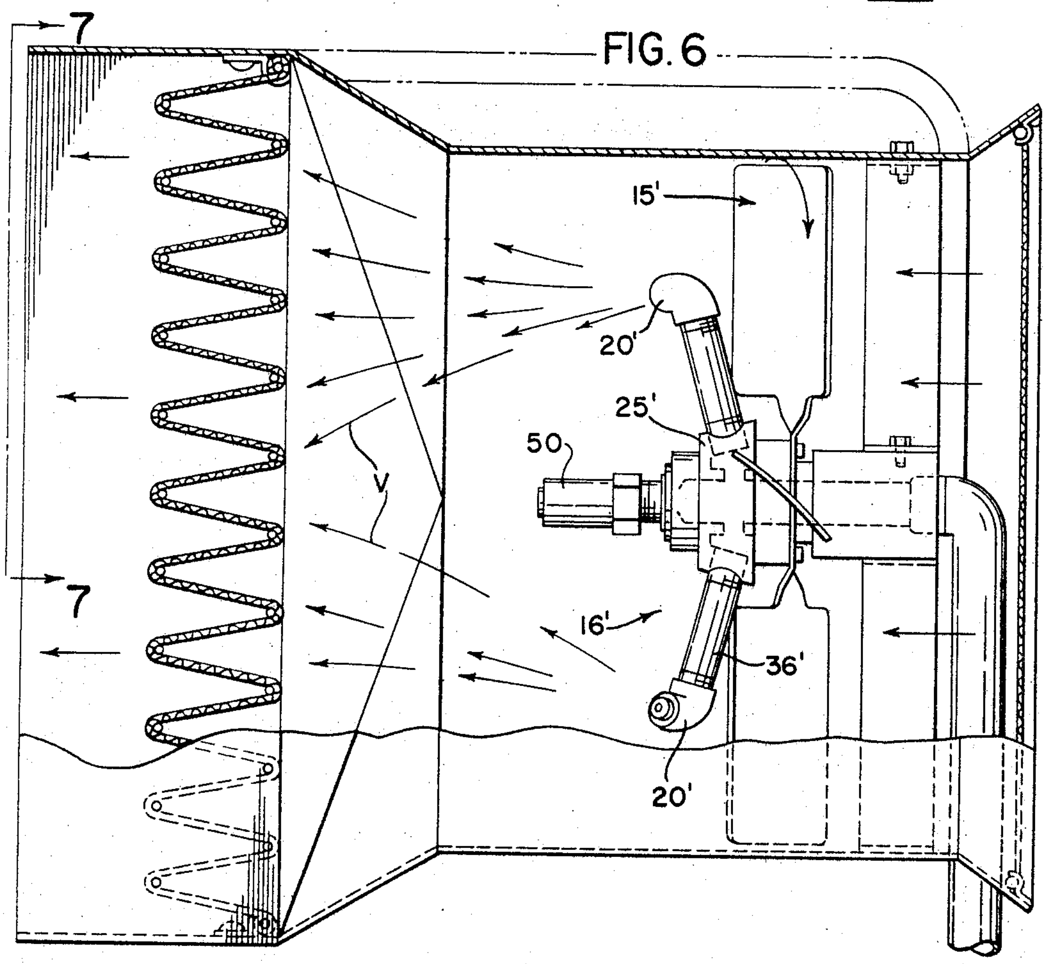
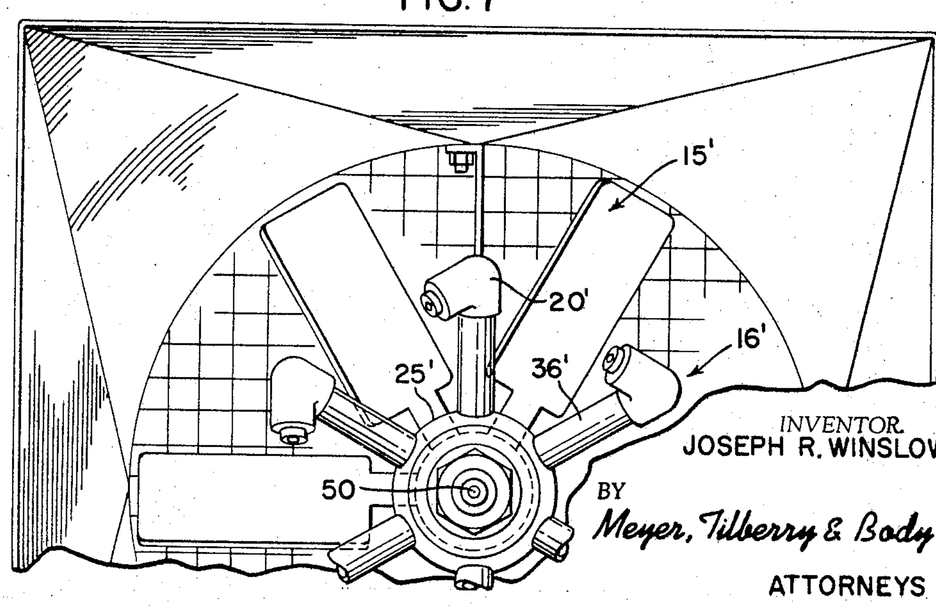


FIG. 7



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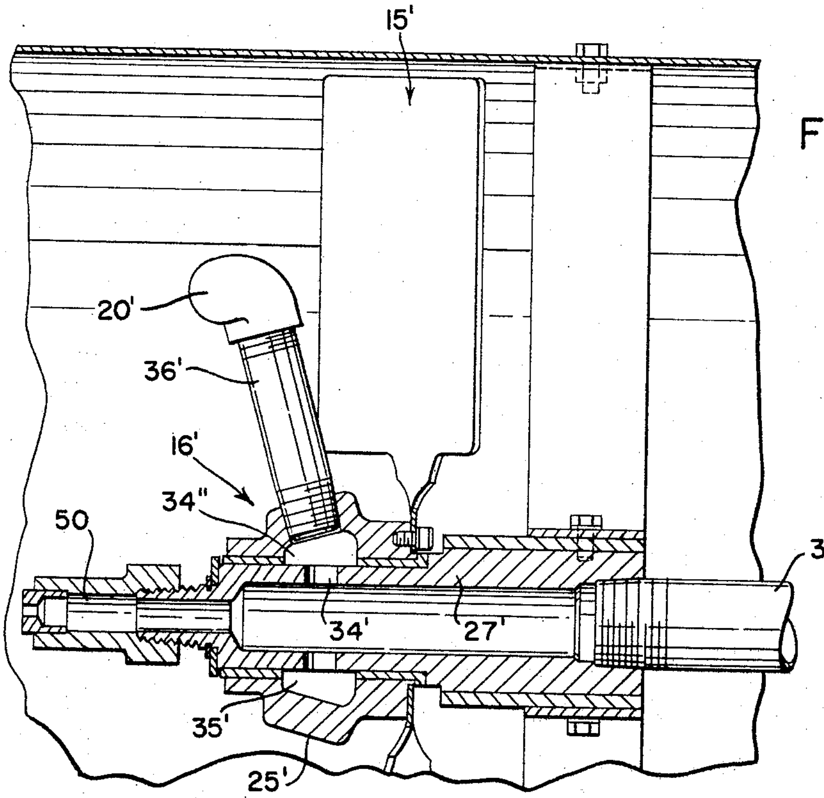
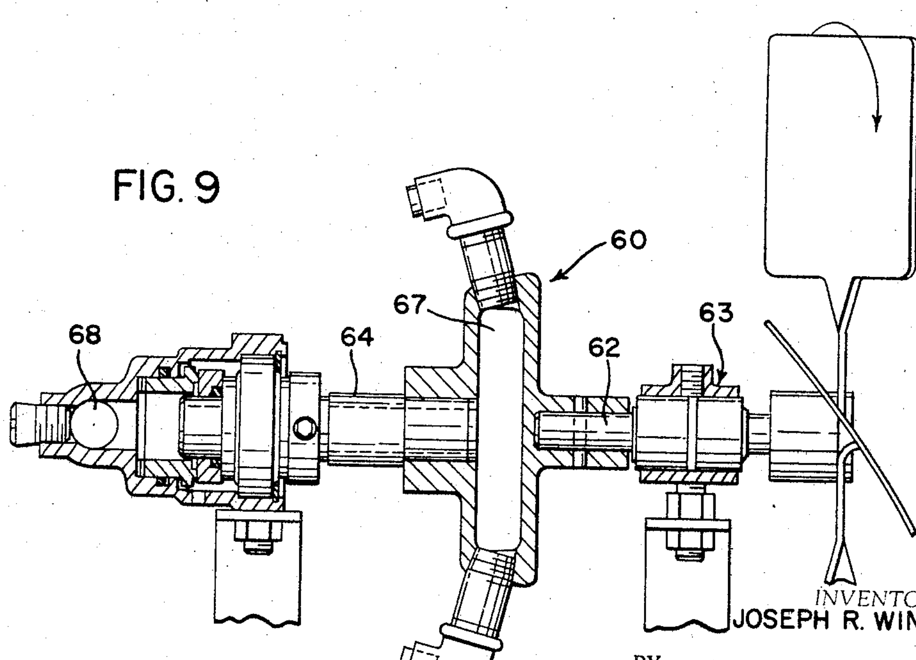


FIG. 8

FIG. 9



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METHOD AND APPARATUS FOR GENERATING FIRE-FIGHTING FOAM

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U.S. Cl. 169—15 7 Claims
Int. Cl. A62c *35/46, 35/18;* B05b *3/06*

ABSTRACT OF THE DISCLOSURE

A fire protection method and apparatus for generating high expansion foam. The disclosed apparatus includes an elongated housing having an inlet and an outlet and a perforated member extending across its free passage area. A fan is positioned in the housing and drivingly rotated by impulse nozzles supplied with pressurized liquid foam solution. The nozzles are arranged to provide a relatively uniform wetting of the perforated means while driving the fan in a direction to provide air flow through the housing and against the perforated means at a pressure sufficient to produce high expansion foam bubbles on the downstream side of the perforated means.

This invention relates to fire protection apparatus and more particularly to a fire fighting foam generator for making foam characterized by having a very high air-to-liquid content known as high expansion foam.

This invention will be described with reference to a tubular foam generator having a fan, a readily wettable sieve downstream of the fan, and jet nozzles for dispersing a spray of liquid foam producing solution over the sieve. As air is forced by the fan through the sieve, bubbles of foam are continuously formed and move forwardly as a foam plug into the area to be protected. Obviously the invention has much broader application, however, and may also be used as a smoke or fume evacuator, ventilator or the like.

By high expansion foam as used hereinafter, the meaning is that the foam plug will contain from 50 to 1500 times more air by volume than it does liquid thus distinguishing it from foam generated by turbulent aeration, i.e., where baffles or rotors are employed to beat air and liquid foam solution into a turbulent foam formation.

Heretofore high expansion foam generators have been operated with electrically powered fans. The employment of such equipment at a fire site is conditioned upon its ability to be moved to the most effective vantage point available to an electrical outlet. Moreover, in fixed installation the electrical wiring must pass certain rigid tests in order to receive an acceptable rating by regulatory and governmental agencies due to the built-in fire hazard of using electricity.

To overcome these and other disadvantages it has been proposed to power the fan hydraulically; and furthermore to power it by means of the same liquid foam solution used to wet the downstream sieve. In a co-pending United States patent application Ser. No. 362,596, filed Apr. 27, 1964, assigned to the assignee of the present invention, such an apparatus is described and claimed. The present invention is a refinement of the invention described in the aforesaid application.

In accordance with the present invention a fire protection apparatus comprises a tubular housing within which is located a fan. A perforated member or sieve covers the free passage area of the housing downstream of the fan. A plurality of jet nozzles attached to the fan and radially positioned relative to the fan axis are angularly directed and mounted so as to rotate therewith. Liquid foam solution under pressure is sprayed by the nozzles causing rota-

tion of the fan in the direction opposite to that at which the nozzles point. The air velocity created by the fan carries the spray downstream against the perforated member for the production of high expansion foam.

In an embodiment of the invention, and particularly where the circumferential force acting on the liquid spray may tend to cause it to deposit largely at the peripheral regions of the perforated member, a second battery of nozzles is positioned radially inwardly of the rotatable nozzles so as to introduce a spray concentrated more along the fan axis and centrally of the perforated member.

As a further aspect of the invention, and especially where the length of the tubular housing is to be minimized, the rotatable nozzles are mounted generally in the plane of the fan are circumferentially positioned between the fan blades.

Further in accordance with the invention, the second battery of nozzles which provide a centrally directed spray when the centrifugal force is high may be eliminated entirely by inclining the rotatable nozzles downwardly toward the fan axis.

Accordingly, it is the main object of the invention to provide fire protection apparatus employing a jet powered fan.

Another object is to provide a high expansion foam generator in which a fan is powered by hydraulic reaction jets which also introduce a spray of foam solution into the air stream created by the fan for wetting a sieve downstream of the fan.

It is a further object of the invention to provide such a foam generator reduced in length so as to be more suitable for installation where space is a problem.

A still further object is to eliminate the safety hazards common to prior art electrically powered generators.

These and other objects and advantages will be more fully appreciated by reference to the following description and drawings wherein:

FIGURE 1 is a side view of one embodiment of the invention;

FIGURE 2 is a front view of the fan embodiment of FIGURE 1 taken along line **2—2**;

FIGURE 3 is exemplary of one type of fixed installation window mounting for the invention;

FIGURE 4 is an enlarged fragmentary view of the fan embodiment of FIGURES 1 and 2;

FIGURE 5 is a schematic representation of the reaction jet motor used to drive the fan embodiment of FIGURE 4;

FIGURE 6 is a side view partially broken away to show another fan embodiment of the invention;

FIGURE 7 is a fragmentary front view of the apparatus in FIGURE 6 taken on line **7—7**;

FIGURE 8 is an enlarged fragmentary view of the reaction motor embodiment depicted in FIGURE 6; and

FIGURE 9 is a view of still another reaction motor embodiment in accordance with the invention.

Referring now to the drawings wherein the showings are for the purpose of illustrating preferred embodiments of the invention only and not for the purpose of limiting the same, in FIGURES 1 and 2, a foam generator **10** is shown to include a tubular housing **12** having an air intake **13** and outlet **14**. A fan **15** mounted within the housing **12** is driven in accordance with the invention by a reaction jet motor generally indicated by the numeral **16** and described more in detail hereinafter. A perforated member or sieve **17** extends across the free passage area of the housing **12** adjacent the outlet **14**. A liquid spray of foam solution is introduced by nozzles **20** which is then borne by the velocity of the air stream created by the fan against the sieve **17**. The number of foam-forming perforations **22** in the sieve **17** is greatly increased by virtue of the zig-zag pattern. The number of bubbles formed, and consequently the volume of foam produced, can be increased, to a degree, by increasing the velocity of the air flow and/or the perforated surface area of the sieve **17**. The upper limit on the velocity of the air stream is dependent on various factors such as the surface tension of the foam solution, which affects its ability to bridge across the foam-forming perforations **22**, and the size of the perforations.

The housing **12** has a constant diameter portion **23** closely surrounding the blades **19** of fan **15** which is joined by an outwardly tapered section **24** of increasing cross-sectional area, the purpose of which will be explained hereinafter. Foam is produced on the sieve **17** by forcing air through the perforations which have been sprayed with the foam solution from nozzles **20**. The principle used is not unlike that of a toy bubble pipe. As the foam is formed upon the sieve **17**, it continuously detaches itself as new foam is generated and advances forwardly as a foam plug. The higher the expansion ratio, i.e., the ratio of the volume of air present to the volume of liquid foam solution, the quicker the affected space will be filled with foam; however, for some applications wetter foam is used for its greater heat barrier properties. For purposes of discussion, wetter foam refers to foam having an expansion ratio of between 50 and 200 to 1. As a general rule, high expansion foam having an expansion ratio of in the order of 500 to 1 will serve most applications and is preferred.

Referring now particularly to FIGURES 4 and 5, the fan **15** includes a hub **25** journaled on a shaft **27** mounted axially of the housing **12** upon a fan support frame **28**. The shaft **27** is hollow and is connected at one end to a line **30** communicating with a source of pressurized foam solution which has been referred to herein and generally comprises mostly water with a detergent chemical added of any well-known type in the proper proportions to insure stable high expansion foam. The shaft **27** and bearing **32** have circumferentially spaced ports **34, 34′** connecting to a chamber **35** in the fan hub. The fan hub **25** supports a plurality of radially extending pipes **36** each connecting with chamber **35** and spaced circumferentially between the fan blades **19** (FIGURE 2). Each pipe **36** carries a nozzle **20**.

Referring now to FIGURE 5 and in accordance with the invention, each nozzle **20** points at an angle to the axis of fan rotation A. Under pressure from line **30**, each nozzle introduces a spray jet of foam solution indicated at B. Since the fan hub **25** which supports the nozzles **20** is free to rotate, the combined thrust from each of the nozzles **20** imparts rotation to the fan **15** in the direction of arrow C. Thus the reaction motor assembly **16** is the sole source of power for the fan **15**. The angulation of the nozzles **20** with respect to the fan axis A is such that there is a substantial downstream force behind the spray as indicated by the spray jet vector D. The angle which the nozzles **20** make relative to the axis of rotation A may be varied but in most cases will be as great as possible without the jet spray impinging directly upon the fan blades **19**. The greater the length of pipes **36**, the greater will be the moment arm of the reaction motor **16** for driving the fan **15**; however, the point is reached where, in the interest of greater fan velocity, the angulation of the nozzles **20** and the length of the pipes **36** will increase to a point where the spray is greatly influenced by the centrifugal action. At this point, it is deposited largely at the marginal boundaries of the sieve **17**.

In this event, and further in accordance with the invention, a nonrotatable spray battery **40** may be provided. As shown in FIGURES 2 and 4, the spray battery **40** includes a cross fitting **41** from which extend four pipes **42** on the ends of which are mounted nozzles **21**. The fitting **41** communicates through the shaft **27** with the pressure line **30**. The nozzles **21** point axially and when under pressure direct a spray of foam solution more or less concentrated toward the center of the sieve **17** and thus insure uniform wetting thereof.

In operation the apparatus **10** could be installed as shown for example in FIGURE 3 within an opening **45** of a building so that the inlet **13** is on the outside and the outlet **14** on the inside. It will be understood that a fixed installation as shown in FIGURE 3 is only one application of the invention and that others can be envisioned, particularly mobile mounted fire truck units, since there is no dependence on electrical power. Under pressure in line **30**, the fan **15** is rotated by the reaction motor **16** which also introduces the foam solution spray wetting the downstream sieve **17**. On high velocity units, the spray battery **40** will insure coverage of the central perforations **22**. The quantity of foam generated is largely a function of the total area of sieve **17** within certain velocity limits; that is, if the velocity of the air stream is too high, bubbles will not bridge across the foam-forming perforations **22** and blown out regions will result in which no foam is generated. A certain percentage of the foam solution will merely drain off of the sieve **17** from the blown out regions. The maximum velocity is a balance of various factors but an important part is the shape of the housing **12**. As previously noted, the constant diameter portion **23** is joined by an increasing cross-sectional area portion **24**. As a result, a significant portion of the velocity head of the air stream is converted into a dynamic pressure head immediately behind the sieve **17**. The fan r.p.m.'s can thus be increased. Thus, in accordance with the invention, by merely increasing the pressure of the foam solution, a coordinated action occurs in which the fan increases in speed automatically to increase foam production consistent with the increased volume of spray introduced.

In the preferred embodiment of the invention, the reaction motor **16** is mounted on the fan hub **25** so that the housing **12** can be considerably shortened, as is apparent in FIGURE 1, thus enabling the installation of window type units as shown in FIGURE 3 with a minimum of overhang. In a second embodiment of the invention where the housing can be longer, reference is made to FIGURES 6, 7 and 8. In this embodiment, like parts are identified by like numerals and similar parts by like numerals with the addition of a prime mark. In the modification, a fan **15′** is driven by a reaction motor **16′** mounted on the fan hub **25′**. The reaction motor **16′** differs from that in the preferred embodiment in that the pipes **36′** are inclined forwardly as shown best in FIGURE 6. The degree of inclination of the nozzles **20′** toward the fan axis is sufficient to compensate for the centrifugal force acting on the spray, indicated by the directional arrows V, so that a more uniform distribution of spray is made on the sieve **17**. Consequently, a secondary or auxiliary group of spray jets, such as the battery of jets **40** in the preferred embodiment of the invention, is unnecessary in the modification however, if desired, an optional, central nozzle **50** may be provided to introduce a spray directly at the center.

In a further embodiment of the invention (FIGURE 9) the reaction motor **60** is connected to a fan shaft **62** journaled at **63**. A hollow shaft **64** supporting the reaction motor **60** connects the chamber **67** thereof with a pressure line **68**. Operation is substantially like the embodiment in FIGURES 6–8.

Having thus described my invention, I claim:

1. The method of generating high expansion foam comprising the steps of

introducing a high velocity spray of liquid foam solution into a tubular housing at an angle relative to the housing axis, to produce a jet reaction force,

causing rotation of a fan about the housing axis in response to said jet reaction force to thereby cause air to flow through the housing, and

depositing the high velocity spray against a perforated member positioned downstream of the fan so as to close the perforations thereof with a film of liquid foam solution, and

forming bubbles of foam on the perforated member as the air becomes trapped in the film, which under the prevailing dynamic pressure head, continuously detach themselves as a high expansion foam plug.

2. The method according to claim **1** wherein the dynamic pressure head is sufficient to form a foam plug having an air to liquid ratio as high as 1500 to 1.

3. A high expansion foam generating fire protection apparatus comprising:

an elongated tubular housing having an inlet end and an outlet end;

fan means positioned within said housing between said inlet end and said outlet end and arranged so that upon rotation in a first direction air is caused to flow from said inlet end to said outlet end;

a perforated member covering the free passage area of said housing downstream of said fan means in the direction of air flow; a plurality of jet spray nozzles positioned within said housing and connected with a source of foam generating liquid solution under pressure, said nozzles being positioned upstream of said perforated means and substantially all of said nozzles being directed generally toward said perforated means and laid out in an arrangement to provide generally uniform wetting of said perforated means by said liquid solution; and,

at least some of said nozzles being rotatably mounted and connected to said fan, a sufficient number of said rotatably mounted nozzles being inclined slightly relative to their axis of rotation so as to produce a reaction force for rotating said fan in said first direction at a velocity sufficient to produce a dynamic air pressure on the upstream side of said perforated means capable of producing a foam plug having an air-to-liquid ratio above 50 to 1.

4. A high expansion foam generating apparatus as defined in claim **3** wherein said rotatably mounted nozzles are carried on elongated arms directly connected to said fan means.

5. A high expansion foam generating apparatus as defined in claim **3** wherein at least one of said nozzles is stationary and positioned generally centrally of said housing.

6. A high expansion foam generating apparatus as defined in claim **3** wherein all of said nozzles are rotatably mounted.

7. A high expansion foam generating apparatus as defined in claim **3** wherein said nozzles are spaced radially and circumferentially of the axis of rotation of said fan.

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U.S. Cl. X.R.

239—251