Feb. 12, 1952 C. F. BOE 2,585,429

TRIPLE EXPANSION NOZZLE AND METHOD OF SPRAYING LIQUIDS

Filed Dec. 4, 1946 2 SHEETS—SHEET 1

Fig. 1.

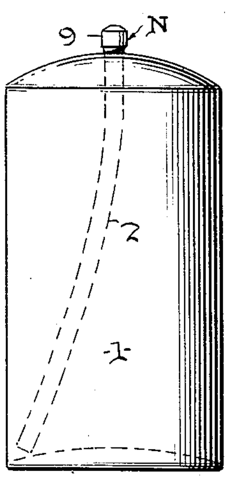


Fig. 2.

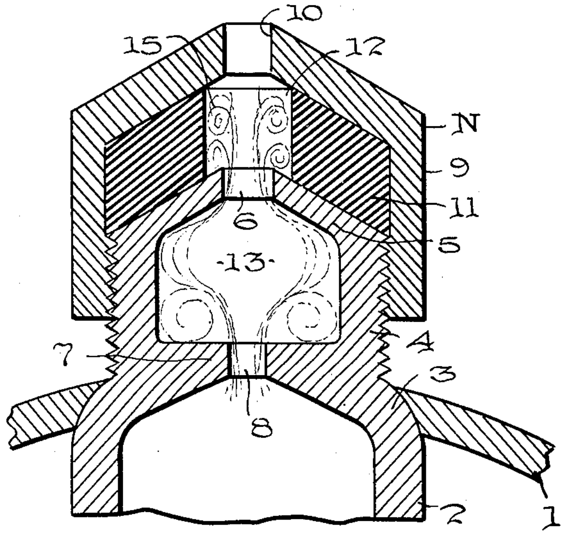


Fig. 3.

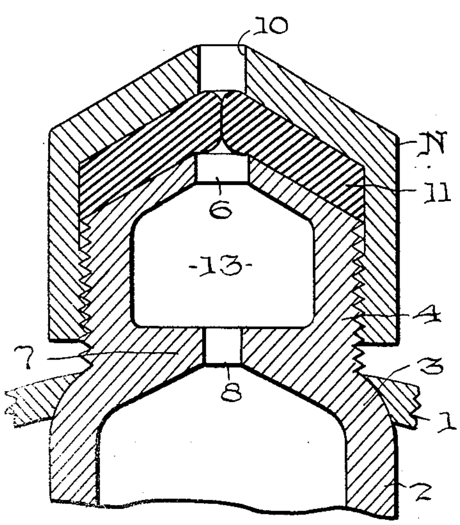
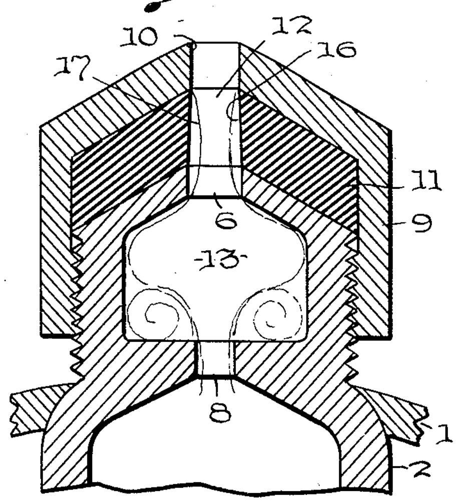


Fig. 4.



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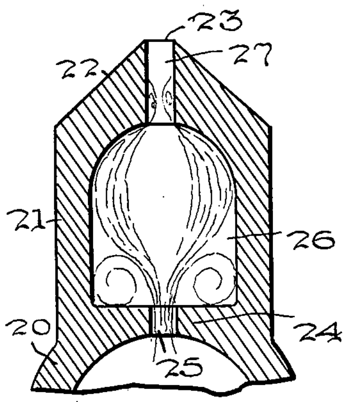

Fig. 5.

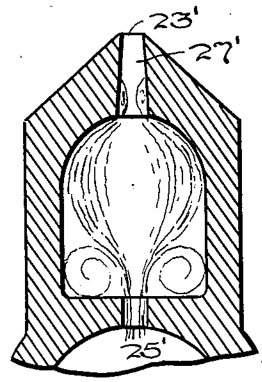

Fig. 6.

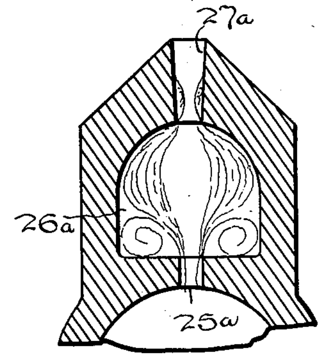

Fig. 7.

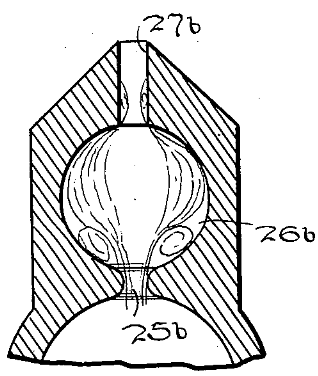

Fig. 8.

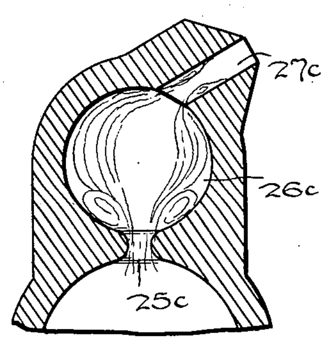

Fig. 9.

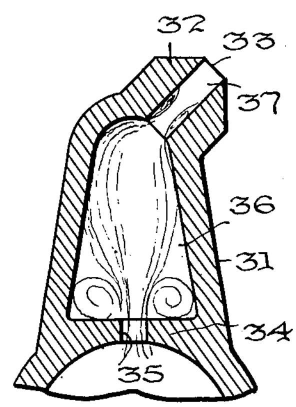

Fig. 10.

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TRIPLE EXPANSION NOZZLE AND METHOD OF SPRAYING LIQUIDS

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Application December 4, 1946, Serial No. 713,961

11 Claims. (Cl. 299—150)

1

This invention relates to a method and apparatus for discharging liquids under pressure in a fine spray containing a minimum of droplets of the liquid of appreciable size. The invention is particularly applicable to the atomization of self-propellant, self-atomizable solutions or emulsions of the type disclosed in my co-pending applications Serial Nos. 627,994 filed November 13, 1945, now Patent No. 2,494,793 and 686,426 filed July 26, 1946, now abandoned, but likewise is applicable to the spraying of any self-propellant liquid, or any liquid which contains an expandable or readily vaporizable component and is maintained in a container under suitable pressure.

The discharge of self-propellant liquids from a container in which they are maintained under a suitable pressure through a capillary tube, or through a simple orifice, resulting in a simple expansion of the liquid, or a component thereof, is well known. Also, it has been proposed to initially or primarily expand a liquefied gas into an intermediate chamber and then discharge the liquid and gas resulting from such preliminary expansion from such chamber through a restricted orifice directly into the atmosphere, thereby resulting in a secondary expansion of the liquid and gaseous mixture as it is discharged from the chamber into the atmosphere.

A single expansion resulting from the discharge of the liquefied gas directly into the atmosphere through a simple orifice results in a spray containing droplets of the unvaporized liquid of uneven size. Also, a single atomization or expansion requires a higher pressure to ensure that the liquid stream will be broken up into droplets.

Aside from the danger attendant the use of high pressures in containers to be handled by the general public, and the added expense in making the containers strong enough to withstand a high pressure, the use of high pressures is undesirable in that to obtain them it is necessary that the self-propellant mixture contain a large proportion of the liquefied gas, with the result that in a container of a given volume the self-propellant liquid will contain less of the material which it is desired to spray.

Where a second stage of expansion is utilized, the pressure under which the liquefied gas is maintained in the container also has to be undesirably high to obtain satisfactory atomization of the droplets entrained in the initially expanded liquefied gas, when such initially expanded mixture of liquid droplets and gas is projected into the atmosphere or other zone where the secondary expansion takes place.

2

Where secondary expansion is utilized, satisfactory atomization can be obtained only by having the pressure in the zone of primary expansion sufficiently high to overcome the dominating tendency of suspended droplets there combining with one another to form large droplets, and the tendency of similar droplets on the confining walls coalescing to form a film of liquid. That results in the necessity for storing the liquefied gas to be sprayed under a high pressure.

I have found that liquefied gases and liquids containing an expandable or readily vaporizable component can be satisfactorily atomized into fine sprays without the necessity of maintaining them under undesirably high pressures by interposing between the initial or primary expansion and the final expansion into the atmosphere, a single, intermediate, additional expansion in an expansion zone which is smaller than the zone of primary expansion, thereby providing expansion of the liquefied gas in three zones.

By providing such an additional, single, intermediate zone of expansion, I have found that satisfactory fine sprays of liquefied gas may be obtained even though the pressure under which the liquefied gas is maintained in the storage container does not exceed 20 lbs. per square inch gage pressure.

Thus, the present invention contemplates a method and apparatus for spraying liquefied gases and liquids containing a readily vaporizable component involving a tertiary or triple expansion of the liquefied gas, or a readily vaporizable component, the final expansion taking place when the gas, having successfully undergone primary and secondary expansion, is sprayed into the atmosphere.

The invention will be further described in connection with the accompanying drawings which represent various forms of apparatus embodying the invention and which may be used to obtain the desired triple expansion of the gases.

In the drawings:

Fig. 1 is a side elevational view of a container for a self-propellant liquid having a valved, triple expansion discharge nozzle made in accordance with the present invention,

Fig. 2 is an enlarged longitudinal sectional view of the nozzle of the container of Fig. 1, the valve being shown in its fully open position,

Fig. 3 is a view similar to Fig. 2 with the valve shown in its fully closed position,

Fig. 4 is a view similar to Figs. 2 and 3 showing the valve in an intermediate position, and

Figs. 5 to 10 inclusive are enlarged, more or less diagrammatic, longitudinal sectional views through nozzles constructed to provide triple expansion of the gases in accordance with the principle of the present invention.

Referring to the drawings, and first to Figs. 1 to 4, 1 designates a container for a self-propellant, self-atomizable liquid, or for a liquid having a relatively low boiling point which is maintained in the container under a gas pressure and which will at least partially evaporate and be atomized on discharge through a restricted orifice. The container 1 has a discharge nozzle N through which the contents thereof are discharged and atomized as hereinafter described. The discharge nozzle, which may take various forms, is adapted to provide for triple expansion of the gases being discharged through it. As shown in Figs. 2, 3 and 4, the nozzle is positioned at the upper end of a discharge tube 2 and comprises an upwardly-extending neck portion 3 having a threaded upper end 4 which is closed by an outer end wall 5, except for a small outlet orifice 6 formed in the center of the end wall.

A partition 7 extends across the neck inwardly from the outer end wall 5. A small opening 8, having sharp edges, is formed in the partition 7, preferably in the center thereof, to permit flow, under pressure, of the self-propellant liquid from the discharge tube 2 and consequently from the main body of the container 1. The partition 7, the side wall of the neck 3, and the outer end wall 5 form a chamber in which the self-propellant liquid in the container is initially or primarily expanded during discharge.

A valve cap 9 is threaded onto the threaded end 4 of the neck and has its outer end closed except for a small discharge opening 10, shown in Figs. 2 to 4 inclusive as being in axial alignment with the outlet orifice 6.

A rubber or other readily compressible and expandable valve gasket 11 is interposed between the outer end 5 of the neck and the inner surface of the outer end of the cap 9. The compressible valve gasket 11 has an opening 12 extending axially therethrough in alignment with the outlet orifice 6 and the discharge opening 10 of the cap 9. The opening 12 in the valve gasket 11 forms, when the valve cap 9 is unscrewed, a secondary expansion chamber as shown in Fig. 2, and as hereinafter described, or, as shown in Fig. 4, cooperates with the outlet orifice 6 and the discharge opening 10 to form a secondary expansion chamber, also as hereinafter described.

When the valve gasket 11 is in a completely expanded or uncompressed state, the diameter of the opening 12 therein is greater than the diameter of the outlet orifice 6 and the discharge opening 10 so that it forms a secondary expansion chamber 15 of greater diameter than either said orifice or said opening, as shown in Fig. 2.

The size of the opening 8, the outlet orifice 6 and the discharge opening 10 is important. The diameter of the outlet orifice 6 should be neither substantially larger nor substantially smaller than the discharge opening 10. Good results have been obtained by so proportioning the diameter of the outlet orifice 6 so that its diameter is from 90% to 120% of the diameter of the discharge opening 10. The optimum size within that range will depend to a large extent upon the properties of the compound to be sprayed, its density, the pressure under which it is maintained within the container 1, its viscosity, and whether or not it is a solution or an emulsion. As a general rule it is desirable that the diameter of the discharge opening 10 be greater than the diameter of the outlet orifice 6. For example, the diameter of the discharge opening 10 may be from 0.01 inch to 0.03 inch, while the outlet orifice 6 is slightly less.

Due to the fact that the liquid being sprayed is partially evaporated and the gases expanded in the chamber 13, with resultant increase in volume of the stream, the outlet orifice 6 and the discharge opening 10 both should be larger than the opening 8, although the latter opening should be sufficiently large to prevent clogging.

The primary expansion chamber 13 is larger for low pressure and large gas volumes, and is substantially larger than the secondary expansion chamber formed by the opening 12 in the valve gasket 11. Its shape may vary, but as a rule it is desired to form it of such shape as to prevent any rotation of the stream of liquid and expanded gases passing therethrough about its axis, as any rotation of the stream would tend to collect more liquid on the walls of the chamber.

The secondary expansion chamber formed by the opening 12 in the valve gasket 11 is shown in Figs. 2, 3 and 4 as being coaxial with the primary expansion chamber but it may extend at an angle to the primary chamber, if desired. As a matter of fact, an angular disposition of the secondary expansion chamber relative to the primary expansion chamber in some instances is preferred, as an angular deflection of the stream being discharged may assist in the expansion of the gases. However, this depends upon the particular characteristics of the liquid to be sprayed. Forms of the invention in which the secondary expansion chamber is angularly disposed with respect to the primary expansion chamber so that an angular deflection of the stream being discharged is obtained are described below. But regardless of the angular position of the secondary expansion chamber to the primary expansion chamber, it should be substantially smaller than the primary expansion chamber.

The liquid to be sprayed is introduced into the primary expansion chamber under a pressure below its vapor-liquid equilibrium pressure, which, in the case of a self-propellant, self-atomizable liquid, will be developed by evaporation of a portion of a liquefied gas component thereof, and at a temperature above its vapor-liquid equilibrium temperature. If the liquid to be sprayed is a solution, the pressure may be only slightly below the vapor-liquid equilibrium pressure and the temperature thereof only slightly above the vapor-liquid equilibrium temperature. On the other hand, if the liquid to be sprayed is an emulsion, the pressure preferably is considerably below the vapor-liquid equilibrium pressure and the temperature considerably above the vapor equilibrium temperature.

In the case of self-propellant, self-atomizable liquids, the deviation from the vapor-liquid equilibrium is brought about in the rising tube 2, the valve and the inlet orifice to the primary expansion chamber. The larger deviation from the vapor-liquid equilibrium which is desirable in the case of emulsions may be obtained by using a smaller rising tube, without reducing the size of the inlet orifice to the primary expansion chamber, as any reduction in the size of the inlet orifice to the expansion chamber might make it so small that it would clog.

Assume the container 1 to contain a body of self-propellant, self-atomizable liquid under a pressure developed by evaporation of a portion of a liquefied gas component thereof. When the nozzle valve is opened by unscrewing the valve cap 9 to the position shown in Fig. 2, any liquid in the primary expansion chamber 13 is discharged through the outlet orifice 6 and discharge opening 10 and that chamber emptied, due to the fact that the orifice 6 and opening 10 are of greater diameter than the opening 8. After that, as the liquid passes from the body of the container through the opening 8 into the primary expansion chamber 13, its velocity is greatly increased and a constriction of the flowing stream occurs, so that the effective diameter of the opening 8 is much smaller than the actual diameter thereof. Due to the increase in the velocity of the stream flowing through the opening 8, a resultant pressure drop occurs and the liquid which previously was at the boiling point, i. e., in a state of equilibrium between the gaseous and liquid phase, boils on entering the primary expansion chamber 13. If the liquid in the container is a solution, such boiling will be quite rapid and violent except for a small supersaturation. If the liquid in the container is an emulsion, instead of a solution, such boiling is delayed to some extent and a larger primary chamber is desirable. The boiling results in the vaporization and expansion of a very substantial portion of the liquefied gas component of the liquid.

The passage of the flowing stream past the sharp edges of the opening 8 into the primary expansion chamber 13 causes eddy currents to be set up as indicated by the lines 14 in Fig. 2, which throw back into the flowing stream and tend to break up any liquid droplets which are thrown therefrom, so that such droplets do not coalesce and form a film on the walls of the chamber. The gas initially expanded in the primary expansion chamber 13, together with such droplets as have not been gasified or atomized then passes through the outlet orifice 6 into the secondary expansion chamber 12 where the gas is subjected to secondary expansion with gasification of any of the entrained droplets which were not gasified in the primary expansion chamber 13. The eddy currents indicated by lines 15 in Fig. 2 which are formed in the secondary expansion chamber 12 further assist in breaking up entrained droplets in the manner indicated above with respect to the eddy currents which are formed in the primary expansion chamber 13. Such eddy currents and the change in direction of the portion of the flowing stream, other than that in alignment with the outlet orifice 6, clearly aid in obtaining a spray of uniform particle size with the use of relatively low pressures in the container.

After being subjected to secondary expansion in the chamber 12, the expanded gases and any entrained liquid droplets pass through the discharge opening 10 into the atmosphere where they are expanded to atmospheric pressure, with resultant further atomization of any entrained liquid droplets containing liquefied gas or a readily vaporizable component.

Triple expansion, as just described, results in substantially complete atomization of the liquid discharged from the discharge opening 10, and gasification of the liquefied gas or any readily vaporizable component of the liquid discharged, with a minimum amount of pressure within the container, and consequently with a minimum expenditure of energy.

It is not necessary that the cap 9 be unscrewed to an extent such that the valve gasket 11 is in its fully opened or uncompressed position, as shown in Fig. 2, with the formation of a secondary expansion chamber having a diameter greater than the diameter either of the outlet orifice 6 or the discharge opening 10. By unscrewing the cap to a lesser extent varying results may be obtained, while still obtaining the benefits of a triple expansion of the gases.

As shown in Fig. 4, the cap has been unscrewed to an extent such that the walls defining the opening 12 in the valve gasket substantially align with the walls of the outlet orifice 6 and the discharge opening 10. When the outlet orifice 6 is slightly larger or smaller than the discharge opening 10, the walls defining the opening in the valve gasket 11 may be appropriately tapered as shown at 16 in Fig. 4.

When the cap 9 is not unscrewed sufficiently to form an enlarged secondary expansion chamber 12 of the character shown in Fig. 2, the passage defined by the walls of the orifice 6 and the discharge opening 10 and the walls of the opening 12 in the valve gasket form an elongated chamber in which secondary expansion of the gases takes place. When the gases initially expanded in the primary expansion chamber 13 enter such elongated secondary expansion chamber, that portion of them adjacent the confining walls at the inner end of the passage will have eddy currents 17 set up in them, as shown in Fig. 4, which not only tend to throw back into the flowing stream any ungasified droplets so that such droplets do not coalesce into a film on the walls of the passage but also form a whirling body just within the entrance to such passage which causes a constriction which imparts a greater velocity to the central portion of the flowing gaseous stream passing through its center, with the result that a further drop in pressure occurs at that point with concomitant secondary expansion in that portion of the passage from where the constriction occurs to the outlet end of the passage. In this case, as in the case described above, tertiary expansion of the gases and further gasification of entrained liquid droplets occurs as the gases, secondarily expanded in the elongated secondary expansion chamber, are discharged into the atmosphere from the end of the passage.

Where the secondary expansion of the gases occurs in an elongated expansion chamber, as just described, the length of the passage relative to its diameter is quite important if satisfactory expansion and atomization of the liquid to be sprayed is to be obtained. The diameter of the discharge opening 10 should be so proportioned to the length of the passage that the number of entrained droplets which strike the wall is insufficient to cause them to coalesce and form a film, so that any droplets which do strike the wall are swept by the flowing stream of gas, as individual droplets, into the expanded gas which is sprayed into the atmosphere from the end of the discharge opening 10. The length of the passage must be sufficiently great that the outlet end thereof will be completely filled with gases which have undergone secondary expansion before they are discharged to the atmosphere. To obtain such results, the length of the passage should be from two to four times its diameter, the criterion being that such passage should be long enough to confine the eddy currents, but not long enough to permit liquid droplets collecting along the confining walls. By making the diameter of the passage small and the length thereof within the limits set forth above, recollection of droplets along the confining walls is practically completely avoided. Furthermore, the velocity of the flowing stream is so high that any film which might tend to form on the confining walls would be extremely thin.

If the length of the passage in which primary expansion is obtained, as last described, is too short, there would be a tendency for liquid to creep down the nozzle on the outside thereof in spite of the air suction at this point. The same result follows if the passage is made into a long capillary tube or increased substantially in diameter.

It is important that the gases not be subjected to more than three stages of expansion. Should a fourth stage of expansion be added, a greater initial pressure in the container would be necessary as the pressure drop per expansion would be less. Any advantage which might be gained by such a fourth stage of expansion would be offset by the very fine entrained droplets coalescing on the walls defining the zone of expansion preceding the discharge of the spray into the atmosphere, with resultant formation of larger droplets which would be expelled into the atmosphere. Furthermore, the greater the number of expansion chambers, the greater is the chance of atomized droplets coalescing by contact with each other and forming larger droplets, which again would require a further drop in pressure to reatomize them.

The principle of triple expansion described above in connection with the spraying nozzle of Figs. 2 to 4 inclusive, may be applied to spraying nozzles of various forms as shown in Figs. 5 to 10 inclusive. In each of those figures, the nozzle is more or less diagrammatically shown and the means for closing the nozzle is omitted. Exterior or interior means of any kind may be utilized to close the nozzle, or the passage leading thereto, when spraying is not desired.

The spraying nozzle shown in Fig. 5 is substantially the same in operation as the nozzle of Figs. 2 to 4, when the cap **9** of the nozzle of those figures is adjusted to the position shown in Fig. 4, that is, with the secondary expansion chamber being defined by the aligned walls of the outlet orifice **6**, the opening **12** in the valve gasket **11** and the discharge opening **10**, except that the primary expansion chamber is made longer, such as is desirable when an emulsion is to be sprayed, as described above.

In Fig. 5, the neck **20** terminates in a nozzle tip **21**, the upper surface **22** of which tapers inwardly and upwardly to a discharge orifice **23**.

The neck **20** has a partition **24** extending across it which is provided with an opening **25** through which the contents of the container pass to enter a somewhat elongated expansion chamber **26**. A passage **27** in this instance of uniform diameter throughout its length connects the primary expansion chamber **26** with the discharge orifice **23** and forms a secondary expansion chamber. Tertiary expansion of the gases occurs as the gases secondarily expanded in the passage **27** are discharged through the orifice **23** into the atmosphere.

The operation of the nozzle of Fig. 5 is the same as described above in connection with the nozzle of Figs. 2 to 4, when adjusted to the position shown in Fig. 4.

The nozzle shown in Fig. 6 generally is the same as that shown in Fig. 5, and similar parts are designated by like reference characters primed, the difference between the two forms being that th walls defining the secondary expansion chamber **27'** converge slightly in an outward direction. In other respects and in operation the two nozzles are the same, or substantially so.

The nozzle shown in Fig. 7 also generally is the same as the nozzle of Fig. 5, and in this figure similar parts are designated by the same reference characters with the exponent *a*, the differences between the nozzle of this figure and the nozzle of Fig. 6 being that the walls defining the secondary expansion chamber **27a** diverge outwardly slightly, and the primary expansion chamber **26** is shorter, such as is used when solutions are to be sprayed. The operation of the nozzle is the same as the operation of the nozzle of Figs. 5 and 6.

In Fig. 8 there is shown another nozzle which generally is similar to the nozzle of Fig. 5. In this figure parts similar to the parts shown in Fig. 6 are designated by the same reference characters with the exponent *b*, the differences between the two nozzles being that the primary expansion chamber **26b** in Fig. 8 is spherical, and the opening **25b** has the edges thereof rounded. While ordinarily it is desirable to have the edges of the opening from the container into the primary expansion chamber sharp, as disclosed in the previously described figures, the edges may be rounded when the primary expansion chamber is spherical.

In all of the forms of the application so far described the secondary expansion chamber has been shown as being in alignment with the longitudinal axis of the primary expansion chamber and the opening from the container into the primary expansion chamber. In Figs. 9 and 10 nozzles are disclosed in which the longitudinal axis of the secondary expansion chamber is at an angle to the longitudinal axis of the primary expansion chamber and the opening from the container into the primary expansion chamber.

Except for the angular disposition of the secondary expansion chamber, the nozzle of Fig. 9 is similar to the nozzle of Fig. 8, and like parts are designated by like reference characters with the exponent *c*.

In Fig. 10, the neck **30** is surmounted by an upwardly and inwardly tapering nozzle tip **31** which has a conical projection **32** extending from one side thereof and terminating in a discharge orifice **33**.

A partition **34** extends across the lower portion of the tip **31**. The partition **34** has a small, sharp-edged opening **35** for the passage of the contents of the container into a primary expansion chamber **36**. An elongated passage **37**, similar, for example, to the elongated passage **27** of Fig. 5, connects the primary expansion chamber **36** with the outlet orifice **33**.

The primary expansion chamber **36** is longitudinally elongated and tapers upwardly and inwardly to the entrance to the passage **37**. Such upwardly and inwardly tapering has the advantage of reducing the area of the walls defining the primary expansion chamber and tends to make the nozzle self-cleaning with respect to deposits from liquid films after repeated use. The converging walls and decreasing diameter tend, by capillary force and surface tension, to thin out any film that may be left on the walls of the primary expansion chamber after a spraying operation.

The secondary expansion chambers **27a** and **37** of Figs. 9 and 10, respectively, preferably are formed at an angle of from 30° to 60° to the longitudinal axis of the primary expansion chambers 26d and 36, respectively. When formed at such an angle, an intimate mixing of coarser liquid droplets with the gases results which, in turn, due to higher velocity and the second pressure drop in the secondary expansion chamber, causes considerably more of the liquid particles to be broken up.

Even though the eddy currents formed in the primary expansion chamber, as described in connection with the nozzles of Figs. 2 to 4, do result in most of the liquid droplets which are thrown from the flowing stream being thrown back into it, the initial pressure drop in that chamber will result in a number of the coarser droplets collecting on the walls defining that chamber. Such droplets agglomerate to larger drops which slide along the walls to the outlet from that chamber into the secondary expansion chamber and are not completely atomized. When the secondary expansion chamber is positioned at an angle to the primary expansion chamber, as shown in Figs. 9 and 10, better atomization is obtained as deflection of the high-velocity flowing stream as it enters the secondary expansion chamber causes it to break up the larger drops of liquid into a fine mist.

The relative sizes of the openings in the partition separating the main body of the container from the primary expansion chamber, the entrance to the secondary expansion chamber and the final discharge orifice in the nozzles of Figs. 5 to 10 will be within the limits described above in connection with the nozzles of Figs. 2 to 4.

In the nozzles shown in Figs. 5 to 10, the tapered end of the nozzle tip adjacent the final discharge orifice preferably is maintained at an angle less than 135° to the longitudinal axis of the secondary expansion chamber in order to obtain air suction at that point and to confine the atomized spray within desired limits.

Regardless of the angular position of the secondary expansion chamber with respect to the primary expansion chamber, the present invention enables a larger discharge orifice into the atmosphere to be used because less pressure in the container is necessary. When the secondary expansion chamber is at an angle to the primary expansion chamber, as shown in Figs. 9 and 10, the greater expansion of pressure due to the deflection of the flowing stream enables the final discharge orifice to be still larger.

The principle of triple expansion of gases or vapors described herein may be applied to various liquids which either are self-propellant, or which are maintained under suitable pressure and which contain a relatively low boiling liquid component which will boil and vaporize as a result of the pressure drop which ensues when the liquid is sprayed into any atmosphere. Typical of such liquids which may be sprayed are emulsions or solutions of fungicides, parasiticides, fumigants, moth-proofing agents, deodorants, perfumes, cellulose derivative compounds, paints, lacquers, enamels, rust-preventive oils, detergents, impregnating compounds, lubricants, polishes, dyes, rubber solutions, oils, etc.

Various changes may be made in the details of the method of obtaining the triple expansion of the gases or vapors and in the form of the nozzles used for obtaining such triple expansion of the gases or vapors without departing from the invention or sacrificing any of the advantages thereof.

I claim:

1. An atomizing nozzle for liquids under pressure comprising a body member having a passage therethrough, a partition across said body member having an opening therein forming a part of said passage, an end portion closing the outer end of said body member except for an outlet orifice, a primary expansion chamber formed in said passage between said partition and said outlet orifice, closing means for said passage including a cap member mounted on said outer end portion, said closing means having a discharge opening therein and being movable relative to said body member to close and open the outer end of said passage, and a secondary expansion chamber between the primary expansion chamber and the outlet from the discharge opening of the closing member.

2. An atomizing nozzle for liquids under pressure comprising a body member having a passage therethrough, an end portion closing the outer end of said body member, except for an outlet orifice, a primary expansion chamber formed in said passage, a compressible valve gasket at the end of said body member, said valve gasket having an opening therein forming a continuation of the passage through the body member when the valve gasket is in a free, uncompressed state, and a cap overlying said valve gasket, said cap having an opening therein, the opening in said cap and the opening in the valve gasket being in alignment with the outlet orifice in the end portion of the body member, said cap having threaded engagement with said body member whereby the valve gasket can be compressed to fully or partially close the opening therein by relative movement of the cap on the body member, the outlet orifice from the body member, the opening in the valve gasket and the opening in the cap member forming a passage, when the valve gasket is in a state in which it is not fully compressed, having a length between about two and four times its diameter, whereby gases primarily expanded in the primary expansion chamber are secondarily expanded in said last-named passage before passing from the outlet orifice of the nozzle to the atmosphere.

3. An atomizing nozzle for liquids under pressure comprising a body member having a passage therethrough, and end portion closing the outer end of said body member, except for an outlet orifice, a primary expansion chamber formed in said passage, a compressible valve gasket at the end of said body member, said valve gasket having an opening therein forming a continuation of the passage through the body member when the valve gasket is in a free, uncompressed state, and a cap overlying said valve gasket, said cap having an opening therein, the opening in said cap and the opening in the valve gasket being in alignment with the outlet orifice in the end portion of the body member, said cap having threaded engagement with said body member whereby the valve gasket can be compressed to fully or partially close the opening therein by relative movement of the cap on the body member, the opening in the valve gasket, when the valve gasket is in a free, uncompressed state, being larger than either the outlet orifice in the outer end of the body member or the opening in the cap, and forming a secondary expansion chamber in which gases primarily expanded in the primary expansion chamber are secondarily expanded before passing from the nozzle to the atmosphere.

4. The method of spraying a self-propellant liquid comprising a normally-liquid material to be sprayed and a liquefied gaseous component

which on vaporization atomizes the normally-liquid material, which consists of maintaining the liquid under pressure generated by vaporization of a portion of the liquefied gaseous component thereof, discharging liquid maintained under said pressure into a primary expansion zone, substantially reducing the pressure on the liquid and primarily expanding the major portion of the liquefied gaseous component thereof, and simultaneously vaporizing the major portion of the liquefied gaseous component and atomizing the liquid in the primary expansion zone, substantially immediately thereafter discharging the primarily-expanded vapors or gases and entrained liquid particles into a secondary expansion zone at a still lower pressure with further vaporization of the liquefied gaseous component and secondary expansion of vapors or gases of the flowing stream and concomitant further atomization of the normally-liquid material, and finally discharging the secondarily-expanded vapors or gases and entrained liquid particles from the secondary expansion zone directly into the surrounding atmosphere with still further reduction of pressure.

5. The method of claim 4 in which the primarily-expanded vapors or gases and entrained liquid particles are discharged from the primary expansion zone into a secondary expansion zone of smaller volume to obtain more rapid flow of the vapors or gases and entrained liquid particles and thereby prevent re-coherence of liquid particles.

6. The method of claim 4 in which the liquid material is an emulsion and is introduced into the primary expansion zone at a pressure substantially below its vapor-liquid equilibrium pressure and substantially above its vapor-equilibrium temperature at normal temperatures.

7. The method of spraying a self-propellant liquid comprising a normally-liquid material to be sprayed and a liquefied gaseous component which on vaporization atomizes the normally-liquid material, which consists of maintaining the liquid under pressure generated by vaporization of a portion of the liquefied gaseous component thereof, discharging liquid maintained under said pressure into a primary expansion zone with substantial reduction of pressure and with resultant substantial vaporization of the liquefied gaseous component and primary expansion thereof and concomitant atomization of the normally-liquid material, almost immediately thereafter discharging the primarily-expanded vapors or gases and entrained liquid particles into a secondary expansion zone at a still lower pressure with further vaporization of the liquefied gaseous component and secondary expansion of vapors or gases of the flowing stream and concomitant further atomization of the normally-liquid material, and finally discharging the secondarily-expanded vapors or gases and entrained liquid particles from the secondary expansion zone directly into the surrounding atmosphere, the discharge of the primarily-expanded vapors or gases and entrained liquid particles from the primary expansion zone into the secondary expansion zone being at an angle to that at which the material flows into the primary expansion zone.

8. The method of claim 7 in which said angle is from about 30° to 60°.

9. An atomizing nozzle for a container for liquids under pressure comprising a primary expansion chamber for partial vaporization and primary expansion of the liquid, a passageway through which liquid is introduced into the primary expansion chamber, a secondary expansion chamber having a discharge opening therefrom directly to the surrounding atmosphere, and a passageway directly connecting the primary expansion chamber with the secondary expansion chamber, the discharge opening from the secondary expansion chamber to the surrounding atmosphere having a diameter of from 0.01 inch to 0.03 inch, the passageway between the primary expansion chamber and the secondary expansion chamber having a diameter from 90% to 120% of the diameter of the discharge opening from the secondary expansion chamber to the atmosphere, and the passageway through which liquid is introduced into the primary expansion chamber being smaller than the discharge opening from the secondary expansion chamber to the atmosphere and the passage from the primary expansion chamber to the secondary expansion chamber.

10. An atomizing nozzle as set forth in claim 9 in which the passageway leading to the primary expansion chamber terminates with a sharp edge to assist in the formation of eddy currents in the primary expansion chamber.

11. an atomizing nozzle as set forth in claim 9 in which the primary expansion chamber is larger than the secondary expansion chamber.

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