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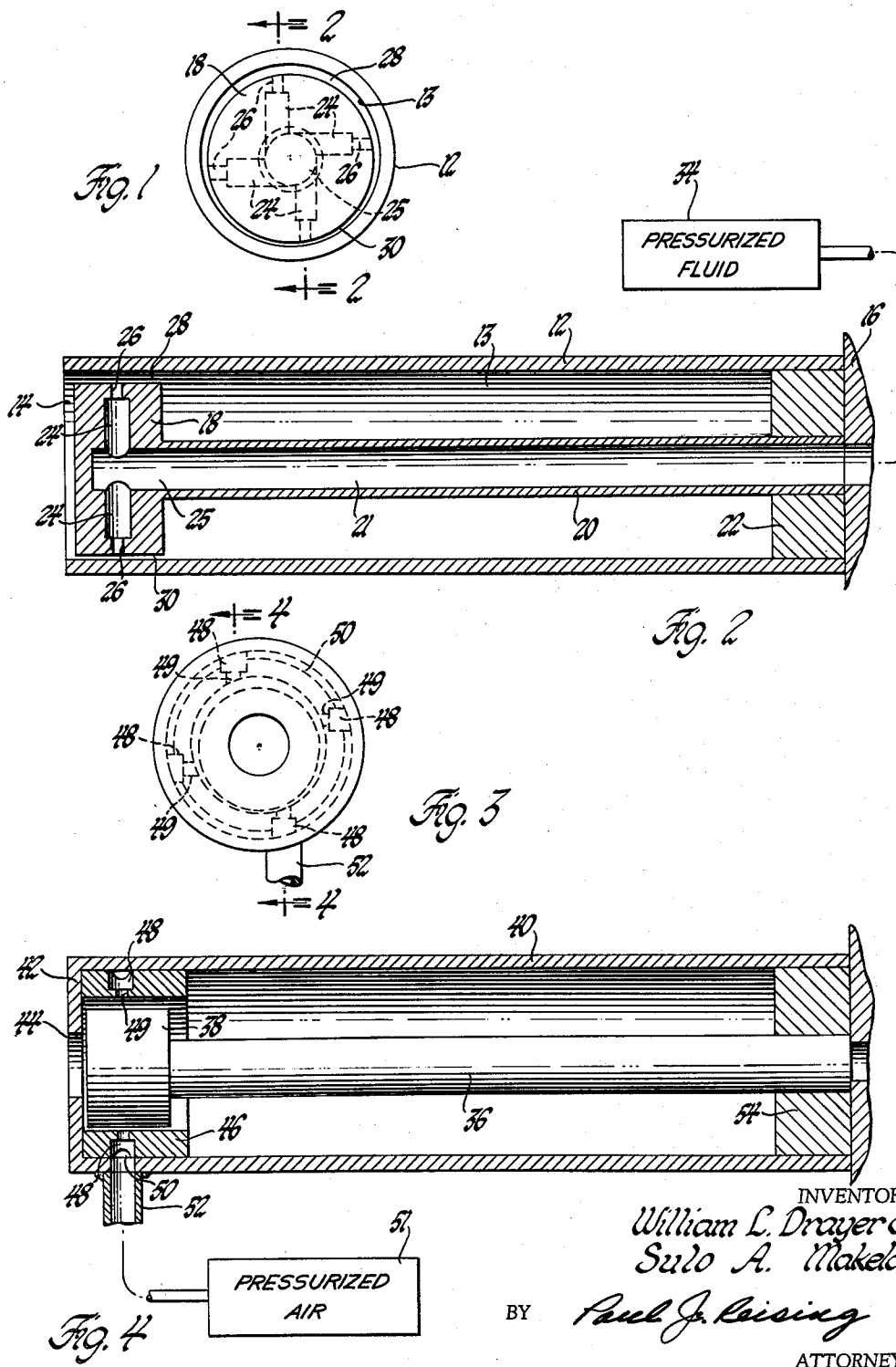
W. L. DRAYER ET AL

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VIBRATORY APPARATUS FOR ATOMIZING LIQUIDS

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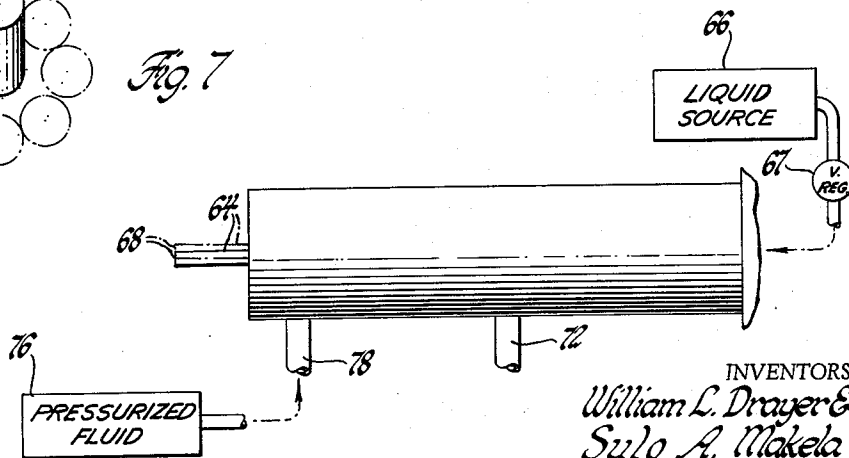
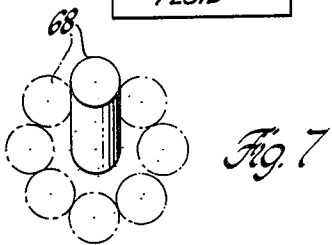
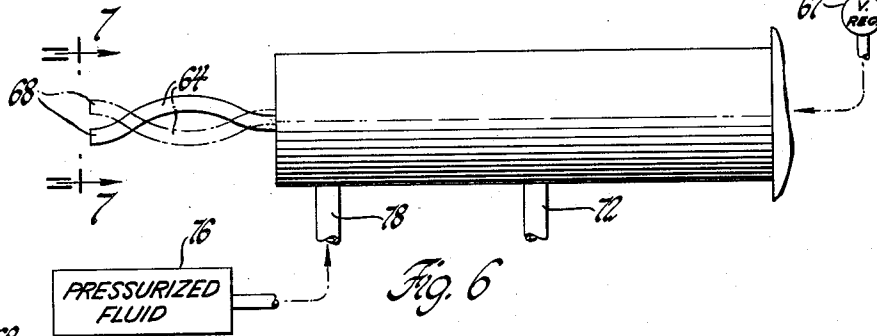
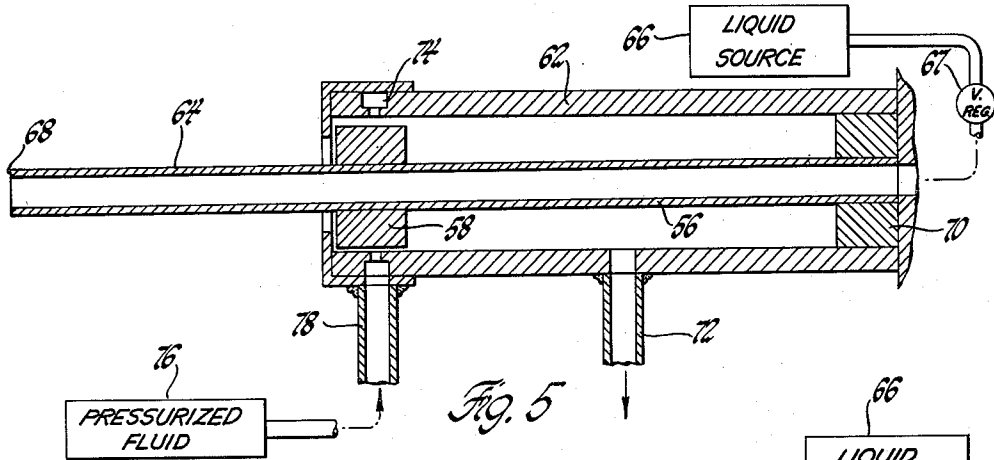


Fig. 8

BY

Paul J. Leising

ATTORNEY

INVENTORS
William L. Drayer &
Sulo A. Makela

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VIBRATORY APPARATUS FOR ATOMIZING LIQUIDS

William L. Drayer, Warren, and Sulo A. Makela, Royal Oak, Mich., assignors to General Motors Corporation, Detroit, Mich., a corporation of Delaware
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This invention relates to a vibration generator and more particularly to a vibrator apparatus and method having particular utility for atomizing liquid.

It is well known that a liquid can be atomized by causing it to contact a vibrating reed or similar member such that the vibratory mechanical energy breaks up the liquid and disperses it as small droplets. However, liquid atomizers of this type have had only limited utility, for one reason because they have heretofore incorporated relatively complex or delicate structures expensive to manufacture and difficult to maintain. Also, there has been the difficulty of adequately controlling the size and dispersion pattern of the droplets produced along with that of accomplishing high efficiency in the utilization of the vibratory energy for the desired atomization and dispersion of the liquid. Hence, vibratory type atomizers have not enjoyed the popularity and wide field of application as in the case of other types of atomizers, for example, the air spray gun or the electrostatic type atomizer.

It is an object of this invention to provide an improved, highly efficient and durable vibration generator having particular utility as a liquid atomizer.

Another object is the provision of an improved method for atomizing a liquid by the utilization of vibrating energy.

Another object is the provision of an improved vibration generator of the type wherein a mass is driven at high speed in an orbital path by means of fluid pressure.

A further object is to provide a liquid atomizing apparatus incorporating a mass which is fluid driven in an orbital path so as to gyrate the free end of a liquid carrying conduit at a speed sufficient to atomize the fluid passing through the conduit.

A still further object of this invention is to provide an apparatus in which a standing gyratory wave is propagated in a tube whereby the free end of the tube is gyrated at a speed sufficient to atomize a liquid passing through the tube.

Another object of the present invention is to provide an apparatus having an elongated tube in which a standing gyratory wave is propagated and the end of the tube is located at the antinode so that sufficient centrifugal force is created to atomize the fluid passing through the tube.

Briefly, the vibration generator of this invention includes an outer confining housing or sleeve member and a generally cylindrical mass within the housing arranged for orbital movement therein. The mass is connected to a shaft that is supported at a point spaced from the mass such that rotation of the shaft about its longitudinal axis is precluded while the free end of the shaft adjacent the mass is free to gyrate by reason of bending and pivotal motion of the shaft about its point of rigid support. Means are provided for directing compressed air or other fluid to the mass so as to drive it in an orbital path within the confines of the housing thereby causing the shaft to gyrate and set up vibrations in the housing. Further, in accordance with the invention, the mass is suspended by the connecting shaft so there is substantially no contact between the outer surface of the mass and the inner surface of the outer housing during its orbital movement; the mass being eccentrically located within the housing so as to create high and low pressure support areas while the pressurized air or other fluid is applied. In effect then, the mass is of the

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nature of a floating bearing which has deliberately been made unstable such that the stream of fluid produces circular translation or orbital movement of the mass within the housing, however without any substantial contact between the two.

It has been found that if the shaft is formed as a tube with the free end thereof extending beyond the mass in a cantilever form, the orbital movement of the mass results in a similar orbital or gyratory movement at the end of the tube. The mass can be orbited at a frequency which sets up a standing gyratory wave in the tube, and by locating the free end of the tube at an antinode and causing it to gyrate at a high frequency, a centrifugal force can be produced which is of a magnitude fully adequate to atomize and disperse a liquid passed through the tube.

Other objects and features of the invention will be apparent from the following detailed description made with reference to the accompanying drawings in which:

FIGURE 1 is an end view of the subject vibration generator constructed in accordance with the invention;

FIGURE 2 is a sectional view taken on lines 2-2 of FIGURE 1;

FIGURE 3 is a modification of the vibration generator shown in FIGURES 1 and 2;

FIGURE 4 is a sectional view taken on lines 4-4 of FIGURE 3.

FIGURE 5 shows the subject vibration generator modified for atomizing a fluid;

FIGURE 6 shows the atomizer of FIGURE 5 with an extending liquid conduit having a standing gyratory wave propagated therein;

FIGURE 7 is an enlarged view taken on lines 7-7 of FIGURE 6;

FIGURE 8 shows the apparatus of FIGURE 5 with an extending liquid conduit being bodily gyrated.

Referring now to the drawings, FIGURES 1 and 2 illustrate one embodiment of the subject vibration generator comprising an elongated sleeve shaped housing 12 terminating with a free end 14 while the other end is appropriately connected to a support 16. Within the housing 12, a cylindrical mass or translator 18 is integrally connected with a tubular shaft 20 having an air or other fluid passage 21 formed therein; the portion of the shaft adjacent the support 16 being rigidly secured by a support member 22, which as shown, is a separate member from the tube and housing. The support member 22 can be made integral with the housing 12 or tube if desired, the only requirement being that a suitable bond exist between the members to form a rigid connection so as to prevent rotative movement of the tube 20 about its longitudinal axis. The generator, as shown, is made of a metallic material, however, it can be made from a tough plastic material such as nylon; the choice of material being dictated by the intended use for the generator.

The mass 18 includes a plurality of circumferentially spaced ports 24 that project tangentially from a passage 25 centrally formed in the mass. Each of the ports 24 connect with a restricted passage or orifice 26 that opens at the peripheral surface of the mass for directing a high velocity flow of fluid against the inner surface of the housing 12. The center passage 25 formed in the mass communicates with the tube opening 21 which in turn is connected to a source of pressurized fluid 34 for purposes which will hereinafter be explained.

The tube 20 is mounted by the support portion 22 in a manner that permits the cylindrical mass to be eccentrically disposed within the inner portion of the housing 12. This is shown in FIGURE 1 with a larger air space or region 28 existing at one side of the mass than at the region 30 located diametrically opposite the region 28. This eccentric arrangement of the mass can be accomplished by either supporting the tube 20 on an axis in-

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clined to the center axis of the housing, or by supporting the tube at a point so removed from the mass 18, that the weight of the mass displaces the latter eccentrically with respect to the housing passage 13. The latter arrangement would be used most effectively where the generator is mounted in a horizontal plane as shown in FIGURE 2.

FIGURES 3 and 4 show a modification of the vibration generator shown in FIGURES 1 and 2, and in this instance, a solid shaft 36 is made integral with a solid cylindrical mass 38 with an outer housing 40 terminating at one end with a wall 42 having an aperture 44 centrally formed therein that serves as an air exhaust passage. A cylindrical liner or sleeve 46 is fixedly secured within the housing 40 and includes a plurality of circumferentially spaced ports 48, each of which connect with an orifice 49, as best viewed in FIGURE 3. The axis of each port and orifice is offset with respect to the center of the housing so as to provide a stream of fluid at a tangential attitude against the peripheral surface of the mass 38. An annular passage 50 formed in the outer surface of the sleeve 46 connects the several ports with a pressurized fluid that is directed to the housing 40 from a source 51 via a conduit 52. As in the generator shown in FIGURES 1 and 2, the shaft 36 is rigidly supported at a point removed from the mass by a support 54 that disposes the mass eccentrically within the housing, and precludes rotative movement of the shaft 36 about its longitudinal axis.

In operating the vibration generator shown in FIGURES 1 and 2, pressurized fluid is directed through the tube 20 to the center passage 25 formed in the mass 18, whereupon the fluid then exits from the mass via the ports 24 and orifices 26 as a high velocity stream tangentially directed against the inner wall of the housing 12. Due to the eccentric disposition of the mass 18 in the housing, the area into which the fluid dispenses varies at points around the mass resulting in a high or low velocity fluid stream with an accompanying low or high pressure region. This can be understood best by considering the fluid flow in two regions when the mass is located as shown in FIGURE 1. In the region 30, a low velocity-high pressure space exists because of the small air space located between the outer surface of the mass and the adjacent surface of the housing with the result of an increased restriction on the flow of the fluid from the adjacent orifice. On the other hand, the airspace in the region 28 is larger than that in region 30 thereby providing a lesser flow restriction on the fluid resulting in a high velocity fluid flow. Because of the high and low pressure regions and the tangential attitude of the outlet ports 24, the mass 18 moves in an orbital pattern toward the regions of lower pressure under the influence of the higher pressure regions. Likewise due to the movement of the mass, the pressure regions adjacent the several orifices continuously vary in value resulting in the mass being pushed from a high pressure region to a low pressure region and thereby creating new regions of low and high pressure. The movement of the mass 18 causes the tube 20 to bend elastically, and direct a rotating force impulse through the support 22 to the housing 12, causing a vibration of the housing at a frequency corresponding to that of the orbiting mass.

It should be noted that during the orbital movement of the mass, a layer of air continuously exists between the outer surface of the mass and the inner surface of the housing with the result that there is substantially no contact between the mass and housing as the former follows an orbital path. The pressurized fluid serves the dual function of driving the mass and also supplies a fluid cushion or support that precludes surface contact between the members. This is a unique feature of this generator, and it can be readily appreciated that with this arrangement the life of the vibration generator is immeasurably increased due to the elimination of any wear problem.

The operation of the generator shown in FIGURES 3 and 4 is similar to that of the generator shown in FIG-

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URES 1 and 2, except that in this embodiment the fluid is being directed onto the mass 38 from the orifices 49 formed in the sleeve 46. Here again, the mass 38 is disposed eccentrically within the housing so that low and high pressure regions exist around the outer surface of the mass causing an orbital movement of the mass during the fluid flow with resulting vibrations being directed to the housing 40, as described above.

Referring now to FIGURES 5 through 8, a generator is shown with a tube 56 rigidly connected to a mass 58 and extending beyond the housing 62 to form a tube extension 64 terminating with a nozzle 68. The tube communicates with a source of liquid 66 that supplies liquid to the nozzle at a controlled rate by a conventional metering unit 67. The tube 56 is fixed in the housing by a support 70 that eccentrically disposes the mass 58 in the housing in a manner similar to the aforementioned generators. A passage 72 is provided in the body of the housing 62 for exhausting the fluid emanating from the ports 74 which receive pressurized fluid from a source 76 via the conduit 78 in a manner similar to that described with regard to the generator shown in FIGURE 3 and 4.

At this time it should be noted that the length of the tube is predicated upon the operating frequency of the generator. By dimensioning the tube so that the natural frequency of the latter is equal to the operating frequency of the generator, a standing wave is propagated in the tube, as shown in FIGURE 6, that results in increased deflection of the nozzle 68. This in turn, results in increased centrifugal forces of a magnitude capable of atomizing the liquid into a fine mist or spray at the nozzle 68. Acceptable atomization can also be obtained if the tube extension 64 is shortened so as to have a natural frequency greater than the operating frequency of the generator with the result that the extension is bodily gyrated to produce an orbital movement of the nozzle 68 as shown in FIGURES 7 and 8. For most efficient operation, the vibration generator should be operated above 100 cycles per second, and as aforementioned, in the resonant frequency range of the tube.

During the operation of the atomizer, a pressurized fluid enters the generator through the passage 78, and exits from the ports 74 as a high velocity stream directed against the outer surface of the mass 58. The eccentric disposition of the mass 58, causes the mass to orbit within the cylindrical housing 62 with similar movement being transmitted to the attached tube 56, as aforementioned. Depending upon the length of the tube and the frequency at which the mass 58 is orbiting, either a standing gyrating wave or a bodily movement is propagated in the tube during which time liquid is directed through the tube 56 at a controlled rate, and as it reaches the nozzle 68, the centrifugal forces created by the orbiting tube serves to break up the liquid into fine particles and project them into the surrounding atmosphere.

Various changes and modifications can be made in my apparatus without departing from the spirit of the invention. It should be understood that these changes and modifications are contemplated and therefore we do not wish to be limited in any manner except as defined by the appended claims.

What is claimed is:

1. An apparatus for atomizing liquid comprising, a housing, a tube extending through said housing and having a free end, means for supplying liquid to the free end of said tube, an enlarged mass rigidly connected with said tube for orbital movement in said housing, said mass being located in said housing at a point spaced from said free end, and means for driving said mass in said orbital path at a frequency at least equal to the resonant frequency of the tube whereby a standing gyratory wave is created in the body of the tube and liquid is centrifugally atomized at the free end of the conduit.

2. An apparatus for atomizing liquid, comprising a cylindrical housing, a tube extending through said hous-

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ing and having a free end, means for supplying liquid to the free end of said tube, an enlarged mass rigidly connected with said tube for orbital movement in said housing, and fluid passages in said housing tangentially located around said mass and adapted to direct a fluid stream against said mass to drive the latter in an orbital path at a speed sufficient to create a gyrotory standing wave in the tube and cause said liquid to be atomized at the free end of the tube.

3. In an apparatus for generating vibrations, a housing having an opening therein, an enlarged mass having an attached shaft disposed in said opening, said mass being located in said opening, a portion of said shaft fixed in said housing with said mass located off-center with respect to said opening, and fluid means for directing a stream of fluid against the mass for driving said mass in an orbital path in close proximity to the housing so as to cause a rotating force impulse to be applied to said portion of said shaft.

4. In an apparatus for generating vibrations, a housing having a circular opening therein, an enlarged circular mass disposed in said opening and having a shaft attached thereto, said mass being located in said opening, a portion of said shaft fixed in said housing so as to prevent rotation about the shaft axis, said circular mass located off-center with respect to said opening, means for supplying pressurized fluid to said housing, and ports in said housing adjacent said mass for tangentially directing said pressurized fluid against said mass whereby said mass is driven in an orbital path in close proximity to the housing whereby a rotating force impulse is applied to said portion of the shaft.

5. In apparatus for generating vibrations, a housing having a circular opening therein, an enlarged circular mass disposed in said opening and having a shaft attached thereto, said mass being located in said opening at one end of said shaft, a portion of said shaft fixed in said housing so as to prevent rotation about the shaft axis, said circular mass located off-center with respect to said opening, means for supplying pressurized fluid to said mass, and ports in said mass for tangentially directing said pressurized fluid against said housing whereby the mass is driven in an orbital path in close proximity to the housing whereby a rotating force impulse is applied to said portion of the shaft.

6. In an apparatus for generating a rotating force impulse, a housing having a circular opening therein, a cylindrical mass disposed in said opening and having a diameter greater than one-half the diameter of the opening, a shaft connected to the center of the mass and having a portion thereof fixed in the housing so as to

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prevent rotation about the shaft axis, a pressurized fluid passage formed in the shaft, a plurality of fluid orifices formed in the mass and located therein so as to direct fluid tangentially against the housing, means for connecting said fluid passage to said orifices, and a source of pressurized fluid for directing fluid through the passage to the orifice whereby a high velocity stream of fluid impinges against the housing and causes an orbital movement of the mass in close proximity to the housing.

7. An apparatus for atomizing liquid, comprising a source of pressurized fluid, a source of liquid, an elongated cylindrical housing having an elongated circular opening formed therein, an elongated tube located in said opening and connected to the liquid source, one end of said tube fixed in the housing and the other end extending beyond the housing, a cylindrical mass centrally fixed to said tube and eccentrically located within the housing opening, a plurality of orifices formed in the housing, said orifices circumferentially spaced around said mass and adapted to direct a stream of pressurized fluid tangentially against the mass, means for connecting said source of pressurized fluid to the orifices, means for controlling the rate of liquid flow from the liquid source to the other end of the liquid tube, a passage formed in the housing for exhausting pressurized fluid therefrom, said pressurized fluid emanating from the orifices being adapted to drive the mass in an orbital path in close proximity to the housing and cause a gyrotory movement of the other end of the tube at a speed sufficient to centrifugally atomize the liquid.

8. The apparatus of claim 7 wherein said pressurized fluid drives said mass at a frequency above 100 cycles per second in the resonant frequency range of the tube.

9. An apparatus for atomizing liquid comprising, a housing, a tube having a portion rigidly secured in said housing and having a free end extending beyond said housing, means for supplying liquid to said free end at a controlled rate, an enlarged mass rigidly connected to said tube at a point intermediate the free end and fixed portion of the tube, said mass being located in said housing, and means including a plurality of passages in said housing for driving said mass in an orbital path at a frequency not less than the resonant frequency of said tube to cause said liquid to be atomized at said free end.

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