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(54) Air curtain discharge device

(57) An air curtain discharge device 33 is provided for use with an air curtain 20 of the type used to separate two spaces A, B from each other in order to protect an opening. The discharge device comprises a plenum chamber 30 for receiving compressed air. An air distribution means 32 is operable for directing and increasing the velocity of pressurized air from the plenum chamber towards an outlet 38. The air curtain discharge device further comprises means 34 for reducing turbulence within the air.

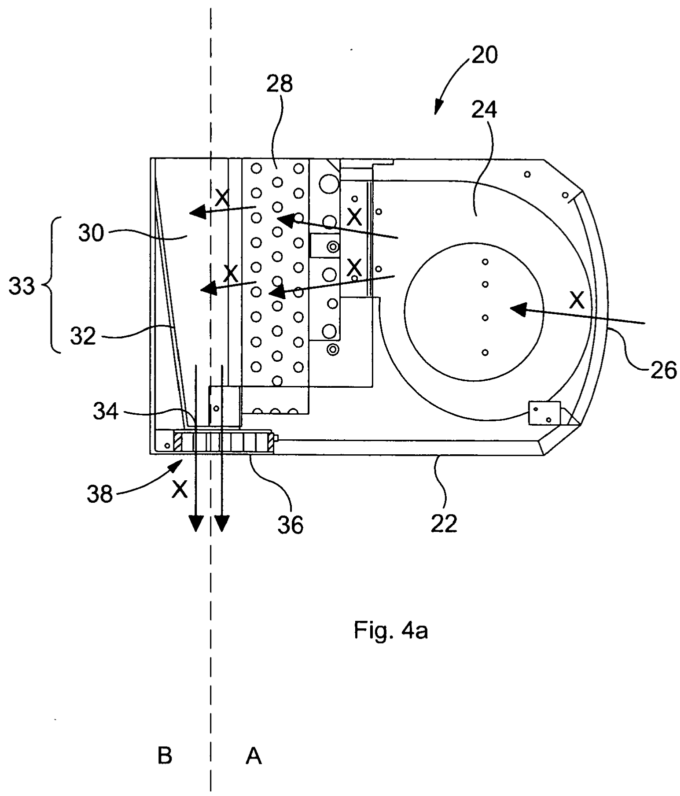

Fig. 4a

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Description

[0001] The present invention relates to an air curtain discharge device for use in or with an air curtain for separating two spaces from each other in order to protect an opening.

[0002] It is known to provide a downward-facing air curtain e.g. above a doorway of a building, the air curtain providing a downwardly projecting stream of air forming a barrier that assists in retaining the atmosphere inside the building e.g. to avoid losing heat to the outside, as well as ensuring contaminants do not enter the building.

[0003] For such systems to be effective, an air stream is required, and two of the most important attributes of the air stream are air velocity projection and air velocity uniformity.

[0004] Good air velocity projection requires maintaining the air velocity within the air stream at a long distance from the discharge nozzle of the air curtain. A test method is described in ISO27327-1 to measure and calculate the average air curtain core velocity (core speed) of the air stream to assess this parameter.

[0005] Good air velocity uniformity requires a consistent air velocity along the entire length of the air curtain. A test method is described in ISO27327-1 where a defining percentage is calculated from the average air core velocity and its standard deviation, with 100% representing perfect uniformity.

Figure 1 represents an air stream provided by an air curtain of ideal efficiency, having both a good air velocity projection and air velocity uniformity of the air curtain air stream. An air curtain 10 is provided above an opening 12, and configured to direct an air stream 14 downwardly (although it could also be configured to direct an air stream sideways or upwardly). In this ideal scenario, the air stream 14 extends uniformly across entire horizontal extent 14a of the opening 12 and projects the full vertical extent 14b of the opening 12 (or the full horizontal extent for a sideways air stream). This effectively reduces or prevents air from entering the space to be protected, or conditions any air that does enter the opening 12.

Figure 2 depicts a scenario where the air velocity projection is poor. Here, the portion of the opening 12 furthest from the air curtain 10 is unprotected by the air stream 14, meaning that although the full horizontal extent 14a' of the opening 12 is covered, the vertical extent of the air stream 14b' does not cover the entire height of the opening 12.

Figure 3 represents a scenario wherein the air velocity uniformity is poor. Here, the air stream 14 protects only some parts of the opening 12 whilst other parts 14c are not protected.

[0006] Known air curtain discharge systems typically suffer from the effects depicted in Figures 2 and 3.

[0007] The present invention has been devised with the foregoing in mind.

[0008] According to a first aspect of the present invention there is provided an air curtain discharge device as defined in claim 1. The invention advantageously provides both good air velocity projection and good air velocity uniformity of the air curtain air stream, enabling the air curtain to reach right across and cover an opening, to thereby reduce or prevent air from entering the space to be protected, or to condition any air that does enter the opening.

[0009] In an embodiment, the air distribution means reduces the area through which the air flows in order to increase the velocity thereof. The air distribution means may comprise a tapering nozzle or a plate arranged with respect to the plenum chamber to reduce the flow area for air received therefrom.

[0010] In an embodiment, the discharge device further comprises means for reducing turbulence within the air. The means for reducing turbulence within the air may comprise a flow air straightener. Preferably, the flow air straightener is a cellular flow air straightener.

[0011] The flow air straightener can be rotatable about its longitudinal axis such as to be operable to direct the air discharged from the outlet either perpendicularly thereto or at an angle thereto.

[0012] In an embodiment, any one or more of the plenum chamber, the air distribution means and the means for reducing turbulence extend substantially the complete length of the air curtain.

[0013] In accordance with a second aspect of the invention, there is provided an air curtain as defined in claim 9.

[0014] Preferably, any one or more of the plenum chamber, the air distribution means and the means for reducing turbulence extend substantially the complete length of the air curtain and/or the housing.

[0015] In accordance with a third aspect of the invention, there is provided a method of discharging air from an air curtain as defined in claim 12.

[0016] In an embodiment, the step of directing and increasing the velocity of pressurized air comprises reducing the area through which the air flows.

[0017] The method may further comprise directing the air discharged from the outlet at a desired angle with respect thereto.

[0018] In an embodiment, the method further comprises reducing turbulence within the air.

[0019] In accordance with a fourth aspect of the invention, there is provided a method of providing an air curtain as defined in claim 16.

[0020] The invention will now be described with respect to the accompanying drawings in which:

Figures 4a to 4c show cross sectional views of an air curtain device according to an embodiment;

Figure 5 shows an open perspective view of the air curtain device of Figures 4a to 4c;

Figure 6 shows an air straightener for use with embodiments of the invention; and

Figure 7 shows a comparison of the air velocity uniformity of the present invention compared to other air curtains of comparable specification

[0021] Referring to Figure 4a and 5, an air curtain device 20 is shown. The air curtain 20 comprises a housing 22. The housing 22 is preferably configured to extend the full width, or more, of the opening to be protected. In the embodiment shown, the air curtain device 20 is configured and depicted to provide a stream of air vertically downwardly, but it will be appreciated that the device 20 could be mounted and/or configured to provide an air stream in a different direction e.g. horizontally sideways or vertically upwards.

[0022] A fan 24 is provided within the housing 22. The fan 24 draws air in to the casing 22 through an inlet 26 from a first space A (e.g. inside a building or space to be protected from an external environment B).

[0023] The fan 24 blows the intake air to a heat transfer/exchange unit 28. The air is pressurized due to the higher static pressure generated by the fan. The housing 22 may comprise a plurality of the fans 24 along its length separated from one another by means of their mountings so that in long curtain devices the need to have excessively long fan rotors, which are hard to balance and frequently accelerate wear and failure due to rotational distortions, is avoided. The heat transfer unit 28 is operable for heating or cooling the air to a temperature desired for the air stream that will protect space A. Heating or cooling batteries e.g. electrical resistance heaters, water heating or cooling coils, DX evaporators/condensers etc may be included in the heat transfer unit 28. Alternatively, the air curtain can also be unheated or uncooled - i.e. ambient air is discharged.

[0024] The pressurized air then flows from the heat transfer unit 28 to a separate plenum pressure chamber 30. The plenum 30 keeps the air therein at a positive static pressure compared to the ambient pressure outside of the housing 22. Preferably, the plenum chamber 30 extends the complete length of the air curtain so that a positive static pressure will distribute uniformly along the complete length of the air curtain. The volume of the plenum chamber 30 provides space for storing air at a static pressure to even out the pressure over the length of the air curtain in order to provide good air velocity and airstream uniformity. In particular, where there are multiple fans 24 provided within the same housing the plenum chamber 30 receives the air flows from all the individual fan units and creates therefrom a single body of air at a uniform static pressure.

[0025] Pressurized air from the plenum chamber 30 discharges into a nozzle 32. In the embodiment shown, one side of the nozzle 32 acts as a converging plate. A portion of the pressure plenum 30 runs parallel thereto, and then the converging nozzle plate starts. The plenum and nozzle may, alternatively, be constructed as a single entity. Preferably, the nozzle 32 also extends the complete length of the air curtain 20. The nozzle 32 converges from the plenum chamber 30 so as to decrease the cross sectional area across which the air can flow. In the embodiment shown, this is achieved by providing a nozzle plate 32 within the housing 20, the plate 32 being provided at an angle with respect to the side of the housing 20. It will however be appreciated that other forms of nozzle 32 could be employed. Due to the Venturi effect, air flowing from the plenum chamber 30 through the converging nozzle 32 is accelerated to a higher velocity due to the pressure drop experienced by the air as the passage thereof is constricted by the tapering nozzle 32. The converging nozzle 32 provides increased airstream penetration (and thus efficiency) in comparison with known devices.

[0026] As the air flow passes from the fan into the plenum chamber it will be turbulent. Turbulence is reduced by the nozzle construction and geometry so making the air more streamlined.

[0027] The higher velocity air then passes from the nozzle outlet 34 through a cellular flow air straightener 36, an example of which is shown in Figure 6. The cellular straightener imposes a degree of air resistance that produces back pressure at the upstream side of the grille, and this enhances the air velocity uniformity along the whole length of the nozzle. Preferably, the flow air straightener also runs the complete length of the air curtain 20 to produce a clearly defined and uniform air stream that projects from the whole length of the air curtain 20 with enhanced penetration compared with known air curtain devices. The air flow path through the nozzle system is depicted in Figure 4 by arrows X. In the embodiment shown, the air stream is discharged from the device 20 perpendicular thereto via an outlet 38, although the discharge air stream does not necessarily have to be perpendicular to the inlet - the air path could be straight through the air curtain.

[0028] In an alternative embodiment, the flow air straightener 36 can rotate around its longitudinal axis to direct the air stream at an angle to the perpendicular, as depicted in Figures 4b and 4c. To direct the air stream partially inwards can be of advantage to ensure most or all of the heated air stream remains inside the building, to minimise or prevent heat energy leaving a doorway.

[0029] It is advantageous to reduce the turbulence before or at the interface with the outside air to minimise disturbance of the exiting air stream and thus maintain the efficiency thereof.

[0030] Together, the plenum chamber 30, the nozzle 32 and the flow air straightener 36 provide an air curtain of improved efficiency. The plenum chamber 30, nozzle 32 and flow straightener 36 work together to give an overall combined effect. The plenum chamber takes the air flow from the fan or fans and creates a single body of uniformly pressurised air. This helps achieve a uniform air velocity exiting from the curtain device. Immediately prior to exiting the curtain device the air is accelerated through the nozzle so as to increase its penetration and, as it exits the air flow is passed through an air flow straightener to produce a substantially parallel air flow with reduced turbulence. The effect of this is also to increase penetration as a) the air flow exits the flow straightners in a clearly defined and uniform air stream and b) turbulence, which is often prevalent around nozzle outlets due to fluid shear between the air stream and the substantially still air into which it is emerging is substantially reduced, thereby ensuring maximum concentration of the air stream to ensure maximum penetration. Therefore the combination of features forming the discharge device 33 and air straightener 36 ensures that the air stream it produces has a high air velocity projection with very good air velocity uniformity approaching 100% and is therefore very effective for use with an air curtain in order to provide complete climate separation across a doorway etc and to condition all air entrained into the doorway.

[0031] Tests were carried out on the air curtain of the invention and on air curtains of similar specification under standardised conditions so as to determine the effect of the invention on the air velocity uniformity at the outlet and at set distances from the outlet. The tests were carried out as described in ISO27327-1. Comparisons were made against the HP 1500W standard unit upon which the invention test unit was based; the T2000W air curtain which is of similar size and air velocity but slightly lower air volume (flow rate) and the Designer PHV 2000E which has similar flow rate and higher air speed, all of which units are manufactured by the Thermoscreens Limited. By conducting comparisons against different units having different air flow and speed ratios it was possible to determine that the effects of the invention are a result of the design and are not merely attributable to flow and speed parameter choices. Test data is given below and Figure 7 shows the data in a chart format for ease of comparison.

Air Curtain of the Invention (Modified HP1500 unit)

	distance from outlet (mm)					
height (mm)	**78**	**500**	**1000**	**2000**	**3000**	**4000**
117	9.94	7.7	5.12	3.97	3.78	2.91
215	9.35	5.74	5.17	4.01	3.71	2.98
310	9.59	6.63	5.28	4.25	3.91	3.23
405	7.35	6.19	5.36	4.69	3.75	3.01
500	9.55	7.25	5.79	4.41	3.49	3.33
595	10.14	7.1	5.39	4.21	3.78	3.25
690	9.69	6.43	5.07	4.01	3.43	2.62
785	7.02	6.26	5.18	4.32	3.77	2.99
880	9.38	7.03	5.79	4.5	3.64	2.74
980	9.48	8.08	5.51	4.12	3.31	2.73
1075	10.02	7.39	5.42	4.11	3.52	3.1
1170	8.31	6.71	5.59	3.75	3.61	2.52
1265	9.62	6.82	5.4	4.38	3.22	2.61
1360	9	5.88	4.89	3.41	3.04	2.65
1456	8.22	6.45	4.03	3.25	2.87	2.62
average speed	**9.1**	**6.8**	**5.3**	**4.1**	**3.5**	**2.9**
std deviation	1.0	0.7	0.4	0.4	0.3	0.3
uniformity	**89.5%**	**90.3%**	**91.9%**	**90.5%**	**91.5%**	**90.8%**

Example Air Curtain 1 (Designer PHV 2000E)

	distance from outlet (mm)						
height (mm)	**95**	**500**	**1000**	**1500**	**2000**	**3000**	**4000**
105	5.96	3.64	3.67	3.16	2.96	2.85	2.58

(continued)

Example Air Curtain 1 (Designer PHV 2000E)

	distance from outlet (mm)						
height (mm)	**95**	**500**	**1000**	**1500**	**2000**	**3000**	**4000**
205	6.89	5.03	3.72	2.89	2.82	2.52	3.3
300	8.19	5.2	4.01	3.2	3.06	2.48	2.57
400	8.51	5.38	4.61	4.15	3.04	2.61	2.78
495	9.52	7.24	5.38	3.96	2.99	3.76	3.23
595	7.09	6.44	4.83	4.2	3.76	3.86	3.41
690	10.22	7.88	5.31	4.21	4.69	3.96	3.11
790	9.49	6.29	4.79	4.53	4.17	3.88	3.04
885	8.84	7.03	5.44	4.95	4.39	3.34	2.41
985	7.68	6.7	5.06	3.7	3.07	2.95	1.71
1080	1.19	4.54	2.5	2.58	3.32	2.57	1.58
1180	3.67	3.89	3.58	3.38	3.27	2.82	1.68
1280	5.75	4.31	3.82	3.72	3.15	2.74	2.57
1375	8.17	5.42	4.99	4.88	4.6	2.98	1.5
1475	9.56	6.18	5.51	5.06	4.02	2.57	1.55
1570	10.27	8.6	6.83	4.39	3.66	2.42	1.73
1670	7.8	6.62	5.05	4.89	3.73	2.22	1.94
1765	9.88	7.36	5.07	3.64	3.19	3.14	1.76
1865	8.52	5.92	4.37	4.51	3.76	2.91	2.02
1960	9.7	5.69	4.02	3.15	3.49	1.83	1.49
2060	5.88	6.78	4.6	3.44	2.49	2.76	2.27
2155	3.67	6.6	4.46	3.18	3.17	1.95	1.65
2255	0.62	4.24	4.37	3.64	2.52	2.13	1.73
average speed	**7.26**	**5.96**	**4.61**	**3.89**	**3.45**	**2.84**	**2.24**
std deviation	2.75	1.30	0.88	0.71	0.61	0.60	0.65
uniformity	**62%**	**78%**	**81%**	**82%**	**82%**	**79%**	**71%**

Example Air Curtain 2 (T2000W)

	distance from outlet (mm)				
height (mm)	**87**	**500**	**1000**	**2000**	**3000**
117	1.24	3.4	3.35	2.61	2.24
215	4.76	5.16	3.29	2.34	2
315	8.03	4.81	3.24	2.18	1.99
410	6.63	4.6	2.91	2.2	2.02
510	4.62	3.17	2.82	2.12	2.13
610	3.67	3.38	3.37	2.2	2.38
705	4.25	4.56	2.98	2.45	2.3
805	6.8	4.46	2.4	3.1	2.17
905	6.25	3.15	2.79	3.06	1.79
1000	3.47	2.84	3.47	3.15	1.3
1100	1.22	4.09	3.67	2.49	2.1
1200	5.85	5.33	3.35	2.11	1.07
1295	7.31	4.36	3.87	2.02	0.78
1395	5.92	3.9	3.54	1.26	0.68
1495	4.6	4.56	2.65	0.99	0.63
1590	3.72	4.97	1.92	0.91	0.32
1690	6.39	4.04	1.56	0.37	0.32
1790	6.92	2.64	1.24	0.58	0.32

(continued)

Example Air Curtain 2 (T2000W)

	distance from outlet (mm)				
height (mm)	**87**	**500**	**1000**	**2000**	**3000**
1885	4.7	1.98	1.02	0.32	0.32
1985	3.18	1.25	0.91	0.32	0.32
2083	0.53	0.83	0.47	0.32	0.32
average speed	4.8	3.7	2.6	1.8	1.3
std deviation	2.08	1.25	1.02	0.99	0.83
uniformity	56%	66%	61%	44%	37%

Example Air Curtain 3 (HP1500W Standard Unit)

	distance from outlet (mm)					
height (mm)	**102**	**500**	**1000**	**2000**	**3000**	**4000**
132	7.53	6.18	4.77	3.64	2.55	2.18
225	7.88	5.51	4.83	2.5	1.63	1.55
320	6.78	5.99	5.25	1.67	1.2	1.41
415	8.01	6.01	3.8	1.4	1.23	1.06
505	7.1	5.74	2.83	1.5	1.64	0.98
600	7.2	4.98	2.09	1.74	1.59	1
695	7.28	3.19	2.7	2.72	1.83	1.24
790	5.64	4.69	3.44	3.02	1.74	1.04
880	6.86	5.11	4.19	3.03	2.07	2.17
975	6.33	5.48	4.49	3.19	1.65	1.73
1070	6.23	5.47	4.23	2.34	2.11	1.73
1160	6.66	5.44	3.93	2.34	1.87	0.91
1255	7.31	6.16	4.06	2.31	1.28	0.99
1350	6.78	5.56	3.96	2.49	1.31	1.01
1443	6.65	5.24	3.97	2.25	1.25	0.96
a verage speed	**6.9**	**5.4**	**3.9**	**2.4**	**1.7**	**1.3**
std deviation	0.6	0.7	0.8	0.6	0.4	0.4
uniformity	**91.0%**	**86.2%**	**78.2%**	**73.1%**	**76.8%**	**66.8%**

[0032] As can be seen from Figure 7, the present invention gives a much improved air velocity uniformity and that the air velocity uniformity is maintained irrespective of the distance from the outlet of the air curtain. This is a significant advantage over the prior art and addresses a longstanding problem associated with poor velocity uniformity resulting in less effective separation of interior and exterior environments on either side of the air curtain.

Claims

1. An air curtain discharge device for use with an air curtain, the device comprising:

a plenum chamber for receiving pressurized air;
air distribution means for directing and increasing the velocity of pressurized air from the plenum chamber towards an outlet; and
means for reducing turbulence within said air.

2. The air curtain discharge device of claim 1, wherein the air distribution means reduces the area through which the air flows in order to increase the velocity thereof.

3. The air curtain discharge device of claim 1 or 2, wherein the air distribution means comprises a tapering nozzle or a plate arranged with respect to the plenum chamber to reduce the flow area for air received therefrom.

4. The air curtain discharge device of any preceding claim, wherein the plenum chamber and/or the air distribution means extend substantially the complete length of said air curtain.

5. The air curtain discharge device of any preceding claim, wherein the means for reducing turbulence within said air comprises a flow air straightener.

6. The air curtain discharge device of claim 5, wherein the flow air straightener is a cellular flow air straightener.

7. The air curtain discharge device of claim 6, wherein the flow air straightener is rotatable about its longitudinal axis such as to be operable to direct the air discharged from the outlet either perpendicularly thereto or at an angle thereto.

8. The air curtain discharge device of any of any preceding claim, wherein the means for reducing turbulence extends substantially the complete length of said air curtain.

9. An air curtain comprising:

   a housing having an inlet and an outlet;
   means for pressurizing air received at said inlet;
   and the air curtain discharge device according to any preceding claim;
   wherein the plenum chamber receives pressurized air from the pressurizing means.

10. The air curtain of claim 9, wherein any one or more of the plenum chamber, the air distribution means and the means for reducing turbulence extend substantially the complete length of said air curtain and/or said housing.

11. A method of discharging air from an air curtain, the method comprising:

   receiving into a plenum chamber an intake of pressurized air;
   directing and increasing the velocity of pressurized air towards an outlet; and
   reducing turbulence within said air.

12. The method of claim 11, wherein the step of directing and increasing the velocity of pressurized air comprises reducing the area through which the air flows.

13. The method of claim 11 or 12, further comprising directing the air discharged from the outlet at a desired angle with respect thereto.

14. A method of providing an air curtain, the method comprising:

   providing an inlet and an outlet;
   pressurizing air received at the inlet; and
   the method of any of claims 11 to 13.

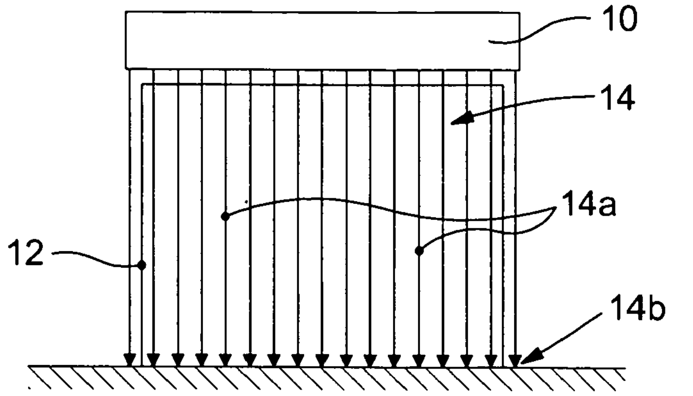

Fig. 1

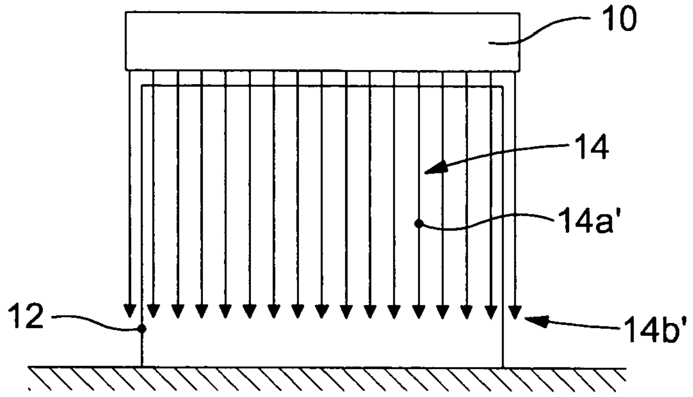

Fig. 2

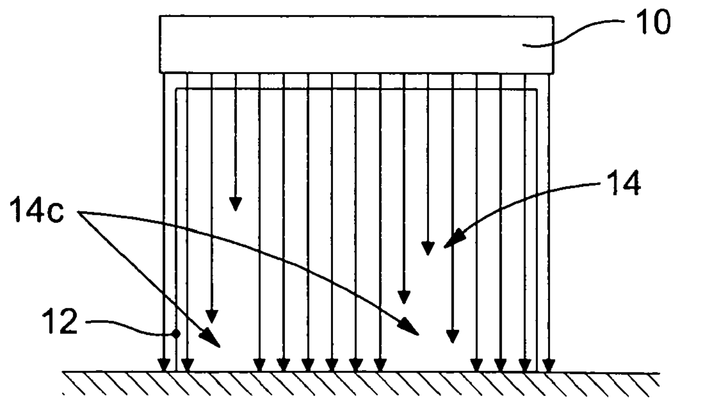

Fig. 3

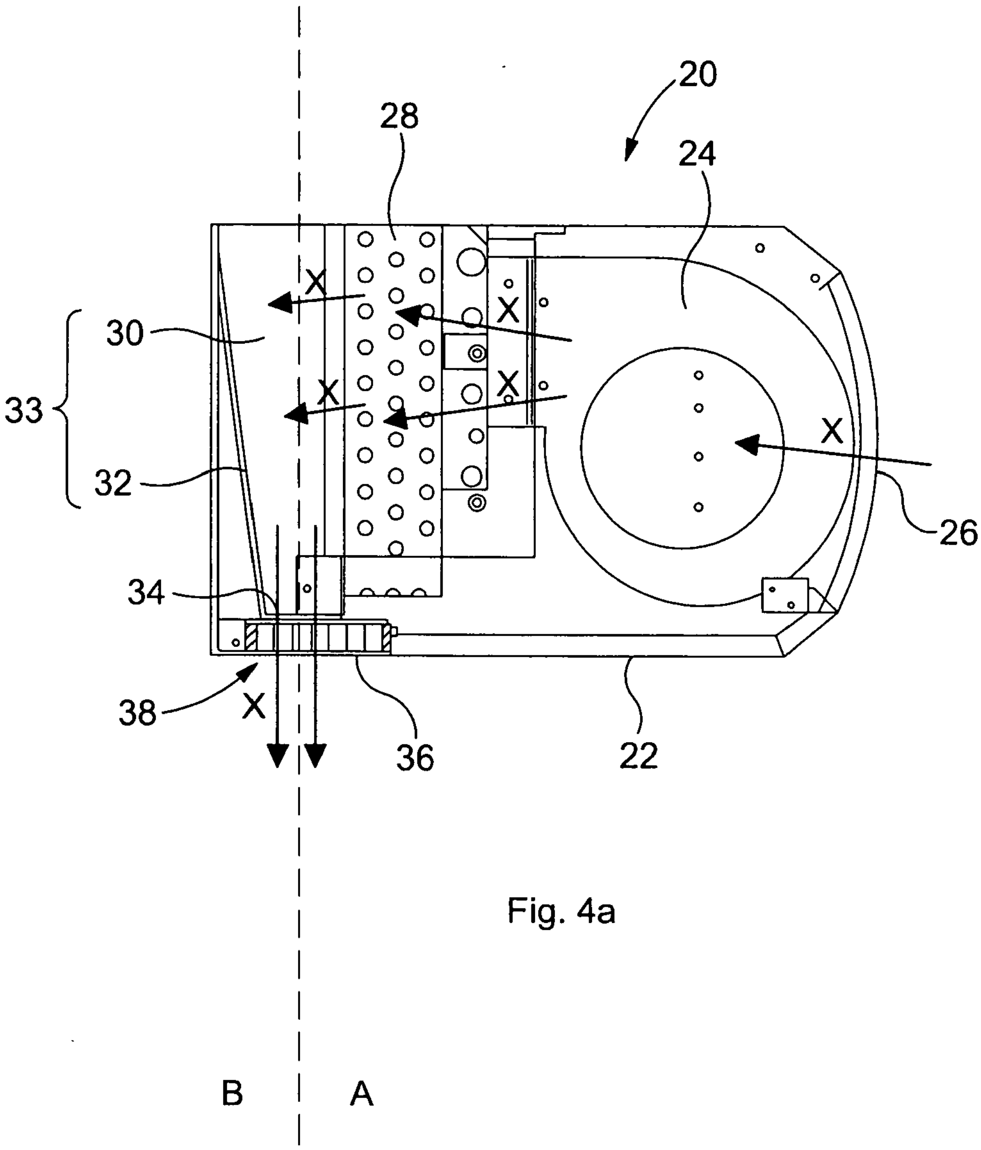

Fig. 4a

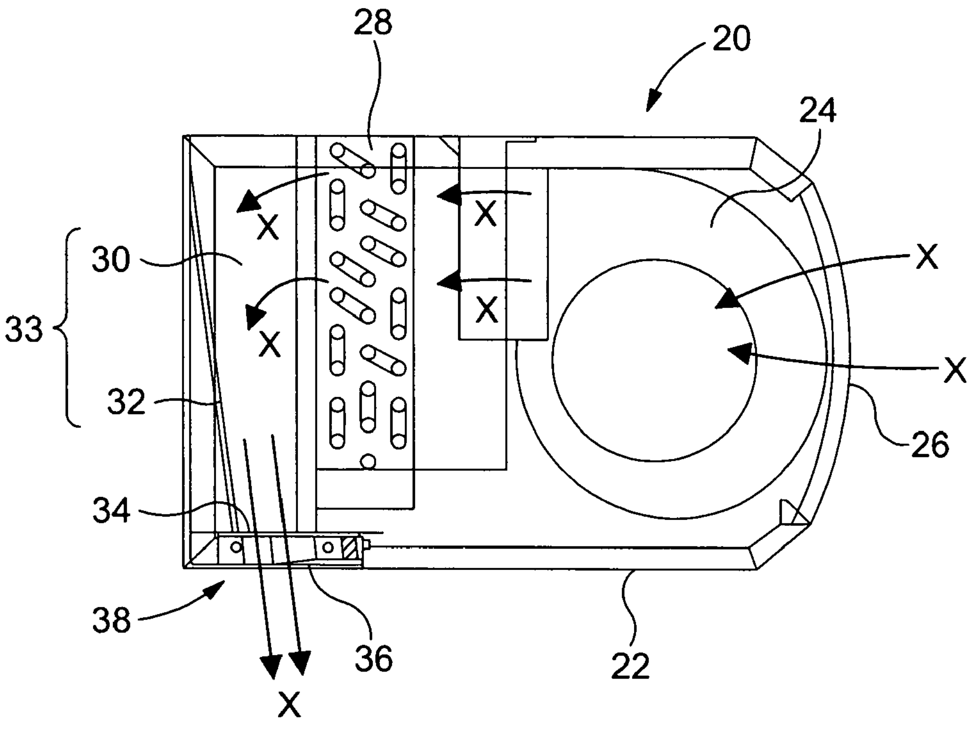

Fig. 4b

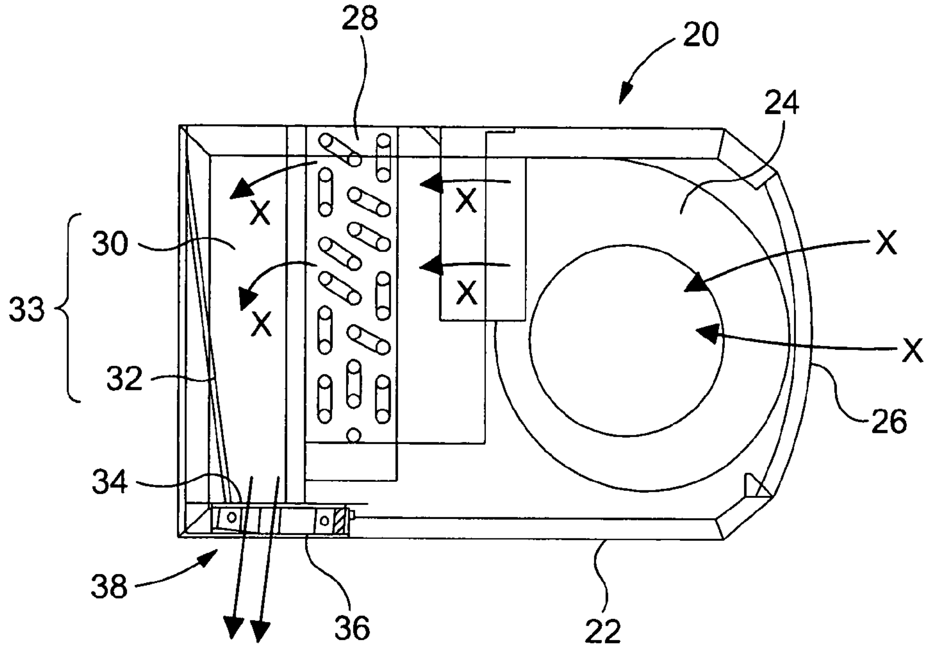

Fig. 4c

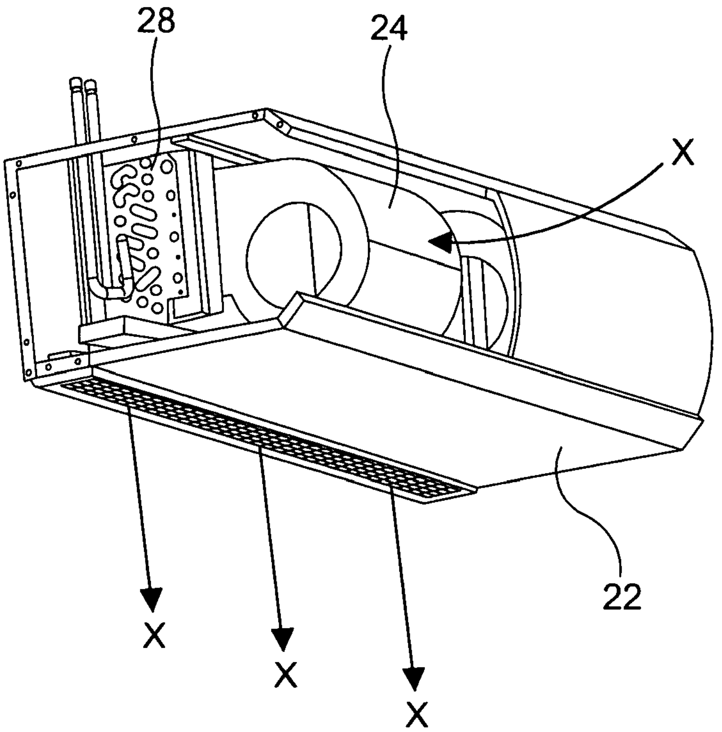

Fig. 5

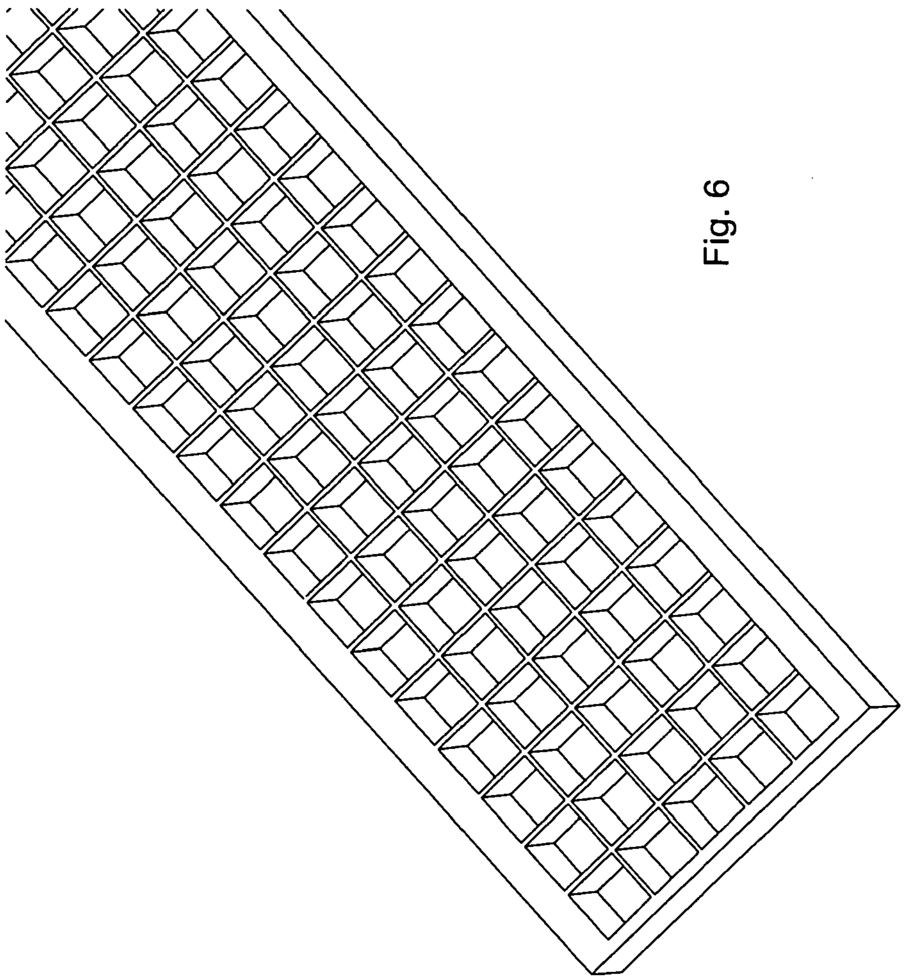

Fig. 6

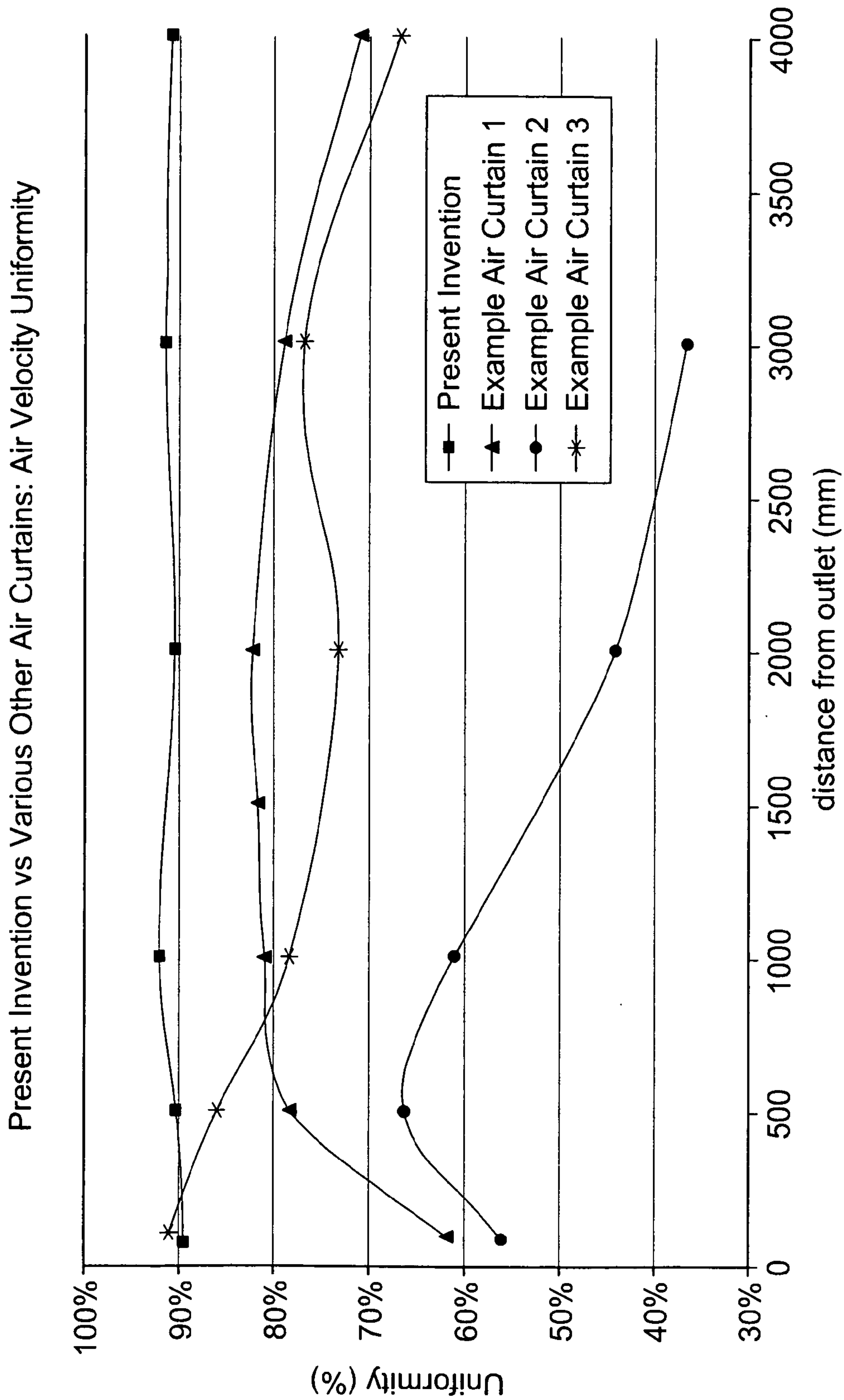
Present Invention vs Various Other Air Curtains: Air Velocity Uniformity
Uniformity (%)
100%
90%
80%
70%
60%
50%
40%
30%
0
500
1000
1500
2000
2500
3000
3500
4000
distance from outlet (mm)
Present Invention
Example Air Curtain 1
Example Air Curtain 2
Example Air Curtain 3

Fig. 7