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2,612,408

ATOMIZING NOZZLE

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FIG. 1

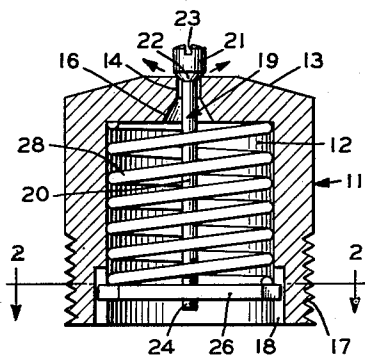


FIG. 3

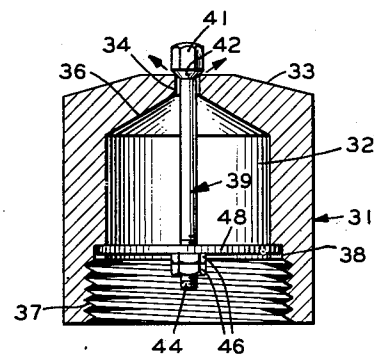


FIG. 2

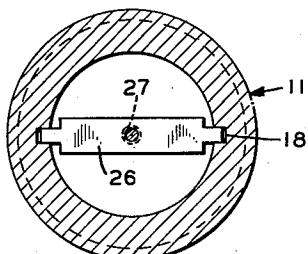


FIG. 4

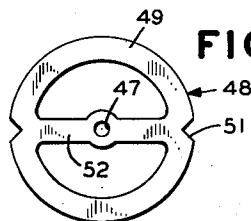


FIG. 5

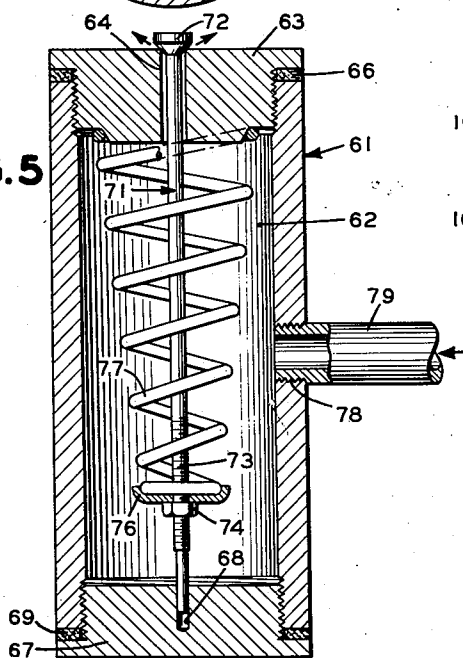
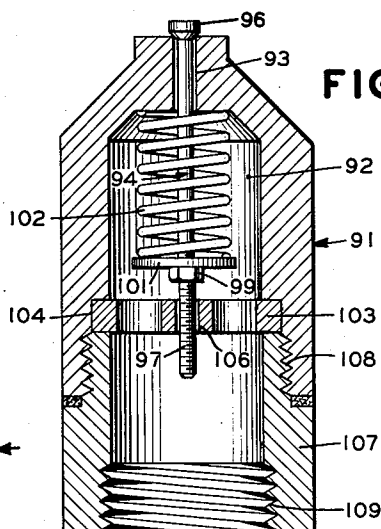


FIG. 6



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ATOMIZING NOZZLE

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10 Claims. (Cl. 299—125)

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The present invention relates to nozzles for atomizing liquids. Particularly in one aspect, this invention relates to such a nozzle in which a vibrating member is employed to bring about the desired degree of atomization. This application is a continuation-in-part of my prior and co-pending application Serial No. 533,720, filed May 2, 1944, and now abandoned.

In the commercial atomizing nozzles on the market today in which pressure alone is employed as the atomizing force as contrasted with those in which a gas under pressure is used as the propelling and disruptive agency the atomization of the liquid is produced by subjecting it to a whirling action before ejecting it from an orifice of the desired shape and size. The whirling motion is imparted to the liquid by passing it under pressure through a chamber of special construction. All of the nozzles of this type are inherently inefficient because of the pressure drop caused by the absorption of energy as fluid friction when the liquid traverses the nozzle chamber.

It is an object of the present invention to produce an atomizing nozzle of a design radically different from that discussed above and in which energy losses due to fluid friction are in a large part eliminated.

It is a further object of this invention to produce an atomizing nozzle in which a much lower fluid pressure is required to obtain a certain degree of atomization than is the case with the presently-known types of atomizing nozzles.

It is still another object of the invention to provide an atomizing nozzle of relatively simple and compact construction which brings about a more efficient atomization of liquids than those presently in use.

It is a still further object of the present invention to produce an atomizing nozzle in which the degree of atomization of the liquid can be readily varied within wide limits.

Another object of this invention is to provide a vibrating atomizing nozzle in which the vibrating mechanism does not interfere with the distribution of the spray produced thereby.

Still another object is to provide a vibrating nozzle in which the vibrating mechanism is protected from the environment in which the nozzle is used.

Various other objects and advantages of the present invention will become apparent from the accompanying description and disclosure.

Figure 1 of the drawings is a front elevational view, partly in cross-section, of the vibrating

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nozzle of this invention employing a cylindrical-helical spring positioned upstream within the chamber of the nozzle as part of the vibrating mechanism. Figure 2 is a sectional view of the nozzle of Figure 1 taken along line 2-2 in the direction shown.

Figure 3 of the drawings is a front elevational view, partly in cross-section, of another modification of the vibrating nozzle of this invention employing a single-leaf spring as part of the vibrating mechanism. Figure 4 is a plan view of the leaf spring employed in the modification shown in Figure 3.

Figure 5 of the drawings is a front elevational view, partly in cross-section, of another modification of the vibrating nozzle employing a conical-helical spring and made of separately assembled chamber and two end sections, one end section containing an orifice and the other end section containing a guide for a vibrating valve member.

Figure 6 of the drawings is a front elevational view, partly in cross-section, of still another modification of different construction but corresponding in the vibrating mechanism substantially to that illustrated in Figure 5.

Referring to the modification shown in Figures 1 and 2 of the drawings, numeral 11 designates a body portion of any desired shape, preferably cylindrical, having a chamber 12 therein and a conically-shaped or beveled end section 13. A discharge orifice or aperture 14 passes through the conically-shaped end section 13 in open communication with internal chamber 12. Chamber 12 and aperture 14 are preferably cylindrical and are axially aligned. In its preferred form chamber 12 narrows by means of a conical section 16 to aperture 14.

The other end of body portion 11 opposite discharge orifice or aperture 14 is externally threaded as indicated by numeral 17 so as to be capable of connection with a conduit (not shown) for supplying liquid under pressure. Other conventional methods known to those skilled in the art may be used to connect chamber 12 to a source of supply of liquid under pressure, such as welding or bolting with flanges, without departing from the scope of this invention. Chamber 12 is slotted or grooved in a longitudinal direction as shown by numeral 18, to receive a spring supporting member 26.

Figure 2 being a view taken along line 2-2 in the direction shown clearly illustrates the shape of the cross-section of body portion 11 and chamber 12 and the insertion of supporting member 26 in grooves 18 of chamber 12. The ends of sup-

porting member 26 freely fit into slots or grooves 18 so that supporting member 26 can move longitudinally within chamber 12 but cannot rotate.

A valve member 19 comprising a stem 20 and a valve head 21 is located centrally within chamber 12 with its valve head 21 seated on the outer edge of discharge orifice 14. That portion of the valve head 21 which seats in orifice 14 is preferably conical as indicated by numeral 22. Valve head 21 may be spherically-shaped without departing from the scope of the invention. An important feature of the nozzle is the seating of the conically-shaped valve head 21 on the outer edge of orifice 14 to make a line contact or a knife edge contact as contrasted to surface contact which would result if the outer edge of orifice 14 had conically shaped sides parallel to sides 22 of valve head 21. Other important features of orifice 14 and valve head 21 will be discussed more fully hereinafter.

Preferably the included or apex angle formed by the conically-shaped portion 22 of valve head 21 is between about 60 and about 150 degrees, the actual angle best suited for any particular valve head will depend on such factors as the size of the orifice and the pressure of the liquid being atomized. Included angles between about 90 and about 120 degrees for valve head 21 have shown good results for a wide range of liquid pressures.

The other end of valve member 19 opposite the valve head 21 is threaded as shown by numeral 24. Threaded end 24 of valve member 19 is screwed into a threaded hole 27 (Figure 2) of supporting member 26. Valve head 21 is notched or grooved at 23 to receive a screw driver.

A cylindrical-helical spring 28 is positioned within chamber 12 surrounding valve stem 20 with one end thereof pressing against the downstream end of chamber 12 and with the other end pressing against supporting member 26 connected to the threaded end 24 of valve member 19. The pressure of spring 28 against the body portion 11 and against supporting member 26 urges the valve head 21 of valve member 19 towards the outer edge of orifice 14 and seats the valve head 21 on the edge of the circular mouth of orifice 14. Various sizes and types of conventional springs may be used for this purpose, as hereinafter described, without departing from the scope of this invention. The force with which spring 28 urges valve head 21 against the outer edge of orifice 14 can be adjusted by inserting a screw driver in groove 23 of valve head 21 and turning valve member 19. Turning valve member 19 changes the position of supporting member 26 so as to increase or decrease the pressure of spring 28 thereon depending on the direction turned. Sufficient clearance between spring 28 and the walls of chamber 12 is allowed to prevent binding or cramping when the spring is compressed.

Supporting member 26 serves also as a guide so that valve member 19 will be axially aligned at all times with orifice 14 and will not vibrate transversely.

The nozzle of Figure 1 of the drawings is of relatively simple construction and can be easily and inexpensively manufactured. Body portion 11 can be made by drilling chamber 12 and orifice 14 from bar stock of steel, alloy, cast iron, brass or bronze. Body portion 11 including chamber 12 may also be cast or molded from suitable metal or alloy. Valve stem 19, supporting member 26 and spring 28 are made in the

conventional manner known to those skilled in the art.

In operating the nozzle of Figure 1, the force exerted by spring 28 is adjusted in the manner previously discussed to correspond to that appropriate for causing vibration of valve member 19 at the pressure of liquid available. Thereafter, liquid under pressure is supplied to chamber 12, which is connected to a supply conduit (not shown) by means of threaded portion 17. Assuming the adjustment of the spring 28 is correct, valve stem 19 will vibrate in a longitudinal direction along the axis of orifice 14. Liquid issues from orifice 14 of the nozzle as a fine spray of uniform particle size as the result of the vibrating action of conically-shaped valve head 21 on the edge of the mouth of cylindrical orifice 14. The size of the orifice 14, the strength of spring 28, and the mass of spring 28 and valve member 19 are so co-related to one another and to the liquid pressure that valve member 19 (and valve head 21) is maintained in forced vibration as part of a resonant system.

In general the greater the mass of the vibrating parts, the lower will be the frequency of vibration; and the greater the spring force the higher will be the frequency of vibration. The frequency of vibration will also tend to increase with an increase of pressure of the liquid to be atomized, but this factor is not as important as the mass of the spring and the parts associated therewith and the spring tension. Thus it is seen that by varying and balancing the co-acting forces, the operable limits of the device may be widely changed and any desired degree of atomization of the liquid can be procured. For most operations, the frequency of vibration will be maintained within the audio range; for example, frequencies of 60 to several thousand cycles per second may be cited.

In operation, the potential energy available from the pressure of the liquid is consumed by the friction of the liquid passing through the nozzle and by the energy necessary to cause vibration of the valve member. For maximum efficiency, therefore, it is desirable to reduce the energy losses by friction to a minimum. The greater the proportion of the total energy available for use in vibrating the valve member, the higher the frequency of vibration that can be obtained which results in the maximum dispersion of the liquid as a spray or mist for a given pressure. In fact, if energy losses by friction are too great the valve member will not vibrate. Accordingly, the dimensions and shape of such elements as orifice 14, the downstream end 16 of chamber 12, and the valve stem 20 of valve member 19 are important and the following dimensions serve as a guide in the construction of a nozzle having minimum frictional losses. The downstream end 16 of chamber 12 is preferably in the form of a 90 to 120 degree cone to minimize the turbulence of the liquid as it passes from chamber 12 to discharge orifice 14. The longitudinal length of aperture or orifice 14 is preferably as short as structural limitations will permit, for example, from about $\frac{1}{8}$ to about $\frac{1}{4}$ of an inch in length, although shorter or longer dimensions may be used, as desired. The diameter of orifice 14 should not be so small as to cause excessive energy losses by the passage of liquid through the annular passageway formed by the walls of the aperture 14 and valve stem 20. Otherwise, the diameter of aperture 14 will be determined by such factors as pressure of the

liquid, capacity of the nozzle, etc., and generally the diameter will be between about $\frac{1}{64}$ to about $\frac{1}{2}$ of an inch, but larger or smaller diameter orifices may be used without departing from the scope of this invention. The clearance between valve stem 20 and the walls of aperture 14 should also be sufficient to minimize frictional losses of the liquid passing through the annular space formed therebetween; preferably a clearance of at least 0.001 of an inch is employed for small orifices and where possible with larger orifices at least $\frac{1}{8}$ of an inch, but not so much clearance as might cause transverse vibration of the valve stem. A clearance of 0.005 of an inch has been found sufficient for producing a spray having particle sizes less than 10 microns.

The diameter of valve head 21 should be only slightly larger than the diameter of the mouth of orifice 14 in order to assure uniform and minimum particle size. If valve head 21 is too large as compared to orifice 14, surface area 22 projects over the edge of orifice 14 to such an extent that the liquid particles produced by the vibrating action cling to surface 22 resulting in agglomeration of the fine particles. Preferably therefore, the diameter of valve head 21 is not more than about $\frac{3}{4}$ of an inch larger than the diameter of the mouth of orifice 14. For example, an orifice $\frac{1}{8}$ inch in diameter should be used with a valve member having a valve head not greater than $\frac{3}{4}$ inch in diameter.

The spray of the nozzle of Figure 1 of the drawing will form a cone having an included or apex angle slightly smaller than the apex angle of conical portion 22 of valve head 21. The particle size of the spray is a function of the tension of spring 28 within a relative narrow range; thus, for a given pressure the particle size of the spray may be varied by adjusting the tension of spring 28 by valve head 21 with a screw driver in the appropriate direction to increase or decrease the tension of the spring as desired. A hexagonal head may replace groove 23 and valve head 21 is then turned by a wrench or like means.

Although the various structural materials used to make the nozzles form no part of this invention, it should be noted that orifice 14 and valve member 19 including valve head 21 may be made of special alloys, or plated or clad with special metals or alloys to prevent wear and erosion. A wear and erosion resistant sleeve of a suitable wear resistant material, such as stainless steel, Monel metal, Stellite, or a jewel such as sapphire, may be inserted and fixed in orifice 14, if desired. It is desirable to make the valve member of softer material than the orifice.

The atomizing nozzle of Figure 1 may be used on liquids at various pressures. Best results are obtained at pressures above about 100 pounds per square inch gage and up to pressures as high as the tension of the spring correlated with orifice diameter will permit. Pressures as high as 6000 pounds per square inch gage have been used with the vibrating type nozzle of this invention with excellent results characterized by efficiencies as high as 80 per cent and higher. Pressures as low as 15 or 25 pounds per square inch gage produce a fine spray of various liquids, such as water and oil, with the nozzles of this invention.

Figure 3 of the drawings illustrates another modification of the nozzle of this invention using a single-leaf spring and since its construction and operation is similar in some of its aspects to that nozzle of Figure 1 only a brief description of it will be made. Referring specifically to the

nozzle of Figure 3, numeral 31 designates the body portion of any desired cross-sectional shape, preferably cylindrical but other shapes, such as polygonal, may be used without departing from the scope of this invention. Body portion 31 contains a chamber 32 therein and a discharge orifice 34 passing through end section 33 in open communication with chamber 32. End section 33 is preferably beveled or conically-shaped as shown. Chamber 32 and orifice 34 are axially aligned. The end of chamber 32 narrows to orifice 34 as indicated by numeral 36 in a somewhat similar manner as was described with respect to Figure 1 except that no shoulder or ledge is necessary for the spring to press against. The other end of chamber 32 opposite orifice 34 is threaded at 37 to receive another threaded member (not shown), such as a conduit for supplying liquid under pressure. Between threaded section 37 and end section 36, chamber 32 is recessed as indicated by numeral 38 to receive a flat or leaf spring 48 which is suspended from the sides of chamber 32. In the modification shown in Figure 3, a single-leaf spring is shown; however, a multi-leaf spring, a coil spring, a semi-elliptical spring, an elliptical spring, etc., may be used to advantage depending on such factors as the size of the orifice and the liquid pressure.

As with the nozzle of Figure 1 of the drawings, the nozzle of Figure 3 also includes a valve member 39 having a valve head 41 which is hexagonal and a threaded end 44. Valve head 41 has a conically-shaped section 42 which seats on the outer edge of orifice 34 to make a knife edge or line contact therewith. The threaded end 44 of valve member 39 passes through an opening 47 (Figure 4) of spring 48. The tension of spring 48 is exerted downwardly on valve stem 39 by conventional hexagonal nuts 46 which are screwed on threaded end 44. Two nuts are used so that the nuts will lock and not rotate as a result of the vibration of valve member 39. By locking nuts 46, the tension of spring 48 will remain constant.

Figure 4 is a view in plan of single-leaf spring 48 of Figure 3. Circular portion 49 rests in the recess 38 of chamber 32 as means for supporting the spring. V-shaped slots 51 fit into corresponding V-shaped projection (not shown) in chamber 32 to prevent rotating of the spring during operation of the nozzle or in adjusting nuts 46. Middle section 52 of spring 48 is flexible and supplies the tension to urge valve member 39 towards orifice 34.

The nozzle of Figure 3 operates in a similar manner as the nozzle of Figure 1.

Figure 5 of the drawing is an elevational view, partly in cross-section, of another nozzle of different modification than Figures 1 and 3. The nozzle of Figure 5 is operated by a conical-helical spring 77 and is of relatively simple construction. This modification comprises a body portion 61, two end sections 63 and 67, spring 77, and valve member 71 having a valve head 72. Body portion 61 comprises an open cylinder forming a chamber 62. Each end of open cylinder 61 is internally threaded to receive threaded and flanged end sections 63 and 67. End section 63 contains an aperture or orifice 64 in open communication with chamber 62. Orifice 64 is of circular cross-section and is axially aligned with chamber 62. Numeral 66 designates a gasket made of suitable gasket material to seal the juncture between body portion 61 and end section 63. End section 67 has a well or hole 68 to receive

the end of valve member 71. Well 68 is of slightly larger dimension than the stem of valve member 71 so that the end of valve member 71 may move freely longitudinally therein, well 68 serving as a guide. The shape of well 68 is similar to the shape of the stem of valve member 71. Conveniently, the end of valve member 71 and well 68 are square so as to prevent turning or rotating of the valve stem when it vibrates. The juncture between body portion 61 and end section 67 is sealed by gasket 69.

Valve member 71 extends through orifice 64 and conically-shaped valve head 72 is seated on the outer edge of cylindrical orifice 64 to form a knife edge contact therebetween. The opposite end of valve member 71 is threaded at 73. A nut 74 is screwed on valve member 71 and supports flanged washer 76. Washer 76 supports one end of a spring 77 which surrounds valve member 71. The other end of spring 77 presses against the bottom of recessed end portion 63.

Body portion 61 contains a threaded hole or aperture 78 which receives a threaded conduit 79. Conduit 79 transmits liquid under pressure to chamber 62.

The operation of the nozzle of Figure 5 is exactly the same as the operation of the nozzles of Figures 1 and 3. The tension of spring 77 may be adjusted by adjusting the position of nut 74 on valve member 71. Various types of springs other than that shown may be used in the modification of Figure 5 without departing from the scope of this invention. Spring 77 may be a cylindrical-helical spring, or other type compression spring. End portion 67 with well 68 serves as a guide to assure alignment of valve member 71 along the axis of chamber 62 and orifice 64 and to minimize transverse vibration of valve member 71.

Figure 6 of the drawings illustrates another modification of the vibrating type nozzle of this invention which is shown in elevation and partly in cross-section. Body portion 91 contains a chamber 92 therein and an aperture 93 in one end thereof. Aperture 93, as shown, has a relatively great longitudinal dimension as compared to the other models shown as the result of which it acts as means for holding valve member 94 in position in assembling the nozzle. Valve member 94 and a cylindrical-helical spring 102 are arranged similar to the arrangement illustrated in Figure 5. One end of spring 102 rests on washer 101 which is supported by nut 99. The other end of spring 102 presses against the orifice or downstream end of chamber 92. Valve member 94 comprises a conically-shaped valve head 96 which seats in the mouth of aperture 93 and threaded end 97 upon which nut 99 is screwed. A perforated disk 103 is positioned in shoulder or recess 104 of chamber 92. Disk 103 contains an opening 106 in the center thereof through which the threaded end 97 of valve member 94 passes. Disk 103 serves as a guide for valve member 94 to assure alignment with the axis of orifice 93 and to minimize transverse vibration. Plug 107 is screwed into the threaded portion 108 of chamber 92 to maintain disk 103 in a fixed and secure position. Plug 107 is threaded at both ends; end 109 receives a conduit (not shown) for transmitting liquid under pressure to chamber 92. Several plugs like plug 107 with different sized end sections 109 may be interchanged with plug 107 so that body portion 91 can be made to fit any size pipe or conduit.

In the modifications of the nozzle shown in Figures 1, 5 and 6, the spring member is located

between the orifice and the guiding member for the valve member. In this manner, the two extremes of the valve member are supported and aligned with the axis of the orifice in order to prevent transverse vibrations or wobbling. It is important in order to obtain maximum dispersion and uniform size of the particles at a given pressure that the valve member vibrate only along the axis of the orifice thereby insuring uniform and continuous contact between the outer edge of the orifice and the conical section of the valve head when the valve head is seated in the orifice. Moreover, correct alignment of the valve member during vibration maintains uniform dispersion of the spray when the valve head is not seated in the orifice.

Contrary to what might be expected, positioning the spring within the liquid in the chamber of the nozzle does not prevent vibration of the valve member and apparently does not affect or impair the vibrating phenomenon which causes atomization. The size and mass of the spring should not be such that it interferes with the flow of liquid through the nozzle or causes excessive frictional losses.

The nozzles of this invention have demonstrated exceptionally high efficiencies as compared to various commercial nozzles on the market. Tests have been made on various commercial nozzles and nozzles of the vibrating type of this invention on brine solutions and oil at pressures between 25 and 6000 pounds per square inch gage. With the best commercial nozzle a maximum of about 2 per cent of the brine solution remained in suspension at the end of a 5 minute spraying period for a pressure of 3000 pounds per square inch gage. With the nozzles of the vibrating type of this invention under similar conditions of operations, 30 per cent of the brine solution remained in suspension at the end of the spraying period. For a spraying period of one minute under otherwise similar conditions, the best commercial nozzle maintained a maximum of 10 per cent of the brine solution in suspension, and the nozzle of the vibrating type maintained a maximum of about 95 per cent of the brine solution in suspension at the end of the spraying period.

A vibrating nozzle similar in construction to that shown in Figure 5 was tested. This nozzle had a $\frac{1}{8}$ inch diameter orifice and a valve stem of $\frac{3}{8}$ of an inch in diameter passing through the orifice which gave a clearance of $\frac{1}{64}$ of an inch. The valve head had a 120 degree cone seated on the edge of the cylindrical orifice. The chamber of the nozzle was about $\frac{3}{4}$ of an inch in diameter and about 3 inches in length. At a liquid pressure of about 3000 to about 5000 pounds per square inch gage, this nozzle had an optimum capacity of 4 gallons per minute and an efficiency above about 80 per cent for spraying both water and oil.

Various alterations and modifications of the nozzles illustrated, such as the size and shape of the spring and the valve member, may be employed without departing from the scope of this invention. Various uses of the nozzle and its principle of operation, such as in humidification, emulsification, milk spraying, spray drying, fuel injection, spray painting, powder metallurgy, surface cooling, fire extinguishing, distillation, etc., may become apparent to those skilled in the various fields of application without departing from the scope of this invention.

The vibrating principle of the nozzle in atom-

izing liquids has its obvious application as integral parts of equipment and appliances, such as oil burners, internal combustion engines, fire extinguishers, etc. In any of these instances, the nozzle portion of the apparatus is defined by the various associated parts necessary to produce the vibrating action, the result of which atomizes the liquid.

In using the nozzle similar to that shown in Figure 1 or Figure 2 as a means of injecting fuel in an oil burner or furnace, the shape of end section 13 of body portion 11 is important. End section 13 in such instances is a 90 to 160 degree cone so as to prevent the accumulation of coke deposits around orifice 14 which would interfere with the dispersion of the spray. The vibration of valve head 21 prevents coke accumulations in the immediate vicinity of orifice 14.

Having described my invention, I claim:

1. An atomizing nozzle comprising in combination a body portion having a chamber within said body portion and a stationary outlet orifice having an edged seat and of substantially smaller cross-sectional dimension than said chamber, a moveable valve member adapted to freely move its normal span of movement in a substantially longitudinal direction along the axis of said orifice and having a valve head terminating adjacent said orifice and seated on the edged seat of said outlet orifice, said valve head having a maximum diameter not greater than $1\frac{1}{2}$ times the diameter of the orifice and an apex angle between about 60° and about 150° at its point of seating on said orifice and a spring positioned within said chamber urging said valve head towards said outlet orifice.

2. An atomizing nozzle comprising in combination a body portion having a chamber within said body portion and a stationary outlet orifice having an edged seat, a moveable valve member adapted to freely move in a direction substantially perpendicular to said orifice and having a valve stem and a valve head having a diameter not more than about $\frac{1}{2}$ of an inch larger than the diameter of said outlet orifice and seated on the edged seat of said outlet orifice, and a helical spring positioned within said chamber urging said valve head towards said outlet orifice.

3. An atomizing nozzle comprising in combination an open cylinder, a first plug having a stationary cylindrical orifice therein connected to one end of said cylinder, a second plug having a well therein connected to the other end of said cylinder, a moveable valve member adapted to freely vibrate in a direction substantially perpendicular to said orifice and having a valve stem and a conically shaped valve head of slightly larger diameter than said orifice, said valve head seated in said cylindrical orifice and said valve stem extending through said orifice into the well of said second plug forming a continuous annular passageway between the sides of said orifice and the valve stem communicating with the interior of said cylinder, and a helical spring positioned within the interior of said cylinder surrounding said valve stem and urging said valve head towards said orifice.

4. An atomizing nozzle comprising in combination a body portion having a longitudinally grooved chamber within said body portion and a stationary cylindrical outlet orifice having an edged seat, a moveable valve member adapted to freely move in its normal span of movement in a substantially longitudinal direction along the axis of said outlet orifice and having a valve stem

and a conically shaped valve head terminating adjacent said orifice and seated on the edged seat of said cylindrical outlet orifice, said valve head having a maximum diameter not greater than $1\frac{1}{2}$ times the diameter of the orifice and an apex angle between about 60° and about 150° at its point of seating on said orifice said valve stem being positioned within said chamber and projecting through said orifice to form a continuous annular passageway between the sides of said orifice and the valve stem communicating with said chamber, a movable supporting member loosely positioned in the grooves of said chamber and connected to said valve stem, and a helical spring positioned in compression within said chamber between the supporting member and the orifice surrounding said valve stem and pressing against one end of said chamber and against said supporting member.

5. An atomizing nozzle comprising in combination a body portion having a chamber containing a circumferential recess within said body portion and a stationary cylindrical outlet orifice of substantially smaller cross-sectional dimension than said chamber and having an edged seat, a moveable valve member adapted to freely move in its normal span of movement in a substantially longitudinal direction along the axis of said outlet orifice and having a valve stem and a conically shaped valve head terminating adjacent said orifice and seated on said edged seat of said cylindrical outlet orifice, said valve head having a maximum diameter not greater than about $1\frac{1}{2}$ times the diameter of the orifice and an apex angle between about 60° and about 150° at its point of seating on said orifice said valve stem being positioned within said chamber and projecting through said orifice to form a continuous annular passageway between the sides of said orifice and the valve stem communicating with said chamber, and a metallic leaf spring resting on the recess of said chamber urging said valve head towards said outlet orifice.

6. An atomizing nozzle comprising in combination a body portion having an internally threaded chamber containing a circumferential recess at one end thereof within said body portion and a stationary cylindrical outlet orifice, a moveable valve member adapted to freely move in a direction substantially perpendicular to said outlet orifice and having a valve stem and a conically shaped valve head terminating adjacent said orifice and seated in said cylindrical outlet orifice, said valve stem being positioned within said chamber and projecting through said orifice to form a continuous annular passageway between the sides of said orifice and the valve stem communicating with said chamber, a helical spring positioned in compression within said chamber urging said valve head towards said outlet orifice, a perforated guide member resting on the circumferential recess of said chamber, and a threaded plug fixed into said threaded chamber adapted to hold said perforated guide member firmly in said recess of said chamber.

7. An atomizing nozzle comprising in combination a body portion having a chamber within said body portion, a stationary cylindrical outlet orifice and a converging passageway in the form of a 90 to 120° cone leading from said chamber to said orifice, said orifice being between about $\frac{1}{8}$ and about $\frac{1}{4}$ of an inch in length and between about $\frac{1}{64}$ and about $\frac{1}{2}$ of an inch in diameter and smaller in diameter than any preceding passageway of said body portion, a moveable valve

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member adapted to freely vibrate in a direction substantially perpendicular to said orifice and having a valve stem and an enlarged valve head in the form of a cone having an apex angle between about 60 and about 150° and a diameter not more than $\frac{3}{4}$ of an inch larger than the diameter of said outlet orifice seated in said cylindrical outlet orifice, said valve stem being positioned within said chamber and projecting through said orifice having a clearance of at least 0.001 of an inch to form a continuous annular passageway between the sides of said orifice and the valve stem communicating with said chamber, and a spring positioned within said chamber urging said valve head towards said orifice.

8. An atomizing nozzle comprising in combination a body portion having a chamber within said body portion, a stationary cylindrical outlet orifice and a converging passageway in the form of a cone leading from said chamber to said orifice, said orifice being between about $\frac{1}{16}$ and about $\frac{1}{4}$ of an inch in length and between about $\frac{1}{16}$ and about $\frac{1}{2}$ of an inch in diameter and smaller in diameter than any preceding passageway of said body portion, a moveable valve member adapted to freely move in a direction substantially perpendicular to said orifice and having a valve stem and an enlarged valve head in the form of a cone having an apex angle between about 60 and about 150° and a diameter not more than $\frac{3}{4}$ of an inch larger than the diameter of said outlet orifice seated in said cylindrical outlet orifice, said valve stem being positioned within said chamber and projecting through said orifice having a clearance of at least 0.001 of an inch to form a continuous annular passageway between the sides of said orifice and the valve stem communicating with said chamber, and a spring positioned within said chamber urging said valve head towards said orifice.

9. In an atomizing nozzle containing a closed moveable valve member seated on the edge of an orifice of said nozzle and employing a spring positioned within said nozzle to urge said valve member towards said orifice, the method for improving the atomization of said nozzle which comprises supplying to said nozzle a liquid at a substantially constant pressure between about 15 and about 6000 pounds per square inch gage, vibrating said moveable valve member in a direction substantially perpendicular to the mouth

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of said orifice at a frequency of at least 60 cycles per second by using only the force supplied by the liquid under substantially constant pressure, and passing liquid through said orifice whereby the liquid is atomized by the vibration of the moveable valve member.

10. In an atomizing nozzle containing a chamber and a closed moveable valve member seated on the edge of a cylindrical outlet orifice, said valve member being positioned within said chamber and projecting through said cylindrical outlet orifice to form a continuous annular passageway between the sides of said cylindrical outlet orifice and said valve member communicating with said chamber, and a spring positioned within said chamber to urge said valve member towards said cylindrical outlet orifice, the method for atomizing a liquid by said nozzle which comprises supplying to said nozzle a liquid at a substantially constant pressure between about 25 and about 6000 pounds per square inch gage, vibrating said moveable valve member in a direction substantially perpendicular to the mouth of said orifice at a frequency of at least 60 cycles per second by using only the force supplied by the liquid under substantially constant pressure, and passing liquid through said orifice whereby the liquid is atomized by the vibration of the moveable valve member.

FRED KURATA.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
638,881	Parker	Dec. 17, 1901
816,810	Molesworth	Apr. 3, 1906
943,780	Hughes	Dec. 21, 1909
1,112,416	Sargent	Sept. 29, 1914
1,286,333	Johnson	Dec. 3, 1918
1,491,915	McLaine	Apr. 29, 1924
1,609,578	Scott	Dec. 7, 1926
1,893,457	Tartrais	Jan. 3, 1933
2,119,966	Scott	June 7, 1938
2,172,556	Edwards	Sept. 12, 1939

FOREIGN PATENTS

Number	Country	Date
367,014	Great Britain	Feb. 12, 1932