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Vehe et al.

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[54] JET STREAM VIBRATORY ATOMIZING DEVICE

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[51] **Int. Cl.** **B05b 17/04**

[58] **Field of Search** 239/102, 101, 4, 99, 585, 590.3

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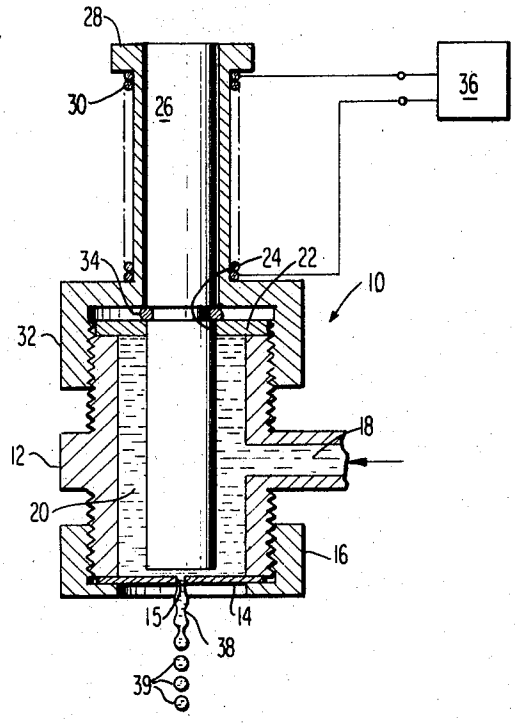
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[57] **ABSTRACT**

In a jet stream vibratory atomizing device including a nozzle body and a nozzle head attached to the nozzle body, a selectively variable constant pressure source of fluid is connected into the nozzle body such that fluid may be force through an opening or openings fashioned in the nozzle head. A volumetric displacement member is positioned to contact the fluid within the nozzle body near the head. High rate cyclic disturbances are transmitted from the volumetric displacement member through the fluid downstream of the openings in the head to induce a uniform formation of droplets in the fluid stream wherein the number of droplets formed corresponds to the rate of displacement of the volumetric displacement member.

4 Claims, 7 Drawing Figures



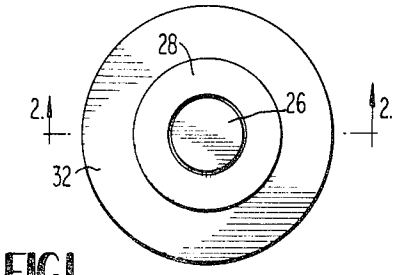


FIG.1

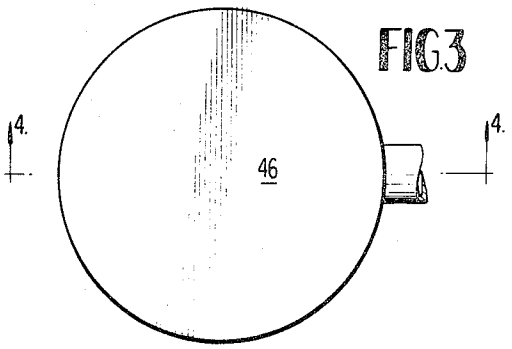


FIG.3

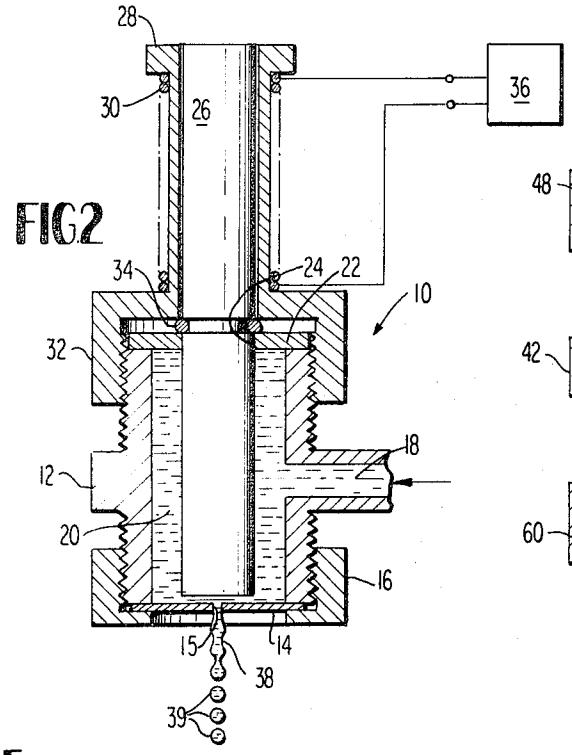


FIG.2

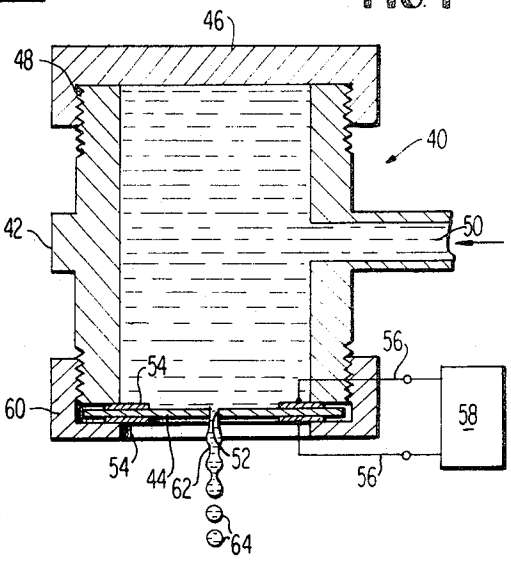
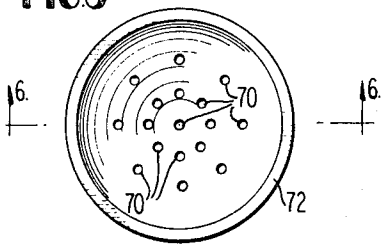


FIG.4

FIG.5



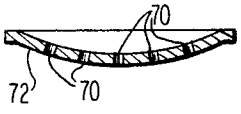


FIG.6

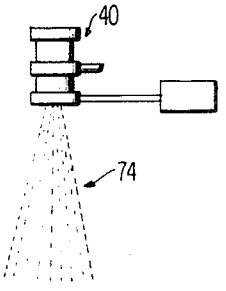


FIG.7

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JET STREAM VIBRATORY ATOMIZING DEVICE

BACKGROUND OF THE INVENTION

This invention relates to a process and apparatus for jet stream atomizing a fluid into droplets of uniform size and at a controllable rate. More particularly this invention relates to improvements in the process and apparatus for atomizing liquid pesticides, herbicides, growth or ripening control agents and the like.

The process of atomization is of primary importance in several branches of engineering, such as in the combustion of liquid fuels, in the chemical industry in operations involving drying, evaporation and absorption, in fire fighting for the production and dissipation of fogs, in agriculture for crop protection, etc. Atomization of a fluid may be accomplished by forcing a fluid under pressure through a restriction into the atmosphere where the fluid breaks up into droplets. These droplets, however, are formed in various sizes. As an example, conventional spray nozzles which would be designed to produce droplets having a mean diameter of 150 microns would generate droplets ranging in size from 1 or 2 microns to 300 or 400 microns in diameter. In many applications this range of droplet sizes is not particularly unacceptable. However, in numerous applications, particularly in agriculture, a more uniform droplet size would be highly desirable.

There has been an increasing utilization of herbicides and pesticides in large-scale agriculture. They are applied either from ground spraying booms and rigs or from aircraft, or in some specific instances by both means. The herbicidal solution often is atomized by being forced under pressure through a flat fan nozzle, a series of such nozzles being incorporated on a single spray boom. Such nozzle dissemination techniques, as previously suggested, commonly produce a wide range of droplet sizes. Droplet size variation is undesirable, however, both from the standpoint of dispersal and travel through the atmosphere and also effectiveness in inhibiting the growth of unwanted plant life, or otherwise controlling biological processes.

In relation to travel through the atmosphere, after the herbicidal liquid leaves the nozzle, it has been found that the finer droplets, such as those in the size range of less than **100** microns in diameter, are often subject to objectionable drift. The drift hazard from standard application techniques is well recognized for the potentially damaging effect upon adjacent productive crops which may be herbicide sensitive. Further, such drift, which typically varies from 10 to 30 percent of the total spray volume represents an economic waste and contributes to the total atmospheric contamination level. Therefore, it is highly desirable to be able to dispense a herbicide or other biological control agent wherein the droplet size could be maintained at a selective large diameter level to minimize drift hazards.

Moreover, and in relation to drop size upon the effectiveness of an active control agent such as a herbicide, it should be noted that a herbicide typically may be a water emulsion having a small percentage by volume of active herbicidal agent such as, for example, a low volatile 2,4-D ester and/or 2,4-D amine. As the herbicide emulsion is dispensed, it collects in droplets upon the weed leaf. The herbicide in the droplet is absorbed by the weed and a water bridge appears to be essential for this uptake. The evaporation rate of a small droplet may result in a water bridge of such limited duration that insufficient active agent is taken up by the leaf and therefore the undesirable plant life is not killed as desired. In contrast, a large droplet may coalesce and run off or fail initially to cling to an inclined leaf surface and therefore tends to be wasteful. It would be highly desirable to be able to dispense a liquid containing an active agent such as a herbicide wherein the droplet size could be maintained within a selected size band to maximize the desired effectiveness of the active agent.

OBJECTS AND SUMMARY OF THE INVENTION

Objects

It is therefore a general object of the invention to provide a process and apparatus for dispensing a fluid which is designed to obviate or minimize problems of the type previously described.

It is a particular object of the invention to provide a process and apparatus for dispensing a fluid wherein the droplet size may be predictably controlled within a desirable range of droplet diameters.

It is another object of the invention to provide a process and apparatus for jet stream atomizing a biological control agent such as a herbicide in liquid form which will minimize the problems of drift and atmospheric pollution and maximize the desired effectiveness of the agent.

It is a further object of the invention to provide a process and apparatus for jet stream atomizing a herbicide liquid of substantially uniform droplet size with a high volumetric flow rate so that a large crop area may be rapidly treated.

It is a still further object of the invention to provide an improved process and apparatus for jet stream atomizing uniform droplets of a vegetation control agent such as a liquid herbicidal composition by imparting a disturbance to the atomized fluid by a volumetric oscillation of a member in contact with the dispensed fluid stream such that the rate of vibration of the member produces a corresponding number of uniform droplets.

It is a related object of the invention to provide a process and apparatus for jet stream atomizing uniform droplets of a liquid herbicide in a cone array.

It is another related object of the invention to provide an apparatus which may be readily adapted to existing nozzle structures to enhance uniform droplet formation of fluid dispensed from the nozzle.

Brief Summary

One preferred form of the invention intended to accomplish at least some of the foregoing objects comprises a generally tubular jetting nozzle having one end thereof sealed and the other end thereof covered with an orifice plate. One or more orifices are fashioned through the orifice plate in a generally central posture therethrough for metering fluid to be dispensed into the atmosphere. A passage is provided in a portion of the nozzle body so that fluid may be delivered to the interior thereof from a constant pressure source which may be selectively varied. A volumetric displacement member is positioned so as to be in fluid contact with the fluid exiting from the orifice. The displacement member is connected to a conventional variable frequency AC power source and is suitable for cyclic volumetric displacement in response to excitation from the power source. The volumetric displacement member transmits cyclic disturbances to the fluid as it exits through the orifice and to the fluid jet column downstream from the orifice. The fluid jet column is thereby dispersed into droplets of uniform size.

A significant process aspect of the invention includes the steps of delivering a fluid under pressure to a dispensing nozzle having an orifice plate across one end thereof, jetting the fluid through the orifice by pressure and transmitting a vibration to the fluid being dispensed downstream of the orifice to induce the formation of uniform fluid droplets in the liquid being dispensed.

THE DRAWINGS

Further objects and advantages of the invention will become apparent from the following detailed description taken in conjunction with the accompanying drawings, wherein:

FIG. **1** is a plan view of a vibratory atomizing device according to a preferred embodiment of the invention;

FIG. **2** is a cross sectional view taken along section line **2—2** in FIG. **1** disclosing more specifically the structure of a preferred embodiment of the invention;

FIG. **3** is a plan view of an alternate preferred embodiment of the invention;

FIG. 4 is a cross sectional view of the vibratory atomizing device disclosed in FIG. 3 taken along section line 4—4;

FIG. 5 is a plan view of an improved orifice plate suitable for use with a jet stream atomizing device;

FIG. 6 is a cross sectional view of the improved orifice plate disclosed in FIG. 5 taken along section line 6—6; and

FIG. 7 is a schematic illustration of a jet stream atomizing device of the invention utilizing the improved orifice plate, as seen in FIG. 5 and 6.

DETAILED DESCRIPTION

Referring to the drawings and specifically to FIGS. 1 and 2 thereof, a vibratory atomizing device **10** according to a preferred embodiment of the invention is shown.

The atomizing device **10** comprises a generally tubular nozzle body **12** having a suitable nozzle head such as an orifice plate **14** disposed across one end thereof. The orifice plate is provided with an orifice **15** generally centrally thereof. The orifice plate **14** may be removably attached to the nozzle body **12** by a conventional threaded connector **16**.

A side passageway **18** is fashioned through a lateral portion of the nozzle body **12** to permit the delivery of a fluid **20** from a pressurized source, not shown, into the internal cavity of the nozzle body **12**. The source of pressurized fluid may be of any conventional type, such as for example a fluid tank with a controllable air pressure head, suitable to deliver the fluid to the nozzle at a selected constant pressure which may be varied from a few pounds per square inch to several hundred pounds per square inch, depending upon the viscosity of the fluid being dispensed and the volume of fluid being dispensed. In any case, the pressure should be sufficient to produce a desirable jet stream emanating from the orifice. The fluid **20** may be selected from a variety of substances such as, for example, water emulsions of pesticides, herbicides or other plant or pest control agents, or solutions of such agents in water or in some other appropriate liquid solvent such as a non-phytotoxic mineral oil fraction.

The other end of the tubular nozzle body **12** is a sealingly covered with a washer **22** having a central opening **24** therethrough. A volumetric displacement shaft **26** formed from a material which will exhibit magnetostrictive properties such as, for example, an iron or nickle alloy, is provided to intimately engage the opening and coaxially extend within the generally tubular nozzle body **12** to a position adjacent the orifice **15** in the orifice plate **14**.

The volumetric displacement shaft also extends exteriorly of the nozzle body **12** and is surrounded by a sheath **28** carrying a plurality of conductor windings **30**. The sheath **28** is provided at one end with a conventional threaded coupling flange **32** suitable to removably connect the sheath to the nozzle body **12**.

In order to axially retain the volumetric displacement shaft **26** within the nozzle body **12** and sheath **28**, an O-ring **34** or other suitable connector means, such as a bellows diaphragm washer, may be connected to the shaft **26** and retained between the washer **22** and a shoulder portion of the sheath **28**.

The coil windings **30** are electrically connected to a conventional variable frequency AC power source **36** which is suitable to produce a varying current from 2,000 to 30,000 cycles per second or higher in the windings depending upon the rate of displacement desired for displacement shaft **26**.

In operation the vibratory atomizing device **10**, as shown in FIGS. **1** and **2**, receives a liquid such as an aqueous emulsion of herbicide into the interior of the dispensing nozzle **12** from a source which is suitable to deliver the herbicide under a selected constant pressure. This fluid then travels toward the orifice plate **14** and is jetted through the orifice **15** in a uniform stream **38**. The frequency generator **36** is activated, which supplies an alternating current to the windings **30**. A magnetic flux will thus be established in the shaft **26**, which as previously mentioned, has been selected to exhibit a high degree of magnetostrictive displacement. More specifically, as the shaft **26** is cyclically magnetized, it will expand and contract in response to the varying current in the windings **30**. This volumetric displacement of the shaft **26** is imposed upon the liquid **20** particularly near the jetting orifice **15** and also upon the liquid jet **38** downstream from the orifice **15**. The cyclic disturbances in the fluid column **38** will result in regular nodes or anodes corresponding to the frequency of volumetric displacement of the shaft **26** and thus produce droplets **39** downstream of the orifice **15** which will be uniform in size and correspond in number to the frequency imposed upon the fluid column **38** by the volumetric displacement of shaft **26**. The number of droplets may be thus established by the rate of displacement of shaft **26** and the size may be varied by varying the constant pressure source acting to jet the fluid from the orifice **15**.

While one skilled in the art will readily be able to practice the invention according to the above disclosed process by selecting operating parameters which would produce the desired results the following example is illustrative of typical operating values.

EXAMPLE

A control agent as previously mentioned may be a water (typically 95 percent by volume) emulsion having a small percentage by volume of an active agent. Therefore water at room temperature (approximately 70° F.) was delivered within a nozzle body as illustrated in FIGS. **1** and **2** under a constant pressure of 30 pounds per square inch gauge. The orifice size was 0.010 inches in diameter and the dimension between the bottom of the magnetostrictive shaft and the top of the orifice plate was 0.010 inches. The magneto-strictive device was vibrated at a frequency of 18,300 cycles per second and an essentially uniform droplet size of 0.015 inches in diameter was obtained.

An alternate embodiment of the vibratory atomizing device **40** may be seen by referring to FIGS. **3** and **4**.

A jet stream vibratory atomizing device **40** is provided with a generally tubular nozzle body **42** having at one end thereof an orifice plate **44** and at the other end thereof a cap **46**. The orifice plate **44** is removably attached to the nozzle body **42** by a conventional coupler **60**.

The nozzle body **42** is further provided with a passageway **50** in a portion thereof for the delivery of fluid, such as for example, herbicide into the interior of the nozzle body **42** for jetting through an orifice **52** formed generally in a central portion of the orifice plate **44**.

The orifice plate **44** is composed of a piezoelectric crystal or in some instances of a plurality of piezoelectric crystals and is provided with electrical contact discs or washers **54** on each face thereof. A pair of lead lines **56** connect the contact discs **54** to a conventional variable frequency AC power source **58** which is suitable to produce a varying voltage from 2,000 to 30,000 cycles per second or greater.

In operation a herbicide is delivered under a selected pressure into the interior of the nozzle body **42** and jetted through the orifice **52** thus forming a generally uniform fluid column **62** downstream of the orifice. The orifice plate **44**, as previously mentioned, is composed of a piezoelectric crystal. This crystal may be excited by imposing a variable potential across its face. The crystal will thus volumetrically expand and contract. The expansion and contraction will occur in a direct relationship to the frequency of the potential applied and therefore the orifice **52** will expand and contract at the frequency of the applied voltage from the variable frequency power source **58**. The volumetric displacement of the orifice will impose upon the fluid column **62** a cyclic disturbance which will induce the formation of nodes and anodes corresponding to the frequency of the disturbance in the fluid column **62** and thus produce uniform droplets **64** downstream of the orifice.

The number of droplets will be identical with the rate of volumetric displacement and the volume of the droplets will be controlled by the selection of the constant pressure under which the fluid is delivered to the nozzle body as previously mentioned in connection with the jet stream atomizing device shown in FIGS. **1** and **2**.

It will be realized by those skilled in the art that the orifice or orifices through the orifice plate presents a potential short circuit avenue. If short circuiting becomes a problem the orifice plate may be covered with a dielectric film or a herbicide may be selected for its nonconductive properties.

While the above discussed embodiments of the invention disclosed in FIGS. **1** and **2** and in FIGS. **3** and **4** disclose an orifice plate having a single orifice fashioned through the center thereof, in those instances where it is desired to dispense a high volume of fluid a plurality of orifices **70** may be formed in an orifice plate as shown in FIGS. **5** and **6**.

Moreover where a plurality of orifices **70** are fashioned through an orifice plate it may be desirable to dish the plate outwardly of the nozzle body, as best illustrated in FIG. **6**, by orifice plate **72**. Such an outward bow of the orifice plate **72** will be suitable to produce a conical spray pattern **74** as best seen in FIG. **7**. In those instances where a dish shaped orifice plate is utilized it may be desirable to form the end of the magnetostrictive shaft **26** with a compatible outwardly curved configuration so that the dis-tance between the end of the shaft and the surface of the orifice plate is substantially uniform.

As previously discussed, utilization of the magnetostrictive device in conjunction with the disclosed nozzle body and orifice plate produces a substantially uniform droplet size. It has been discovered, however, that utilization of a magnetostrictive volumetric displacement member, such as previously described, upstream of a conventional nozzle head universally enhances the droplet size control during jet stream atomization of a fluid. For examples of typical nozzle head structures, such as a cone spray, flat spray or flooding head, reference may be had to the Transactions of the American Society of Agricultural Engineers, Volume 9, No. 3, pages 303, 304, 305 and 308 (1966), the disclosure of which is incorporated herein by reference as though set forth at length.

It will be appreciated by those skilled in the art that the above disclosure provides a process and apparatus for precision jet stream atomizing a fluid into a uniform selected droplet size. In addition, the above described process and apparatus may be utilized for delivering a high volumetric flow of uniform droplets which may be produced at a rate of **30,000** or greater droplets per second.

It will further be appreciated that the above described vibratory atomizing devices will enhance the delivery or dispensing capability of an agent such as a pesticide or herbicide by minimizing the drift and atmospheric pollution while maximizing the effectiveness of the application. Further, it will be recognized that a degree of downstream pattern control may be provided by the utilization of a dish shaped orifice.

Further, it will be appreciated that the magnetostrictive volumetric displacement member may be readily mounted upstream of a conventional nozzle head configuration of various designs to enhance jet stream atomization of fluid through the nozzle head into droplets of uniform size.

Although the invention is described with reference to preferred embodiments, it will be appreciated by those skilled in the art that additions, deletions, modifications, substitutions and other changes, not specifically described and illustrated in these embodiments, may be made which will fall within the purview of the appended claims.

We claim:

1. A process for jet stream dispensing a biological control agent by atomizing the control agent into generally uniform droplets comprising the steps of:

delivering a biological control agent to be atomized into a generally tubular nozzle body having one end thereof sealed and a nozzle head covering the other end thereof with at least one fluid jetting opening therethrough;

jetting the biological control agent through the at least one opening by pressurizing the biological control agent within the nozzle; and

imparting a high frequency vibration to the biological control agent for breaking the jet of biological control agent downstream of the opening into generally uniform droplet size.

2. A process as defined in claim **1** wherein said step of imparting a high frequency vibration to the biological control agent comprises:

cyclically magnetizing a magnetostrictive shaft having one end thereof extending interiorly within the nozzle body.

3. A process as defined in claim **1** wherein said biological control agent comprises a herbicide.

4. A process as defined in claim **1** wherein said biological control agent comprises a pesticide.

* * * * *