

(19)



Europäisches Patentamt

European Patent Office

Office européen des brevets



(11)

EP 0 845 300 A2

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
03.06.1998 Bulletin 1998/23

(51) Int. Cl.⁶: **B05B 7/04**

(21) Application number: **97119735.5**

(22) Date of filing: **11.11.1997**

(84) Designated Contracting States:
**AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC
NL PT SE**
Designated Extension States:
AL LT LV MK RO SI

(72) Inventors:
• **Takahashi, Masashi**
Yokohama City, Kanagawa Prefecture 245 (JP)
• **Murata, Shinichi**
Kawaguchi City, Saitam Prefecture 332 (JP)

(30) Priority: **27.11.1996 JP 316637/96**

(74) Representative:
DIEHL GLAESER HILTL & PARTNER
Flüggenstrasse 13
80639 München (DE)

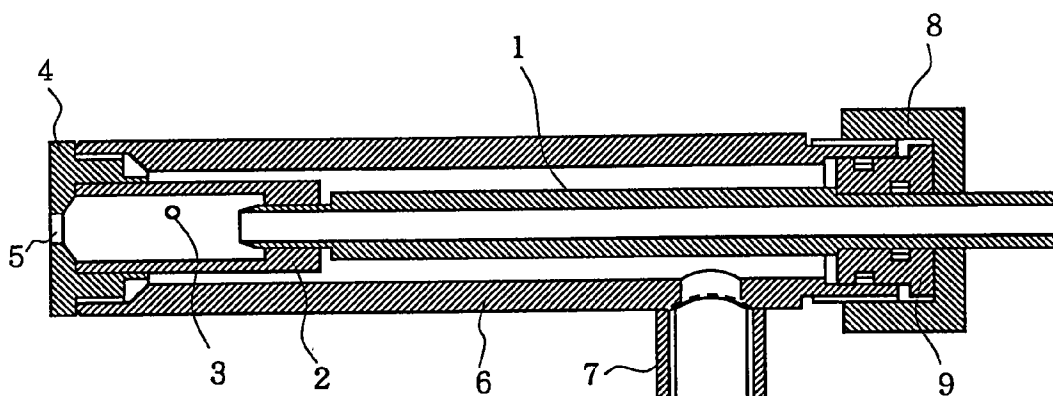
(71) Applicant: **POWDERING JAPAN K.K.**
Tokyo 105 (JP)

(54) Liquid atomizing nozzle

(57) The present invention provides a liquid atomizing nozzle for atomizing liquid material being highly viscous or containing bulky solid materials, comprising a liquid supplying pipe (1), a cylindrical chamber (2) for whirling of air being connected at one end with the liquid supplying pipe (1), having an inside diameter larger than that of the liquid supplying pipe (1), and being provided with one or more through holes (3) for passing

through pressurized air tangentially, an orifice (4) at the top of the cylindrical chamber (2) with a circular opening (5) being smaller than the inside diameter of the cylindrical chamber (2), and an external cylinder (6) covering the cylindrical chamber (2) and at least partly the liquid supplying pipe (1) and being provided with a pressurized air supplying pipe (7).

FIG.1



EP 0 845 300 A2

Description

The present invention relates to a liquid atomizing nozzle used in the field of spray drying, humid pelletizing, coating, combustion and the like, and the nozzle is especially suited for atomizing liquid materials having high viscosity or containing bulky solid materials.

Liquid atomizing nozzles having compressed air power sources are widely used e. g. in spray drying and coating works of liquid materials. The nozzle is basically composed of a liquid supplying pipe and a compressed air supplying pipe coaxially arranged outside of the liquid supplying pipe. By means of compressed air from the head of the air supplying pipe and by blasting at a high speed in the axial direction, the liquid pushed or sucked outward from the head of liquid supplying pipe is sheared and atomized.

The amount of liquid processed by this kind of coaxial double-pipe liquid atomizing nozzles is usually from several liter/h to dozens liter/h, because atomizing features of the nozzles worsen when the nozzle is enlarged analogously in proportion to an increased amount of liquid to be processed (increased ratio of compressed air and flattened distribution of atomized liquid particles).

Since an enlarged diameter of the liquid supplying pipe worsens the atomizing features, diameters of liquid supplying pipe are set at around 0.5-3.0mm. Accordingly, liquid atomizing nozzles of this type are not suitable for atomizing liquids of high viscosity of tens of thousands cP (mPa · s) or those containing bulky solid materials. Further, atomizing nozzles of this type are too narrow in spray angles to be employed as atomizing equipments of spray dryers and so they can not substitute for pressurized spray nozzles having spray angles of larger than 70 degree. For relatively low viscous (below 500 cP) liquids capable of being atomized with pressurized spray nozzles, conventional double-pipe fluid atomizing nozzles require 2-5 times more atomizing energy (kW) than that required by pressurized spray nozzles. This is the reason why large capacity double-pipe fluid atomizing nozzles are not so popular.

The present invention is directed to provide a liquid atomizing nozzle capable of atomizing liquid materials of high viscosity or containing bulky solid materials charged not only at a small feed rate but also at several thousands liter/h rate, by which the liquid is atomized and sprayed uniformly with predetermined spray angles.

The liquid atomizing nozzle according to the present invention comprises a liquid supplying pipe, a cylindrical chamber for whirling of air being connected at one end with the liquid supplying pipe, having an inside diameter larger than the inside diameter of the liquid supplying pipe, and being provided with one or more through holes for passing through pressurized air in the direction tangential to the circular internal surface of the cylindrical chamber, an orifice disposed at the top

of the cylindrical chamber and having a circular opening being smaller than the inside diameter of the cylindrical chamber, and an external cylinder covering the cylindrical chamber and at least a part of the liquid supplying pipe and being provided with a pressurized air supplying pipe.

Fig.1 is a longitudinal section of the liquid atomizing nozzle according to the present invention; Fig.2 is a longitudinal section of the liquid supplying pipe; Fig.3 is a longitudinal section of the cylindrical chamber; Fig.4 is a sectional view seen along A-A of the cylindrical chamber of Fig.3; Fig.5 is a longitudinal section of the orifice; Fig.6 is a view of the orifice of Fig.5 seen from the direction C; Fig.7 is a longitudinal section of the external cylinder; Fig.8 is a longitudinal section of a seal cap; Fig.9 is a longitudinal section of the liquid atomizing nozzle equipped with a reverse conical body and a disc-type liquid distributor; Fig.10 is a side view of the reverse conical body; Fig.11 is sectional view of the orifice used in combination with the reverse conical body; Fig.12 is a top view of the disc-type liquid distributor; Fig.13 is sectional view along D-D of the disc-type liquid distributor of Fig.12; Fig.14 is a top view of a disc-type liquid revolving plate; Fig.15 is a side view of the disc-type liquid revolving plate.

The liquid atomizing nozzle according to the present invention will be explained by reference to the attached drawings.

Reference number 1 indicates the liquid supplying pipe, and the pipe is connected with the cylindrical chamber for whirling of air 2 at one end exemplified by the left end in Fig.1. The cylindrical chamber 2 has a cylindrical shape having an inside diameter larger than the inside diameter of the liquid supplying pipe 1, and is provided at the cylindrical portion with one or more through holes 3 for passing through pressurized air in the direction tangential to the circular internal surface of the cylindrical chamber. As shown by Fig.4 by the cross-sectional view, a plurality of the through holes 3 for passing through pressurized air may be disposed along the same circumference (c.f. Fig.4) or in rows in axial direction of the cylindrical chamber (e.g. at A-A and B-B in Fig. 3). A plurality of through holes may be arranged along the same circumference and a plurality of circumferential arrangements may be disposed in rows in the axial direction. The orifice 4 having the circular opening 5 with a diameter smaller than the inside diameter of the cylindrical chamber is disposed at the head of the cylindrical chamber 2. Further, the external cylinder 6 is so disposed as to cover the cylindrical chamber 2 and at least a part of the liquid supplying pipe 1, and the pressurized air supplying pipe 7 is connected therewith. Reference number 9 is a seal for sealing the other end of the external cylinder 6, and reference number 8 is a seal cap.

The liquid atomizing nozzle according to the invention can be assembled easily by steps of inserting the liquid supplying pipe 1 into a connection opening dis-

posed at the bottom of the cylindrical chamber 2, inserting into the external cylinder 6 the cylindrical chamber attached with the liquid supplying pipe, fastening the orifice 4 to the front end of the external cylinder 6 to fasten the front end of the cylindrical chamber 2, engaging the seal cap 8 having a through hole for the liquid supplying pipe 1 at the back end of the external cylinder 6; and making the assembled nozzle air-tight or water-tight by means of applying appropriately sealing materials. Disassembling or exchanging such parts as the cylindrical chamber 2 and/or orifice 4 can be done easily.

The working mechanism of the liquid spray nozzle of the present invention will be explained hereunder. Liquid material supplied into the cylindrical chamber 2 through the liquid supplying pipe 1 is revolved and accelerated in the cylindrical chamber by virtue of the pressurized air coming in at a high speed from the through holes 3 in the direction tangential to the circular internal surface of the cylindrical chamber. The accelerated revolving liquid material moves by means of centrifugal force toward the internal surface of the cylindrical chamber, becomes a thin film, moves toward the circular opening 5, and is sprayed therefrom accompanied by a whirling air stream. In this case, fine liquid particles are accompanied by an air stream ejected into the cylindrical chamber. Other liquid flows in a thin film state along the internal surface of the cylindrical chamber and is atomized at the opening 5 of orifice and sprayed.

In conventional liquid spray nozzles utilizing compressed air, the nozzle has structural features that the pressurized air and the liquid are maintained separately until reaching at the head of double-pipe fluid atomizing nozzle, and suction, shearing and atomizing occur instantly upon contacting at the front end of the double-pipe. In this case, the pressurized air discharged in high speed from an outside pipe induces highly negative pressure around the front end portion to cause the liquid being sucked from the inner pipe and sheared. However, due to simultaneous sucking of air from outside of the system, a large portion of kinetic energy of the compressed air is wasted for accelerating the external air.

On the other hand, in the atomizing nozzle of the present invention, the nozzle has the structural features that the liquid material is revolved and accelerated in the cylindrical chamber by the ejected pressurized air to be atomized partly, and the remaining portion is forwarded to the orifice under a film state of accelerated revolution. For example, when a compressed air of 3 kg/cm² pressure* is employed, around 2 kg/cm² pressure is consumed in the cylindrical chamber and the remaining pressure becomes the kinetic energy for spraying from the orifice, though the ratio varies in accordance with ratios of the area of circular opening 5 of the orifice to the total cross-sectional area of through holes 3 for compressed air. As the result, the portion of energy con-

sumed for atomizing liquid is larger than that of conventional spray nozzles.

The ratios of the necessary amount of the compressed air to the amount of liquid varies widely in accordance with the properties of the liquid (viscosity, surface tension, size of solid material, etc.) and the average particle sizes desired. The compressed air employable is 4-7 kg/cm² pressure, as general purpose air compressors usually have 7 kg/cm² specifications. Air through holes of the cylindrical chamber are set to have a total cross-sectional area allowing to pass through a predetermined amount of air under a pressure difference of 1 kg/cm² lower than the set air pressure. The orifice is set to have an opening area capable of passing a predetermined amount of air under 0.5-1.5 kg/cm² pressure difference. A too large orifice opening area leads to a lowered axial velocity compared with the whirling velocity, which causes difficulty in atomizing liquid film rings at the orifice portion. Thus, unfavorably larger particles tend to appear in outward direction, though a widened spray angle may be obtainable. From this viewpoint, the ejecting air at the opening of orifice preferably has a velocity corresponding to 0.5-1.5 kg/cm² pressure difference. In order to attain desirous atomization with such a small amount of pressurized air, it is quite important to select properly the (total) cross-sectional area of the air through holes in the cylindrical chamber and opening area of the orifice. It is preferred that the ratio of the diameter of the circular opening 5 of the orifice inside diameter of the cylindrical chamber 2 is in the range of 1 : 1.5-4.0, and the ratio of the area the circular opening 5 of the orifice/total cross-sectional area of through holes 3 opened tangentially to the circular internal surface of the cylindrical chamber is in the range of 1 : 0.2-1.0.

Different from conventional liquid atomizing nozzles employing two fluids, the nozzle according to the present invention can employ an enlarged diameter liquid supplying pipe thanks to being scarcely affected on the atomizing features by the pipe diameters, and the diameter of orifice can also be enlarged. Accordingly, it is possible to atomize liquid materials not only in large amounts or of high viscosity but also containing coarse solid materials. Since the atomized liquid particles possess higher revolving momentum and lower axial velocity in comparison with those of conventional nozzles, the atomized liquid particles can be spread so broadly as to be beneficial for usages in spray dryers.

In order to enlarge further the spray angle, a reverse conical body 10 is disposed coaxially inside of the opening 5 of the orifice 4 as shown in Fig.9, which enables a spray angle of near to that of pressure spray nozzles. Fig.10 shows the reverse conical body 10 attached to the connecting rod 11. By fixing the end of connecting rod 11 to the head of the liquid supplying pipe 1, the reverse conical body 10 can be disposed coaxially inside of the opening 5 of the orifice 4. In this case, the circular opening 5 of the orifice 4 is preferably

*(1 kg/cm² = 0.98 bar)

shaped into the reverse conical shape, as shown in Fig.11. As mentioned previously, a liquid material passed into the cylindrical chamber 2 from the liquid supplying pipe 1 is dispersed, revolved and accelerated in the cylindrical chamber by virtue of the pressurized air coming into at a high speed from the through holes 3 in the direction tangential to the circular internal surface of the cylindrical chamber, and is transformed into a thin liquid film through centrifugal force, and transferred toward the internal surface of the cylindrical chamber. In order to enhance transferring of the liquid material to the internal surface of the cylindrical chamber, a disc-type liquid distributor 12 having a plurality of liquid ejecting holes 13 (top view: Fig.12; sectional view: Fig.13) placed evenly and concentrically is preferably disposed (in the cylindrical chamber) at a place between the one or more through holes 3 for passing through pressurized air in the direction tangential to the circular internal surface of the cylindrical chamber and the connecting portion of the liquid supplying pipe (cf. Fig.9). When the reverse conical body 10 is disposed in the opening 5 of the orifice 4 as shown by Fig.9, since the front end of the liquid supply pipe 1 is clogged by the connecting rod 11 of the reverse conical body 10, it may be so arranged that the liquid material can be supplied to the end portion of the cylindrical chamber 2 through the side hole 14 disposed near the front end of the liquid supplying pipe 1, and the liquid supplied is introduced around the internal surface of the cylindrical chamber 2 through the liquid ejecting hole 13 of the disc-type liquid distributor 12. Even when the reverse conical body 10 is not attached, liquid distributor 12 can be disposed effectively.

In order to provide the liquid material with rotary movement prior to be charged to the bottom portion of the cylindrical chamber 2, a disc-type liquid revolving plate 15, shown by Fig.14 in top view and by Fig.15 in side view, having one or more of inclined slits 16 circumferentially for revolving liquid is disposed effectively (in the cylindrical chamber) at a place between the one or more through holes for passing through pressurized air in the direction tangential to the circular internal surface of the cylindrical chamber and the connecting portion of the liquid supplying pipe. For conventional nozzles of coaxial double-pipe fluid atomizing nozzles, the larger the difference in discharge velocities between the liquid material and the swift air stream, the larger the shearing and atomizing effects. Thus, an increased supply pressure of the liquid material for increasing the discharge velocity worsens atomizing and results in adverse effects. In the present invention, the arrangement of the inclined slit 16 enables pressurized supply of the liquid and decreases greatly the amount of pressurized air, which solves the essential defect of conventional double-pipe fluid atomizing nozzles. The present nozzle can be installed in existing spray dryers in place of pressurized spray nozzles, and atomization of highly viscous liquid materials unable to be atomized so far, becomes

feasible.

When the present nozzle is employed for a spray dryer, the nozzle is to be inserted close to the hot air supplying portion. In that case, since the cylindrical chamber 2 and the liquid supplying pipe 1 are covered with the external cylinder 6, overheating and charring of the liquid can be prevented effectively.

When the cylindrical chamber and the orifice are so designed that they are not integrated but separable as shown in the Figs, parts having respectively several kinds of cross-sectional area enable nozzles capable of being combined suitably for processing various liquid materials. In ordinary double-pipe fluid atomizing nozzles, preparation of tens of kinds of nozzles of the same series are required usually, since the amount of liquid material to be processed by one specified nozzle is narrowly restricted. In the present invention, 5 kinds of nozzle openings corresponding to orifice diameters can manage liquid materials amounting from several liter/h - several thousands liter/h . By combining cylindrical chambers having several kinds of (total) air through hole diameters with orifices having several kinds of opening sizes, optimum atomization features are available.

In the present invention, nozzles having optional lengths for the liquid supply pipe and for the external cylinder can be fabricated, and even extremely lengthy ones are manageable by mere increases in costs added for the increased weight of the pipe materials. Even when the head portion of the nozzle is inserted into high temperature regions of a spray dryer or drying-incinerator, connecting portions of the liquid supplying pipe and pressurized air supplying pipe remain outside of the inserting portion of nozzle, which enables easy releasing of connection pipes and hoses. Further, since the nozzle is overhauled easily for cleaning without using special tools, the nozzle is suitable for uses in food industries and changeover of multiple products.

Example 1

Waste liquors of SHOUCHU spirit contains 90% or more of water and includes grain shells of several mm and fibrous materials of several tens mm. Though those apparently solid materials as dehydrated activated sludges can be incinerated with rotary kilns, waste liquors of SHOUCHU spirit are not treated similarly because of being truly liquid materials. However, by use of the liquid atomizing nozzle according to the present invention having the below mentioned specification, waste liquors of SHOUCHU spirit could be atomized and sprayed in a rotary kiln for evaporating the main portion of the water, and the residue was deposited on the kiln wall. The deposit was a solid material containing about 50% of water and resembled to dehydrated activated sludges, which was easily incinerated in the kiln and turned to ash. Since bulky solid materials hinder the atomization, they must be crushed for processing with a spray dryer, but they cause almost no trouble in inciner-

ating in a kiln.

Inside diameter of liquid supplying pipe

: $\varnothing 9.5$ mm

Diameter of orifice opening

: $\varnothing 7.5$ mm

Amount of liquid supplied

: 600 l/h

Air pressure

: 3kg/cm^2 (2,94 bar)

Amount of pressurized air supplied

: $0.6\text{Nm}^3/\text{min}$

Example 2

A viscous liquid of over 20,000 cP(mPa · s) which was unable to be atomized by use of a spray dryer with a small pressurized spray nozzle was turned to dried powder by use of the liquid atomizing nozzle according to the present invention having the below mentioned specification. The pressurized spray nozzle exhibited a spray angle of larger than 70° for a low viscosity liquid.

The present atomizing nozzle without the reverse conical body exhibited about 30° of spray angle but provided an atomized liquid capable of being dried without adhesion and turning into dried powder of good quality.

Inside diameter of liquid supply pipe

: $\varnothing 7.0\text{mm}$

Diameter of orifice opening

: $\varnothing 4.0\text{mm}$

Amount of liquid supplied

: 40l/h

Air pressure

: 3kg/cm^2 (2,94 bar)

Amount of pressurized air supplied

: $0.2\text{Nm}^3/\text{min}$

Average particle size

: 25μ

Claims

1. A liquid atomizing nozzle, comprising a liquid supplying pipe (1), a cylindrical chamber (2) for whirling of air being connected at one end with the liquid supplying pipe (1), having an inside diameter larger than the inside diameter of the liquid supplying pipe (1), and being provided with one or more through holes (3) for passing through pressurized air in the direction tangential to the circular internal surface of the cylindrical chamber (2), an orifice (4) disposed at the top of the cylindrical chamber (2) and having a circular opening (5) with a diameter smaller than that of the inside diameter of the cylindrical chamber (2), and an external cylinder (6) covering the cylindrical chamber (2) and at least a part of the liquid supplying pipe (1) and being provided with a pressurized air supplying pipe (7).

2. The liquid atomizing nozzle according to claim 1, wherein said through holes (3) for passing through pressurized air in the direction tangential to the circular internal surface of the cylindrical chamber (2) are disposed in plurality rows in the axial direction of the cylindrical chamber (2).

3. The liquid atomizing nozzle according to claim 1 or 2, wherein the ratio of the diameter of the circular opening (5) of the orifice (4) to the inside diameter of the cylindrical chamber (2) is 1 : 1.5-4.0.

4. The liquid atomizing nozzle according to any of claims 1 to 3, wherein the ratio of the area of the circular opening (5) of the orifice (4) to the total cross-sectional area of the through holes (3) for passing pressurized air tangential to the circular internal surface of the cylindrical chamber (2) is 1 : 0.2-1.0.

5. The liquid atomizing nozzle according to any of claims 1 to 4, wherein a reverse conical body (10) is disposed coaxially at the circular opening (5) of orifice (4).

6. The liquid atomizing nozzle according to any of claims 1 to 5, wherein a disc-type liquid distributor (12) having a plurality of liquid ejecting holes (13) placed evenly and concentrically for supplying dispersed liquid to the cylindrical chamber (2) is disposed in the cylindrical chamber (2) at a place between the one or more through holes (3) for passing through pressurized air in the direction tangential to the circular internal surface of the cylindrical chamber (2) and the connecting portion of the liquid supplying pipe (1).

7. The liquid atomizing nozzle according to any of claims 1 to 6, wherein a disc-type liquid revolving plate (15) having one or more of inclined slits (16) circumferentially for revolving liquid is disposed in the cylindrical chamber (2) at a place between the one or more through holes (3) for passing through pressurized air in the direction tangential to the circular internal surface of the cylindrical chamber (2) and the connecting portion of the liquid supplying pipe (1).

FIG.1

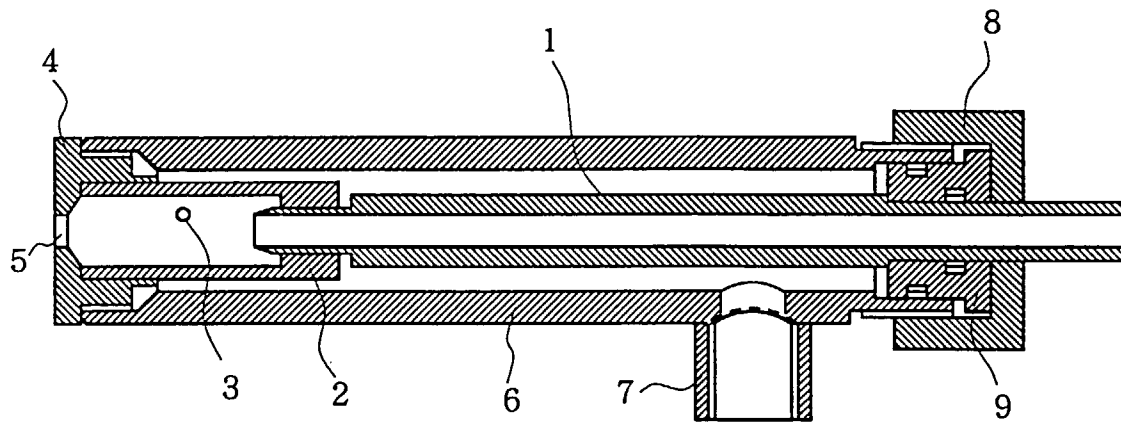


FIG.2

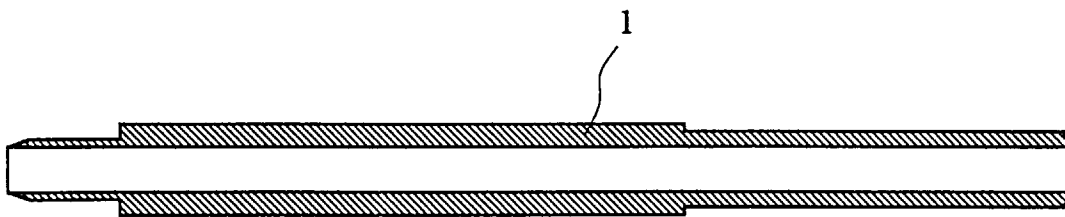


FIG.3

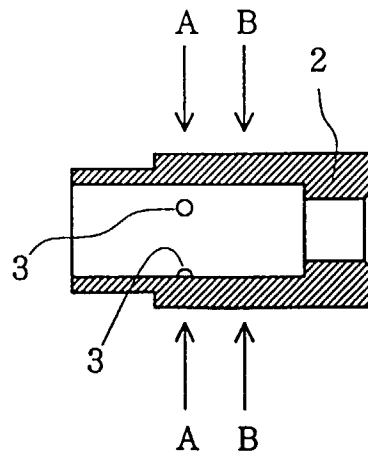


FIG.4

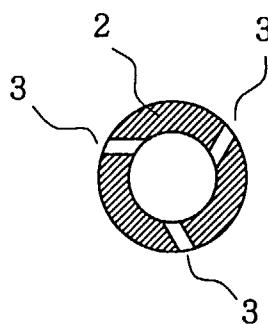


FIG.5

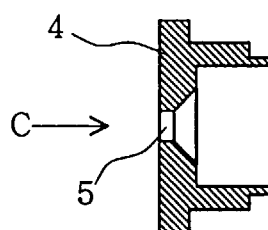


FIG.6

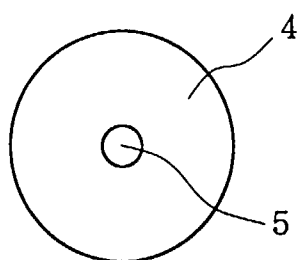


FIG.7

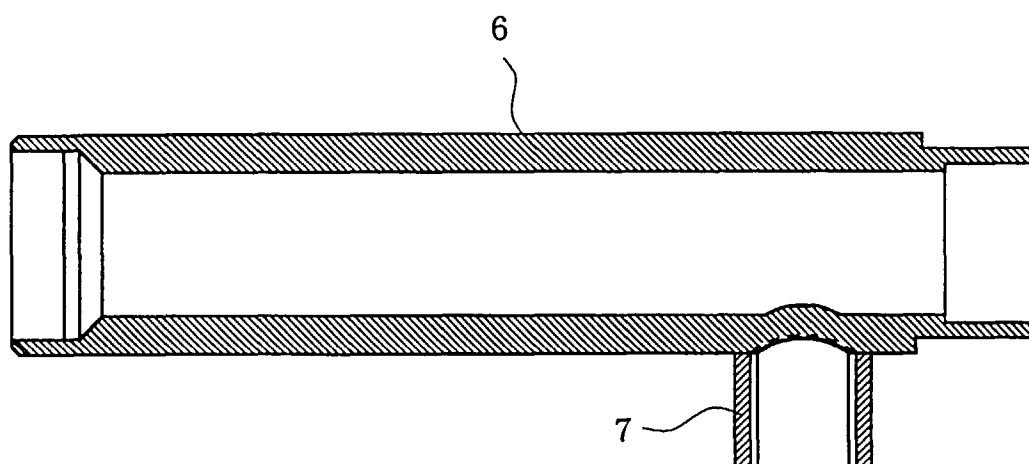


FIG.8

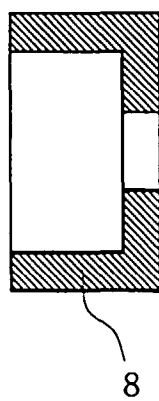


FIG.9

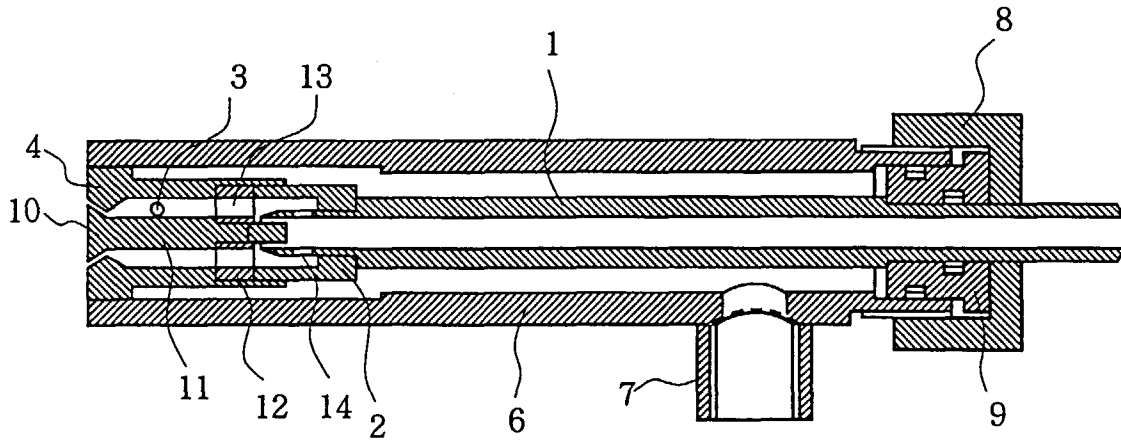


FIG.10

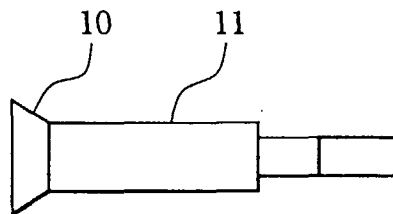


FIG.11

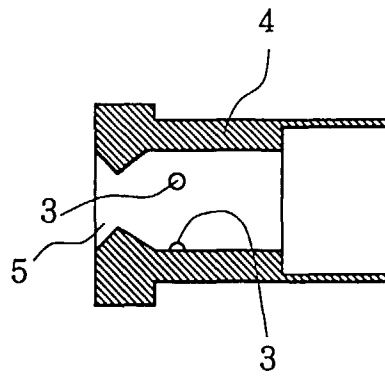


FIG.12

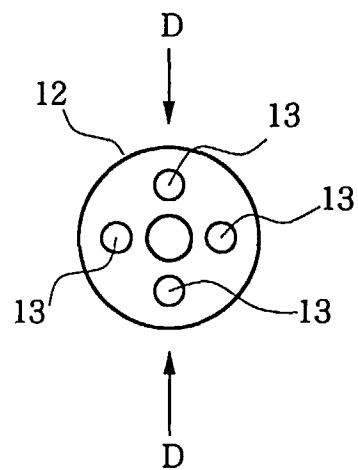


FIG.13

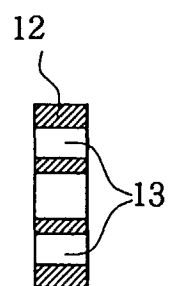


FIG.14

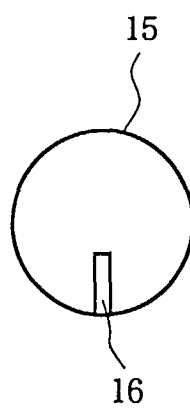


FIG.15

