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(54) Air distribution system for paint spray booth

(57) The present invention relates to an air distribution device (2) for supplying an air flow to a paint spray booth (1), the air distribution device (2) comprising a housing (11) having opposed first (3) and second (4) transverse side walls and opposed first (5) and second (6) longitudinal side walls, an upper wall (7) and a bottom wall (8), the bottom wall (8) allowing for an air flow from the housing (11) to the paint spray booth (1). At least one of the side walls of the housing (11) comprises an air inlet (9). n partition walls (10) divide the housing (11) into n+1 compartments (20). The partition walls (10) extend in height direction of the housing (11) over part of the height thereof. The partition walls (10) are provided for guiding the air flow from the air inlet (9) throughout the housing (11) and for distributing the air flow over the compartments (20) in such a way that each compartment (20) allows for an air flow to the paint spray booth (2) which approximately corresponds to (the total air flow multiplied by (bottom surface area of the compartment/total bottom surface area).

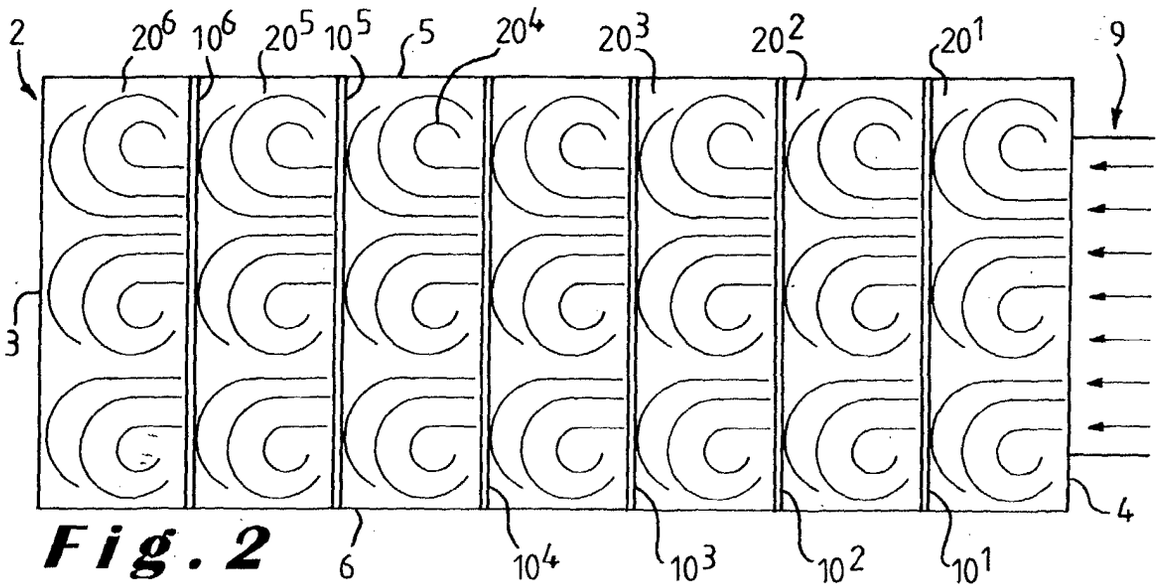

Fig. 2

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Description

[0001] The present invention relates to an air distribution system for use with a paint spray booth, as described in the preamble of the first claim.

[0002] In US-A-5.634.975 an attempt is made to provide an air distribution arrangement for use in a spray booth plenum, with which the uniformity of the output airflow from the plenum into the spray booth application zone, may be improved. Such paint spray booths are commonly found in production lines for vehicle bodies and parts. The plenum is separated from the paint spray area by a filter ceiling which allows air to pass from the plenum into the paint application zone.

[0003] The plenum is divided into three compartments by means of partitioning walls. Each compartment comprises an air distributor which controls the direction of the air flow within each compartment. Air introduced through an air inlet flows through the air distributor into the corresponding compartment and further through the filter ceiling into the paint spray booth. The air distributor includes an air flow regulator and means for controlling the direction of the air flow. The air flow regulator operates to control the air flow rate, whereas the flow directing means function as a guiding to direct predetermined proportions of the airflow leaving the flow regulator into predetermined sections of each plenum chamber.

[0004] The air distribution arrangement disclosed in US-A-5.634.975 however has the disadvantage that it is a rather complicated system. Also, once the air flow is passed into the plenum chamber, there is no system present for further distributing the air in a uniform way over the plenum chamber.

[0005] It is the object of the present invention to provide a simplified/improved air distribution system with which the uniformity of the output airflow from the air distribution device into the paint spray booth may be improved.

[0006] It was found that with the air distribution system of the present invention the uniformity of the output airflow from the air distribution device into the paint spray booth may be improved. The inventors are of the opinion that this is due to the presence of the n partition walls which divide the housing of the air distribution chamber into n+1 compartments. The partition walls are provided for guiding the air flow from the air inlet throughout the housing and for distributing the air flow over the compartments in such a way that each compartment allows for an air flow to the paint spray booth which corresponds to (the total air flow multiplied by (bottom surface area of the compartment/total bottom surface area)).

[0007] With the device of this invention, each compartment allows for an air flow to the paint spray booth which corresponds to

$$\text{Total air flow} \times \frac{\text{bottom surface area of the compartment}}{\text{total bottom surface area}}$$

[0008] In this way, equal surface areas of the bottom wall of the housing allow for the passing of an equal air flow from the air distribution device into the paint spray booth. In other words, there is a uniform output airflow from the housing into the paint spray booth. As a result, the velocity differences of the air flow supplied to the paint application chamber may be minimised, and the risk to build-up of pressure differences within the paint application chamber may be minimised. In this way, the air flow in the paint spray booth will be substantially turbulent-free, even when using an air flow rate higher than the conventionally used air flow rates. The risk that the air flow disturbs paint applied to a vehicle may thereby be minimised, so that a better result may be obtained.

[0009] As the air flow towards the paint spray booth is subdivided in a plurality of smaller air flows with a smaller flow rate, flow rate differences occurring in the air flow supplied to the paint spray booth may be minimised. As a result thereof, the building of a low pressure zone at the air inlet and of an over pressure in a region in the vicinity of the wall opposite the air inlet, may be prevented. This has the consequence that in stead of a few large turbulences, a large number of smaller turbulences are created, which are evenly distributed over the housing. As a result, the air flowing into the paint spray booth is built up of an air flow comprising a plurality of small turbulences, which are evenly distributed over the bottom wall of the housing.

[0010] The air flow supplied to the paint spray booth is needed to remove the paint overspray present in the booth's atmosphere. This overspray must be removed from the paint spray booth to prevent it from falling back on the painted vehicle or from being inhaled by the operators of the equipment.

[0011] With the air distribution system of the present invention, the risk that the air flow disturbs paint applied to a vehicle may be minimised, so that a better result may be obtained. Besides this, the uniform distribution of air flow rates within the paint spray booth results in an increased efficiency of the paint transfer and assists in minimising overspray and paint build-up on the painted object. Especially in powder spray booths, velocity differences would have resulted in such overspray in high velocity areas and in such paint build-up in low velocity areas. In addition, the high velocity of the air flow within the paint spray booth results in a maximized removal of paint-loaded air, thereby ensuring that the inhalation of paint by the operators may be minimized.

[0012] Preferably, the compartments all have approximately the same size. As in this case each compartment has approximately the same surface area, each compartment allows for the passing of an equal amount of air to the paint spray booth.

[0013] The invention is further elucidated in the following figures and description of the figures.

[0014] Figure 1 shows a front view to an air distribution device of the invention in a first preferred embodiment.

[0015] Figure 2 shows a top view to the air distribution device shown in Figure 1.

[0016] Figure 3 shows a front view to an air distribution device of the invention in a second preferred embodiment.

[0017] Figure 4 shows a top view to the air distribution device shown in Figure 3.

[0018] Figure 5 shows a front view to an air distribution device of the invention in a third preferred embodiment.

[0019] Figure 6 shows a top view to the air distribution device shown in Figure 5.

[0020] Figure 7 shows a front view to an air distribution device of the invention in a fourth preferred embodiment.

[0021] Figure 8 shows a top view to the air distribution device shown in Figure 7.

[0022] The air distribution device for supplying an air flow to a paint spray booth 1 shown in Figures 1-8 comprises a housing 2 having opposed first 3 and second 4 transverse side walls extending in transverse direction of the air distribution device, opposed first 5 and second 6 longitudinal side walls extending in longitudinal direction of the air distribution device, and an upper 7 and bottom 8 wall. An air inlet 9 is provided at at least one of the side walls. An air flow from the air inlet 9 passes into the housing 2, throughout the bottom wall 8 and into the underlying paint spray booth 1.

[0023] The upper 7, bottom 8, transverse 3, 4 and longitudinal 5, 6 side walls enclose a central space 12. The central space is divided by a number n of partition walls 10 in a number n+1 of compartments 20. These compartments 20 all have approximately the same size. The partition walls 10 extend in height direction of the housing 2 over a part of the height of the housing 2.

[0024] In a first preferred embodiment of the air distribution device of the invention shown in Figures 1-2, the air inlet 9 is provided at the second transverse side wall 4. The air inlet 9 extends over substantially the entire length of the side wall 4 and over substantially the entire height of the housing 2.

[0025] As it can be seen from Figure 2, a first partition wall 10^1, a second partition wall 10^2, a third partition wall 10^3, a fourth partition wall 10^4, a fifth partition wall 10^5, and a sixth partition wall 10^6 are positioned substantially perpendicular to the air flow. These partition walls are thus parallel to the transverse side walls 3, 4 and parallel with respect to each other. The partition walls 10 may however also extend under an angle with respect to the air flow, for instance under an angle of 60°-90°. The partition walls 10^1-10^6 are positioned at an equal distance from each other. As a result, the space 12 enclosed within the housing is divided in 7 adjacent compartments of approximately the same size, namely a first compartment 20^1, a second compartment 20^2, a third compartment 20^3, a fourth compartment 20^4, a fifth compartment 20^5, a sixth compartment 20^6 and a seventh compartment 20^7. The partition walls may however also be positioned at different distances from each other, thereby dividing the space 12 into compartments with different sizes. Also, the number of partition walls 10 may however also be lower or higher. Generally, the number of partition walls will be adjusted to the dimensions of the air distribution device so as to achieve a uniform output airflow from the air distribution device into the paint spray booth. The height of the partition walls 10 increases with increasing distance from the air inlet 9.

[0026] The height of each partition wall is such that the air flow over the partition wall 10 towards the next compartment 20 is equal to the total air flow multiplied by the number of compartments m behind the partition wall 10 in the direction of the second transverse side wall 3, 4 and divided by the total number of compartments n +1. Thus, for the embodiment shown in Figure 2, the air flow over the first partition wall 10^1 towards the other compartments 20^2-20^6 is approximately equal to the total air flow multiplied by a factor 6/7. The remaining part of the air flow (the total air flow multiplied by a factor 1/7) is left in the first compartment 20^1, from where it flows to the paint spray booth 1. Of the part of the air flow (total air flow multiplied by a factor 6/7) passed over the first partition wall 10^1, an air flow approximately equal to the total air flow multiplied by a factor 5/7 passes over the second partition wall 10^2. Again the other part of the air flow (the total air flow multiplied by a factor 1/7) remains behind in the second compartment 20^2, from which it flows to the paint spray booth 1. The same applies for the air flowing over the subsequent partition walls $10^{2\text{-}6}$. From this it will be clear that each compartment 20 allows for an air flow to the paint spray booth which corresponds to (the total air flow multiplied by (bottom surface area of the compartment/total bottom surface area)). In this way, the air flow passing over equal surface areas will be approximately the same. Since in Figure 2 each compartment 20^1-20^6 has substantially the same surface area, the amount of air flowing to the paint spray booth from each compartment is substantially the same. In the case the compartments 20^1-20^6 would all have a different surface area, it is clear that, although the amount of air flowing from each compartment to the paint spray booth will be different, the air flow passing over equal surface areas will be approximately the same.

[0027] In a second preferred embodiment of the air distribution device of the invention shown in Figures 3-4, the air inlet 9 is provided at the first longitudinal side wall 5. The air inlet 9 occupies a part of the length of the side wall 5 adjacent the transverse side wall 4 and extends over substantially the entire height of the housing 2.

[0028] As it can be seen from Figure 4, two parallel partition walls, namely a first partition wall $10a^1$ and a second partition wall $10a^2$, are positioned opposite the air inlet 9. Thereby, the space opposite the air inlet is divided into three compartments, a first compartment $20a^1$, a second compartment $20a^2$ and a third compartment $20a^3$. The number of partition walls 10a may however also be lower or higher. Generally, the number of partition walls will be adjusted to the dimensions of the air distribution device so as to achieve an output airflow from the air distribution device into the paint spray booth which is as uniform as possible. These partition walls $10a^1$ and $10a^2$ are positioned under an angle with respect to the longitudinal side walls 5, 6 in such a way that the compartments $20a^1$ and $20a^2$ are open in the direction of the partition walls 10b. In the embodiment shown in figure 4, the partition walls $10a^1$ and $10a^2$ are positioned under an angle < 75° with respect to the longitudinal side walls 5, 6. The height of the partition walls 10a increases as the distance to the air inlet 9 increases. The height of the partition walls 10a and their position with respect to the air inlet are such as to allow the partition walls 10a to guide part of the air flow towards the remote transverse side wall 3 and to allow for an air flow towards the opposite longitudinal wall 6.

[0029] At the left end of these partition walls 10a, i.e. the end of the partition wall 10a remote from the transverse side 4 to which the air inlet 9 is adjacent to, four partition walls 10b are positioned: a first partition wall $10b^1$, a second partition wall $10b^2$, a third partition wall $10b^3$ and a fourth partition wall $10b^4$. As shown in Figure 4, the partition walls are parallel to each other and to the transverse side walls 3, 4. These partition walls 10b may however also be positioned under an angle with respect to the transverse side walls 3, 4. As can be seen from figure 4, the partition walls 10b are positioned under an angle < 90° with respect to the partition walls 10a. The number of partition walls 10b may however also be lower or higher. Generally, the number of the partition walls 10b will be adjusted to the dimensions of the air distribution device so as to achieve a uniform output airflow from the air distribution device into the paint spray booth. The partition walls 10b are positioned at equal distances from each other, thereby dividing the space adjacent the space opposite the air inlet into four compartments 20b, a first compartment $20b^1$, a second compartment $20b^2$, a third compartment $20b^3$ and a fourth compartment $20b^4$.

[0030] The height of the partition walls 10b is adjusted to the height of the partition walls 10a so as to achieve a guiding of the air flow from the air inlet throughout the housing and for distributing the air flow over the compartments in such a way that there is a substantially uniform output airflow from the air distribution device into the paint spray booth. Thereto, as can be seen from figure 3, the height of partition wall $10b^1$ is substantially equal to the height of partition wall $10a^1$. As the distance to the air inlet 9 increases, the height of the partition walls 10b gradually increases. The height of partition wall $10b^2$ is larger than the height of the partition wall $10a^1$, but smaller than the height of partition wall $10a^2$. The height of partition wall $10b^3$ is approximately equal to the height of partition wall $10a^2$. The height of the fourth partition wall $10b^4$ is larger than the height of partition wall $10a^2$.

[0031] The height of each partition wall 10a and 10b, the position of the partition walls 10a with respect to each other and to the air inlet, and the position of the partition walls 10b with respect to each other and to that of the partition walls 10a, are such as to allow for a distribution of the air flow over the compartments in such a way that each compartment 20a, 20b allows for a substantially equal air flow to the paint spray booth which corresponds to (the total air flow multiplied by (bottom surface area of the compartment/total bottom surface area)). This implicates that the air flow passing over equal surface areas will be approximately the same.

[0032] Alternatively, with the positioning of the air inlet 9 at the first longitudinal side wall 5 as described above for figures 3-4, a number of partition walls n may be positioned substantially perpendicular to the air flow. The partition walls are in this case thus parallel to the longitudinal side walls 5, 6 and parallel with respect to each other, and extend between both transverse side walls 3, 4. The partition walls may be positioned at equal or varying distances from each other, thereby dividing the central space in n+1 compartments of respectively approximately the same size or varying size. The height of the partition walls may increase with increasing distance from the air inlet 9, and the number of partition walls will be adjusted to the dimensions of the air distribution device so as to achieve a uniform output airflow from the air distribution device into the paint spray booth.

[0033] In a third preferred embodiment of the air distribution device of the invention shown in Figures 5-6, the air inlet 9 is provided at the first longitudinal side wall 5. The air inlet 9 again occupies a part of the length of the longitudinal side wall 5. As compared to the position of the air inlet 9 in the air distribution device of the second embodiment, the air inlet is shifted away from the transverse side wall 4 towards a more central region of the longitudinal side wall 5. The air inlet 9 extends over substantially the entire height of the housing 2.

[0034] As it can be seen from Figure 6, two parallel partition walls 10a, namely a first partition wall $10a^1$ and a second $10a^2$, are positioned opposite the air inlet 9, thereby dividing the space opposite the air inlet into three compartments 20a, a first compartment $20a^1$, a second compartment $20a^2$ and a third compartment $20a^3$.

[0035] In this third embodiment, the partition walls 10a are wedge shaped. The wedge shaped partition walls comprise a first 13a and a second 13b wall part. The two wall parts 13a and 13b forming the wedge shaped partition wall are positioned with respect to each other under an angle >90°, the tip 13 of the wedge-shaped partition wall 10a pointing towards the air inlet 9. These wall parts 13a and 13b have an unequal length. The wall part 13a pointing towards the transverse side wall 3 being the most distant from the air inlet 9 has a larger length as compared to the wall part 13b

pointing towards the transverse side wall 4 being the closest to the air inlet 9. The dimensions of both wall parts 13a and 13b relative to each other depends, amongst others, on the exact position of the air inlet 9 in length direction of the longitudinal side wall 5. The height of the partition walls 10a increases as the distance to the air inlet 9 increases. The position of the partition walls 10a with respect to the air inlet 9, the length of both side walls 13a, 13b and the angle between them, and the height of the partition walls 10a are such to allow the partition walls 10a to guide parts of the air flow towards both transverse side walls 3,4 and to allow for an air flow towards the opposite longitudinal wall 6.

[0036] At the left and right end of these partition walls 10a, partition walls 10b are positioned parallel to each other and to the transverse side walls 3, 4. These partition walls 10b may however also be positioned under an angle with respect to the transverse side walls 3, 4. As can be seen from figure 6, the partition walls $10b^1$-$10b^3$, respectively $10b^4$, are positioned under an angle < 90° with respect to the first 13a, respectively second 13b, wall part of the partition walls 10a.

[0037] At the left end, i.e. the end of the partition wall 10a distant from the air inlet 9, three partition walls 10b are present: a first partition wall $10b^1$, a second partition wall $10b^2$ and a third partition wall $10b^3$. The partition walls 10b are positioned at equal distances from each other, thereby dividing the space adjacent the space opposite the air inlet into three compartments 20b of approximately the same size: a first compartment $20a^1$, a second compartment $20a^2$ and a third compartment $20a^3$.

[0038] At the right end, i.e. the end of the partition wall 10a nearest the transverse side 4 to which the air inlet 9 is nearest to, one partition wall $10b^4$ is present. Thereby, one additional compartment $20b^4$ is formed between the latter partition wall 10b and the transverse side wall 4.

[0039] The height of the partition walls 10b at both ends of the partition walls 10a is again adjusted to the height of these partition walls 10a so as to achieve a guiding of the air flow from the air inlet throughout the housing and for distributing the air flow over the compartments in such a way that there is a uniform output airflow from the air distribution device into the paint spray booth. Thereto, as can be seen from figure 5, at the left end of the partition walls 10a, the height of the first partition wall $10b^1$ is substantially equal to the height of partition wall $10a^1$. As the distance to the air inlet 9 increases, the height of the partition walls 10b gradually increases as described for the second embodiment. The height of the second partition wall $10b^2$ is larger than the height of partition wall $10a^1$, and is smaller or equal than the height of partition wall $10a^2$. The height of the third partition wall $10b^3$ is larger than the height of partition wall $10a^2$. At the right end of the partition walls 10a, the height of partition wall $10b^4$ is larger than the height of partition wall $10a^1$, and substantially equal to the height of partition wall $10a^2$ positioned behind the first partition wall 10a.

[0040] The height of each partition wall 10a and 10b, the position of the partition walls 10a with respect to each other and to the air inlet 9, the length of both side walls 13a, 13b of the partition walls and the angle between them and the position of the partition walls 10b with respect to each other and to that of the partition walls 10a, are again such as to allow for a distribution of the air flow over the compartments in such a way that that each compartment 20a, 20b allows for a substantially equal air flow to the paint spray booth 1 which corresponds to (the total air flow multiplied by (bottom surface area of the compartment/total bottom surface area)).

[0041] Alternatively, with the positioning of the air inlet 9 at the first longitudinal side wall 5 as described above for figures 5-6, a number of partition walls n may be positioned substantially perpendicular to the air flow. The partition walls are in this case thus parallel to the longitudinal side walls 5, 6 and parallel with respect to each other, and extend between both transverse side walls 3, 4. The partition walls may be positioned at equal or varying distances from each other, thereby dividing the central space in n+1 compartments of respectively approximately the same size or varying size. The height of the partition walls may increase with increasing distance from the air inlet 9, and the number of partition walls will be adjusted to the dimensions of the air distribution device so as to achieve a uniform output airflow from the air distribution device into the paint spray booth.

[0042] In a fourth preferred embodiment of the air distribution device of the invention shown in Figures 7-8, the air inlet is shifted over a larger distance away from the transverse side wall 4 towards and is positioned substantially central with respect to the longitudinal side wall 5 as compared to the position of the air inlet 9 in the air distribution device of the third embodiment. Because of this, the two wall parts 13a and 13b forming the wedge shaped partition wall 10a have an equal length to allow the partition walls 10a to guide proportional amounts of air towards both transverse side walls 3,4 and to allow for an air flow towards the opposite longitudinal wall 6.

[0043] All other features are similar as described in the third embodiment.

[0044] Alternatively, with the positioning of the air inlet 9 at the first longitudinal side wall 5 as described above for figures 7-8, a number of partition walls n may be positioned substantially perpendicular to the air flow. The partition walls are in this case thus parallel to the longitudinal side walls 5, 6 and parallel with respect to each other, and extend between both transverse side walls 3, 4. The partition walls may be positioned at equal or varying distances from each other, thereby dividing the central space in n+1 compartments of respectively approximately the same size or varying size. The height of the partition walls may increase with increasing distance from the air inlet 9, and the number of partition walls will be adjusted to the dimensions of the air distribution device so as to achieve a uniform output airflow from the air distribution device into the paint spray booth.

Claims

1. An air distribution device (2) for supplying an air flow to a paint spray booth (1), the air distribution device (2) comprising a housing (11) having opposed first (3) and second (4) transverse side walls and opposed first (5) and second (6) longitudinal side walls, an upper wall (7) and a bottom wall (8), the bottom wall (8) allowing for an air flow from the housing (11) to the paint spray booth (1), at least one of the side walls of the housing (11) comprising an air inlet (9), n partition walls (10) dividing the housing (11) into n+1 compartments (20), **characterised in that** the partition walls (10) extend in height direction of the housing (11) over part of the said height, the partition walls (10) being provided for guiding the air flow from the air inlet (9) throughout the housing (11) and for distributing the air flow over the compartments (20) in such a way that each compartment (20) allows for an air flow to the paint spray booth (1) which approximately corresponds to (the total air flow multiplied by (bottom surface area of the compartment/total bottom surface area)).

2. An air distribution device (2) as claimed in claim 1, **characterised in that** the housing (11) is divided into n+1 compartments (20) with approximately the same surface area, and the partition walls (10) are provided for distributing the air flow over the compartments (20) in a uniform manner in such a way that equal surface areas of the bottom wall (8) allow for an equal air flow to the paint spray booth (2).

3. An air distribution device (2) as claimed in claim 1 or 2, **characterised in that** the air inlet (9) is provided to take place along substantially the entire length of a transverse side wall (3, 4) of the housing (11), **in that** the partition walls (10) and the side wall (3, 4) containing the air inlet (9) extend substantially perpendicular to the air flow and substantially parallel to each other, the height of the partition walls (10) increasing with increasing distance of the partition wall (10) to the air inlet (9), the height of each partition wall (10) being such that the air flow over the partition wall (10) towards the next compartment (20) is equal to the total air flow multiplied by the number of compartments (20) m behind the partition wall (10) in the direction of the second transverse side wall (3, 4) and divided by the total number of compartments (20) n +1.

4. An air distribution system (2) according to any one of claims 1-3, **characterised in that** the partition walls (10) are positioned perpendicular to the air inlet (9).

5. An air distribution system (2) according to any one of claims 1-4, **characterised in that** the partition walls (10) are positioned at an equal distance from each other, the height of the partition walls (10) increasing with increasing distance from the air inlet (9).

6. An air distribution system (2) as claimed in claim 1 or 2, **characterised in that** the air inlet (9) occupies a part of the length of a longitudinal side wall (5, 6), **in that** at least one first partition wall (10a) is positioned opposite the air inlet (9) and slants with respect to the air inlet (9) so as to guide part of the air flow towards at least one transverse side wall (3, 4) and to allow for an air flow towards the opposite longitudinal wall (5, 6), **in that** on at least one side of the first partition wall (10a) at least one second partition wall (10b) is mounted which slants with respect to the first partition wall (10a) to allow for an air flow in the direction of the transverse side wall (3, 4).

7. An air distribution system (2) as claimed in claim 6, **characterised in that** the air inlet (9) is mounted at a part of the longitudinal side wall (5, 6) adjacent the transverse side wall (3, 4), **in that** at least one first partition wall (10a) is mounted under an angle < 75 ° with respect to the longitudinal side wall (5, 6) for deviating part of the air flow towards the remote transverse side wall (3, 4) and **in that** at least one second partition wall (10b) is mounted under an angle < 90 °with respect to the first partition wall (10a).

8. An air distribution system (2) as claimed in claim 7, **characterised in that** the at least one second partition wall (10b) is approximately parallel to the transverse side wall (3, 4).

9. An air distribution system (2) as claimed in claim 6, **characterised in that** the air inlet (9) is shifted towards a central region of the longitudinal side wall (5, 6) and **in that** in front of the air inlet (9) at least one first partition wall (10a) is mounted, the first partition wall (10a) being wedge shaped, the tip of the wedge pointing towards the air inlet (9), **in that** at the far ends of the at least one first partition wall (10a) at least one second partition wall (10b) is mounted under an angle < 90 ° with respect to the first partition wall (10a).

10. An air distribution system (2) as claimed in claim 9, **characterised in that** the at least one second partition wall (10b) extends parallel to the transverse side wall (3, 4).

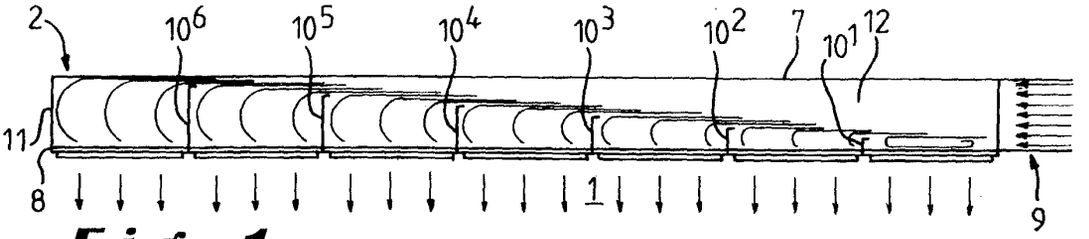

Fig. 1

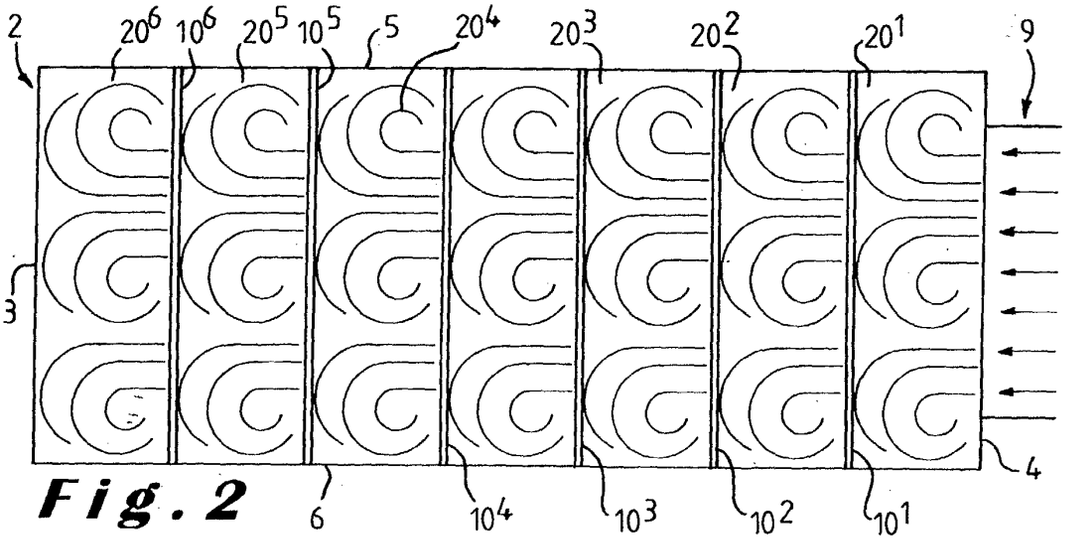

Fig. 2

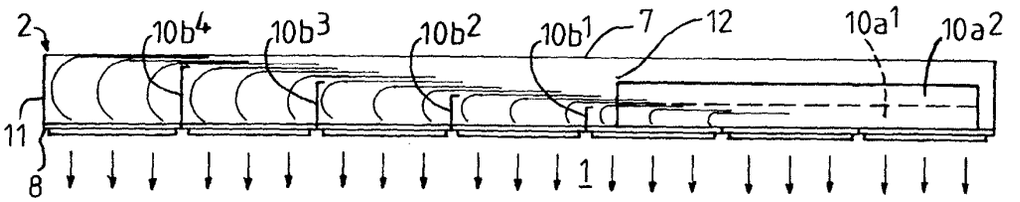

Fig. 3

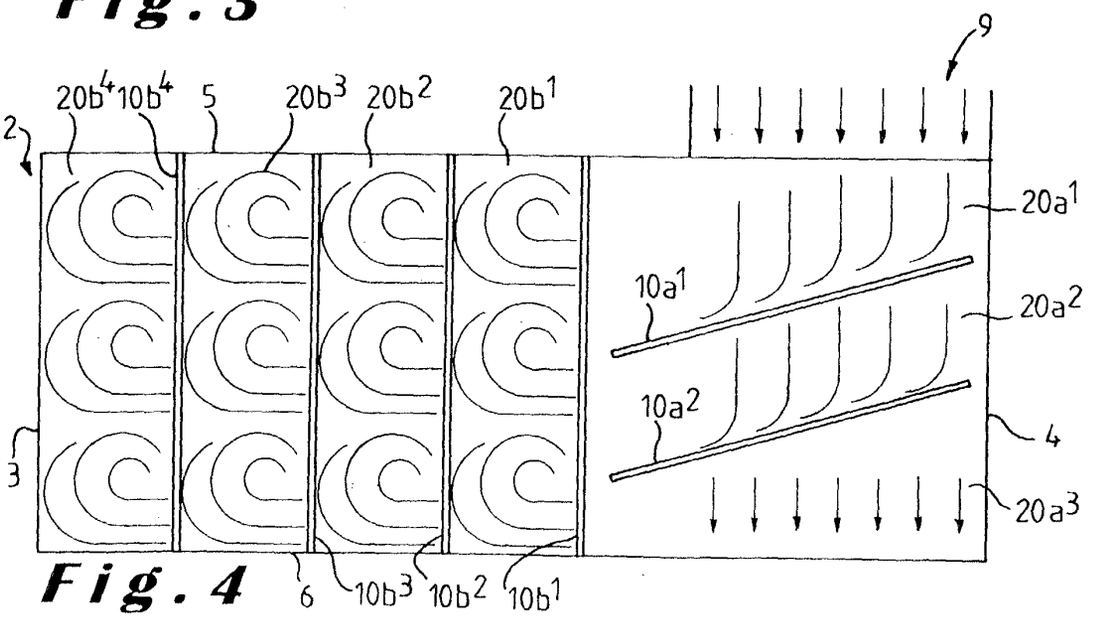

Fig. 4

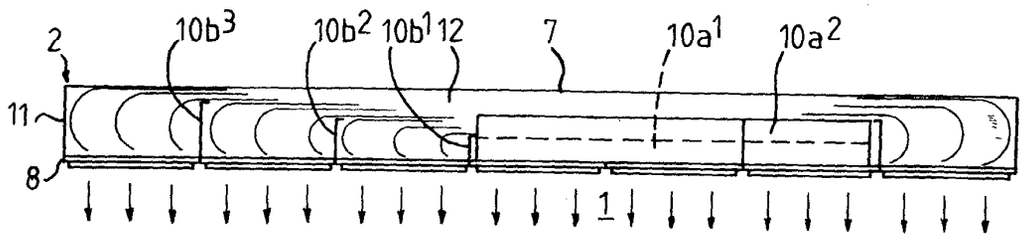

Fig. 5

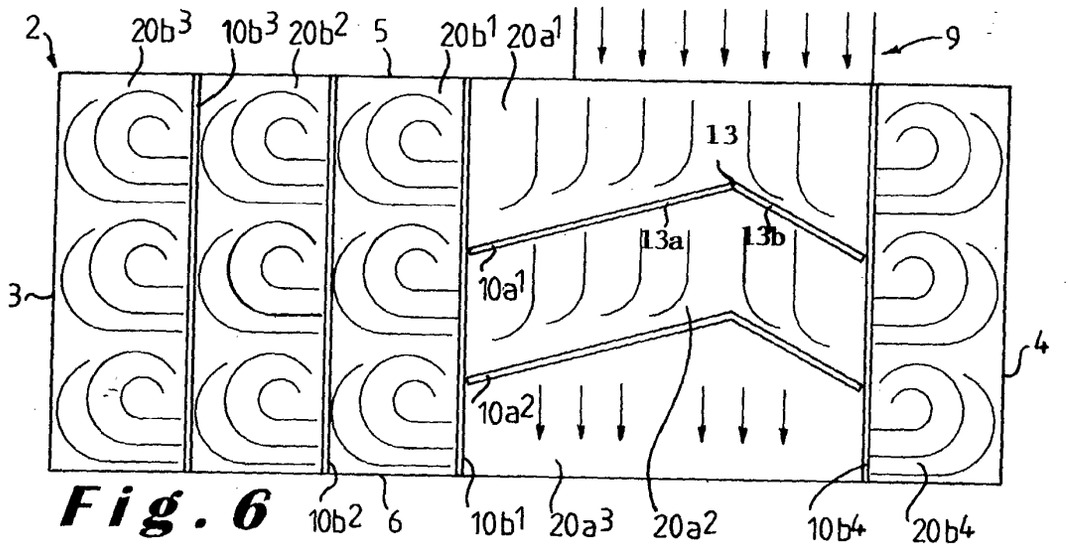

Fig. 6

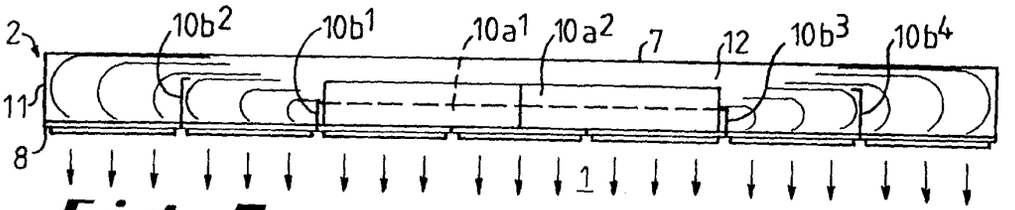

Fig. 7

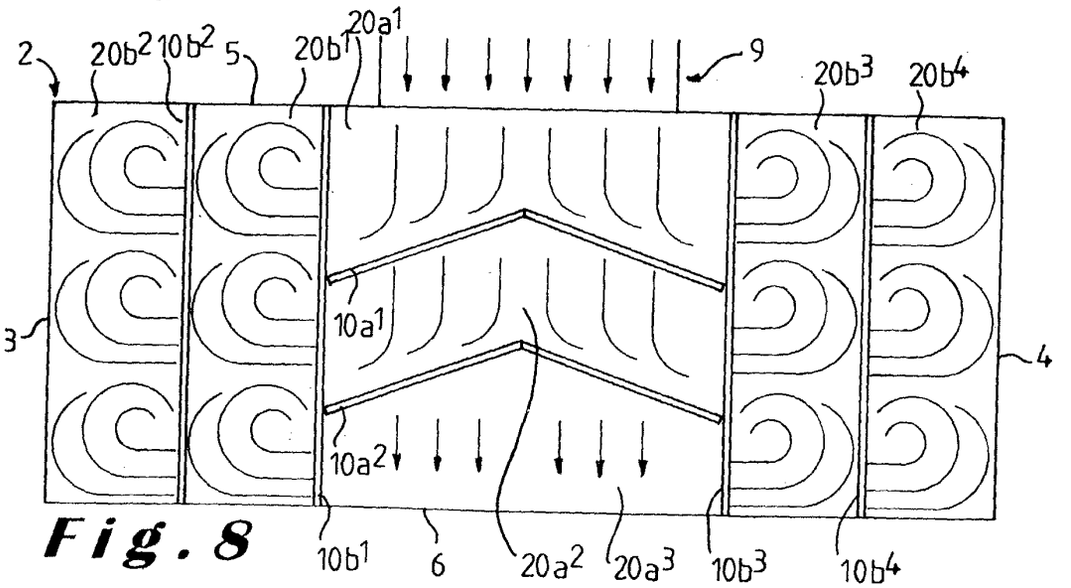

Fig. 8