July 24, 1951 L. T. HERRMANN 2,562,096

NOZZLE

Filed June 23, 1947

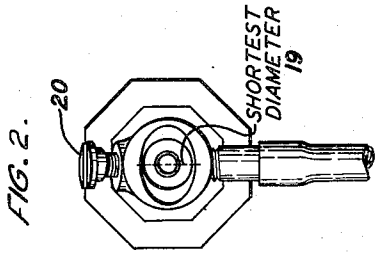


FIG. 2.

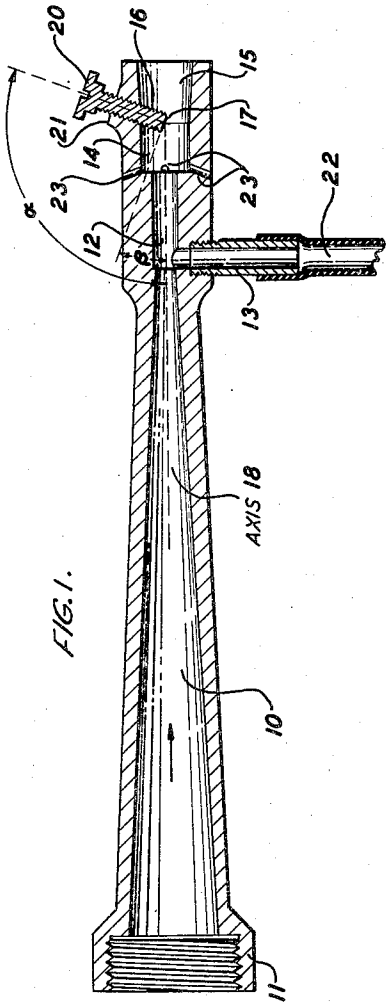


FIG. 1.

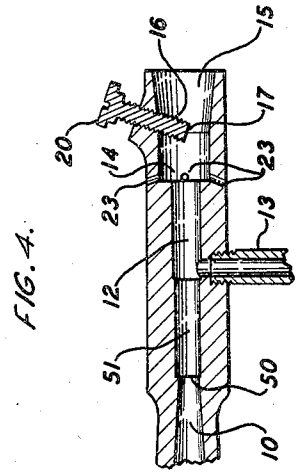


FIG. 4.

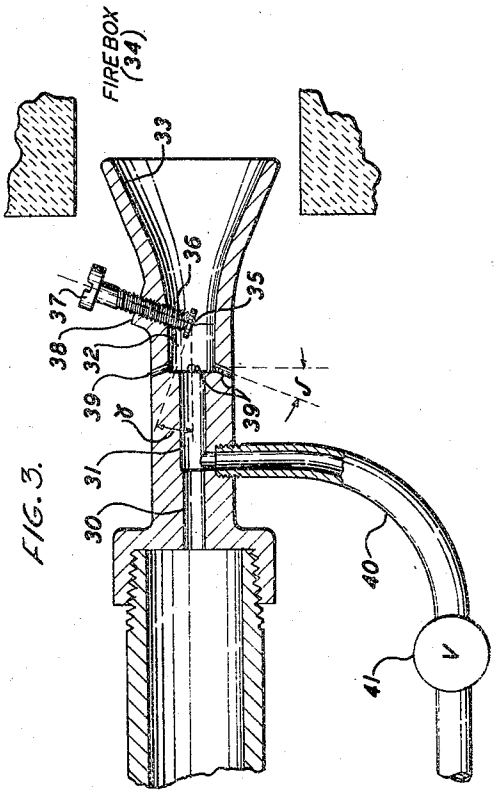


FIG. 3.

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NOZZLE

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4 Claims. (Cl. 299—127)

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This invention is concerned with aspirator nozzles and provides an improved nozzle having high aspirator efficiency, to the end that a main stream of fluid will suck in a side stream with but little diminution in the force with which the stream is ejected as compared with the force when nothing is being sucked in. The aspirator nozzle of the invention is particularly adapted for tree spraying and the like where a powerful stream of long range is required. However, it has a variety of applications. Thus it may be used to suck insecticide into a stream of water, to suck fuel oil into a stream of air, or to suck dust into a fluid stream, for example, powdered insecticide employed in plant dusting. The aspirator of the invention is simple and rugged in its construction and forms a long range jet more efficiently than many prior apparatus.

It has been proposed heretofore to use an aspirator nozzle provided with a restricted throat section and a side leg, the two of which form an eductor. Suction produced by a high velocity fluid stream in the restricted throat sucks in a side stream which mixes with the main stream as it passes through the eductor. However, heretofore customary nozzles incorporating such eductors have been relatively inefficient, so that there has been marked diminution of the flow of the nozzle when substantial proportions of material are sucked in through the side leg.

As a result of my investigations I have discovered that it is possible to so shape and proportion as aspirator nozzle provided with an eductor that marked increase in the suction efficiency is obtained with little or no decrease in the throw of the nozzle, i. e. in the range of the jet produced, even when a substantial amount of material (preferably fluid) is being sucked in through the side leg.

My invention contemplates an aspirating nozzle having a throat portion of relatively small cross section. This throat is enlarged abruptly into a concentric chamber having substantially parallel side walls. Thus the chamber may be of cylindrical form and concentric with the throat. The width of the chamber should be 4.0% to 12.5% greater than the width of the throat at the point where it enters the chamber and the length of the chamber should be from 2.8 to 5.2 times its width. An aspirating conduit is connected to the chamber, preferably immediately ahead of the point at which the throat is abruptly expanded into the chamber. I have found that a nozzle eductor proportioned as described above is extremely efficient and that substantial aspiration does not decrease perceptibly the range of the jet projected therefrom.

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Preferably the chamber into which the aspirator conduit or side leg enters is followed by a second or mixing chamber. The mixing chamber is concentric with the first chamber and the first expands abruptly into the mixing chamber, for example by entering a wall running transverse to the axis of the nozzle. The mixing chamber should be about twice as wide as the first chamber and about as long as it is wide. Thus it may be of cylindrical form, the diameter of the cylinder approximating its depth.

The main passage for fluid through the nozzle (i. e. through the throat, the first chamber and the second chamber), preferably continues in a flared end piece. This end piece for most efficient throw and break up of a jet should be oval or elliptical in cross section at least toward its outside end.

In order to break up the stream issuing from the first chamber into the mixing chamber it is desirable to provide a disperser member having a flat end which makes an angle ranging from 15° to 25° with the axis of the apparatus, i. e. the axis of the throat and the chambers. In other words, the angle between the axis of the stream as it approaches the flat disperser surface, and the surface itself, measured in a plane perpendicular to the surface is 180° minus 15° to 25° or 165° to 155°. This flat disperser surface should be adjustable with respect to the depth that it may be inserted into the issuing jet. This is done conveniently by forming it on the inside end of a screw threaded through the side of the nozzle, and providing an adjusting knob or handle on the outer end of the screw.

Further dispersion of this jet into finer drops may be obtained by sucking air into the mixing chamber preferably through a ring of side ports which pass through the wall of the nozzle and slope slightly backwards and outward.

For use in tree spraying and the like the throat of the nozzle of the invention should be a long frusto conical section tapering in the direction of flow, so as to increase the velocity of the water passing through the throat into the first chamber. For example, the throat may be a section at least 6 inches long tapering from an inside diameter of about 5/8 of an inch to an inside diameter of 3/16 of an inch in this length.

For use as a fuel oil burner or the like with high pressure air passing through the main channel of the eductor and with a liquid being sucked in from the side or aspirator leg, the long tapering

throat may be omitted and instead a short throat employed. This short throat connects directly with a pipe of much larger diameter.

Increased suction can be obtained in the apparatus, although not without substantial reduction in "throw" of the stream, by placing another "step" in the throat ahead of the first chamber. Such step takes the form of a smaller throat expanded abruptly into a parallel sided chamber ahead of that into which the side leg enters.

These and other aspects of the invention will be apparent in the light of the following detailed description taken in conjunction with the accompanying drawings in which:

Fig. 1 is a longitudinal section through a preferred form of my aspirating nozzle particularly adapted for use in tree spraying and the like;

Fig. 2 is a front view of the apparatus of Fig. 1;

Fig. 3 is a longitudinal section through another form of the aspirating nozzle of my invention particularly designed as a fuel oil burner; and

Fig. 4 illustrates a modification of the structure.

Referring to Figs. 1 and 2, the tree spraying nozzle aspirator comprises a long frusto conical throat portion **10** tapering in the direction of fluid passage and preferably circular in interior cross section. The rear end of the throat portion has an enlarged female threaded section **11** adapted to take standard male hose or pipe fittings. Although the degree of taper is not critical it should be roughly comparable to that obtaining when a conduit of circular cross section is tapered from ⅝ inch diameter to about $\frac{3}{16}$ inch diameter in a total length of about 6 inches.

The small end of the throat opens abruptly into a first coaxial cylindrical chamber **12**, i. e. the end wall of the chamber makes approximately a right angle with the axis of the throat. This chamber is from 4.0 to 12.5% wider than the throat at the point where it enters the chamber. I have found that this proportion coupled with the length of the chamber is relatively critical in assuring maximum efficiency of suction. Thus the chamber **12** should be from 2.8 to 5.2 times as long as it is wide, the optimum proportion being about 4.

A suction leg **13** enters the first chamber transversely to its axis immediately adjacent the point at which the throat enters the chamber. The cross section of this suction leg or conduit is not critical with respect to dimension. However, it should not be made too large. For an apparatus having a throat constricted to a diameter of $\frac{3}{16}$ of an inch at its small end a suction pipe made of ¼ inch outside diameter copper tubing of ordinary wall thickness is satisfactory. In such case the diameter of the first chamber is about $^{13}/_{64}$''.

The first chamber opens abruptly into a mixing chamber **14**. This is cylindrical and coaxial with the first chamber and should be approximately twice as wide as the first chamber, its length being substantially the same as its width. The mixing chamber is followed by a flared nozzle end **15** into which the inside wall of the mixing chamber runs smoothly. I have found that the flared end is somewhat more efficient from the standpoint of stream or jet distribution if it is somewhat flattened towards its outside end so as to assume an elliptical or oval cross section as shown in Fig. 2.

For efficient breaking up of the stream issuing from the mixing chamber I prefer to employ a novel type of dispersing element. Conveniently this takes the form of a screw **16** having a flat interior end or dispersing surface **17**. The axis of this screw lies in a plane defined by the axis **18** of the jet and the shortest diameter **19** of the elliptical end (see Fig. 2). The flat end of the screw is at right angles to its axis which in turn makes an angle α (alpha) of about 110° with the axis of the nozzle (see Fig. 1). In other words, the end of the dispersing screw makes an angle β (beta of 15° to 25° and preferably 20° with the axis of the nozzle. The jet issuing from the first chamber into the mixing chamber thus impinges on the end of the screw, which has a marked dispersing effect. If the flat end projects too deeply into the stream, the break up of the stream will not be optimum. Conversely, if the end does not project deeply enough into the stream break up will not be efficient. The screw may be turned to move its flat dispersing end in or out of the stream to optimum position by means of the adjusting knob **20**. The screw is threaded through a boss **21** formed integrally on the outside of the nozzle.

The side leg **13** is provided with an extension hose **22** through which any suitable fluid (or dust suspended in fluid) may be sucked. For tree spraying with a fungicide or the like a concentrated solution of the fungicide is placed in a container and sucked therefrom through the flexible hose into the aspirator leg and thence into the jet.

For additional break up and the production of extremely fine droplets the mixing chamber is provided with the plurality of peripheral suction ports **23** which slope backwards and outward through the wall of the nozzle, say at an angle of 20°.

The apparatus of Figs. 1 and 2 may be connected to the end of a hose which in turn is connected to a main of high pressure water. The solution to be mixed with the water is placed in the container and sucked up into the aspirator nozzle as described. It is then a simple matter to direct the issuing jet of mixed solution and water against a plant, say a tree to be sprayed, the adjusting screw being turned to place the disperser member in position for maximum break up of the stream.

I have discovered that whether the main stream passing through the nozzle is a liquid or a gas, the proportions indicated above for width and length of the first chamber apply. The following table gives throat diameters, chamber diameters, and chamber lengths for various sizes of nozzles:

Table

(1)	(2)	(3)	(4)
Throat Diameter	Increase in Diameter, Throat to Chamber	Chamber Diameter	Chamber Length
Inches	*Inches*	*Inches*	*Inches*
$\frac{1}{32}$			
$\frac{3}{16}$	$\frac{1}{64}$	$\frac{13}{64}$	$\frac{3}{4}$
¼	$\frac{35}{128}$	$\frac{35}{128}$	1
⅜	$\frac{1}{32}$	$\frac{13}{32}$	1½
½	$\frac{3}{64}$	$\frac{35}{64}$	2
¾	$\frac{1}{16}$	$\frac{13}{16}$	3

Permissible tolerance in dimension, ±50%–30%

From the foregoing permissible tolerance in the difference between throat and chamber cross section it will be seen that the diameter of the first chamber may be from about 4% to about 12.5% greater than the diameter of the throat and still

obtain the desired high efficiency of jet throw. Outside this range of proportions, however, the efficiency drops off rapidly, and the same applies if the chamber length lies outside the range of about 4 times its width, plus or minus 30%.

The suction effect drops rapidly if the point at which the side leg enters the chamber is moved forward from the point at which the throat enters the chamber and the position shown in Fig. 1 is optimum.

The apparatus of Fig. 4 is identical with that of Figs. 1 and 2 (like parts being indicated by like reference characters) save that an additional "step" is placed in the throat immediately ahead of the chamber into which the aspirator leg enters. Thus the long tapering throat is in effect moved back and its taper is increased to give a restricted orifice **50**. This is expanded abruptly into a concentric cylindrical throat chamber **51** which is about as long as the first chamber **12** into which the aspirator leg enters. The proportions of the throat chamber are not precisely critical, but its entrance should be smaller than its exit and in general it should, as indicated above, be about as long as the chamber **12**.

The effect of the small orifice at the entrance to the throat chamber is to increase the proportions of fluid sucked into the side leg, with however some diminution in the range of the jet from the nozzle. By way of example, a nozzle constructed in accordance with Fig. 1 with a throat diameter of $\frac{3}{16}$'' (at the point where it enters the chamber **12**) and with a side leg of about the same diameter, the first chamber having a diameter of $\frac{27}{128}$'', will under given water pressure conditions suck in about 1 volume of water from the side leg for each 9 volumes forced through the throat. If this structure is altered by employing a throat chamber of $\frac{3}{16}$'' diameter and ¾'' long ahead of the first chamber, the orifice at the rear of the throat chamber being $\frac{5}{32}$'' in diameter, the nozzle will suck in 1 volume through the side leg for each 3 volumes in the main stream, pressure conditions remaining equal.

In the light of the foregoing discussion, it will be apparent that the modification illustrated in Fig. 4 should be employed when nozzle range may be subordinated to the suction of increased proportions through the side leg.

The nozzle of Fig. 3 takes the form of a fuel burner. The apparatus is provided with a relatively short cylindrical throat **30** followed by a coaxial cylindrical first chamber **31** which is about 8% larger in diameter than the throat. The first chamber is followed by a coaxial cylindrical mixing chamber **32** whose diameter is about twice that of the first chamber and whose length is also about twice the diameter of the first chamber. As in the case of the tree spraying nozzle, the length of the first chamber is approximately four times the diameter of the throat.

It will be observed that the throat opens abruptly into the first chamber and that similarly the first chamber opens abruptly into the second or mixing chamber. Thus the rear end walls of both first and second chambers should be roughly perpendicular to the axis of the nozzle considered as a whole.

The mixing chamber of the apparatus of Fig. 3 is followed by a flaring or funnel shaped outlet member **33** which may be directed into a port of a fire box **34**.

As in the case of the tree spray apparatus a disperser head **35** is mounted within the mixing chamber. It has a flat end which makes an angle γ (gamma) of about 20° with the main axis of the apparatus. This head is mounted on a screw **36** which has an adjusting knob **37** at its other end, the screw being threaded into an integral boss **38** in the wall of the nozzle proper.

A ring of aspirator holes **39** for sucking in secondary air is provided around the wall of the mixing chamber, i. e., peripherally. These holes slope slightly backward, say at an angle δ (delta) of 20°.

The rear end of the aspirator nozzle of Fig. 3 has an enlarged female threaded section which may be screwed directly onto a pipe of say ¾'' inside diameter. Fuel is sucked into the first chamber immediately in front of the throat through a metal tube **40** or the like which provides a conduit entering at right angles to the axis of the throat. This tube may be provided with a valve **41** for controlling the amount of fuel oil or other liquid fuel sucked into the aspirator or eductor.

The operation of the apparatus of Fig. 3 is simple. High pressure air is supplied to the throat from the feed pipe. The air creates a suction in the first chamber which draws fuel oil up through the side leg. The oil and the air are mixed in the mixing chamber and dispersed by the disperser head, some additional air being sucked in through the ring of ports. The mixture is then discharged through the funnel shaped front end into the fire box, where it is ignited.

As in the case of the tree spray, the disperser head is moved in or out of the stream until optimum effect is obtained.

The burner of Fig. 3 operates principally upon the primary air supplied through the throat, the amount of secondary air drawn in being relatively slight. The purpose of the secondary air is, as indicated above, to aid in breaking up the droplets aspirated through the side leg.

Although the expansion between steps, i. e., from the tapered conduit into the throat chamber (in the case of the apparatus of Fig. 4) and from the throat into the first chamber and from latter into the mixing chamber in the case of the other forms of the apparatus, should be as abrupt as possible, the rear wall of the several chambers need not make precisely a right angle with the main axis of the apparatus. A slight forward slope, say 20% of this end wall away from the axis may be tolerated, hence the chambers may be drilled with a drill having a rather flat conical point.

As indicated previously, the apparatus of the invention is rugged, efficient and relatively cheap to manufacture. It may be used for aspirating both liquids and gases, and even dust, if sufficiently free and unpacked, may be aspirated through the side leg.

I claim:

1. In an aspirating nozzle, the combination which comprises a throat portion of relatively small cross-section, a first enlarged chamber into which the throat opens abruptly, the first enlarged chamber being concentric with the throat portion and cylindrical in shape, the diameter of the first chamber being from 4.0% to 12.5% greater than the smallest diameter of the throat portion and the length of the first chamber being from 2.8 to 5.2 times its diameter, an aspirating conduit connected to the first chamber, a second enlarged cylindrical chamber downstream from the first chamber and concentric therewith but of still greater cross section the first chamber

opening abruptly into the second larger chamber, and a disperser member having a flat end, said flat end being disposed in the second enlarged chamber at an angle of 15° to 20° with the axis of the nozzle and of a stream which impinges on said flat end.

2. Apparatus according to claim 1 provided with means for moving the flat end of the disperser member into and out of the stream while maintaining said angularity with respect to said stream.

3. Apparatus according to claim 1 in which the disperser member comprises a screw threaded into the wall of the second enlarged chamber.

4. In an aspirating nozzle having a front chamber from which a stream is ejected, the combination which comprises a disperser member having a flat surface set in the chamber at an angle of 15° to 25° with the axis of the nozzle and the stream which impinges on said flat surface, and means for moving this member toward and away from this axis without changing the angle which said flat surface makes with the axis.

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