



Process for mass transfer between liquid and gaseous media

The invention relates to a process for mass transfer between liquid and gaseous media by spraying the liquid medium into a flow of the gaseous medium generated by forced delivery, and to a device for carrying out the process.

For air humidification or flue gas purification, for example, it is known to spray a liquid through spray nozzles into a flow channel of relatively large cross-section, in order to achieve vaporisation of the greatest possible proportion of the liquid into the gas stream. At the end of the flow channel, impingement plates are provided for precipitating unvaporised liquid droplets and to return them to a collecting tank.

GB-A 364,239 has disclosed a gas-washing device which at the same time can be used for humidifying or dehumidifying gases. The device has a spray chamber in which the liquid to be washed is sprayed into a gas flow. Downstream of the spray chamber, a scrubber is provided in which a multiplicity of plates provided with small holes are located. Forcing of the gas through the perforations effects strong turbulence and more complete washing of the gas.

EP-A2 0,352,902 describes a device for mass transfer and heat exchange between a fluid stream and a boundary layer, for example on a membrane. The device has a flow channel for the fluid and a pump for pulsed feeding of the fluid. To obtain improved exchange, obstacles for creating turbulence of the fluid are provided in the flow channel.

The invention is based on the object of finding a process of the type described, by means of which more intensive mass transfer is achieved, so that the device for carrying out the process can be constructed in a more compact manner coupled with high throughput and,

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REPLACED SHEETS		SG
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☒	Drawing(s) : paged 8 to paged 9	
☒	Abstract : paged 1 to paged 1	
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moreover, a greatly reduced proportion of unvaporised return water results. The achievement of this object is based on the features of Patent Claim 1. A device for carrying out the process is the subject of Patent Claim 3. The dependent patent claims relate to preferred embodiments of the process and device.

By means of the invention, a surprisingly great improvement in mass transfer is achieved, so that a device of relatively small dimensions is sufficient to enrich the gaseous medium up to saturation with liquid medium. Moreover, in spite of the obstacles, the flow resistance in the flow channel is substantially lower than would have to be expected. Presumably, the standing air vortices guiding the axially directed main stream are formed in the spaces between the obstacles, so that the flow resistance is relatively low in spite of the energy expended on generating the vortices. The intensified mass transfer can be explained by the special flow dynamics which are characterised by periodic changes in pressure and alterations in velocity (resonance), as are forced by the arrangement of the obstacles and/or the cavities (resonance spaces) formed by them.

The invention is explained below in more detail by reference to illustrative examples shown in the drawings, in which:

Figure 1 shows a diagrammatic representation of a device according to the invention in longitudinal section,

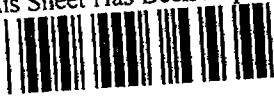
Figure 2 shows a longitudinally cut detail of the device according to Figure 1 in the region of the obstacles,

Figure 3 shows a detail of an obstacle of the device according to Figures 1 and 2,

Figure 4 to Figure 6 show design examples of the cross-sectional shape of a flow channel of a device according to the invention,

Figure 7 shows a diagrammatic representation of a flow channel with obstacles having flow around them,

Figure 8 shows a diagrammatic representation of



a flow channel with obstacles having flow through them and around them, and

Figure 9 shows a perspective detail of a honeycomb-type arrangement of mutually parallel flow channels.

5 An axial fan 3 is located in the flow channel 1 of the device downstream of the inflow opening 2. The fan is adjoined by a guide section 4, so that the gaseous medium passes in uniform flow to the region 5 of the device, where the two media come together. In this region, the device can, corresponding to the illustrative example according to Figures 1 and 2 be divided into a plurality of mutually parallel part channels 6, 7 (Figure 2), in each of which a high-pressure nozzle 8, 9 is located which distributes the liquid medium in very small droplets into the gas stream. The liquid medium is fed via a pipe grid 10 which is arranged in the flow channel 1 and from which one nozzle line 11, 12 in each case leads parallel to the axis of the flow channel 1 centrally into each part channel 6, 7, at the end of which the particular high-pressure nozzle 8, 9 is located. A suitable high-pressure nozzle: JATO molecular atomizer is supplied, for example, by JATO-Düsenbau AG, 6015 Reussbühl/Switzerland. Liquid medium not taken up by the gas stream, such as can occur especially during the starting phase of the device, is taken off from the lowest region of the flow channel via a line 41.

To generate pulsating velocity changes in the gas stream, where the liquid medium is introduced in sprayed form into the flow channel, numerous obstacles 14, 15 are installed in the region 5 or in the said part channels 6, 7, which obstacles form cavities acting as resonance spaces between themselves and cause periodic extensive constrictions of the flow pattern as a result of their arrangement in rows in the direction of flow. The resulting special flow forms effect a substantial improvement in mass transfer, without leading to an unduly great increase in the flow resistance.

The cross-sectional form of the flow channel or



of the flow part channels can be designed in different shapes, as illustrated by the examples in Figures 4 to 6 and 9. The obstacles 16, 17, 18, 19 here preferably protrude constantly in the peripheral direction of the cross-section into the flow channel, or they are provided with a constant, radially measured width, so that they follow the cross-sectional contour of the flow channel. The cross-sectional forms of Figures 5 and 6 effect faster flow in the lower cross-sectional region, so that droplets sinking into this region are more easily carried along again by the gas stream. In addition, this results in improved drainage of liquid wetting the channel wall. However, the obstacles essential to the invention largely ensure that liquid cannot precipitate out of the gas stream on the channel wall. To enable liquid collecting in the lower part of the flow channel to flow off, the latter is arranged with a slight inclination, and the annular obstacles have a small orifice 13 at the bottom.

To contribute to a reduction in the flow resistance, arcuately curved flow vessels 30, 31, 32, which guide the gas stream in the manner of nozzles into the free cross-sectional region of the flow channel, into which the obstacles 20 to 27 do not protrude, are arranged, according to the illustrative examples of Figures 7 and 8, at the start of the region 5', 5" having the obstacles 20 to 27.

In the examples shown, the obstacles consist of sheet metal parts which are adapted to the cross-sectional shape of the flow channel and are preferably annular or disc-shaped and which, for intensified turbulence in the direction opposite to that of the flow, can be bent off along the edge or bent into a conical shape, as shown by the obstacles 21, 22, 25 (Figure 8). A further variant of the shaping of the flow obstacles with a folded-in edge 28 and corrugations 29 is shown in Figure 3.

For an adequate effect of the obstacles, they protrude considerably into the flow cross-section of the flow channel, for example by one third of the radius



thereof, and their axial mutual spacing is of the order of magnitude of their radial dimension.

Figure 9 shows an illustrative example of the device, in which metal sheets bent into corrugations are arranged in parallel at a small mutual spacing, so that they form a plurality of flow channels 34 to 38 with interposed outflow gaps 39 which lead into the flow channel located below.



Patent Claims

1. Process for mass transfer between liquid and gaseous media by spraying the liquid medium into a flow of the gaseous medium generated by forced delivery, characterised in that the gaseous medium is passed, in the direction of flow, through successive constrictions and widenings of the flow path, so that it undergoes changes in velocity and pressure in contact with the sprayed medium, and the liquid medium is sprayed by means of at least one high-pressure nozzle into the flow of the gaseous medium, which has already passed through at least one constriction.
2. Process according to Claim 1, characterised in that the liquid medium is sprayed by means of the high-pressure nozzle (8, 9) at a pressure in the range from 5 to 600 bar, preferably more than 60 bar.
3. Device for carrying out the process according to Claim 1, having means for generating a gas stream, at least one flow channel for guiding the gaseous medium and at least one high-pressure nozzle leading into the flow channel, characterised in that, at least in a part (5) of the flow channel (1), a number of obstacles (14-27) aligned transversely to the axis of the flow channel (1) are provided at mutual spacings in the direction of flow, which obstacles greatly reduce the flow cross-section within narrow local limits and form cavities between themselves, the outlet of the high-pressure nozzle (8, 9), of which there is at least one, being located in this part (5) of the flow channel, and the part (5, 5', 5''), provided with the obstacles (14-27), of the flow channel starting before the outlet of the high-pressure nozzle (8, 9) as viewed in the direction of flow.
4. Device according to Claim 3, characterised in that the obstacles are formed by transverse walls (16-20) of the type of orifice plates in the flow channel (1), so that there is a flow through them.
5. Device according to Claim 3, characterised in that the obstacles (21-27) in the central region of the cross-section of the flow channel (1, 5'') are fixed at a





mutual spacing and at a distance from the wall of the flow channel, so that there is a flow around them.

6. Device according to Claim 3, characterised in that obstacles with flow both through them and around
5 them are arranged in the flow channel (1, 5').

7. Device according to one of Claims 3 to 6, characterised in that, upstream of the part (5, 5', 5'') of the flow channel (1) with the obstacles (14-27), at least one flow vessel (30-32) is located which has an arcuately
10 curved cross-section and which leads the gaseous medium into the cross-sectional part, free of obstacles (14-27), of the flow channel.

8. Device according to one of Claims 3 to 7, characterised in that the obstacles (14-27) consist of flat or
15 slightly curved thin walls aligned perpendicular to the axis of the flow channel (1, 5, 5', 5'').

9. Device according to one of Claims 3 to 8, characterised in that a plurality of flow channels of honeycomb-type overall cross-section are arranged parallel to
20 one another, adjacent flow channels having common walls.

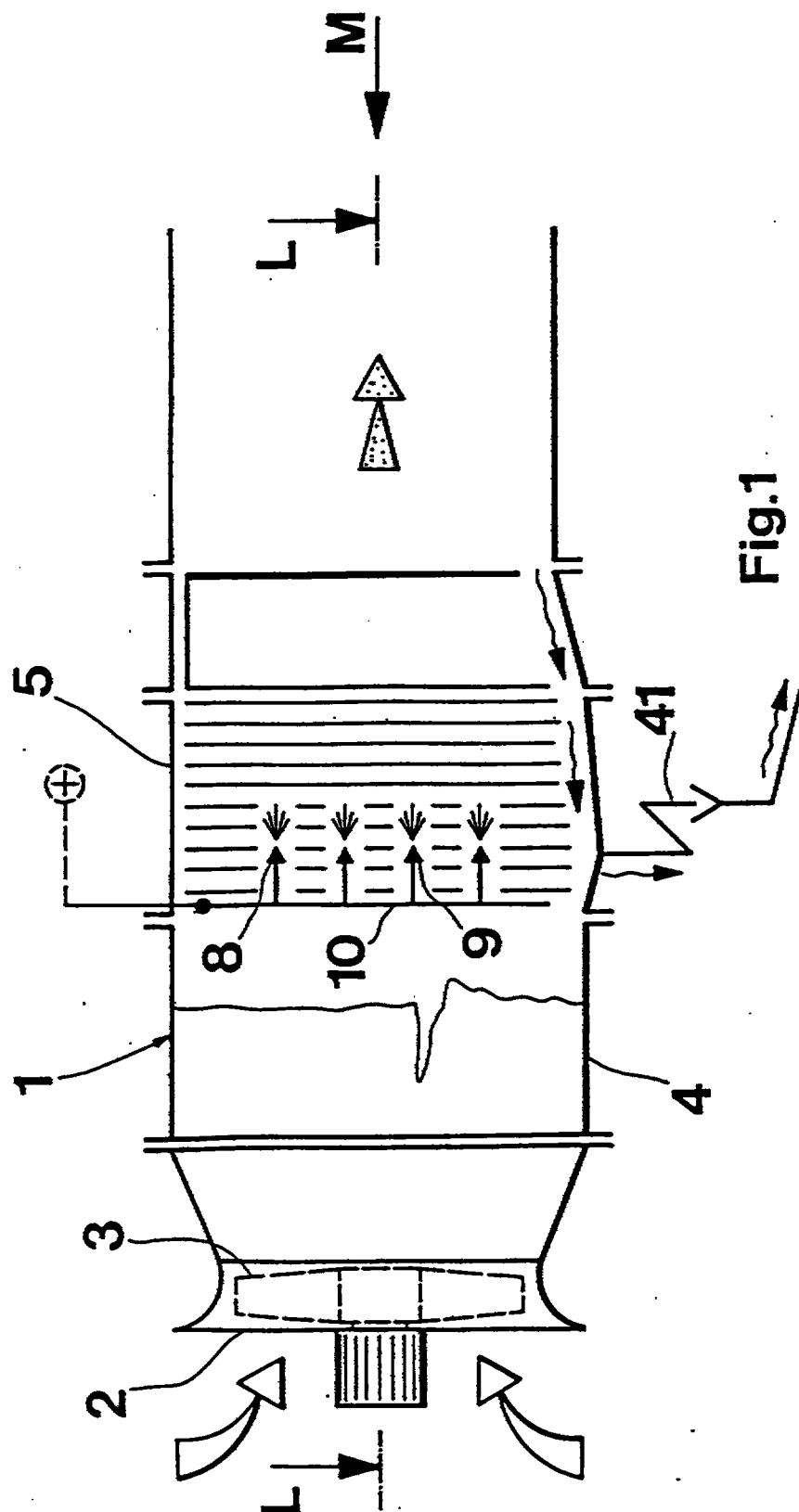


Abstract

Obstacles (20-22) in the form of orifice plates or discs are installed in a flow channel (5'), bearing a gaseous medium, of the device; the obstacles form cavities acting as resonance spaces between themselves and result in flow forms and pulsations which lead to improved mass transfer with the liquid medium sprayed in through a high-pressure nozzle (8).

(Figure 8)





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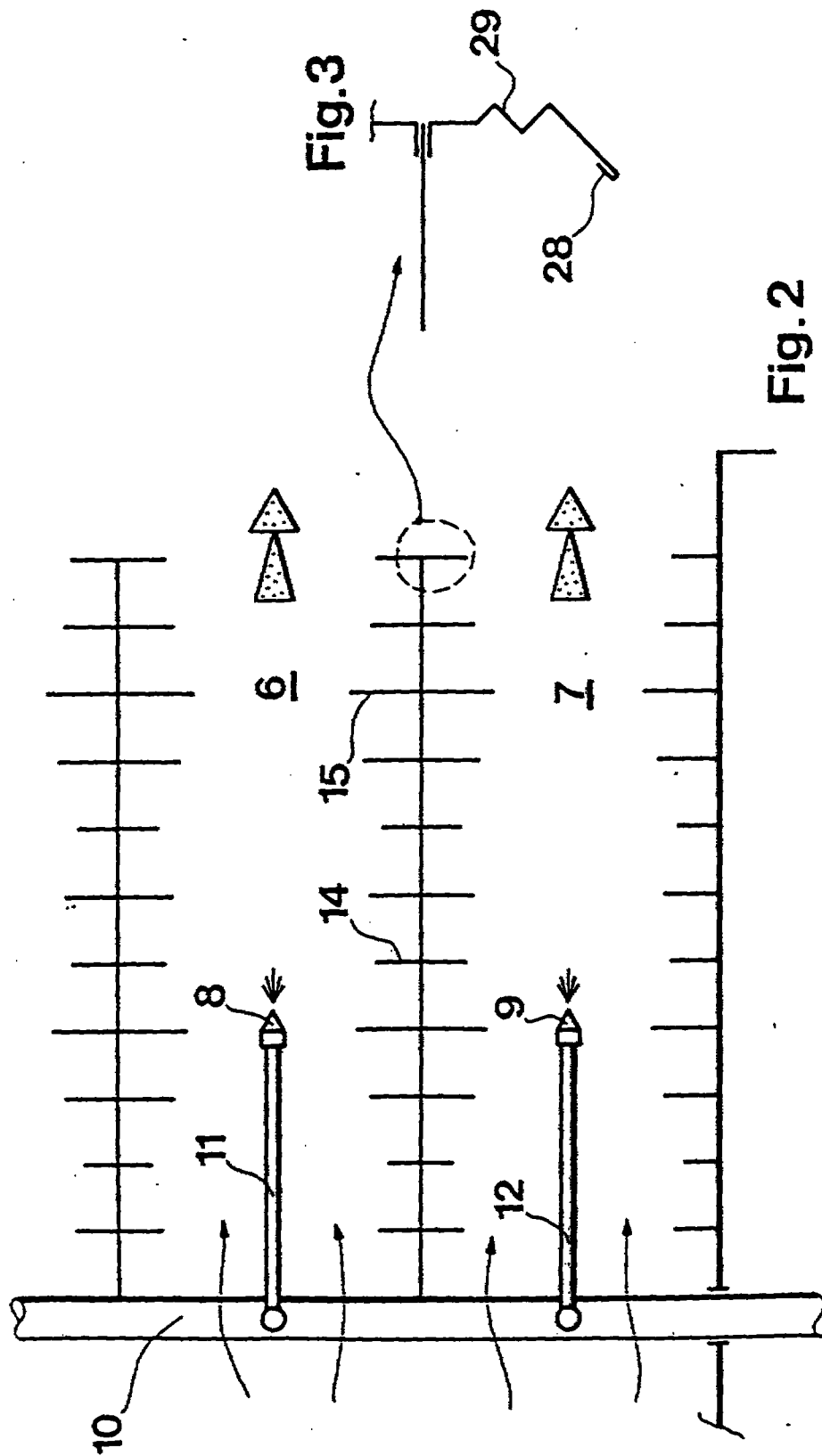


Fig. 2

Fig. 3



Fig. 4

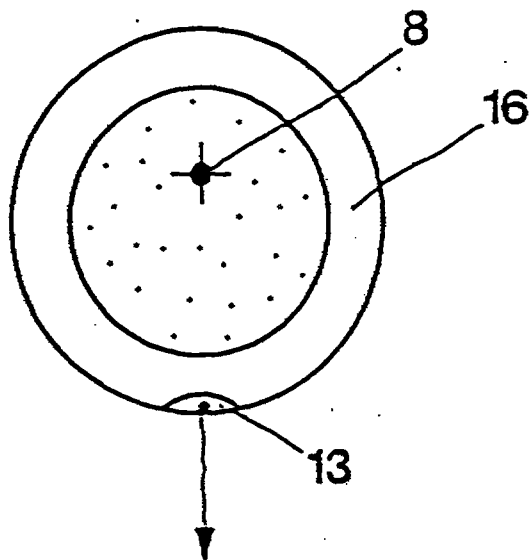


Fig. 5

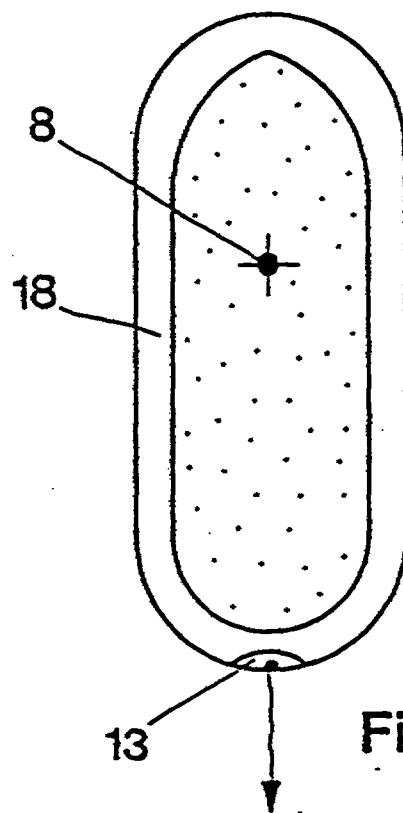
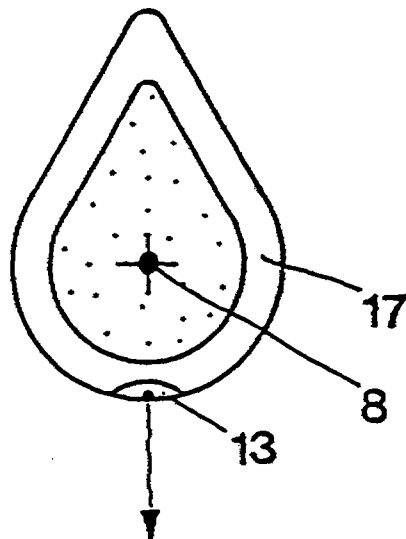
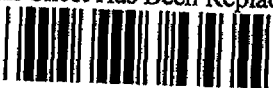


Fig. 6

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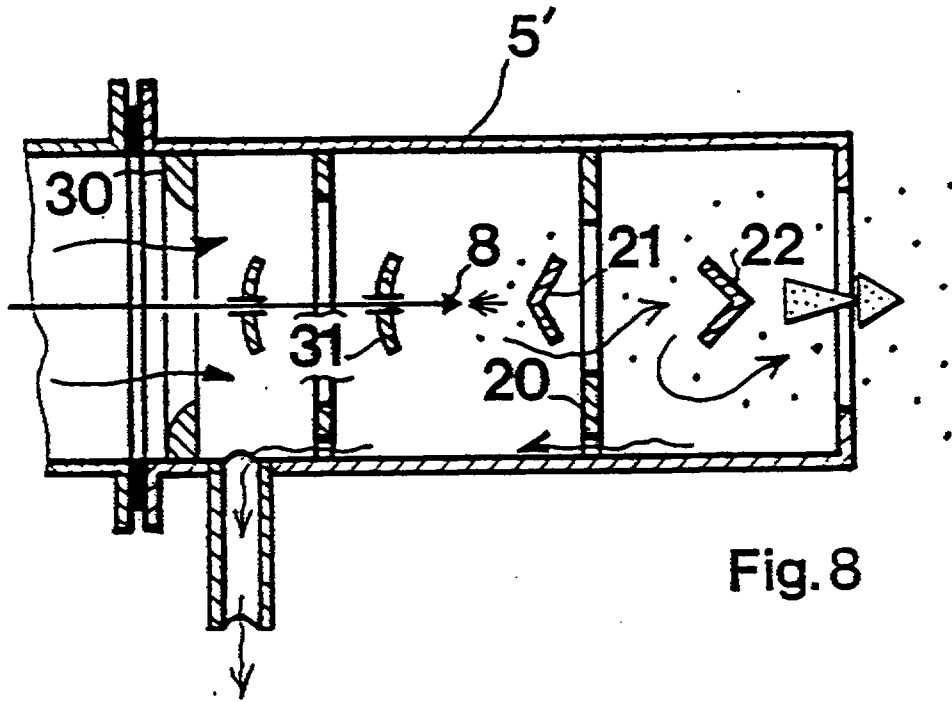


Fig. 8

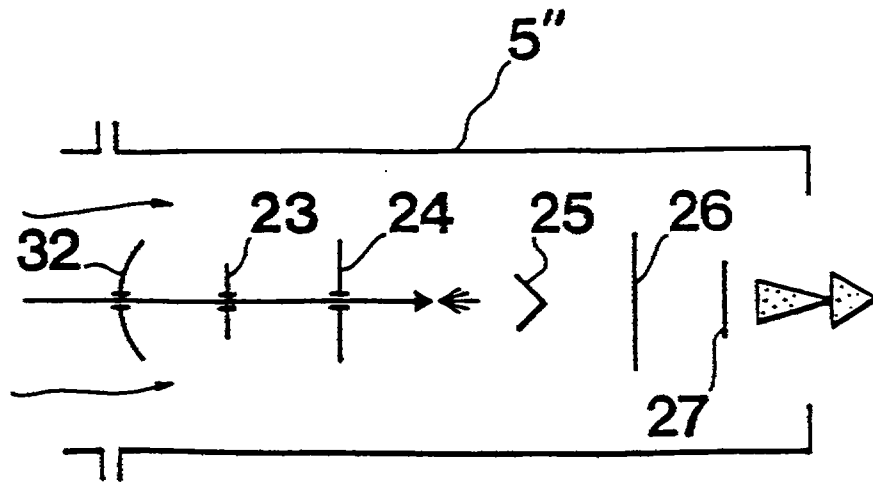


Fig. 7

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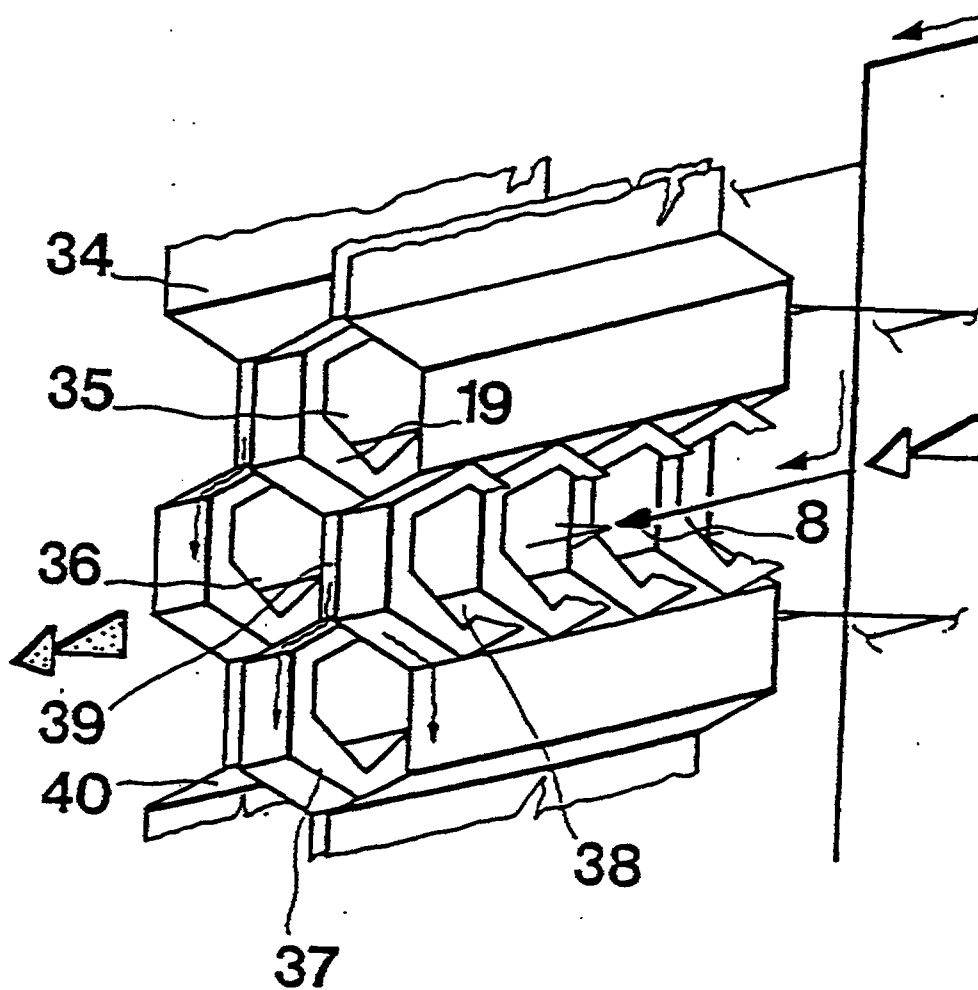


Fig.9

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✓ (1) (b) : page 1. to page 7.
✓ (1) (c) : page 1. to page 7.
✓ (1) (d) : page 1. to page 7.

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For air humidification or flue gas purification, for example, it is known to spray a liquid through spray nozzles into a flow channel of relatively large cross-section, in order to achieve vaporisation of the greatest possible proportion of the liquid into the gas stream. At the end of the flow channel, impingement plates are provided for precipitating unvaporised liquid droplets and to return them to a collecting tank.

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EP-A2 0,352,902 describes a device for mass transfer and heat exchange between a fluid stream and a boundary layer, for example on a membrane. The device has a flow channel for the fluid and a pump for pulsed feeding of the fluid. To obtain improved exchange, obstacles for creating turbulence of the fluid are provided in the flow channel.

The invention is based on the object of finding a process of the type described, by means of which more intensive mass transfer is achieved, so that the device for carrying out the process can be constructed in a more compact manner coupled with high throughput and,

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moreover, a greatly reduced proportion of unvaporised return water results. The achievement of this object is based on the features of Patent Claim 1. A device for carrying out the process is the subject of Patent Claim 3. The dependent patent claims relate to preferred embodiments of the process, and device.

By means of the invention, a surprisingly great improvement in mass transfer is achieved, so that a device of relatively small dimensions is sufficient to enrich the gaseous medium up to saturation with liquid medium. Moreover, in spite of the obstacles, the flow resistance in the flow channel is substantially lower than would have to be expected. Presumably, the standing air vortices guiding the axially directed main stream are formed in the spaces between the obstacles, so that the flow resistance is relatively low in spite of the energy expended on generating the vortices. The intensified mass transfer can be explained by the special flow dynamics which are characterised by periodic changes in pressure and alterations in velocity (resonance), as are forced by the arrangement of the obstacles and/or the cavities (resonance spaces) formed by them.

The invention is explained below in more detail by reference to illustrative examples shown in the drawings, in which:

Figure 1 shows a diagrammatic representation of a device according to the invention in longitudinal section,

Figure 2 shows a longitudinally cut detail of the device according to Figure 1 in the region of the obstacles,

Figure 3 shows a detail of an obstacle of the device according to Figures 1 and 2,

Figure 4 to Figure 6 show design examples of the cross-sectional shape of a flow channel of a device according to the invention,

Figure 7 shows a diagrammatic representation of a flow channel with obstacles having flow around them,

Figure 8 shows a diagrammatic representation of

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a flow channel with obstacles having flow through them and around them, and

Figure 9 shows a perspective detail of a honeycomb-type arrangement of mutually parallel flow channels.

An axial fan 3 is located in the flow channel 1 of the device downstream of the inflow opening 2. The fan is adjoined by a guide section 4, so that the gaseous medium passes in uniform flow to the region 5 of the device, where the two media come together. In this region, the device can, corresponding to the illustrative example according to Figures 1 and 2 be divided into a plurality of mutually parallel part channels 6, 7 (Figure 2), in each of which a high-pressure nozzle 8, 9 is located which distributes the liquid medium in very small droplets into the gas stream. The liquid medium is fed via a pipe grid 10 which is arranged in the flow channel 1 and from which one nozzle line 11, 12 in each case leads parallel to the axis of the flow channel 1 centrally into each part channel 6, 7, at the end of which the particular high-pressure nozzle 8, 9 is located. A suitable high-pressure nozzle: JATO molecular atomizer is supplied, for example, by JATO-Düsenbau AG, 6015 Reussbühl/Switzerland. Liquid medium not taken up by the gas stream, such as can occur especially during the starting phase of the device, is taken off from the lowest region of the flow channel via a line 41.

To generate pulsating velocity changes in the gas stream, where the liquid medium is introduced in sprayed form into the flow channel, numerous obstacles 14, 15 are installed in the region 5 or in the said part channels 6, 7, which obstacles form cavities acting as resonance spaces between themselves and cause periodic extensive constrictions of the flow pattern as a result of their arrangement in rows in the direction of flow. The resulting special flow forms effect a substantial improvement in mass transfer, without leading to an unduly great increase in the flow resistance.

The cross-sectional form of the flow channel or

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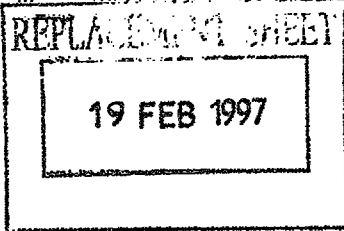
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of the flow part channels can be designed in different shapes, as illustrated by the examples in Figures 4 to 6 and 9. The obstacles 16, 17, 18, 19 here preferably protrude constantly in the peripheral direction of the cross-section into the flow channel, or they are provided with a constant, radially measured width, so that they follow the cross-sectional contour of the flow channel. The cross-sectional forms of Figures 5 and 6 effect faster flow in the lower cross-sectional region, so that droplets sinking into this region are more easily carried along again by the gas stream. In addition, this results in improved drainage of liquid wetting the channel wall. However, the obstacles essential to the invention largely ensure that liquid cannot precipitate out of the gas stream on the channel wall. To enable liquid collecting in the lower part of the flow channel to flow off, the latter is arranged with a slight inclination, and the annular obstacles have a small orifice 13 at the bottom.

To contribute to a reduction in the flow resistance, arcuately curved flow vessels 30, 31, 32, which guide the gas stream in the manner of nozzles into the free cross-sectional region of the flow channel, into which the obstacles 20 to 27 do not protrude, are arranged, according to the illustrative examples of Figures 7 and 8, at the start of the region 5', 5" having the obstacles 20 to 27.

In the examples shown, the obstacles consist of sheet metal parts which are adapted to the cross-sectional shape of the flow channel and are preferably annular or disc-shaped and which, for intensified turbulence in the direction opposite to that of the flow, can be bent off along the edge or bent into a conical shape, as shown by the obstacles 21, 22, 25 (Figure 8). A further variant of the shaping of the flow obstacles with a folded-in edge 28 and corrugations 29 is shown in Figure 3.

For an adequate effect of the obstacles, they protrude considerably into the flow cross-section of the flow channel, for example by one third of the radius



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thereof, and their axial mutual spacing is of the order of magnitude of their radial dimension.

Figure 9 shows an illustrative example of the device, in which metal sheets bent into corrugations are arranged in parallel at a small mutual spacing, so that they form a plurality of flow channels 34 to 38 with interposed outflow gaps 39 which lead into the flow channel located below.

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Patent Claims

1. Process for mass transfer between liquid and gaseous media by spraying the liquid medium into a flow of the gaseous medium generated by forced delivery, characterised in that the gaseous medium is passed, in the direction of flow, through successive constrictions and widenings of the flow path, so that it undergoes changes in velocity and pressure in contact with the sprayed medium, and the liquid medium is sprayed by means of at least one high-pressure nozzle into the flow of the gaseous medium, which has already passed through at least one constriction.
2. Process according to Claim 1, characterised in that the liquid medium is sprayed by means of the high-pressure nozzle (8, 9) at a pressure in the range from 5 to 600 bar, preferably more than 60 bar.
3. Device for carrying out the process according to Claim 1, having means for generating a gas stream, at least one flow channel for guiding the gaseous medium and at least one high-pressure nozzle leading into the flow channel, characterised in that, at least in a part (5) of the flow channel (1), a number of obstacles (14-27) aligned transversely to the axis of the flow channel (1) are provided at mutual spacings in the direction of flow, which obstacles greatly reduce the flow cross-section within narrow local limits and form cavities between themselves, the outlet of the high-pressure nozzle (8, 9), of which there is at least one, being located in this part (5) of the flow channel, and the part (5, 5', 5''), provided with the obstacles (14-27), of the flow channel starting before the outlet of the high-pressure nozzle (8, 9) as viewed in the direction of flow.
4. Device according to Claim 3, characterised in that the obstacles are formed by transverse walls (16-20) of the type of orifice plates in the flow channel (1), so that there is a flow through them.
5. Device according to Claim 3, characterised in that the obstacles (21-27) in the central region of the cross-section of the flow channel (1, 5'') are fixed at a

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mutual spacing and at a distance from the wall of the flow channel, so that there is a flow around them.

6. Device according to Claim 3, characterised in that obstacles with flow both through them and around
5 them are arranged in the flow channel (1, 5').

7. Device according to one of Claims 3 to 6, characterised in that, upstream of the part (5, 5', 5'') of the flow channel (1) with the obstacles (14-27), at least one flow vessel (30-32) is located which has an arcuately
10 curved cross-section and which leads the gaseous medium into the cross-sectional part, free of obstacles (14-27), of the flow channel.

8. Device according to one of Claims 3 to 7, characterised in that the obstacles (14-27) consist of flat or
15 slightly curved thin walls aligned perpendicular to the axis of the flow channel (1, 5, 5', 5'').

9. Device according to one of Claims 3 to 8, characterised in that a plurality of flow channels of honeycomb-type overall cross-section are arranged parallel to
20 one another, adjacent flow channels having common walls.

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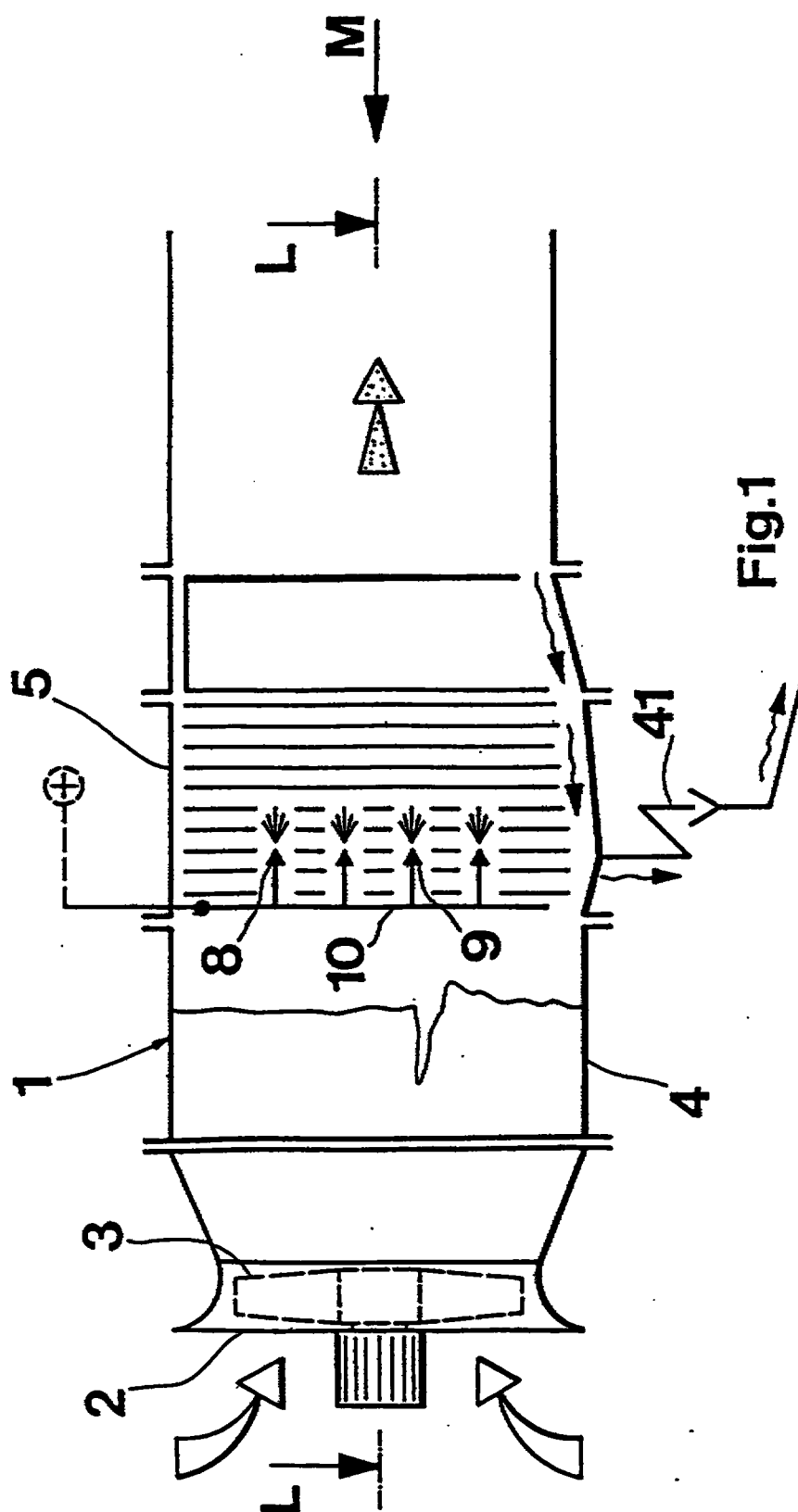
PROCESS FOR MASS TRANSFER BETWEEN LIQUID AND GASEOUS MEDIA

Abstract

Obstacles (20-22) in the form of orifice plates or discs are installed in a flow channel (5'), bearing a gaseous medium, of the device; the obstacles form cavities acting as resonance spaces between themselves and result in flow forms and pulsations which lead to improved mass transfer with the liquid medium sprayed in through a high-pressure nozzle (8).

(Figure 8)

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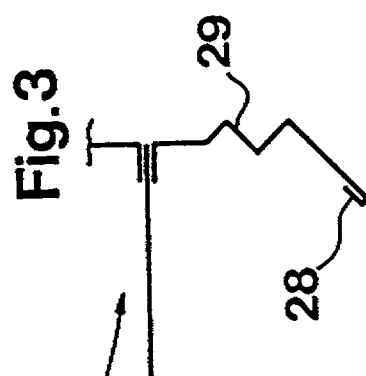
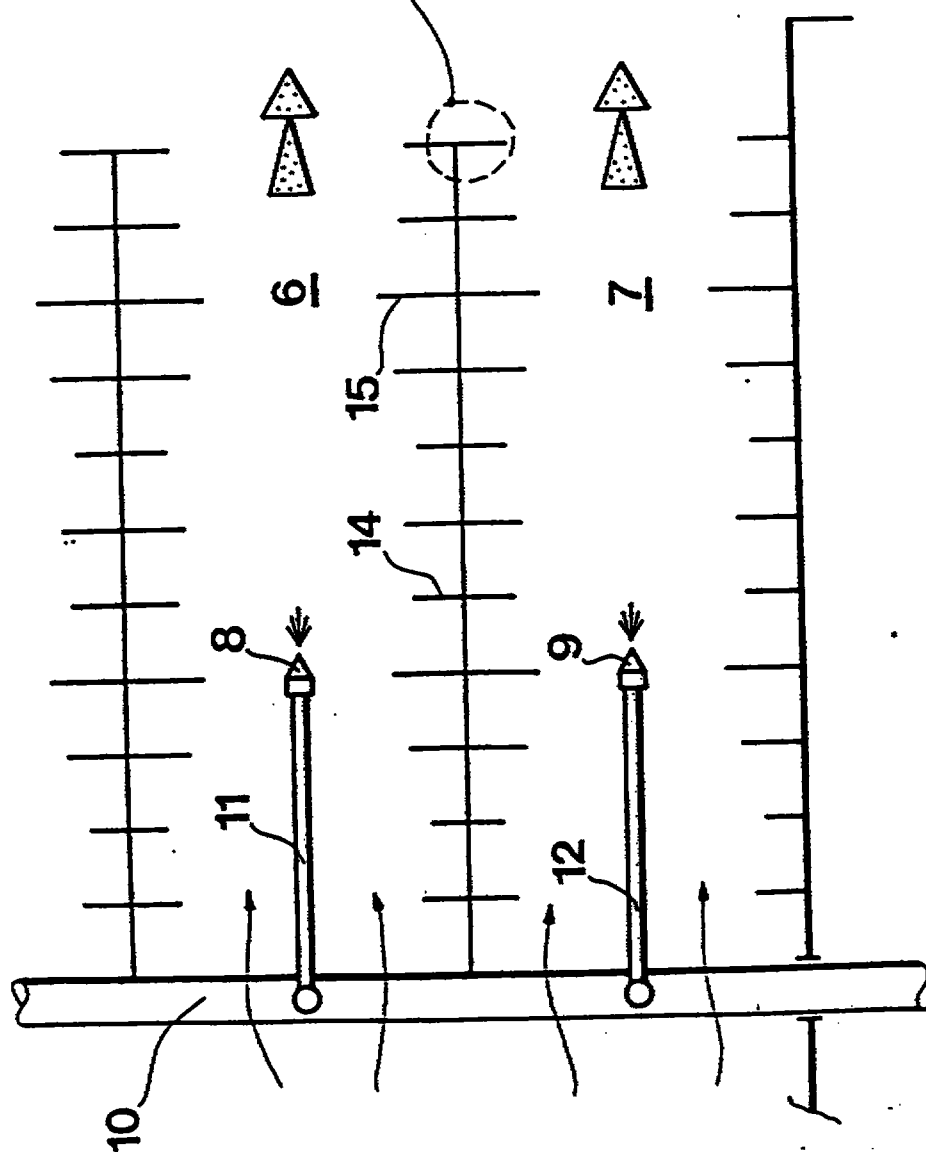


Fig.4

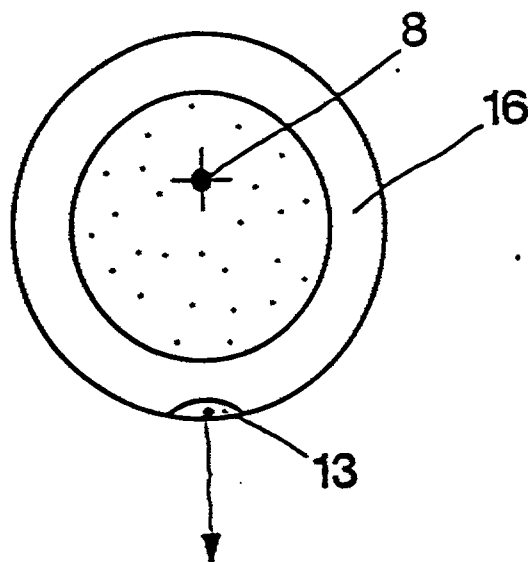


Fig.5

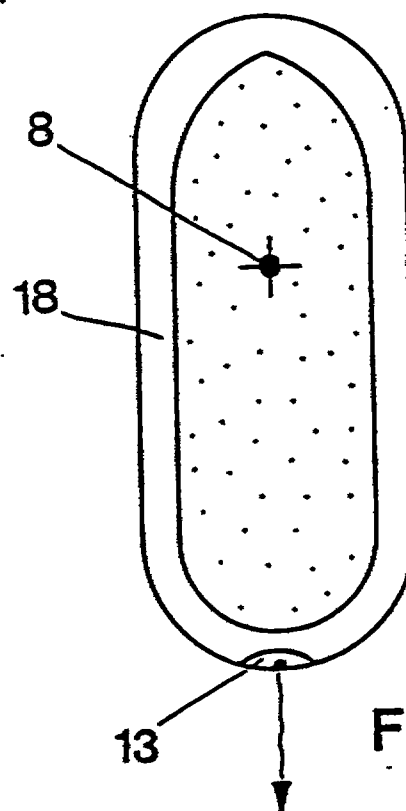
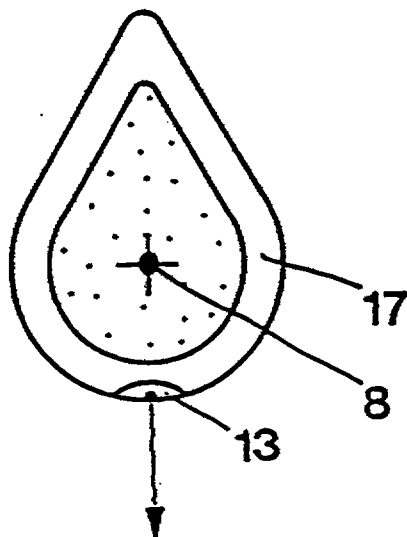


Fig.6

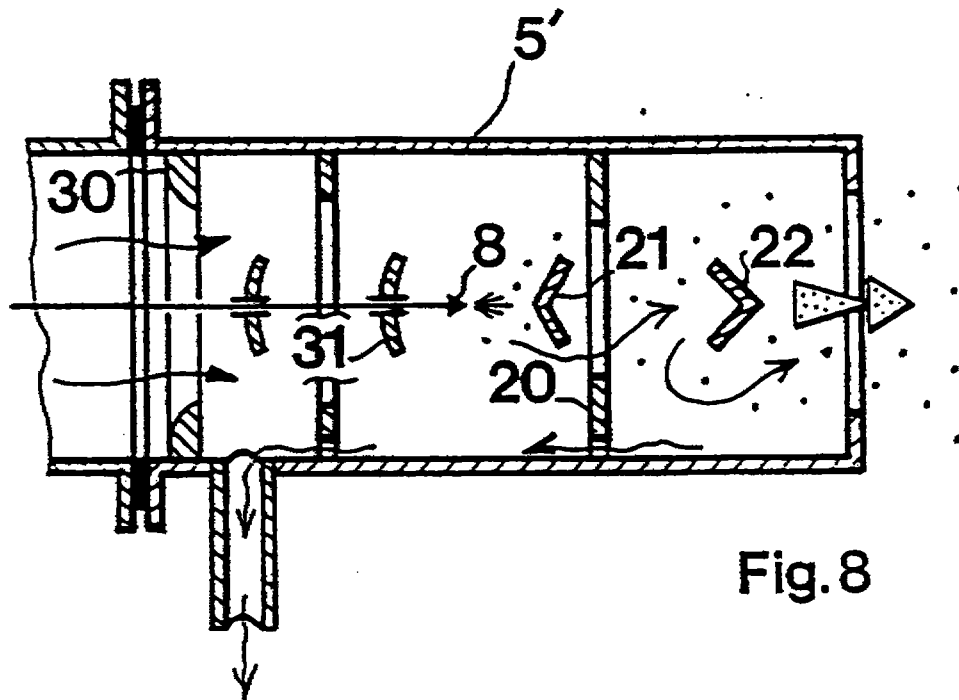


Fig. 8

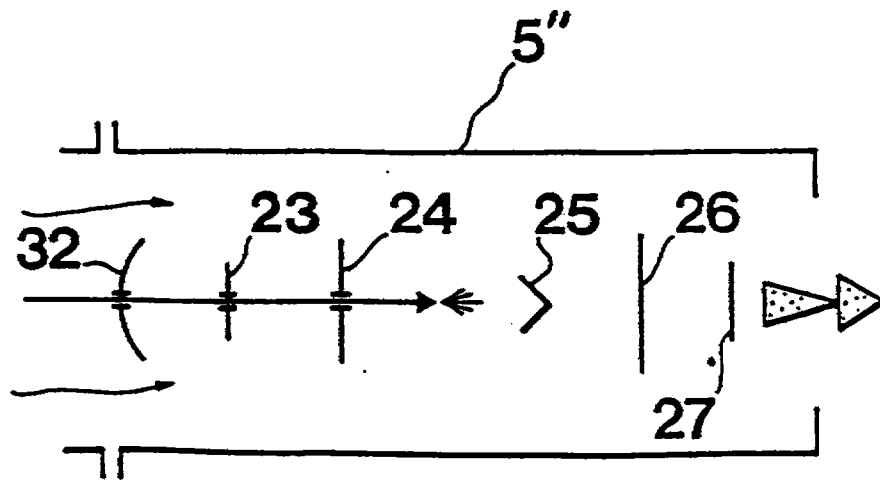


Fig. 7

