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AL LT LV MK(71) Applicant: **Polyspray sprl****1348 Louvain-La-Neuve (BE)**

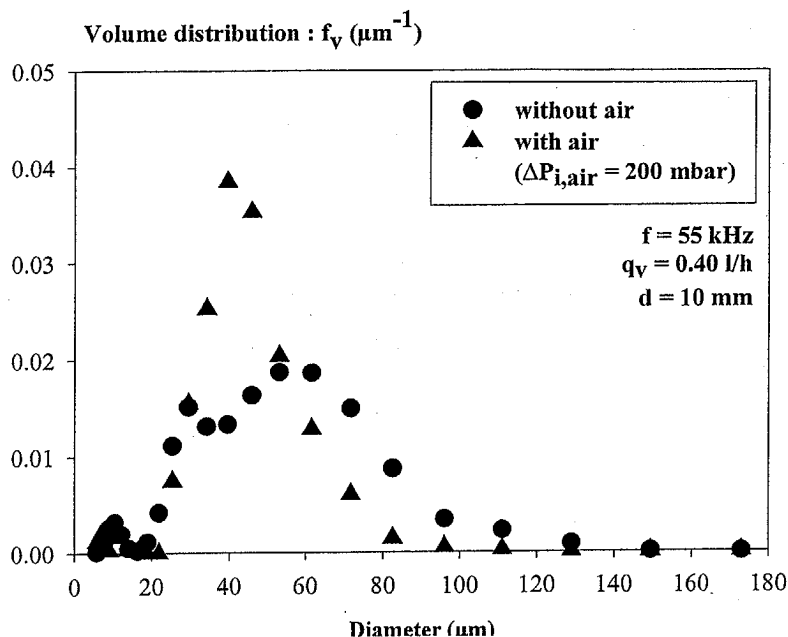
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• **Sindayihebura, Daniel****1020 Brussels (BE)**• **Dumouchel, Christophe****76000 Rouen (FR)**(74) Representative: **Van Malderen, Joelle et al****Office Van Malderen,****Place Reine Fabiola 6/1****1083 Bruxelles (BE)**(54) **Air-assisted ultrasonic atomizer**

(57) The present invention is related to a method for atomising a liquid, comprising the steps of

- providing an ultrasonic atomiser comprising a mechanical amplifier (2) having a free end that constitutes an atomising surface (4), and a liquid feeding channel (7) supplying liquid to said atomising surface (4),

- fixing said ultrasonic atomiser in a case (5) by means of a fixing strap (6) provided with gas passages (10), said case (5) not being in contact with said mechanical amplifier (2),
- inducing an gas flow around said ultrasonic atomiser directed towards a series of holes in said atomising surface (4), and
- atomising liquid on said atomising surface (4).

**Fig. 11****EP 1 508 382 A1**

Description

Field of the invention

[0001] The present invention is related to an air-assisted ultrasonic atomiser with an increased flow rate of the liquid to be atomised, an improved atomisation quality and a controlled and reduced spray drop size distribution.

State of the art

[0002] Ultrasonic atomisers composed of piezoelectric elements efficiently tied against a mechanical amplifier are well known. The mechanical amplifier allows increasing the acoustic wave energy generated by the piezoelectric elements up to a sufficient intensity level to initiate and maintain the atomisation process. Ultrasonic atomisers can be classified in two main categories according to the drop-formation physical mechanism.

[0003] The first category refers to ultrasonic atomisers for which the drop production is mainly controlled by the disintegration of a liquid jet thanks to a capillary-wave instability. These waves appear in a liquid subject to a flow that stays in contact with a vibrating solid surface. This solid surface is often constituted of an internal part of a small channel made in the mechanical amplifier, the mechanical vibrations being parallel to the liquid flow. Atomisation occurs as soon as the liquid leaves the channel (see e.g. patent US-A-5687905). The present invention does not concern this type of ultrasonic atomisers.

[0004] The second category refers to ultrasonic atomisers characterised by droplet production based on the disintegration of a mass of ligaments resulting from a square-pattern of surface wave instability. This process takes place on an atomising surface that can have different shapes : conical, spherical, flat with or without a plateau.... When the liquid arrives on the atomising surface, it almost instantaneously spreads under vibration effect and forms a film whose thickness is a function of the flow rate. The liquid film is subject to transverse vibrations and a square wave pattern develops on its interface. The liquid feeding can be ensured through a channel made in the mechanical amplifier up to the atomising surface or through an external tube that ends very near the atomising surface. In any case the required injection pressure is very small. Sindayihebura, Bolle, Cornet and Joannes (J. Acoust. Soc. Am. 103 (3), 1998, pp. 1442-1448) developed a mathematical model allowing a precise determination of the optimum dimensions of the second category ultrasonic atomisers according to a given frequency.

[0005] Although these ultrasonic atomisers produce sprays much finer than classical mechanical injectors, the resulting spray drop size distribution might not be as narrow as expected. As a matter of fact, big drops are sometimes produced. The presence of these drops

makes the atomiser inappropriate for some domestic or industrial applications. Furthermore, it has been observed that the variation of the liquid flow rate might be accompanied by non-negligible variations of the spray characteristics and drop size distribution. The increase of the flow rate induces a coarse atomisation and higher energy consumption. Such behaviour limits the possible use of these atomisers in domestic or industrial applications requiring very low flow rates only.

Aims of the invention

[0006] The present invention aims to provide a low frequency ultrasonic atomiser with a significantly increased flow rate of the liquid to be atomised, an improved atomisation quality and a controlled and reduced spray drop size distribution, overcoming the drawbacks of the state of the art solutions.

Summary of the invention

[0007] The present invention relates to a method for atomising a liquid, comprising the steps of

- providing an ultrasonic atomiser comprising a mechanical amplifier having a free end that constitutes an atomising surface, and a liquid feeding channel supplying liquid to said atomising surface,
- fixing said ultrasonic atomiser in a case by means of a fixing strap provided with gas passages, said case not being in contact with said mechanical amplifier,
- inducing a gas flow around said ultrasonic atomiser directed towards a series of holes in said atomising surface, and
- atomising liquid on said atomising surface.

[0008] Advantageously the gas flow is induced by an injection pressure below 1 bar. Preferably the gas flow is an airflow.

[0009] In a typical embodiment the ultrasonic atomiser operates at a frequency below 400 kHz.

[0010] In a second object the invention relates to a device for atomising a liquid. The device comprises an ultrasonic atomiser operating at a frequency below 400 kHz, said atomiser comprising a mechanical amplifier having a free end that constitutes an atomising surface, and a liquid feeding channel that supplies liquid to the atomising surface. The device further comprises a fixing strap confining the ultrasonic atomiser in a case, whereby there is no contact between the case and the mechanical amplifier. The fixing strap comprises gas passages and the atomising surface comprises a series of holes through which gas flows.

[0011] Advantageously the gas flow is an airflow.

[0012] Said case is typically shaped as a twyer.

[0013] In a preferred embodiment the liquid feeding channel is positioned inside the ultrasonic atomiser. In

an alternative embodiment the liquid feeding channel is external to the ultrasonic atomiser.

[0014] In another object the invention relates to a humidification device, comprising a device for atomising a liquid as described before.

Short description of the drawings

[0015] Fig. 1 represents a side section of the atomising system according to the present invention.

[0016] Fig. 2 represents a side section of an alternative embodiment of the atomisation system.

[0017] Fig. 3 represents the atomising surface of the systems presented in Figs. 1 and 2.

[0018] Fig. 4 represents a side section.

[0019] Fig. 5 represents the atomising surface of the systems presented in Fig. 4.

[0020] Fig. 6, 7, 9 represent alternatives of the atomisation systems presented in Figs. 1, 2 and 4. A liquid feeding system external to the atomiser mainly characterises such alternatives.

[0021] Fig. 8 represents the atomising surface of the atomisers shown in Figs. 6 and 7.

[0022] Fig. 10 represents the atomising surface of the atomiser shown in Fig. 9.

[0023] Fig. 11 represents the volume-based drop-size distribution for a liquid flow rate of 0.4 l/h.

[0024] Fig. 12 represents the volume-based drop-size distribution for a liquid flow rate of 0.65 l/h.

Detailed description of the invention

[0025] Actual challenge in ultrasonic atomisation technology is the increase of liquid flow rate to levels suitable for use in large scale industrial applications. The ultrasonic atomiser described in the present invention is suited for air treatment applications, especially the ones that need high liquid flow rates like humidification. Many other industrial and domestic applications do exist like the atomisation of fuel in internal combustion engines and in burners and the diffusion of specific liquids in artificial snow production systems.

[0026] The ultrasonic atomiser of low frequency (less than 400 kHz) disclosed in the invention belongs to the second category of ultrasonic atomisers as described in the prior art. The problems of the prior art solution are overcome thanks to an adequate and efficient airflow, generated through a series of small orifices made in the atomising surface of the atomiser. The airflow is induced by a very small injection pressure ($\Delta P_i < 1$ bar). Unexpectedly a small dimension fan or a deviation of a small air fraction passing through the ventilation shaft suffices to produce the required effect.

[0027] This air flow technique allows to decrease the contacts between ligament ends whose rupture induces the drop formation process, to limit drop impacting and to have a better evacuation of the drops in the atomising surface vicinity. Other advantages comprise :

- significant increase of the atomised liquid flow rate while keeping a very good atomisation quality without increased energy consumption,
- production of liquid sprays finer than those produced by the classical second-category ultrasonic atomisers : for example, at a working frequency of 55 kHz, the measured diameter of the biggest droplets in the sprays is equal to 150 μm for a non-air-assisted ultrasonic atomiser and equal to 98 μm for an air-assisted ultrasonic atomiser at an injection air pressure of about 200 mbar, and
- possibility to control the spray angle acting to the air flow direction.

[0028] Figure 1 presents the downstream part of an air assisted ultrasonic atomiser. The ultrasonic atomiser itself is made of a pair of piezoelectric elements (1), a mechanical amplifier (2) and a support (3) that sandwiches the piezoelectric elements against the amplifier. The free end of the mechanical amplifier constitutes the atomising surface (4). It comprises a series of holes of small dimension (9) through which a high fraction of the air flows. The liquid feeding is realised thanks to the use of a channel of small diameter (7) made in the mechanical amplifier (2) (Fig. 1 to 5) or in contact with the atomising surface (4) and supplying liquid to said surface (Fig. 6 to 10). A fixing-strap (6) fixes the ultrasonic atomiser in a case (5) that confines the airflow. The atomiser fixing-strap is symmetrically perforated (8) in order to make air passages (10). The confining case can advantageously be shaped as a twyer. Its internal geometry is designed such that the airflow is directed towards the holes at the atomising surface. It is important that no contact exists between the twyer (confining case (5)) and the mechanical amplifier (2). Thus, the downward part of the twyer and the atomising surface delimit an annular gap of a very small thickness ('d' in Fig.1). This allows minimising the gas flow-rate that issues from this gap. The positioning of the atomiser in the confining case is realised in order to ensure a symmetric gas flow around the ultrasonic atomiser.

[0029] Several embodiments can be envisaged. As discussed above, in Fig.1 the twyer only leaves a very narrow gap with the confining case. Some channels to pass the air can be foreseen. The atomising surface (4) is shown in Fig.3, together with the holes (9) of small dimension and the outlet of the liquid feeding channel (7). Figure 2 the air immediately passes to the atomising surface. In Fig. 4 the confining case is shaped differently, giving rise to an atomising surface with less holes, as can be seen in Fig.5.

[0030] Figures 6, 7 and 9 represent embodiments wherein the liquid feeding channel is positioned otherwise. For these cases no hole in the middle of the atomising surface is needed for supplying the liquid.

[0031] Some results with a 55 kHz ultrasonic atomiser are discussed now.

The maximum water flow rate (q_v) of a 55 kHz atomiser

not air assisted is equal to 1.1 l/h. With an air flow induced by an injection pressure of 200-mbar (ΔP_i air = 200 mbar), the maximum liquid flow rate (q_v) increases up to 4.2 l/h. Figures 11 and 12 show volume-based drop-size distribution obtained for two different liquid-flow rates, 0.40 l/h and 0.65 l/h, respectively. In both cases the air injection pressure is equal to 200 mbar. It can be seen that the resulting spray is much finer when the atomisation is air assisted.

Claims

1. Method for atomising a liquid, comprising the steps of

- providing an ultrasonic atomiser comprising a mechanical amplifier (2) having a free end that constitutes an atomising surface (4), and a liquid feeding channel (7) supplying liquid to said atomising surface (4),
- fixing said ultrasonic atomiser in a case (5) by means of a fixing strap (6) provided with gas passages (10), said case (5) not being in contact with said mechanical amplifier (2),
- inducing a gas flow around said ultrasonic atomiser directed towards a series of holes in said atomising surface (4), and
- atomising liquid on said atomising surface (4).

2. Method for atomising a liquid as in claim 1, **characterised in that** said gas flow is induced by an injection pressure below 1 bar.

3. Method for atomising a liquid as in claim 1, **characterised in that** said gas flow is an airflow.

4. Method for atomising a liquid as in claim 1, **characterised in that** said ultrasonic atomiser operates at a frequency below 400 kHz.

5. A device for atomising a liquid, comprising an ultrasonic atomiser operating at a frequency below 400 kHz, said atomiser comprising a mechanical amplifier (2) having a free end that constitutes an atomising surface (4), and a liquid feeding channel (7) supplying liquid to said atomising surface (4), said device further comprising a fixing strap (6) confining said ultrasonic atomiser in a case (5), said case not being in contact with said mechanical amplifier (2), **characterised in that** said fixing strap (6) comprises gas passages (10) and said atomising surface (4) comprises a series of holes through which gas flows.

6. The device for atomising a liquid as in claim 5, **characterised in that** said gas flow is an airflow.

7. The device for atomising a liquid as in claim 5, **characterised in that** said case (5) is shaped as a twyer.

8. The device for atomising a liquid as in claim 5, **characterised in that** said liquid feeding channel (7) is positioned inside said ultrasonic atomiser.

9. The device for atomising a liquid as in claim 5, **characterised in that** said liquid feeding channel (7) is external to said ultrasonic atomiser.

10. A humidification device, comprising a device for atomising a liquid as in any of claims 5 to 9.

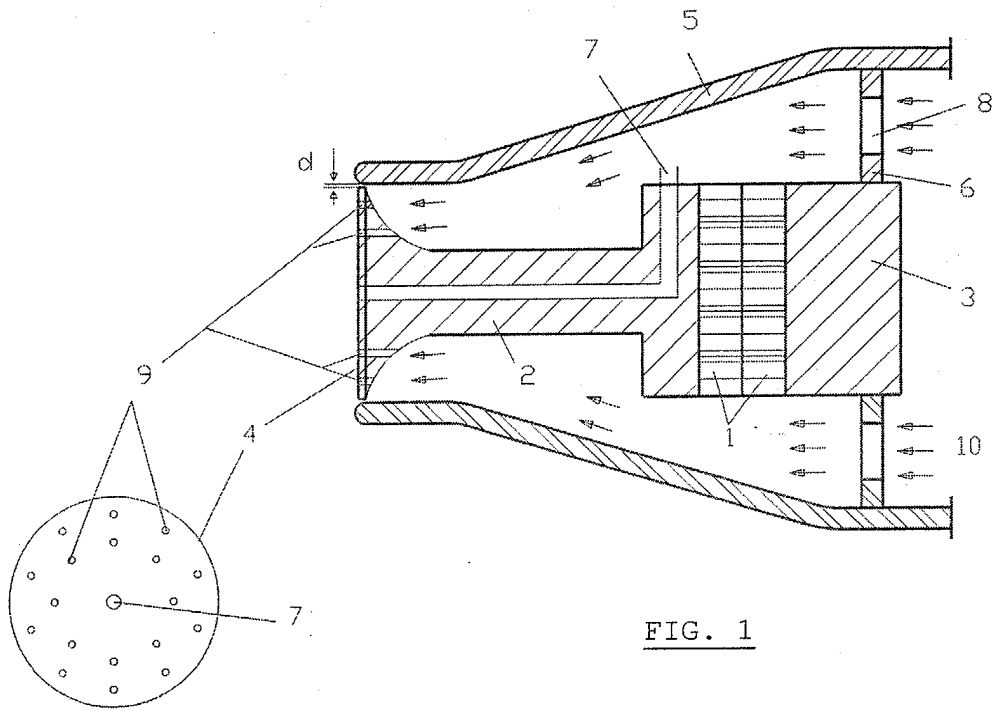


FIG. 1

FIG. 3

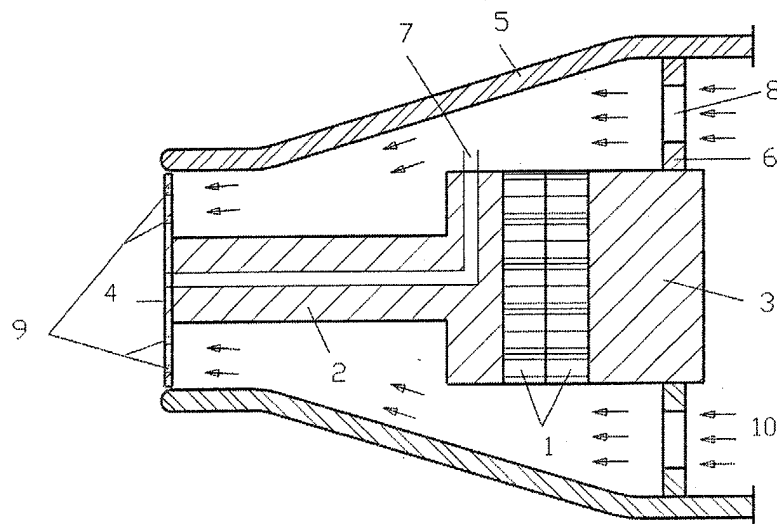
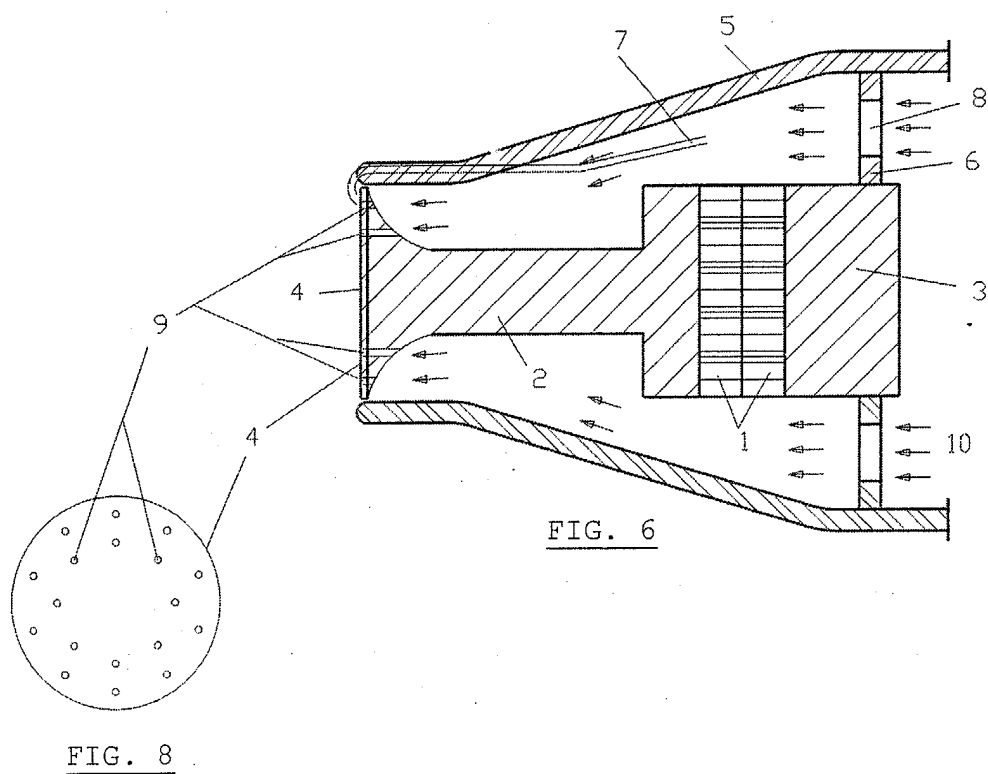
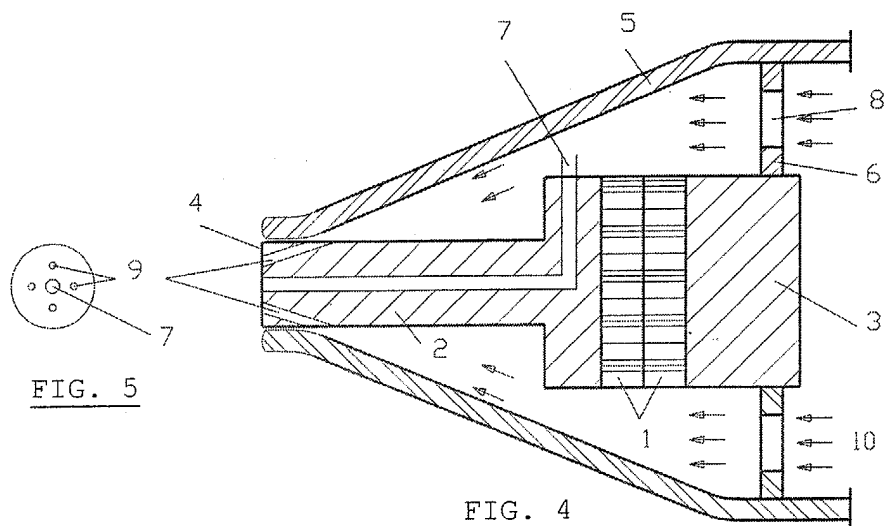


FIG. 2



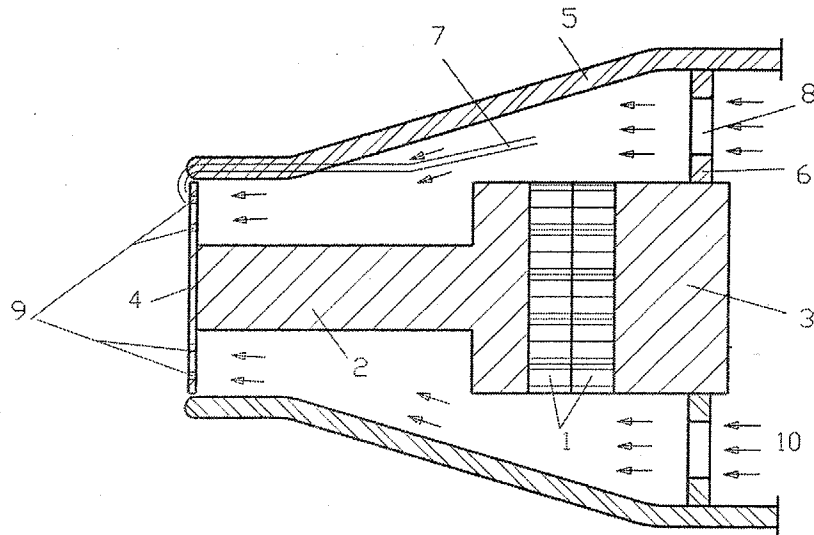


FIG. 7

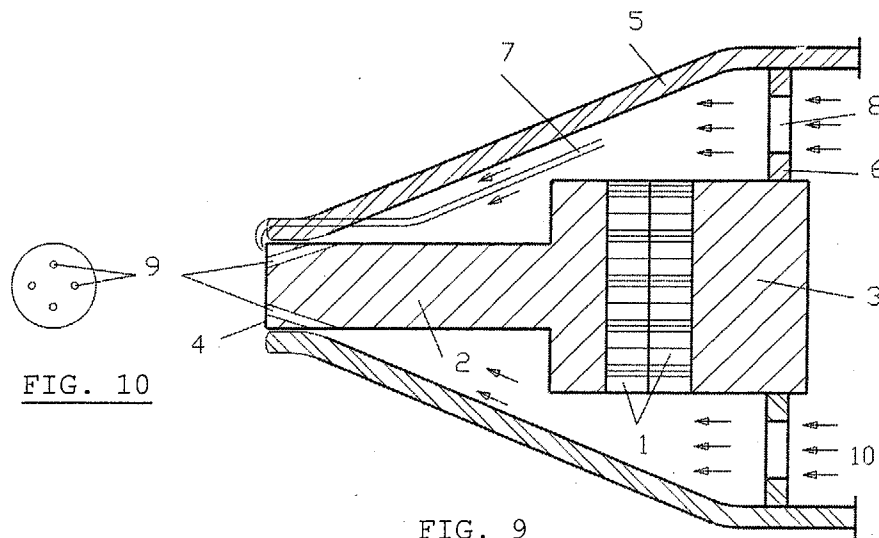
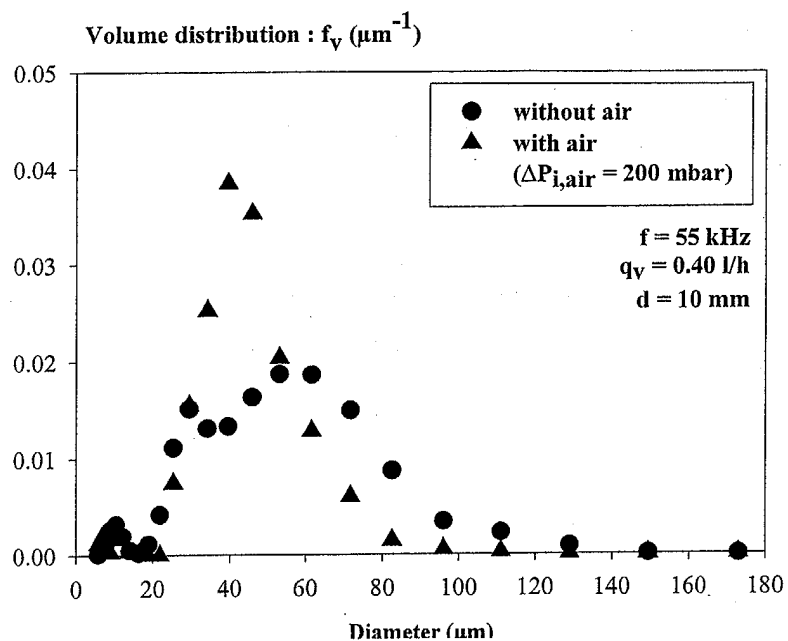
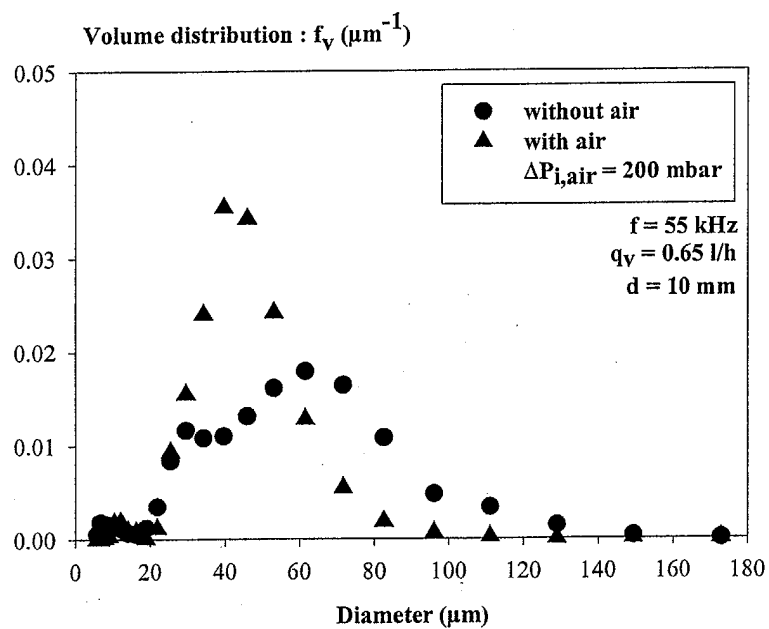


FIG. 9

FIG. 10

Fig. 11Fig. 12



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EUROPEAN SEARCH REPORT

Application Number
EP 03 44 7215

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The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int.Cl.7) B05B
Place of search MUNICH		Date of completion of the search 9 January 2004	Examiner Innecken, A
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

EPO FORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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