March 4, 1969 F. M. McDOUGALL 3,430,865

FOAM GENERATOR

Original Filed Feb. 9, 1966

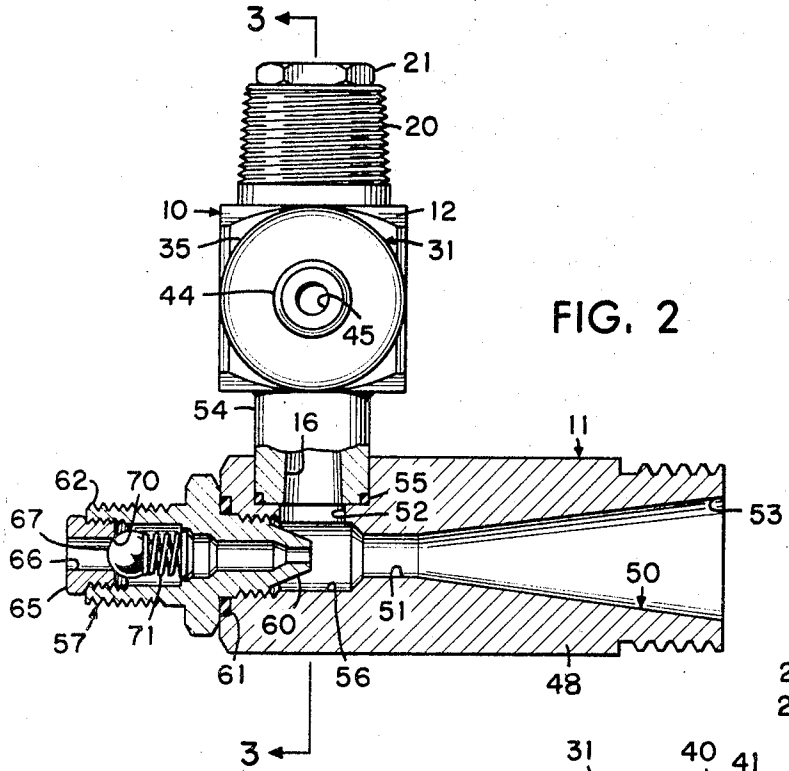


FIG. 2

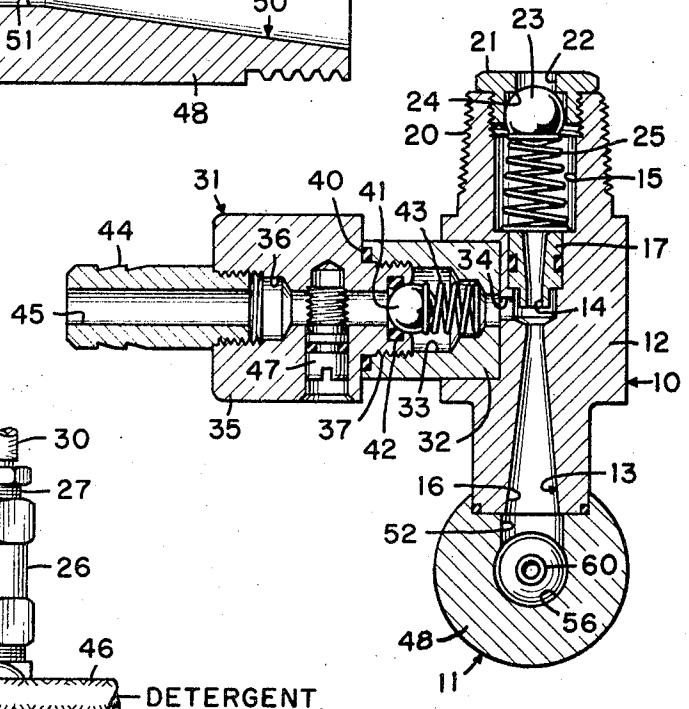


FIG. 3

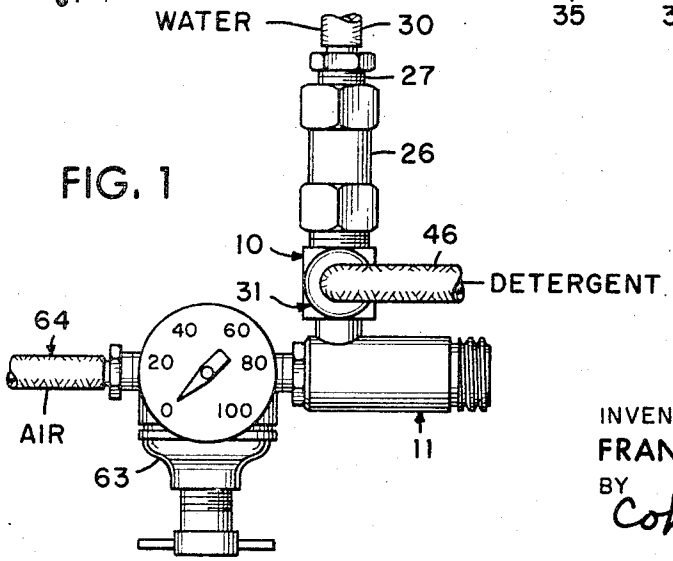


FIG. 1

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FOAM GENERATOR

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U.S. Cl. 239—427.5 3 Claims
Int. Cl. B05b 7/00, 7/04; A47k 5/14

ABSTRACT OF THE DISCLOSURE

A first injector, including a venturi having a constricted throat, interposed between an inlet and an outlet receives water under pressure. An induction passage communicates with the throat so that detergent is induced into the injector by pressure drop at the throat, there to be mixed with the water. The resulting mixture is discharged from the first injector into a second injector, which includes a second venturi. The second injector is substantially transverse to the first injector. The outlet of the first venturi communicates with a chamber ahead of the throat of the second venturi. An air nozzle communicates with the chamber to introduce air under positive pressure into the chamber so that the mixed water and detergent liquid are air entrained. The resultant stream is discharged through the second venturi and into the atmosphere to create a foam. Check valves disposed in the first venturi, the detergent induction passage, and the air nozzle, preclude reversal of flow at these locations.

This application is a continuation of application Ser. No. 526,111 filed Feb. 9, 1966, now abandoned.

This invention relates generally to improvements in a foam generator, and more particularly to a method of generating foam and to the apparatus utilized.

An important object is to provide a foam generator that is capable of producing a thick foam which can be applied directly to any surface, such foam adhering to the surface regardless of its shape, size or disposition. The generator is especially useful in cleaning walls of all types, and in cleaning vehicle bodies such as trucks, airplanes and automobiles. When used for such cleaning operations, the foam consists of water and detergent of predetermined proportions having a predetermined dryness.

It is an important object to provide a method of generating foam which comprises the steps of moving water under pressure through a venturi of a first injector, inducing liquid detergent into the water flow substantially at the throat of the venturi of the first injector, feeding the resultant liquid stream of mixed water and detergent from the first injector into a second injector, moving air under pressure into the second injector, mixing and entraining the air with the liquid stream, and discharging the liquid stream and entrained air through a venturi of the second injector and from the second injector to the atmosphere to create a foam.

An important object is realized by feeding the resultant liquid stream of mixed water and detergent into the second injector ahead of the throat of the venturi of the second injector, and mixing and entraining the air with the liquid stream ahead of of the throat of the venturi of the second injector.

Another important object is afforded by inducing the liquid detergent into the water flow in a predetermined proportion, and mixing the air under pressure into entrainment with the proportioned liquid stream after the water and detergent have been proportioned and where there is a substantial amount of kinetic energy in the liquid stream. The air is placed into the liquid stream without sacrificing any of the liquid pressure.

Still another important object is attained by feeding the resultant liquid stream of mixed water and detergent into a chamber of the venturi of the second injector ahead of the venturi throat of the second injector, moving the air in a jet under pressure into the chamber and in a direction toward the venturi throat of the second injector, mixing and entraining the air with the liquid stream in the chamber, and discharging the liquid stream and entrained air primarily under the motive force of the liquid stream through the venturi of the second injector and from the second injector to the atmosphere to create the foam.

An important object is achieved by the provision of a foam generator apparatus in which a first injector includes a first venturi having a throat between an inlet and an outlet, the inlet being adapted for connection to a water source under pressure, and includes an induction passage having a port communicating with the throat of the first venturi, the induction passage being adapted for connection to a liquid detergent source so that the liquid detergent is induced into and mixed with the water flow to provide a resultant liquid stream discharged from the outlet of the first venturi. A second injector includes a second venturi having a throat between an inlet and an outlet. Means interconnects the first venturi outlet to the second venturi inlet to feed the liquid stream from the first injector to the second injector, and an air nozzle communicates with the second venturi inlet, the nozzle being adapted for connection to an air source under pressure so that the nozzle mixes and entrains air with the liquid stream. The liquid stream and entrained air is discharged through the second venturi throat and from the second venturi outlet to the atmosphere to create the foam.

Another important objective is provided by a structural arrangement of a chamber ahead of the second venturi throat into which the proportioned liquid stream is discharged by the first venturi outlet, and of the air nozzle directing an air jet into the chamber to mix and entrain the air with the liquid stream ahead of the second venturi throat, the liquid stream and entrained air being discharged through the second venturi throat and outlet primarily under the motive force of the liquid stream.

Yet another important object is realized by constructing the cross-sectional flow area of the chamber so that it is at least as large as the cross sectional flow area of the first venturi outlet, whereby the air is mixed and entrained under pressure with the proportioned liquid stream at a point where the liquid stream is under substantial pressure and before flow through the second venturi throat.

An important objective is afforded by communicating the first venturi outlet with the chamber laterally relative to the longitudinal flow axis passing through the second venturi throat, and by arranging the air nozzle so that it is directed into the chamber toward the second venturi throat and is substantially aligned with the longitudinal flow axis of the second venturi throat.

Another important objective is attained by the provision of a first check valve in the first venturi of the first injector ahead of the first venturi throat and the induction port so as to preclude reverse flow through the first venturi inlet, by the provision of a second check valve in the induction passage which precludes reverse flow from the first venturi throat through the induction port and induction passage, and by the provision of a third check valve in the air nozzle which precludes reverse flow through the nozzle from either the first venturi outlet or from the second venturi inlet.

A further important objective is to provide a foam generator apparatus that is simple and durable in con-

struction, economical to manufacture and assemble, highly efficient in operation, and which can be utilized by any one with little or no instruction.

The foregoing and numerous other objects and advantages of the invention will more clearly appear from the following detailed description of a preferred embodiment, particularly when considered in connection with the accompanying drawing, in which:

FIG. 1 is a side elevational view of the foam generator assembly;

FIG. 2 is an enlarged elevational view of the first and second injectors, the second injector and part of the first injector being shown in cross section, and

FIG. 3 is a cross-sectional view as taken along line 3—3 of FIG. 2.

Referring now by characters of reference to the drawing, and particularly to FIG. 1, it will be understood that the assembly of the foam generator includes a first injector generally indicated by **10** secured and operatively connected to a second injector referred to by **11**. The detailed construction of the first injector **10** is best illustrated in FIG. 3, while the detailed construction of the second injector **11** is best shown in FIG. 2.

From FIG. 3, it will be apparent that the first injector **10** includes an elongate body **12** having a first venturi generally indicated by **13** extending therethrough. This venturi **13** includes a narrow throat **14** between an inlet **15** and an outlet **16**. The narrow venturi throat **14** is part of a bore through a plug **17** inserted into the first injector **10** and sealingly engaging the injector body **12**. For convenience, the plug **17** can be removed and another corresponding plug having a venturi throat **14** of a different cross section can be substituted. The selective placement of a plug **17** having a predetermined venturi throat size is advantageous in regulating and controlling the minimum pressure in the venturi throat **14** desired or necessary in order to induce detergent into the first venturi **13**, as will be later described.

The first injector body **12** includes a threaded end **20** containing the first venturi inlet **15**. The body end **20** is partially threaded internally of the first venturi inlet **15** to receive and connect a cooperating nut **21**. The nut **21** is provided with an inlet port **22** adapted to communicate with the first venturi inlet **15**. A check valve is located in the first venturi **13** of the first injector **10**. Specifically, the check valve includes a ball **23** constituting a valve member, located within the first venturi inlet **15** and engaging the nut **21**, constituting a valve seat **24** at the periphery of the inlet port **22**. A compression spring **25** is disposed within the first venturi inlet **15**, one end of the spring **25** engaging the ball **23**, and the other end engaging the injector body **12** and plug **17**. The spring **25** tends to urge the ball **23** against the valve seat **24** to close the inlet port **22**.

Threadedly connected to the body end **20** is a pipe coupling **26** (FIG. 1). A hose adapter **27** is attached to the opposite end of the pipe coupling **26**, the hose adapter **27** being connected to a hose **30**, constituting a conduit, which is connected to a source of water under pressure. As will be understood, the maximum water pressure required with this foam generator assembly is approximately 40 p.s.i.

Attached to the first injector body **12** is a detergent fitting referred to by **31** consisting of several interconnected parts. The detergent fitting **31** includes a tubular core **32** attached to the first injector body **12** adjacent the first venturi throat **14**. The core **32** is provided with an internal bore **33** communicating with an induction port **34** formed in the first injector body **12** immediately opposite to and communicating with the first venturi throat **14** substantially in the region of the lowest pressure existing in the first venturi **13**.

Fastened to the fitting core **32** is a meter cap **35** having an internal bore **36** extending therethrough and communicating with the core bore **33**. The meter cap **35** has a threaded nipple **37** inserted into and threadedly connected to the fitting core **32**. An O-ring **40** forms an effective seal between the fitting core **32** and meter cap **35**.

Another check valve is disposed within the detergent fitting **31**. Specifically, the check valve includes a ball **41**, constituting a valve member, located within the bore **33** of fitting core **32**, the ball **41** being adapted to close the cap bore **36**, constituting a part of the detergent induction passage, by engaging an O-ring **42**, constituting a valve seat, retained within the nipple **37**. A compression spring **43** is located within the core bore **33**, one end of the spring **43** engaging the ball **41**, and the other end engaging the core **32**. The spring **43** tends to urge the ball **41** against the O-ring **42** to close the detergent induction passage.

Threadedly connected to the meter cap **35** is a hose adapter **44** having an internal bore **45** that communicates with the bore **36** of meter cap **35**. It will be understood that the operatively interconnected bores **33**, **36** and **45**, together with the induction port **34** form and constitute the detergent induction passage through the detergent induction fitting **31**. As is indicated in FIG. 1, a hose **46** is operatively connected to the hose adapter **44**. The opposite end of the detergent hose **46** is submerged in a liquid detergent or in any other liquid concentrate to be induced into the water flow through the first injector **10**. The liquid detergent can be stored in any size shipping container (not shown).

A metering valve **47** is threadedly connected to the meter cap **35**, the meter valve **47** extending across the bore **36**. The cross sectional dimension of bore **36** and the body of meter valve **47** are related so that when the meter valve **47** is fully inserted, the body of such meter valve **47** will effectively close the bore **36** to preclude any flow of detergent through the detergent induction passage. By backing off the meter valve **47**, the bore **36** is opened to such a predetermined extent to control and regulate the amount of detergent flow through the passage. Obviously, the metering valve **47** selectively regulates or meters the detergent flow through the detergent flow passage and into the first venturi **13** of the first injector **10**, and thereby precisely regulates the proportion of water and detergent mixed in the first venturi **13**.

The second injector **11** (FIG. 2) includes an elongate body **48** in which a second venturi referred to by **50** is formed. This second venturi **50** includes a relatively narrow throat **51** between an inlet **52** and an outlet **53**.

The first injector body **12** includes a reduced end **54** in which the first venturi outlet **16** is located. The reduced body end **54** is fastened to the body **48** of the second injector **11** so that the first venturi outlet **16** communicates directly with the second venturi inlet **52**. An O-ring **55** provides an effective seal between the end **54** of the first injector **10** and the body **48** of the second injector **11**.

The second venturi inlet includes a chamber **56** ahead of the second venturi throat **51**. The cross sectional flow area of chamber **56** is at least as great as the cross sectional flow area of the first venturi outlet **16** so that the water pressure within the chamber **56** has a substantial value. The first venturi outlet **16** communicates with the chamber **56** laterally relative to the longitudinal flow axis passed through the second venturi throat **51**.

An air injector generally indicated by **57** includes a nozzle **60** threadedly attached to the second injector body **48** and extending into the chamber **56**. An O-ring **61** provides an effective seal between the nozzle **60** and the second injector body **48**. The nozzle **60** introduces an air jet into the chamber **56** to mix and entrain air with the proportioned liquid stream passing into and through the chamber **56** from the first venturi **13** of the first injector **10** before the liquid stream passes through the second venturi throat **51**. The air is mixed and entrained with the liquid stream in chamber **56** where there is a substantial amount of kinetic energy remaining in the liquid stream. In other words, the air is mixed and entrained

into the liquid stream without sacrificing any of the liquid pressure.

The nozzle **60** is directed toward the second venturi throat **51** and is aligned with the longitudinal flow axis passed through the second venturi throat **51**.

The nozzle **60** includes a threaded nipple **62** adapted to be connected to an air pressure regulator and gauge indicated by **63** and illustrated in FIG. 1. An air hose **64** is operatively connected to the pressure regulator and gauge **63**, and thence is operatively connected to the nozzle **60**. The air hose **64** is operatively connected to a compressed air source (not shown) capable of producing a maximum air pressure of 60 p.s.i.

A check valve is provided in the air injector **57** as is best seen in FIG. 2. The check valve includes a nut **65** threadedly attached to and located internally of the nipple **62**. The nut **65** includes an inlet port **66** consituting of part of the air flow passage through the nozzle **60**. A ball **67**, constituting a valve member, is located within the nozzle **60** and is adapted to engage the nut **65** about the periphery of inlet port **66**, constituting a valve seat **70**. A compression spring **71** is located within the nozzle **60**, one end of the spring **71** engaging the ball valve **67**, and the other end of the spring **71** engaging the nozzle **60**. The spring **71** tends to urge the ball **67** against the valve seat **70** to close the air passage through nozzle **60**.

It is thought that the usage of the foam generator has become fully apparent upon the detailed description of parts, but for completeness of disclosure, the operation and functional advantages will be briefly described.

It will be assumed that the first injector **10** is fixed to the second injector **11**, that the detergent fitting **31** is fixed to the first injector **10**, that the air injector **57** is fixed to the second injector **11**, and that the pipe coupling **26** and air regulator and gauge **63** all have been assembled as illustrated in FIG. 1. The hose **30** connected to the first injector **10** is operatively connected to a source of water supply to provide a water flow under pressure of approximately 40 p.s.i. The detergent hose **46** is fastened to the hose adapter **44** and is placed in liquid detergent stored in a suitable container. The air hose **64** is connected to the regulator and gauge **63**, and thence to the second injector **11**, and is connected to a source of compressed air to provide an air pressure of approximately 60 p.s.i. Any suitable hose or pipe (not shown) may be attached to the discharge end of the second injector **11**, if desired, to direct and apply the discharged foam created by the generator onto the surface to be cleaned.

The water flows under pressure past the ball **23** and into the venturi inlet **15**, and thence through the first venturi throat **14**. Because the velocity of the water flow through the narrow first venturi throat **14** is increased, the pressure existing at such narrow throat **14** is correspondingly reduced so that the pressure differential existing in the detergent flow passage and the first venturi **13** at throat **14** causes or induces a detergent flow through the detergent hose **46** and into the detergent fitting **31** past the ball **41** and through the induction port **34**. The meter valve **47** can be selectively adjusted to provide a predetermined flow rate for the liquid detergent moving through the detergent induction passage.

The liquid detergent is mixed with the water in a predetermined proportion, and the resultant, proportional liquid stream is discharged through the first venturi outlet **16** into the second venturi inlet **52**, and thence into the venturi chamber **56** ahead of the narrow second venturi throat **51**.

The source of compressed air provides air under pressure of approximately 60 p.s.i. through the regulator and gauge **63**, and thence to the nozzle **60**. The air under pressure flows past the ball **67** and is discharged in an air jet through the nozzle **60** into the venturi chamber **56** wherein the air is mixed and entrained with the proportioned liquid stream under conditions of relatively high liquid pressure. After the air has been mixed and entrained with the proportioned liquid stream in the venturi chamber **56**, the liquid stream and entrained air flows through the second venturi throat **51** and through the second venturi outlet **53** primarily under the motive force of the liquid stream. Upon discharge of the liquid stream and entrained air to the atmosphere, a thick foam is created that can be applied to the surface to be cleaned, the foam adhering to such surface and facilitating cleaning operations.

The ball **23** precludes reverse water flow from the first venturi inlet **15** and induction port **34** back into the source of water supply. The ball **41** precludes reverse flow from the first venturi throat **14** and induction port **34** back through the detergent induction passage and into the supply of liquid detergent. The ball **67** precludes reverse flow through the nozzle **60** from either the first venturi outlet **16** or from the second venturi inlet **52** or chamber **56**.

Although the invention has been described by making detailed reference to a single preferred embodiment, such detail is to be understood in an instructive, rather than in any restrictive sense, many variants being possible within the scope of the claims hereunto appended.

I claim as my invention:

1. In a foam generator:

(a) a water source under pressure,

(b) a first injector including a first venturi having a throat between an inlet and an outlet,

(c) means connecting the first venturi inlet to the water source,

(d) a liquid detergent source,

(e) the first injector including an induction passage having a port communicating laterally, substantially with the throat of the first venturi,

(f) means connecting the induction passage to the liquid detergent source, the liquid detergent being mixed with the water flow substantially at the first venturi throat to provide a resultant water-detergent stream discharged from the first venturi outlet,

(g) a second injector including a second venturi having a throat between an inlet and an outlet, the throat being substantially peripherally enclosed about the diameter,

(h) the second venturi inlet including a chamber ahead of the second venturi throat,

(i) the first venturi outlet communicating with the chamber laterally relative to the longitudinal flow axis of the second venturi throat, and discharging the water-detergent stream into the chamber for flow under pressure through the second venturi along the longitudinal flow axis,

(j) an air source under pressure,

(k) an air nozzle opening into the chamber in substantial alignment with the longitudinal axis of the second venturi throat, and

(l) means connecting the air nozzle to the air source,

(m) the air nozzle directing an air jet into the chamber, and into the water-detergent stream in the direction of flow along the longitudinal axis, the water-detergent stream and entrained air being discharged along the longitudinal axis through the second venturi throat and from the second venturi outlet primarily under the motive force of the water-detergent stream and assisted by the air jet, to the atmosphere to create the foam.

2. In a foam generator:

(a) a first injector including a first venturi having a throat between an inlet and an outlet, the inlet being adapted for connection to a water source under pressure,

(b) the first injector including an induction passage having a port communicating substantially with the throat of the first venturi, the induction passage being adapted for connection to a liquid detergent source, the liquid detergent being mixed with the water flow to provide a resultant liquid stream discharged from the outlet of the first venturi,

(c) a second injector including a second venturi having a throat between an inlet and an outlet,
(d) means interconnecting the first venturi outlet to the second venturi inlet to feed the liquid stream of mixed water and detergent from the first injector to the second injector, and
(e) an air nozzle communicating with the second venturi inlet and adapted for connection to an air source under pressure, the nozzle mixing and entraining air with the liquid stream, the liquid stream and entrained air being discharged through the second venturi throat and from the second venturi outlet to the atmosphere to create a foam,
(f) the second venturi inlet including a chamber ahead of ther second venturi throat,
(g) the first venturi outlet communicating with and discharging the proportioned liquid stream into the chamber,
(h) the air nozzle directing an air jet into the chamber, and mixing and entraining the air with the liquid stream ahead of the second venturi throat, the liquid stream and entrained air being discharged through the second venturi throat and outlet primarily under the motive force of the liquid stream to the atmosphere to create the foam,
(i) a first check valve being disposed in the first venturi of the first injector ahead of the first venturi throat and ahead of the induction port, the check valve precluding reverse flow through the first venturi inlet,
(j) a second check valve being disposed in the induction passage, precluding reverse flow from the first venturi throat through the induction port and passage, and
(k) a third check valve being disposed in the air nozzle precluding reverse flow through the nozzle from either the first venturi outlet or the second venturi inlet.

3. In a foam generator:
(a) a first injector including a first venturi having a throat between an inlet and an outlet, the inlet being adapted for connection to a water source under pressure,
(b) the first injector including an induction passage having a port communicating substantially with the throat of the first venturi, the induction being adapted for connection to a liquid detergent source, the liquid detergent being mixed with the water flow to provide a resultant liquid stream discharged from the outlet of the first venturi,
(c) a second injector including a second venturi having a throat between an inlet and an outlet,
(d) means interconnecting the first venturi outlet to the second venturi inlet to feed the liquid stream of mixed water and detergent from the first injector to the second injector,
(e) an air nozzle communicating with the second

venturi inlet and adapted for connection to an air source under pressure, the nozzle mixing and entraining air with the liquid stream, the liquid stream and entrained air being discharged through the second venturi throat and from the second venturi outlet to the atmosphere to create a foam,
(f) the first injector and the air nozzle being attached to the second injector,
(g) the second venturi inlet including a chamber ahead of the second venturi throat,
(h) the first venturi communicating with the chamber laterally relative to the longitudinal flow axis passed through the second venturi throat,
(i) the air nozzle extending into the chamber and being directed toward the second venturi throat and being substantially aligned with the longitudinal axis passed through the second venturi throat, the air nozzle mixing and entraining air under pressure into the proportioned liquid stream under pressure while in the chamber before passage through the second venturi throat,
(j) the cross sectional flow area of the chamber being at least as large as the first venturi outlet so that the air is mixed and entrained with the proportioned liquid stream when the liquid stream is under substantial water pressure and before flow through the second venturi throat, the proportioned liquid stream and entrained air being discharged through the second venturi throat and from the second venturi outlet to the atmosphere primarily under the motive force of the liquid stream to create the foam,
(k) a first check valve being disposed in the first venturi of the first injector ahead of the first venturi throat and ahead of the induction port, the first check valve precluding reverse flow through the first venturi outlet,
(l) a second check valve being disposed in the induction passage precluding reverse flow from the first venturi throat through the induction port and passage, and
(m) a third check valve being disposed in the air nozzle precluding reverse flow through the nozzle from either the first venturi outlet or the second venturi inlet.

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U.S. Cl. X.R.

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