June 2, 1970 L. J. HIERTA ET AL 3,515,676

OIL FOG GENERATING DEVICE

Filed Sept. 18, 1967 5 Sheets-Sheet 1

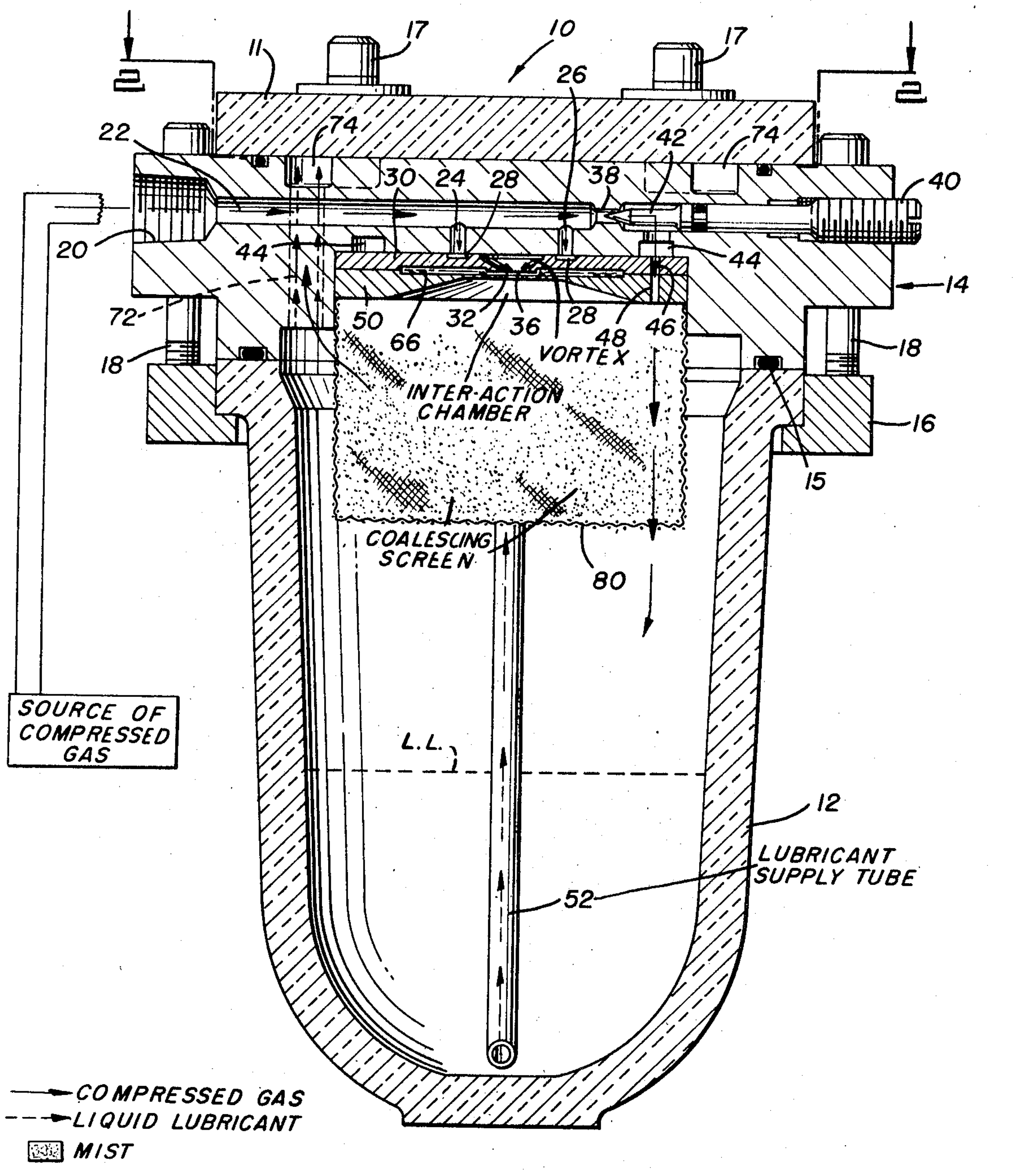

Fig 1

INVENTORS
WERNER G. MANNHARDT
BY LARS J. HIERTA

ATTORNEY

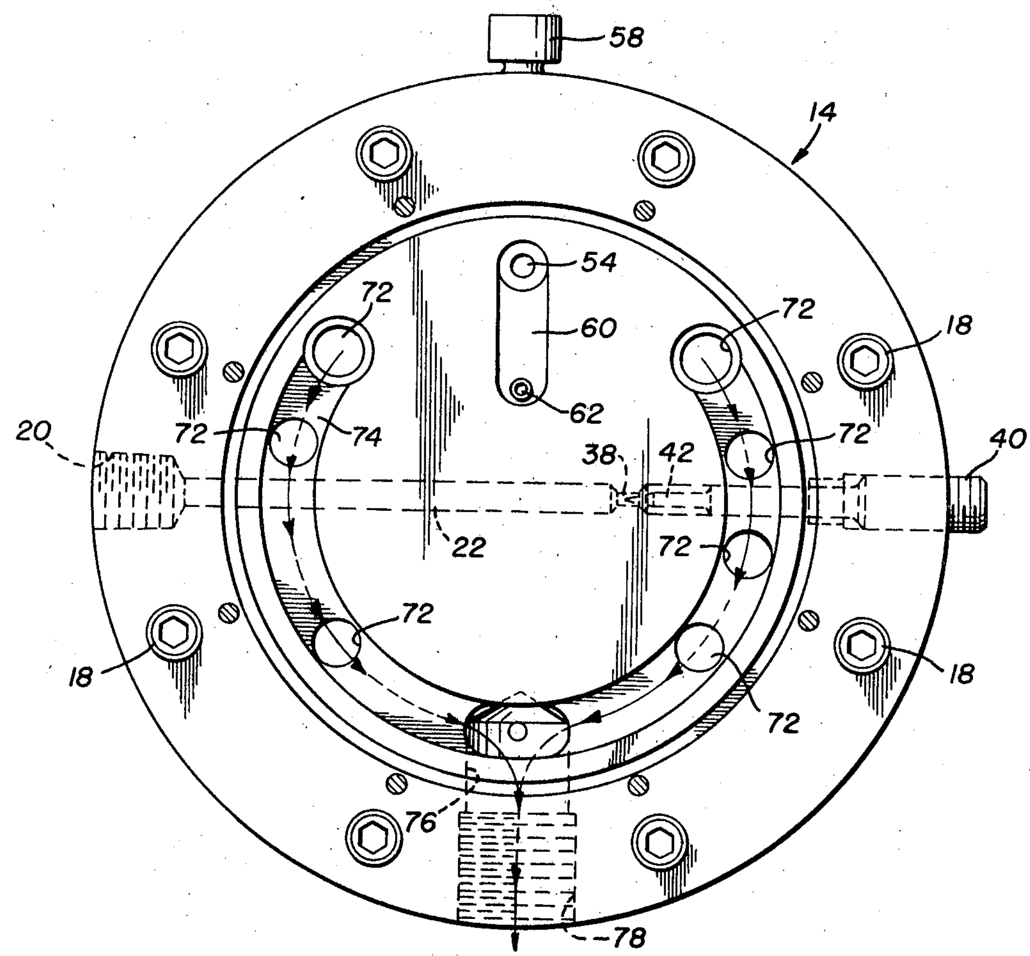

Fig 2

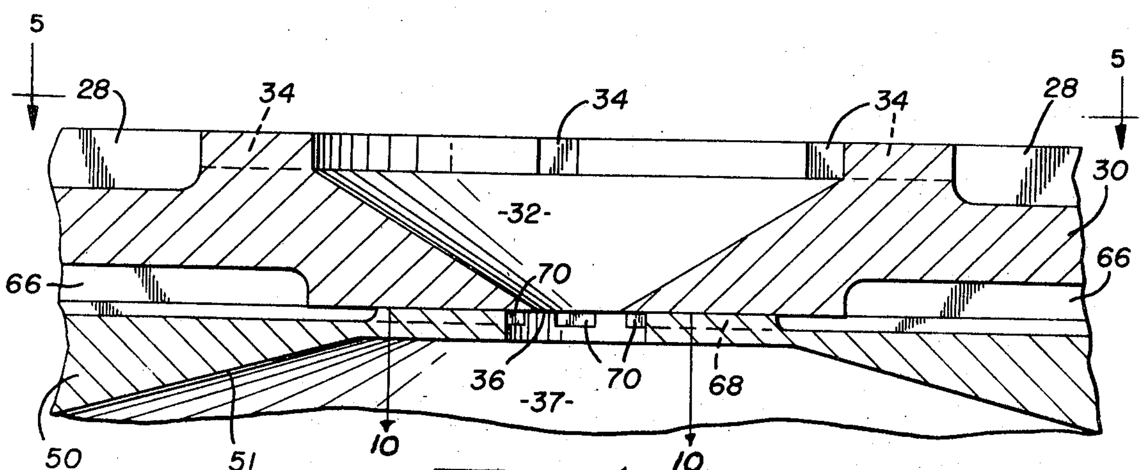

Fig 4

INVENTORS
WERNER G. MANNHARDT
BY LARS J. HIERTA

ATTORNEY

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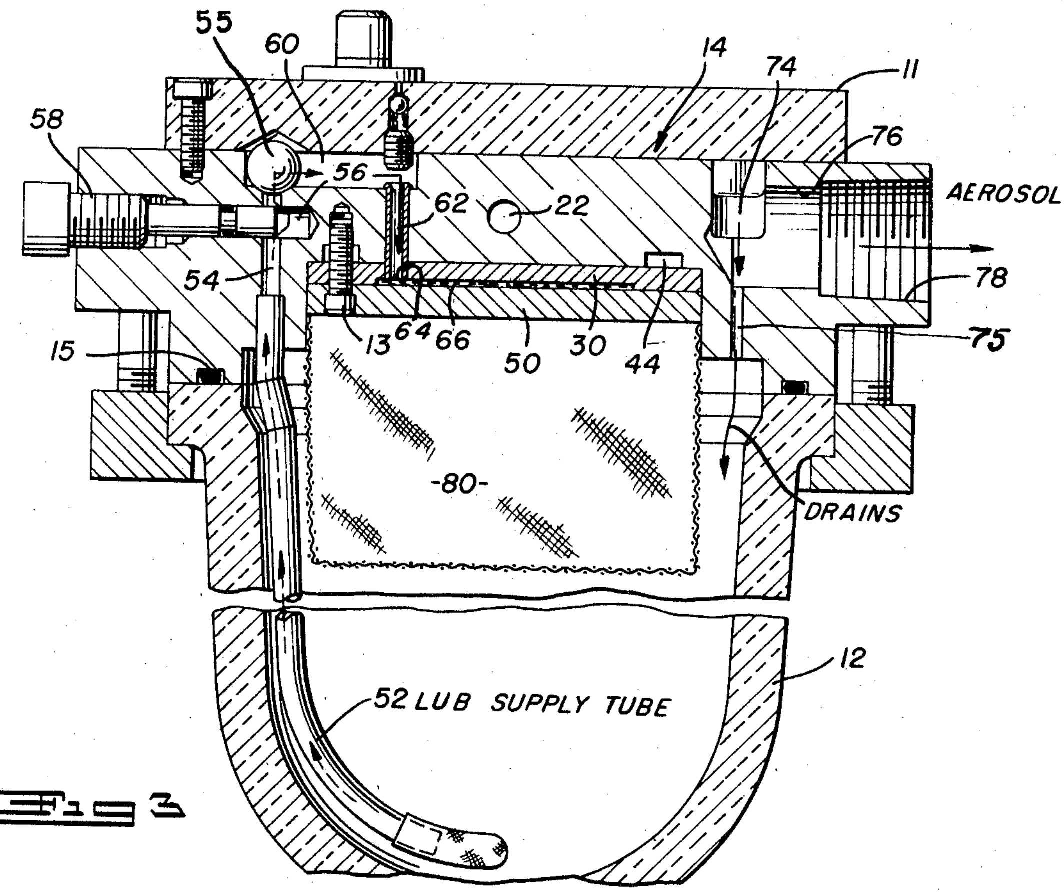


Fig 3

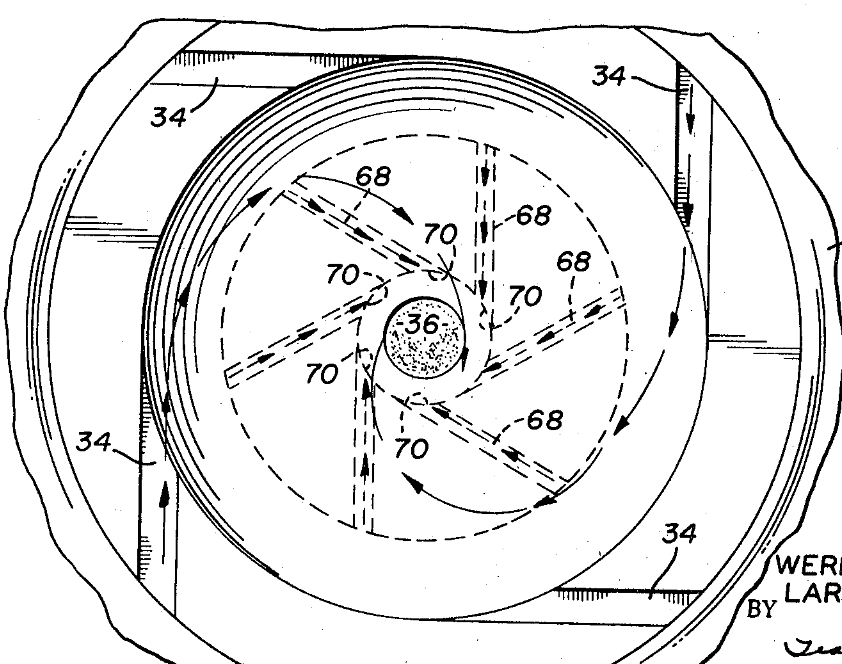


Fig 5

INVENTORS
WERNER G. MANNHARDT
LARS J. HIERTA
BY Teague & Tuddy
ATTORNEY

Fig 6

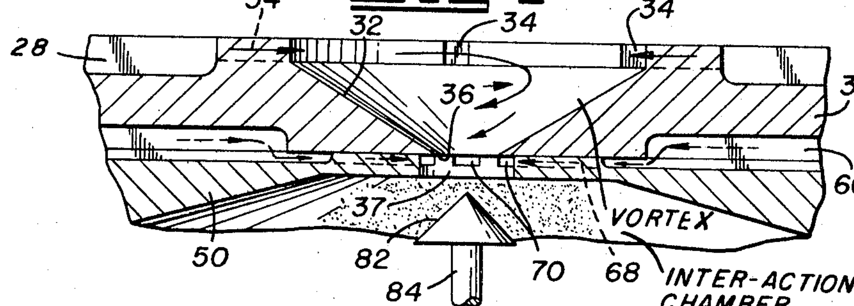


Fig 7

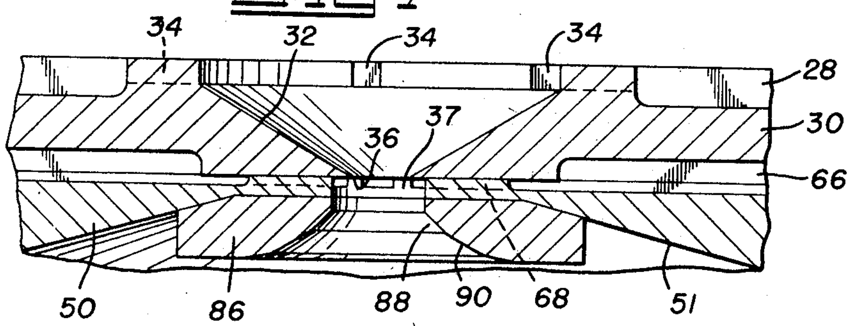
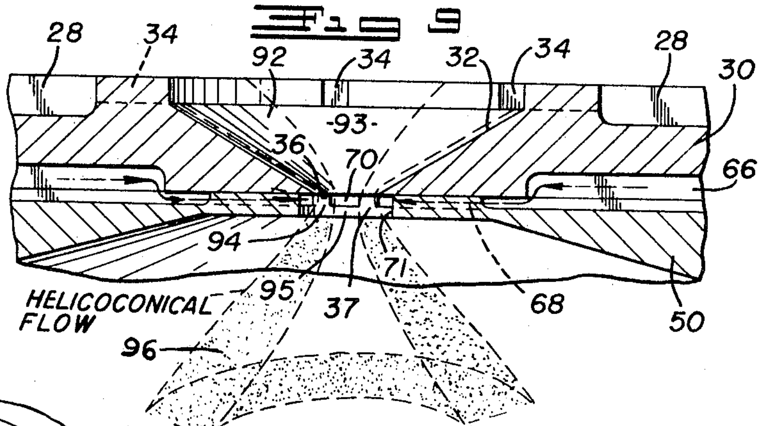


Fig 9



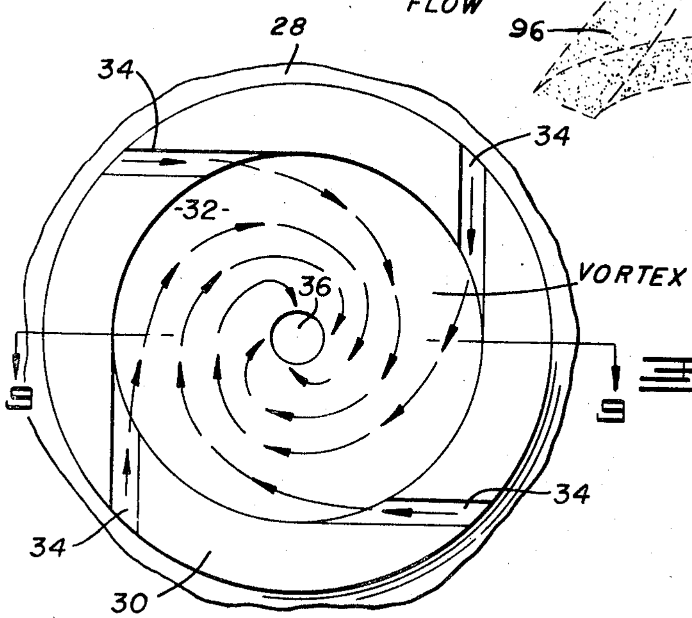


Fig 8

INVENTORS
WERNER G. MANNHARDT
LARS J. HIERTA
BY
ATTORNEY

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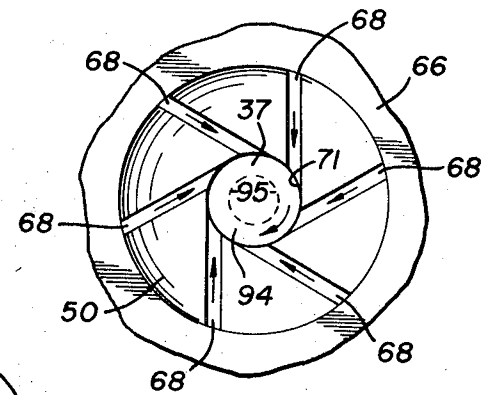


Fig 10

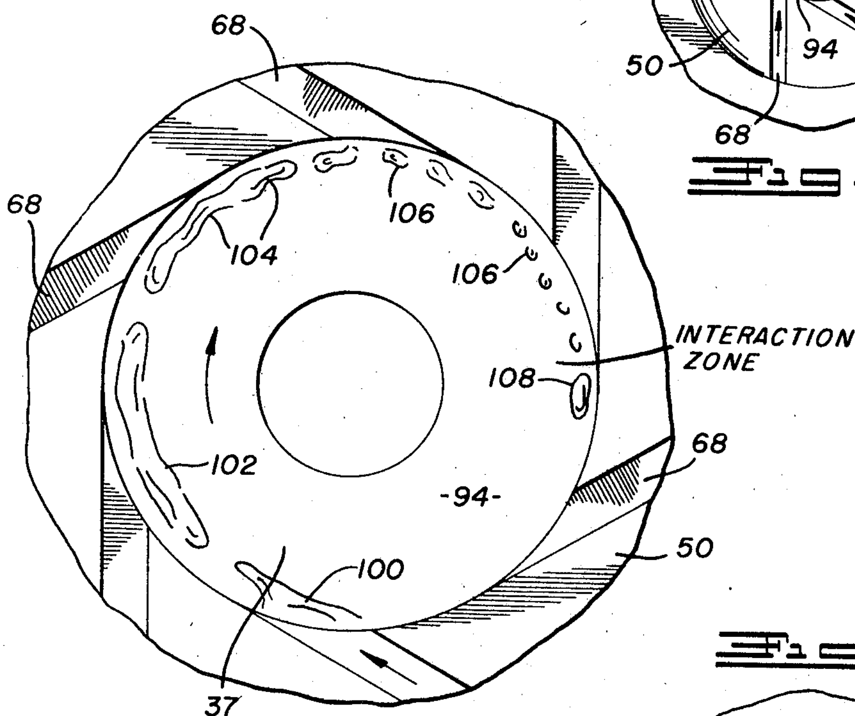


Fig 11

Fig 13

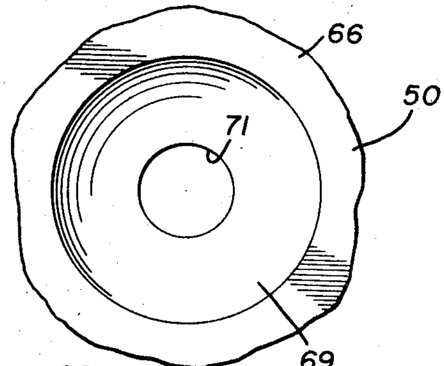
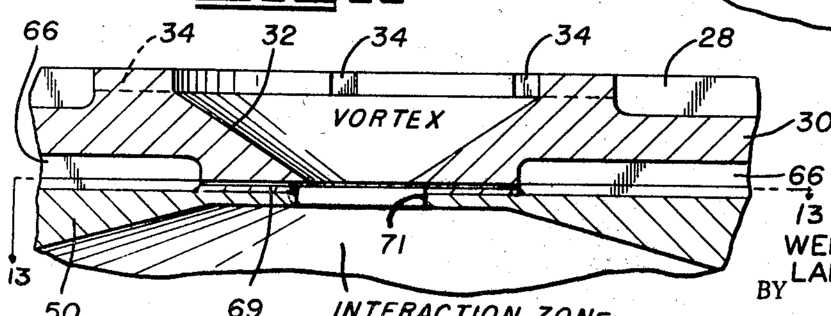


Fig 12



INVENTORS
WERNER G. MANNHARDT
LARS J. HIERTA
BY Teagno & Toddy
ATTORNEY

United States Patent Office

3,515,676
Patented June 2, 1970

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3,515,676

OIL FOG GENERATING DEVICE

Lars J. Hierta, Westland, and Werner G. Mannhardt, Detroit, Mich., assignors to Eaton Yale & Towne Inc., Cleveland, Ohio, a corporation of Ohio

Filed Sept. 18, 1967, Ser. No. 668,625
Int. Cl. B05b *7/30*
U.S. Cl. 252—359 **4 Claims**

ABSTRACT OF THE DISCLOSURE

This invention relates to an aerosolization or fog generating unit for aerosolizing liquid lubricant or other liquids into finely divided particles. Pressurized gas is fed into a vortex generating chamber wherein the gas is accelerated to high velocity and discharged through an opening which is proximate a supply of liquid. The high velocity gas aspirates the liquid into an inter-mixing zone and through the process of ligamentation, a liquid fog or aerosol is generated.

BACKGROUND OF INVENTION

Field of invention

This invention relates to a device for generating a liquid aerosol or fog generally and more particularly this invention relates to a device for generating a liquid fog utilizing the principles of fluid amplification.

Discussion of the prior art

The aerosolization of liquids and the generation of liquid fog for the purpose of lubricating machinery parts such as bearings, itms or areas with an oil particle aerosol is well known in the art. The aerosolizing units utilized in the prior art have generally been of the type having a venturi and the liquid to be aerosolized is aspirated into the throat of the venturi where it is then particalized. The liquid aerosolizers of the prior art have been limited in their usefulness in the aerosolization of low viscosity lubricant. In an attempt to aerosolize more than a nominal amount of high viscosity lubricant within a reasonable period of time, various changes and additions have been made to the aerosolizing units of the prior art. For example, one prior art unit requires the use of a heated aerosolizing fluid. Another prior art aerosolizing unit requires the use of a heated aerosolizing fluid and a heated lubricant. Still another prior art device requires the utilization of a heated aerosolizing fluid ,a heated lubricant and the impingement of the generated particles upon an abutment in order to properly size the lubricant particles. Still another prior art lubricant aerosolizing device requires the utilization of unduly high pressure aerosolizing fluid and lubricant, on the order of about 700 p.s.i.

The limitations of the prior art aerosolizing devices have severely restricted their use because of the added expense incident to the heating of either the aerosolizing fluid or the lubricant or both and also in the pressurization of the aerosolizing fluid or the lubricant to an unduly high pressure. Another limiting factor on the utilization of the prior art lubricant misting devices has been the relatively low volumes of lubricant which the prior art devices have been capable of misting even when operating under ideal conditions.

A further problem with the use of venturi nozzles to aerosolize a liquid is the inherent limitation on the ratios of surface area to volume with which the liquid and the high speed aerosolizing fluid are presented to each other. Only a small portion of the high velocity aerosolizing fluid is utilized to particalize the liquid since only a single liquid nozzle may be used and thus only a single liquid ligament is available for particalization at a given time.

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SUMMARY OF THE INVENTION

The present invention solves the problems of the prior art by providing an extremely simple structure which will generate large quantities of a lubricant particle fog having a proper particle diameter range and which functions with the use of an unheated, low pressurized aerosolizing fluid, an unpressurized, unheated lubricant and absent the requirement for a surface against which the particles must be impinged in order to obtain the proper particle diameters. The invention in its broadest form comprises a housing having a fluid inlet, a fluid accelerating vortex chamber, an outlet, and a liquid inlet in communication with an inter-action chamber located proximate the fluid outlet where the liquid is particalized. In operation a low or moderately pressurized fluid is fed through the housing by the fluid inlet to the fluid accelerating vortex chamber where the fluid is accelerated to a high velocity according to a known phenomenon and discharged from the housing. A supply of liquid is in communication with an inter-action zone located proximate the fluid outlet in the housing. The high velocity aerosolizing fluid causes an aspiration of the liquid into the inter-action zone where the liquid is particalized under the theory of ligamentation known in the field of aerosolization. The increased effectiveness of this invention is attributable to the existence of a high ratio of fluid surface area to liquid volume with which the liquid and the high speed aerosolizing fluid are presented to each other in the arrangement of the inter-action zone. A plurality, or even an infinite number of liquid ligament producing zones may be utilized easily and effectively in the structure of the present invention.

BRIEF DESCRIPTION OF THE DRAWING

Reference will now be made to the attached drawing wherein a preferred embodiment of the present invention is shown and wherein:

FIG. 1 is an elevational view of the present invention shown in cross-section.

FIG. 2 is a view taken along line **2—2** of FIG. 1.

FIG. 3 is an elevational view of the present invention shown in cross-section and illustrating further details of the present invention.

FIG. 4 is an enlarged partial sectional view taken from FIG. 1 and illustrating certain details of the present invention.

FIG. 5 is a partial top plan view of FIG. 4.

FIG. 6 is a similar view of FIG. 4, but illustrating an alternative embodiment of the present invention.

FIG. 7 is similar to FIG. 4, but illustrating a still further embodiment of the present invention.

FIG. 8 is a partical top plan view of FIG. 4 and illustrates the fluid flow paths in the vortex generating chamber.

FIG. 9 is an enlarged partial sectional view of FIG. 1 illustrating in elevation the fluid flow through the structure of the present invention.

FIG. 10 is an enlarged partial plan view taken along the line **10—10** of FIG. 4.

FIG. 11 is an enlarged partial plan view similar to FIG. 10.

FIG. 12 is an enlarged partial sectional view similar to FIG. 4 illustrating a further embodiment of the invention.

FIG. 13 is a partial plan view taken along the line **13—13** of FIG. 12.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. 1 there is shown structure for misting oil or the like which is illustrated in the form of an oil mister **10** comprising a generally cup-shaped lubricant reservoir

12 and a generally cylindrical head or housing member 14 secured to the reservoir 12 by means of a generally L-shaped ring member 16 and suitable removable fasteners 18. The reservoir 12 and the head member 14 are secured together in a sealing relationship by the L-shaped ring member 16 and the removable fasteners 18 in such a manner that a sealing ring 15 is generally compressed therebetween.

Also shown in FIG. 1 is an aerosolizing fluid inlet fitting 20 in the form of a common pipe fitting. The inlet fitting 20 continues as a generally horizontal bore 22 into the housing member 14. The inlet bore 22 intersects a plurality of secondary fluid delivery bores 24 and 26. The secondary fluid delivery passages 24 and 26 intersect an annular groove 28 in a generally cylindrical plate member 30. The annular groove 28 in the plate member 30 is connected to a fluid accelerating vortex chamber 32 by a plurality of tangential fluid delivery channels 34, FIG. 5. The relationship between the annular groove 28, the fluid delivery channels 34, and the vortex chamber 32 is most clearly illustrated in FIGS. 6–9. The fluid accelerating vortex chamber 32 terminates at a fluid outlet 36 in the plate member 30. The fluid inlet bore 22 also communicates with the interior of the lubricant reservoir 12. Fluid inlet bore 22 is connected to orifice 38 which in turn communicates with annular groove 44 in housing member 14. The annular groove 44 is in communication with the interior of the lubricant reservoir 12 by means of a plurality of openings 46 through the plate member 30 and corresponding fluid openings 48 in a plate member 50 to supply pressure fluid to the interior of the reservoir 12 directly. Fluid flow through orifice 38 is variably controlled by valve member 40 having a needle valve portion 42 to control the orifice area. The openings 46 through which a regulated amount of fluid supplied to the reservoir 12 provide a supply of so-called "secondary fluid" to the reservoir for the purpose of causing the liquid particle fog generated to flow from the reservoir 12 through the head member 14 and finally to location where the fog is to be utilized.

Located within the reservoir 12 is a lubricant supply tube 52 for delivering a quantity of oil to the head member 14. The lubricant supply tube 52 is connected to an opening 54 which intersects a lubricant flow regulator bore 56 which is best seen in FIG. 3. Located within the lubricant flow regulator bore 56 is a lubricant flow regulator valve 58 for adjustably controlling the quantity of lubricant which flows through the opening 54. Lubricant flows up lubricant supply tube 52, through duct 54, into the lubricant flow regulating bore 56 and past ball check valve 55 into groove 60. Lubricant flow continues through groove 60. FIG. 3, in the head member 14 and through a duct 62 in the head 14 through an opening 64 in the plate 30 to an annular groove 66 defined cooperatively by the plate 30 and the plate 50.

The plate members 30 and 50 are secured to the head member 14 by a plurality of removable fasteners 13, and form a part thereof.

A cover plate member 11 is removably secured to the head member 14 by a plurality of fasteners 17 for the purpose of covering the head member 14 and may be of a transparent material to allow visual inspection of the lubricant flow through the various grooves and passages, if desired.

From the annular groove 66 the oil is delivered through a plurality of lubricant flow openings 68, FIG. 5, to the lubricant discharge 70.

The ball check valve 55 is located at the termination of duct 54 in the groove 60. The ball check valve 55 allows normal fluid flow from duct 54 into groove 60 but will prevent any back-flow should an abnormally high pressure occur in the vortex chamber 32. The prevention of back-flow causes a more efficient operation of the mister 10 and further prevents frothing in the reservoir due to back-flowing fluid bubbling through the liquid reservoir.

An alternative embodiment is shown in FIGS. 12 and 13 wherein the lubricant passages 68 are replaced by an annular recess 69 in the plate 50. The annular recess 69 serves to present a sheet of lubricant to the inter-action zone 37 such that ligaments of liquid may form at any point around the inner-section of the recess 69 with the zone 37 thereby increasing, in some instances, the effectiveness of the generation of liquid particles in the manner hereinafter described. Also located in the head member 14 are a series of discharge ports 72, best seen in FIG. 2, which are in communication with the interior of the lubricant reservoir 12 and an annular channel 74 in the head member 14. The annular channel 74 is in communication with a discharge bore 76 and a discharge fitting 78.

The annular channel 74 is provided for the purpose of condensing from the generated fog any liquid particles which have the tendency to condense. It is known that a certain percentage of particles generated tend to condense within a relatively short time after being generated and are not therefore, useful. The annular channel 74 is provided with an opening 75, FIG. 3, to allow drainage of the condensible particles back to the reservoir for later recirculation. The prior art has compensated for the condensible particles by sloping the piping ducting or tubing carrying the fog from the generator in a manner such that the condensed particles will return to the reservior for recirculation. The annular groove 74 has a length substantially greater, by 10 or more times, than the greatest dimension of the cross-section of the groove 74 which serves to condense those readily condensible particles and thus alleviates, if not eliminates, the necessity of sloping the mist carrying piping, ducting or tubing.

Attached to the head member 14 and defining a chamber within the rservoir 12 is coalescing screen member 80.

Shown in FIG. 6 is a conical deflector 82 located proximate the inter-action zone 37 and supported in the reservoir 12 by a support member 84.

Another embodiment of the present invention is shown in FIG. 7 wherein an annular ring member 86 is attached to the undersurface 51 of plate member 50. The ring member 86 has a plurality of surfaces 88 and 90 at increasing angles from the axis of the fluid discharge opening 36.

DESCRIPTION OF OPERATION

In operation, a source of compressed fluid (not shown) is connected to the head member 14 at the fluid supply fitting 20 and a supply of lubricating liquid is placed in the lubricant reservoir 12. The pressurized fluid is caused to flow through the fluid inlet 22 and through the secondary fluid passages 24 and 26 to the annular groove 28 in the plate member 30 and through the fluid supply channels 34 through the fluid accelerating chamber 32 defined by the plate member 30 and out through the fluid outlet 36 in the plate member 30. The annular channel 28 in the plate member 30 acts as an orifice and supplies an equal amount of fluid to each of the tangential passage 34 in the plate member 30. The pressurized fluid thus delivered to the vortex chamber 32 expands and is accelerated in a wtll known manner in the chamber 32 and is discharged at the discharge opening 36 with a relatively high velocity. The liquid lubricant is in communication with the high velocity fluid at the lubricant discharge openings 70 and through the mesne connections described above so that the lubricant is separated through the duct 54, ball check valve 55, ducts 60, 62, 66, 68 and is finally discharged through the openings 70 in the plate 50. The high velocity fluid in the embodiment shown has obtained a high tangential velocity due to the nature of the vortex generating chamber 32. The fluid flowing at high velocity creates an area of low pressure which causes the lubricant to be aspirated into the fluid stream. From the ligamentation theory of aerosolization, the lubricant is aspirated from the lubricant discharge openings **70** in the form of ligaments, which are relatively long cylindrical chains of liquid molecules. These ligaments flow into the air stream and because of the existence, in all systems, of mechanical vibrations break down into liquid particles having diameters depending on the frequency of the mechanical vibrations present in the system. It has been found that with the present device lubricant particles suitable for transmission in pipe lines and for lubrication of bearings and the like are readily obtainable. It is, of course, to be understood that lubricant aerosols having particle diameters on the order of between about 0.5 micron and 5 microns are useable to be transported in pipe lines and are useable in bearing lubrication. The aerosolized lubricant flows through the coalescing screen **80** located within the reservoir **12** and is discharged through the ports **72**, annulus **74** and discharge ducts **76** and **78** to the bearings, items, areas, or the like which are to be lubricated. Although the useable lubricant particle size is generally uniform in the range of between 0.5 and 5 microns in diameter, the coalescing screen **80** tends to coalesce those particles which may exceed the useable range in diameter and return them to the reservoir **12** for recirculation through the aerosolizing head at a later time. The liquid lubricant fog is discharged through the ports **72** in the aerosolizing head member **14** and passed through the annular groove **74** where those particles tending to coalesce will be condensed before passage through the outlet **76** to the bearings, items or areas to be lubricated.

In order to obtain the maximum amount of aerosol generation it is necessary that the air flow from the fluid accelerating chamber 32 be discharged through the opening **36** in contact with the lubricant around the entire periphery of the opening **71** in the plate **50**. This insures that a maximum number of ligaments are formed and that there are therefore a maximum number of lubricant particles formed.

The spray pattern emitted from a vortex nozzle is generally in the shape of a hollow cone. By varying the shape of the exit orifice it is possible to form spray patterns of virtually any desired shape.

Although aerosolizing fluid flowing from the discharge opening **36** in the plate **30** will generally inherently assume a conical configuration **96** as shown in FIG. 9 wherein there is a helicoconical flow of aerosolizing fluid and liquid particles, in order to assure the existence of the conical configuration **96**, it is possible to add a deflector assembly, such as the conical deflector **82**, shown in FIG. 6. The deflector **82** tends to destroy any excessive axial fluid flow vectors received by the aerosolizing fluid during the flow through the vortex chamber **32** and cause the aerosolizing fluid to assume the helicoconical flow pattern illustrated in FIG. 9.

Another embodiment for assuring helicoconical fluid flow from the opening **36** is shown in FIG. 7. In FIG. 7, there is shown an annular ring **86** secuerd to the undersurface **51** of the plate **50**. The ring **86** has a plurality of angled surfaces **88** and **90**. According to a theory first advanced by Mr. H. Coanda, a flowing fluid has a tendency to flow along defined surfaces. Flowing fluids exhibit this Coanda effect even though the defined surfaces may not lie in a straight line. Therefore, the surfaces **88** and **90** of the annular ring **86** serve as defined surfaces along which the aerosolizing fluid has a predeliction to flow because of the Coanda effect and as a result, the annular ring **86** will effectively generate a helicoconical flow from the opening **36** in the plate **30**.

The use of the deflector **82** or the Coanda effect ring **86** are desirable where there is a possibility that the axial fluid flow velocity vector is so large as to prevent the discharged aerosol or fog and fluid from assuming the inherent heliconical flow path of FIG. 9. The excessive axial component of velocity may be a result of the vortex chamber **32** having walls of excessive steepness or where the aerosolizing fluid pressure is excessive.

The helicoconical fluid flow path is desirable because as generally indicated above, the efficiency of the present invention is dependent on the aerosolizing fluid flow being tangential to the opening **36** in the plate **30** and in the inter-action zone **37**. Tangential aerosolizing fluid flow in the inter-action zone **37** results in the generation of a maximum number of liquid ligaments **100** as illustrated in FIG. 11.

The precise manner of operation of the aerosolizing unit **10** may be best explained by reference to FIGS. 8–11.

In FIG. 8 pressurized aerosolizing fluid is supplied as described above to the annular groove **28** in the plate **30**. The annular groove **28** has a sufficiently large volume as compared to the volumes of the fluid passages **34** so as to act as an orifice or reservoir, that is, aerosolizing fluid is supplied to the passages **34** at a substantially uniform pressure. Since the interior of the liquid reservoir **12** is at substantially atmospheric pressure the aerosolizing fluid flows through the passages **34** and enters the vortex generating chamber **32** tangentially. The vortex generating chamber **32** is frustoconical in configuration and the aerosolizing fluid is accelerated by expansion in an effort to escape through the opening **36** into the reservoir **12**.

Because the acceleration of the aerosolizing fluid is always in a straight line, the fluid flow tends to remain tangential. However, the constant influx of pressurized fluid at high density causes the expanding lower density fluid to be displaced inwardly towards the opening **36** with the result that a vortex flow **92** is established, as is shown in FIG. 9. This vortex **92** of fluid has established boundaries and a void or vacuum **93** exists at the center of vortex flow. The velocity of the pressurized aerosolizing fluid becomes greatest at the opening **36** where the pressure is substantially atmospheric. As shown in FIG. 9, the aerosolizing fluid leaving the opening **36** inherently tends to form a helicoconical flow path **96** or as indicated above the helicoconical flow path **96** can be established with the deflector **82** of FIG. 6 or the Coanda effect ring **86** of FIG. 7.

As can be seen in FIGS. 9 and 10, there is existing, immediately after discharge from the opening **36**, a high velocity stream of aerosolizing fluid immediately proximate the lubricant discharge openings **70** in the plate **50**. The discharged fluid is thus in the inter-action zone **37** flowing as indicated at **94** in a helicoconical flow path **94** substantially tangential to the interaction zone defining wall **71** of the plate **50**.

The effect of the high velocity tangential fluid flow in the inter-action zone **37** is best illustrated in FIG. 11 wherein the formation of liquid particles is shown. It is to be understood that although for purposes of illustration a liquid ligament **100** is shown as emanating from liquid passage **68** only, in operation a plurality of ligaments would be formed, one for each passageway **68** or nearly infinite number of ligaments if the passageway were continuous as shown in FIGS. 12 and 13.

The liquid ligament **100** is a generally cylindrical chain of liquid molecules drawn into the inter-action zone **37** by aspiration due to the high velocity aerosolizing fluid flow. When the ligament **100** reaches a certain length the tensile strength of the liquid will be exceeded and the ligament **100** will be severed and will move into the fluid stream as a link **102**. Due to the behavior of liquids and the theory of liquid particle formation the link **102** will develop narrow belts or neck portions **104** at a plurality of points depending on numerous factors including surface tension and the frequency of mechanical vibrations present in the system. The belts or neck portions **104** continue to contact until there is formed a plurality of liquid particles **106** from the original ligament **100**.

There exists throughout the flow of the fluid and liquid particles in the inherent helicoconical flow path a differential inner-pressure lower than the outer-pressure which may create at least a partial vacuum condition **95** which is believed to be a factor for maintaining the fluid in the helicoconical flow path **96**.

The liquid particles **108** having a diameter greater than is useable in fog lubrication systems, such particles **108** will be coalesced on the screen **80** or in the annular groove **74** and returned to the reservoir **12** for later recirculation.

The particles **106** generated which are in the useable range of particle diameters are distributed to the bearings to be lubricated in the manner described above.

It is, of course, to be understood that the fog generating device described is useful in many applications and that a preferred embodiment has been described for purposes of illustration only without limiting the scope of this invention.

Having thus described our invention, it will become immediately obvious to those skilled in the art that we have made a significant contribution to the state of the art for which protection is sought in the form of the appended claims.

Having thus described our invention, we claim:

1. Apparatus for generating a liquid fog in a gaseous carrier comprising:
   - a housing means defining a gas vortex generating chamber and having a pressurized gas inlet leading tangentially to said vortex chamber, a vortical gas flow outlet leading from said chamber, and a liquid inlet leading from a liquid source feeding into said housing proximate said outlet from the vortex generating chamber and discharging liquid into the exhausting vortical gas flow;
   - means defining an interaction chamber proximate said vortex chamber outlet wherein the liquid is aerosolized by said vortical gas flow;
   - a channel associated with said interaction chamber downstream from the interaction chamber having a substantially greater length than the greatest dimension in cross-section of the channel for coalescing liquid particles which are readily coalescable; and
   - means for collecting the coalesced liquid particles for recirculation to the liquid source.

2. Apparatus for generating a lubricant fog in a gaseous carrier comprising:
   - a source of pressurized gas;
   - a housing in communication with said source defining a vortex chamber having an inlet and an outlet wherein pressurized gas at the inlet is transformed into high velocity, helicoconically flowing gas at the outlet;
   - a source of lubricant in communication with said outlet;
   - a means defining an inter-action chamber wherein the lubricant is aerosolized by the high velocity, helicoconically flowing gas;
   - means for conducting the fog to points requiring lubrication in communication with the means defining an interaction chamber; and

   - a coalescing baffle interposed between said interaction chamber means and said conducting means where lubricant particles of a diameter of greater than a predetermined maximum are coalesced out of the fog.

3. Apparatus for generating a liquid particle suspension in a gaseous carrier comprising:
   - a source of pressurized gas;
   - a housing defining a vortex chamber having an inlet and an outlet wherein pressurized gas at the inlet is transformed into high velocity, helicoconically flowing gas at the outlet, said chamber being frusto-conical in shape with the larger diameter being the inlet and the smaller diameter the outlet, pressurized gas being introduced substantially tagent to the base of the frustum;
   - a housing defining an inter-action chamber in axial justaposition to and in communication with the outlet of the vortex chamber having an inlet and outlet, said chamber being frusto-conical in shape, the larger diameter being the outlet and the smaller diameter being the inlet;
   - a source of liquid having an outlet interposed at the outlet of the vortex chamber and the inlet of the inter-action chamber, said liquid being particlized and placed into suspension by the helicoconically flowing gas within said inter-action chamber;
   - a means in communication with said inter-action chamber for conducting the liquid particle suspension to external points; and
   - a coalescing baffle interposed between said means and the interaction chamber whereat liquid particles having a diameter greater than a predetermined maximum are coalesced out of the suspension.

4. Apparatus as defined in claim 3 wherein:
   - the source of liquid is in aspirational communication with its outlet.

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NORMAN YUDKOFF, Primary Examiner

J. SOFER, Assistant Examiner

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