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Ultrasonic vibratory atomizer.

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An ultrasonic atomizer has the nozzle body horn formed with the vibrational node in the region of an annular mounting flange about the largest diameter of the nozzle body. The fluid inlet and bypass passages for the nozzle body are located in the mounting flange and a resilient seal ring is provided on each opposite side of the mounting flange. The seal rings are in radial compression between the nozzle body and the housing for providing the dual function of vibrational mounting equally about the nodal region and fluid pressure sealing about the inlet and bypass ports.

EP 0 057 466 A2

ULTRASONIC VIBRATORY ATOMIZER

BACKGROUND OF THE INVENTION:

- 5 The present invention relates to an atomizer for controlling a flow of fluid, such as, for example, liquid fuel injected into an internal combustion engine or other applications where a precisely controlled flow of fluid in response to a control signal is required.
- 10 In particular, the present invention relates to an atomizer which is excited by ultrasonic vibration to cause controlled opening and closing of a fluid valve located in a discharge nozzle. The invention relates in particular to ultrasonic fuel injection atomizers of the
- 15 type wherein the vibratory excitations are generated by supplying an electrical control signal to a piezoelectric crystal attached to the nozzle forming member which contains the control valve.
- 20 In the design of ultrasonic vibratory atomizers it is known to mount the vibrating nozzle member to a stationary housing by providing a resilient mount located in the region of the vibratory node, or region of near zero vibratory amplitude as, for example, according to the technique described in U.K. patent
- 25 application GB 2029270 A published 19 March 1980. In the aforesaid '270 British patent publication, the nozzle member has an exponential horn configuration which at its largest diameter has an annular flange against which a resilient O-ring is retained and a
- 30 second resilient O-ring is provided in contact with the exponential curved portion of the nozzle horn, where the longitudinal vibratory node is located. The ultrasonic nozzle member of the aforesaid known device is thus mounted between two seal rings of substantially

differing diameter and which therefore are exposed to differing amplitudes of radial component of vibrations.

Furthermore, in such ultrasonic atomizers, where it is desired to provide a fluid flow passage in the vibrating nozzle member and to provide fluid communication therewith from a pressurized source without the need of connecting a conduit or tubing to the body member, it is necessary to provide a fluid pressure sealed region about the periphery of the nozzle body member for providing pressurized fluid to the control valve. In the aforementioned known ultrasonic atomizers employing resilient mounting rings one ring contacts the exponential surface of the nozzle horn. This arrangement has proved to be disadvantageous when the mounting ring is required to provide a fluid pressure seal. It has proven difficult to obtain a reliable fluid pressure seal along the exponential curve shape of the nozzle member horn. Thus, it has been desired to find a means of mounting the nozzle body member in an ultrasonic atomizer in a manner which provides convenient fluid pressure sealing thereabout and yet permits the resilient mounting to contact the vibrating nozzle member in regions of zero or minimum vibrational amplitude.

SUMMARY OF THE PRESENT INVENTION

The present invention provides an ultrasonic vibratory atomizer in which the vibrating nozzle body member is resiliently mounted at its nodal region such that the resilient mounting is subjected to a minimum of longitudinal and radial vibratory amplitude. The atomizer of the present invention employs a nozzle body member having a generally exponentially curved horn portion containing at the free end thereof the fluid

flow control valve. The horn has the opposite, larger diameter end, terminating in a cylindrical portion to which the vibratory generator is attached. The nozzle body member of the present ultrasonic atomizer has an
5 annular flange formed about the larger end of the horn and the horn is configured such that the vibratory nodes are located in the region of the annular flange.

The nozzle body horn of the present atomizer is resiliently mounted in its nodal region to a housing by
10 a pair of resilient annular seal rings disposed on axially opposite sides of the annular flange in the larger diameter portion of the nozzle body member. The resilient annular seal rings engage the housing in fluid pressure sealing contact to provide an annular fluid
15 pressure chamber about the outer periphery of the flange. Fluid passages are provided in the nozzle body member through the periphery of the flange for communication with the valve provided in the free end of the nozzle horn. The resilient annular mounting seal
20 and mounting rings of the present invention are of the substantially same diameter and contact the nozzle body member along the cylindrical periphery of the larger diameter portion thereof, thus avoiding reliance upon sealing contact with the exponentially curved portions
25 of the nozzle body horn.

The present invention thus provides the vibratory node of the nozzle body horn in the region of the largest diameter comprising an annular mounting flange which permits the fluid flow passage through the nozzle
30 body member to be located in the periphery of the flange and thus in the region of lowest vibratory amplitude.

The resilient annular mounting seals located immediately adjacent opposite sides of the annular mounting flange of the nozzle body member thus provide

the dual function of resiliently mounting the nozzle body member to the housing in the nodal region and simultaneously contact the housing in fluid pressure sealing contact for providing an annular collecting chamber about the nozzle body member for providing communication of pressurized fluid to the passage in the nozzle body member thereby eliminating the need to connect a conduit or tubing to the vibrating nozzle body member for fluid flow thereto.

10 The present invention thus provides a unique and novel construction for the resilient mounting of the vibrating nozzle body member of an ultrasonic fluid atomizer to the housing portion thereof. The invention provides a construction which minimizes the effects of
15 the ultrasonic vibration of the nozzle body on the resilient mounting and which provides for convenient and improved porting of the pressurized fluid supply to the nozzle member.

20 BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a cross-sectional view of the atomizer assembly of the present invention;

FIGURE 2 is an enlarged view of the lower portion of Figure 1;

25 FIGURE 3 is a view illustrating the construction of devices known in the prior art; and

FIGURE 4 is a view taken along section indicating lines 4-4 of Figure 1.

FIGURE 5 is an enlarged view of the lower portion of
30 Figure 2 showing the valve in the open position.

DETAILED DESCRIPTION

Referring now to Figure 1, the ultrasonic atomizer assembly is indicated generally at 10 and comprises a

nozzle body indicated at 12 and a housing means 14 into which the nozzle body is received and mounted thereon for vibratory isolation. In the presently preferred practice the nozzle body 12 is formed of a suitable corrosion resistant metal to permit handling of motor fuels and other liquids having corrosive properties.

The nozzle body 12 includes a nozzle horn portion 16 configured generally in an exponentially or other suitable curved taper as shown in the lower portion in Figure 1, which extends downwardly from the housing means 14. The nozzle body 12 has the upper portion thereof as shown in Figure 1 formed in a cylindrical larger diameter portion 18 which is received in the housing 14.

The upper portion 18 of the nozzle body has an annular mounting flange 24 formed thereon which flange has a generally cylindrical outer surface and upper and lower radial faces 26, 28. The upper surface 22 of the large diameter portion 18 of nozzle body 12 has an ultrasonic generator 20 attached thereto for vibratory stimulation. In the presently preferred practice of the invention, the generator 20 comprises a piezoelectric crystal bonded or mechanically clamped to the upper surface 22 of the cylindrical portion 18 of the nozzle body. In the presently preferred practice of the invention piezoelectric vibratory generator 20 (Fig. 1) imparts vibrations to the nozzle body 12 at frequencies in the ultrasonic range or frequencies greater than 25 kilohertz.

The nozzle body 12 is received in the housing means 14 in a bore 30 provided therein which bore has a diameter suitable to clear the outer periphery of the upper portion 18 of the nozzle body. Bore 30 has a counterbore 32 which is formed to provide clearance for the outer periphery of the nozzle body flange 24.

In the presently preferred practice of the invention the horn portion 16 of the nozzle body is configured so as to locate the longitudinal node of induced vibratory motion in the region of the annular flange 24 by
5 techniques known to those skilled in the art.

A pair of resilient seal rings 34, 36 are received over the larger diameter 18 of the nozzle body and each contact respectively one of the upper and lower faces 26, 28 of the annular flange 24. The upper seal ring 36
10 is radially compressed between the larger diameter 18 of the nozzle body and the counterbore 32 to provide fluid sealing contact therebetween and vibratory isolation between the nozzle body and the housing 14. The lower seal ring 34 is retained in radial compression between
15 diameter 18 of the nozzle body by a counterbore 38 provided in a retaining ring 40 attached to the housing means 14. In the presently preferred practice, the retaining ring 40 is sealed about its outer periphery by a seal ring 42 received in a counterbore 44 provided in
20 the lower portion of the housing means 14. The retaining ring 40 has an inwardly extending annular flange 46 which retains the lower seal ring 34, and consequently the nozzle body 12, in a fluid pressure sealing yet resilient vibrationally isolated mounting in
25 the housing 14. In the presently preferred practice the seal rings 34, 36 are in only radial compression, thus requiring only control of the dimensions of part diameters 18, 32 and 38 for ease of manufacture and assembly.

30 The nozzle body 12 has a central bore 46 formed in the horn 16, which bore extends vertically upward in Figure 1 along the central axis of the horn 16. A tubular member 48 preferably formed of corrosion resistant metal is received in the bore 46 with the

upper end of the tube 48 having its outer periphery sealed against the bore 46 by any convenient means as, for example, an interference press fit. The bore 46 in the horn has a counterbore 50 provided therein which
5 counterbore has the diameter thereof sufficiently large so as to provide an annular clearance about the outer periphery of the tube 48.

A fluid inlet passage 52 is provided in the outer periphery of the annular nozzle body flange 24 and the
10 passage 52 extends generally radially inwardly through the nozzle body to communicate with the counterbore 50. A bypass passage 54 is formed in the nozzle body circumferentially spaced from the passage 52 and extends generally radially outwardly having its inner end
15 communicating with nozzle body bore 46 and its outer end ported to the outer periphery of the body flange 24.

Referring now to Figure 2, the lower portion of the horn 16 is shown in enlarged view wherein the tube 48 has a sleeve member 56 preferably of corrosion resistant
20 metal received in the inner periphery of the lower end of tube 48 with the sleeve 56 retained therein in fluid tight connection between the outer periphery of sleeve 56 and the inner periphery of tube 48.

A nozzle member 58 preferably formed of corrosion
25 resistant metal having a fluid atomizing discharge port 60 provided in the lower surface thereof is provided.

Member 58 is received in counterbore formed in counterbore 50 in the horn 16.

Discharge port 60 communicates with a valve seat 62 which forms a valve chamber 63 in member 58 in
30 cooperation with the lower end of tubular member 56. In the presently preferred practice of the invention the nozzle member 58 is received over the lower portion of sleeve 56 and attached thereto in fluid pressure sealing arrangement to form the valve seat chamber and retain

the nozzle member 58 onto the sleeve 56. The outer diameter of the nozzle member 58 is retained in the horn 16 by a suitable fluid pressure sealing engagement such as an interference press fit in the counterbore 51.

5 A check ball valve member 64 is received in the valve chamber and is movable between a position sealing against valve seat 62 in which position fluid flow is prevented through discharge orifice 60 as shown in solid outline in Figure 2, and an upwardly displaced position
10 contacting the lower surface of tube 56 in which position fluid flow is permitted through orifice 60.

 A feed passage 66 is provided through the nozzle member 58 which passage communicates the annular space between counterbore 50 and the outer periphery tube 48
15 with the valve seat chamber.

 With the check ball 64 in the closed position as shown in Figure 2, liquid or fuel, as the case may be, flows from the annular space surrounding tube 48 through passage 66 and upwardly around the check ball 64 through
20 the space between the upper surface of the ball and the lower portion of sleeve 56 and through the inner periphery of the sleeve into the inner periphery of tube 48 and upwardly therethrough to passage 54 (see Fig.1) for return to the source.

25 Referring now to Figure 5, the check ball 64 is shown in the open position as spaced from the valve seat 62 under the influence of the vibratory motion of the horn 16 and is restrained in its upward travel by the lower end of the sleeve 56. With the ball in the upward
30 or valve-opened position, pressurized fluid flows from the annular space surrounding tube 48 through cross port 66, around the lower portion of valve 64 over valve seat 62 and exits through the discharge port 60.

Thus, in operation with the ultrasonic generator exciting the nozzle body 12, the check ball 64 is moved relative to seat 62 alternately from the position in Figure 2 wherein fluid flow through cross port 66 and upwardly around the ball to return through the center of tube 48 to the discharge passage 54 (Fig. 1) to the position shown in Figure 5 with the ball in upward position wherein fluid flows through cross port 66 and downwardly through the discharge nozzle 60.

Referring now to Figure 1, the housing 14 has an inlet port 68 to a source of pressurized fluid which port 68 communicates with an inlet passage 70 which extends through the lower portion of the housing to communicate with the counterbore 32 surrounding the nozzle body flange 24. The counterbore 32 thus provides an annular collector chamber which communicates with the nozzle body inlet passage 52 for permitting fluid flow therethrough. The housing 14 has a bypass chamber 72 formed in communication with the counterbore 32 which chamber 72 is disposed circumferentially spaced from the inlet passage 70 such that chamber 72 receives fluid flow from bypass passage 54. Chamber 72 communicates with an upwardly extending passage 74 which has its upper end adapted to receive a fluid conduit connection thereto for return flow to the source (not shown) of pressurized fluid.

Referring now to Figures 1 and 4 the housing means 14 has an electrical connector assembly indicated generally at 76 which comprises a connector housing 78 which is attached to the housing 14 by any suitable expedient as, for example, lugs 80 deformed over a base flange portion 82 of the housing 78. The electrical connector housing 78 may be formed of any suitable metal or plastic material.

A pair of electrical connector pins 84, 86 are disposed in a hollow region 88 formed in the upright portion 79 of the connector housing and the pins are disposed in spaced parallel upwardly extending arrangement. The electrical connector pins 84, 86 extend through the wall of the housing 78 to the interior region thereof. The pins 84, 86 have respectively flexible leads 90, 92 connected to the lower ends thereof by suitable means as, for example, riveting or soldering, with the opposite ends of flexible leads 90, 92 connected to attachment terminals 94, 96 provided on the ultrasonic generator 20. The upstanding portion 79 of the electrical connector housing is adapted to have received thereover a corresponding mating electrical connector for electrical connection to pins 84, 86 for providing electrical power to the ultrasonic generator. The flexible leads 90, 92 provide vibratory isolation of the ultrasonic generator 20 from the electrical connector housing 78 and the main housing 14.

The present invention thus provides a unique ultrasonic atomizer for use in providing controlled flow of atomized liquid, as for example, fuel injected into an internal combustion engine. The ultrasonic nozzle body and generator of the present invention are vibratorily isolated from the atomizer housing by a pair of equiannular resilient mounting rings disposed on opposite sides of an annular mounting flange located at the vibrational node of the nozzle body. The nozzle body inlet and bypass flow ports are conveniently located between the mounting rings which serve the dual functions of providing vibration isolation and fluid pressure sealing between the nozzle body and the atomizer housing.

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Although the invention has been described
hereinabove in the present practice with reference to
the accompanying drawings, modifications and variations
will be apparent to those skilled in the art and the
5 invention is intended as limited only by the following
claims:

I CLAIM:

1. An ultrasonic atomizer comprising:
 - (a) a nozzle body means including means defining a fluid flow passage therethrough having a fluid inlet port and a nozzle outlet port, said body means including means defining a valve seating surface in said passage;
 - (b) a valve member received in said fluid flow passage and movable between a position contacting said valve seat for preventing fluid flow to said nozzle outlet port and a position spaced from said valve seat for permitting fluid flow to said nozzle outlet;
 - (c) generator means attached to said body means, said generator means being operable upon receipt of an electrical control signal to ultrasonically vibrate said body means and effect movement of said valve member in contact with and away from said valve seat for controlling fluid flow through said nozzle outlet;
 - (d) housing means having said body means resiliently mounted therein for vibratory movement with respect thereto, wherein said resilient mount comprises:
 - (i) an annular flange defined by said body means said flange having said fluid flow inlet formed in the region of the outer periphery thereof;
 - (ii) a pair of resilient annular seals disposed on axially opposite sides of said flange, said seals having substantially equal annuli;

- 35 (iii) said seals each being radially compressed between said body means and said housing means such that fluid flow therebetween is prevented and said flange is retained between said seals thereby resiliently suspending said body means on said seals with respect to said housing means; and,
- 40 (e) said housing means includes means defining an inlet passage having a port adapted for connection to a source of pressurized fluid, said inlet passage communicating with said inlet defined by said body means passage.
2. The device defined in claim 1 further comprising:
- (a) a bypass passage defined by said nozzle body means, said bypass passage communicating with said fluid flow passage such that fluid flows from said inlet port to said bypass passage when said valve is closed; and,
- 5 (b) a return passage defined by said housing means including a return port adapted for connection to a return to said pressurized source, said return passage communicating with said bypass passage for receiving fluid therefrom.
- 10 3. The device defined in claim 1, wherein said body means further defines a bypass passage communicating with said fluid flow passage, said bypass passage terminating in discharge port disposed in the outer periphery of said annular flange.
- 5 4. A method of injecting fuel from a pressurized source into an internal combustion engine comprising the steps of:
- (a) providing an electrical control signal having predetermined frequency characteristics;
- 5

- (b) ultrasonically vibrating a nozzle member in response to said control signal;
- (c) alternately opening and closing a valve member in response to said ultrasonic vibration for
10 controlling flow of fuel through the nozzle member;
- (d) porting said nozzle member in the region of a vibratory node and resiliently mounting said
15 nozzle member on opposite sides of said node in the direction of said ultrasonic vibratory motion; and,
- (e) locating said resilient mounting annularly
20 about said nozzle member and at equal annulii closely spaced on said opposite sides of said vibratory node.

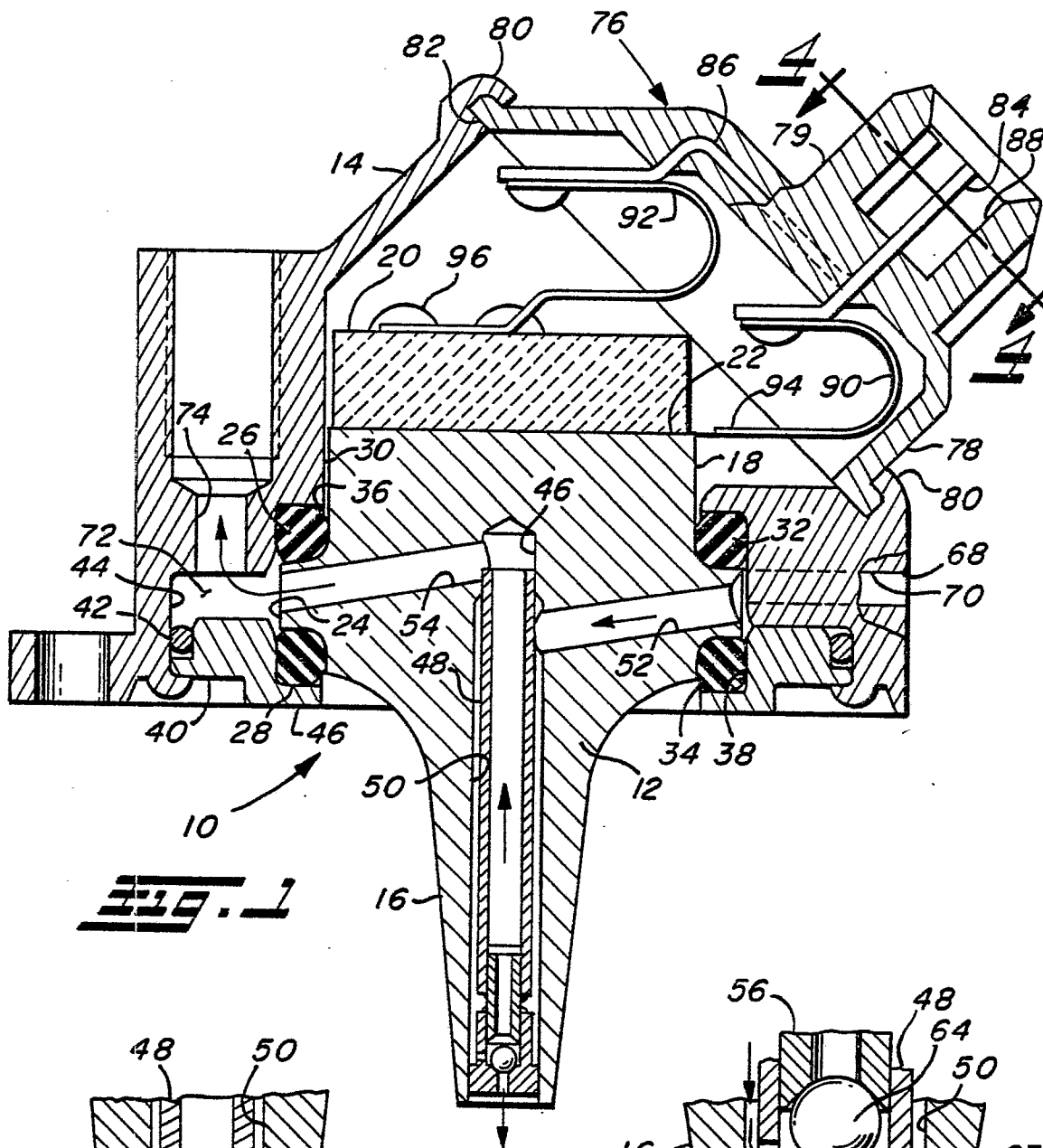


FIG. 1

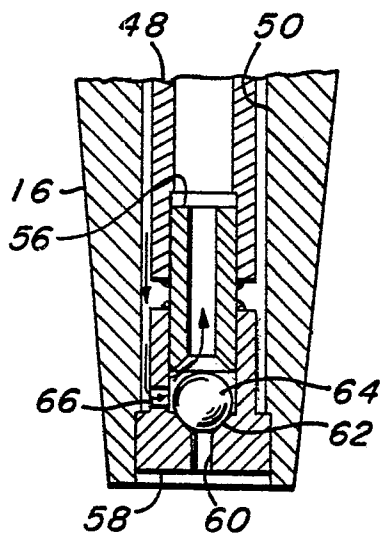


FIG. 2

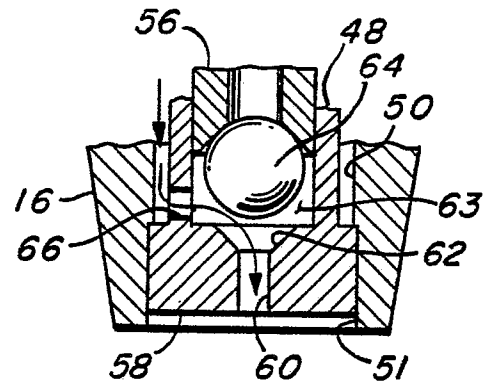


FIG. 3

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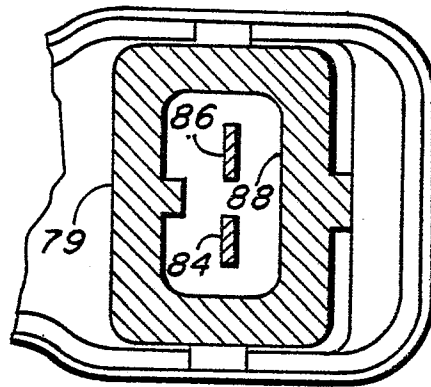
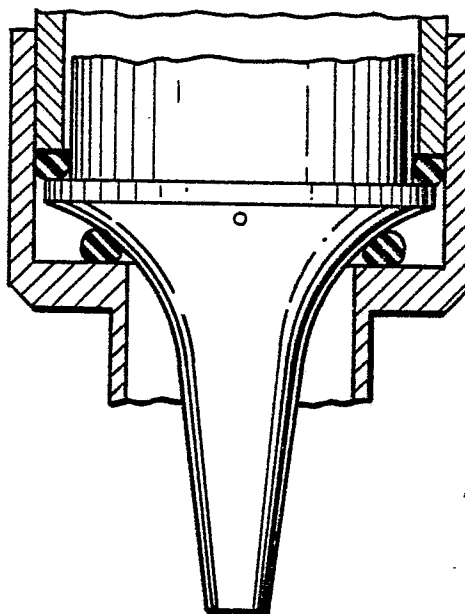


FIG. 4



PRIOR ART

FIG. 3