PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : F24F 13/068, 13/26

A1

(11) International Publication Number: WO 98/49499

(43) International Publication Date: 5 November 1998 (05.11.98)

(21) International Application Number: PCT/FI98/00325

(22) International Filing Date: 9 April 1998 (09.04.98)

(30) Priority Data:
971590 15 April 1997 (15.04.97) FI

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

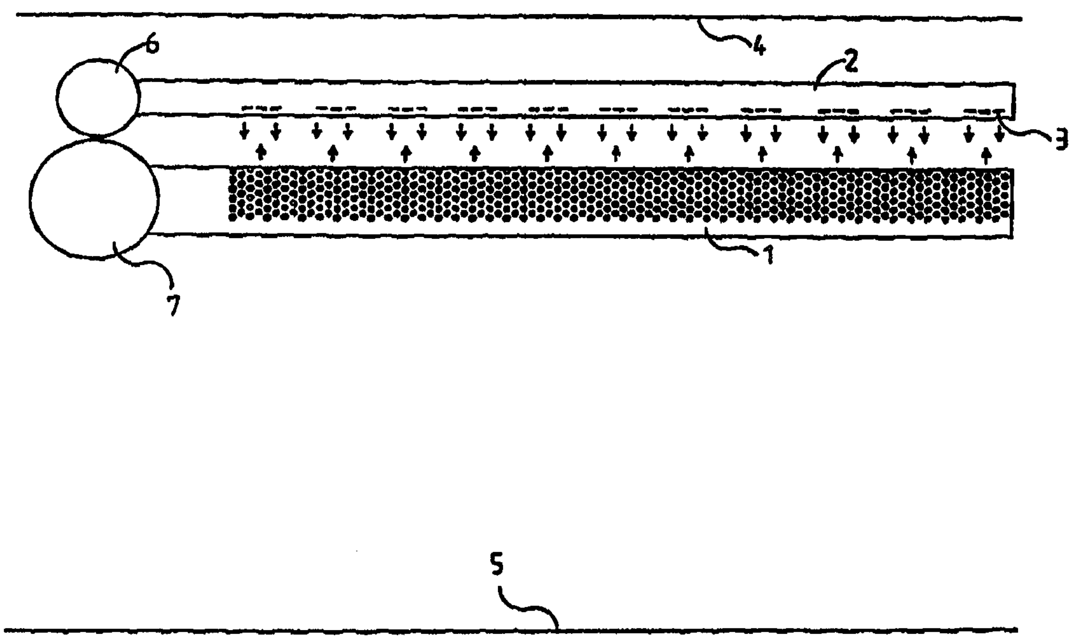
Published
With international search report.
In English translation (filed in Finnish).

(71) Applicant *(for all designated States except US)*: ABB FLÄKT OY [FI/FI]; Kalevantie 39, FIN-20520 Turku (FI).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: HAKALA, Into [FI/FI]; Hirvitie 10, FIN-15880 Hollola (FI). SALORANTA, Markku [FI/FI]; Vehkakatu 7, FIN-15240 Lahti (FI). POHJA, Jukka [FI/FI]; Kekkurintie 3 A, FIN-15880 Hollola (FI). SARIN, Dan [FI/FI]; Tilkankuja 6 C 21, FIN-00300 Helsinki (FI). LESKINEN, Seppo [FI/FI]; Gumbontie, FIN-01120 Västerskog (FI). ROLIN, Ingmar [FI/FI]; Laaksopohjantie 5 A, FIN-02730 Espoo (FI).

(74) Agent: KOLSTER OY AB; Iso Roobertinkatu 23, P.O. Box 148, FIN-00121 Helsinki (FI).

(54) Title: APPARATUS FOR DISTRIBUTION OF INCOMING AIR TO ROOMS TO BE VENTILATED



(57) Abstract

The invention relates to an apparatus for distribution of incoming air particularly to large and/or medium–high rooms to be ventilated, the apparatus comprising a plurality of elongated air distribution devices that are installed substantially in parallel and substantially in a horizontal position. In order to provide an apparatus with good and versatile performance and low costs, the apparatus has, one after the other, a nozzle blowing device or devices (2) and a displacing air distribution device or displacing air distribution devices (1).

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

APPARATUS FOR DISTRIBUTION OF INCOMING AIR TO ROOMS TO BE VENTILATED

The invention relates to an apparatus for distribution of incoming air particularly to large and/or medium-high rooms to be ventilated, the apparatus comprising a plurality of elongated air distribution devices that are installed substantially in parallel and substantially in a horizontal position.

In large and/or high buildings, it is known to use strong air jets for conducting incoming air into a room and/or controlling air flows in a room. Such air distribution systems are disclosed, for instance, in FI 66,484, FI 77,3852, DE 2,919,793, FI 962,774 and EP 085,428.

The advantages of the above-mentioned systems are that few air-conditioning ducts are needed, which leads to low investment costs. Even as such, a strong air jet extends far in a free space, and so air need not be conducted in ducts to the vicinity of the space to be ventilated. An especially advantageous system is one in which air jets are used, for instance, for conducting a main air flow supplied to one side of a large factory hall to the entire space, and distributing it to the occupied zone. The amount of ambient air that a strong air jet draws with it by what is known as an induction phenomenon is much larger than the air flow of the jet itself on leaving a nozzle. When nozzles blowing horizontally are placed one after the other at suitable distances under the ceiling, even a large incoming air flow can be conducted by rather a small air flow, and distributed to the occupied area by air jets blown vertically. The ratio of the main incoming air flow to the air flow from the jets may be, for instance, 5 to 1. The costs of air ductwork decrease correspondingly.

Moreover, systems based on air jets are the only way to handle air conditioning satisfactorily in spaces where large ducts cannot be arranged, for instance, because of crane rails, or in individual working points to the vicinity of which ducts cannot be laid because of the working process or for some other reason.

The equalizing of temperature differences in high buildings can be mentioned as a particular advantage/application. Warm air rises upwards, whereby a so called temperature stratum, which may easily be 5 to 7 °C higher depending on the sources of heat, is formed in buildings, in other words, the temperature of air in the upper part of a space may easily be 5 to 7 °C higher than at the floor level that people occupy, however. Downward pointing jets placed on the ceiling draw warm air with them down to the occupied level and thus equalize the temperature differences. Since a 1 °C drop in temperature usually corresponds to a 5% decrease in the consumption of heating energy, it is easy to see that considerable energy savings can be achieved with the equalization of temperature differences.

The conventional nozzle systems have serious drawbacks, however. To get the air induced, i.e. to get it drawn along, it is necessary to install a plurality of nozzles with a high velocity of air. Firstly, this results in high ductwork and installation costs, particularly, because in general each nozzle has to be directed afterwards, when the positions of people within the ventilated area are determined, in order that the air jet will not create inconvenient draught in the occupied area. Secondly, the high jet velocity inevitably leads to great loss of pressure in the nozzle, and further, to great consumption of power in a fan supplying air to the nozzle system, to an expensive fan and electric motor, to electric wiring, to a connection fee, etc. The high nozzle velocity also inevitably leads to high noise level, which is experienced disturbing especially in spaces where background noise is low, i.e. in other than industrial premises.

Moreover, it is a serious drawback that most of the power consumed is used for circulating the air purposelessly in the space to be ventilated instead of equalizing the temperature differences. The reason for this is that when air is blown from a relatively large nozzle (with a diameter of e.g. 50 to 150 mm) at a high rate, the jet velocity is still high several metres away from the starting point. The jet then induces air not only from the ceiling but also from the middle and lower parts of the space, where the air is cooler and only part of the total air flow participates in the equalization of the temperature differences.

The simplest way of reducing drawbacks caused by the high nozzle velocity is to reduce the velocity of the jet. The air flow, however, must then be increased, so as to achieve the same induction, i.e. the mixing of ambient air with the jet and the same extent of the jet. This increases the ductwork costs and makes it more difficult to arrange the ducts, the number and/or size of the nozzles increase, and so on, in other words, an essential part of the advantages of the system is lost.

Finnish Patent Application 962,774 discloses a method by which a major part of induction air is taken from the vicinity of the hall ceiling, and on the other hand, the air velocity in the jet can be reduced and hence the power consumption can be reduced and the noise level lowered. The method is based on combining a plurality of jets in such a way that a carrier jet in the middle is surrounded by several minor jets generated essentially freely.

The above-mentioned nozzle systems are useful when the building is relatively high, generally in excess of 6 m. If the height is less than that, the nozzle diameter and/or the nozzle velocity of the jet have to be reduced, to avoid inconvenient draught in the occupied area due to excessive velocity of air. Both operations lead to an increased number of nozzles. In addition, both operations impair induction, so the air flow has to be increased, which further increases the number of nozzles. This results in such a high increase in ductwork and installation costs that, in general, the nozzle systems are not competitive in buildings that are less that 6 metres high, in spite of several good features.

The most serious drawback is, however, that the nozzle systems function poorly when the building needs cooling. In summer, it would be advantageous to let the heat rise upward and form a stratum from which the overheated air could be discharged. The nozzle system blows the overheated air down and thus increases the thermal load of the occupied level. A temperature stratum of only 4 °C would generally decrease the cooling power required by the building by 20 to 40%, depending on internal loads.

Recently, so called active displacement has been developed for spaces that require cooling. The distribution of air is spread onto a wide surface. Air flows into a room through small nozzles at a high velocity and sets large air mass in motion. As the air jet from the small nozzle is small, noise problems will not arise despite the high velocity. In the small jet, the velocity of air decreases rapidly, so draught will not readily occur. When large air mass is on the move, disturbances have no effect on the flow except just locally, so air conditioning in the entire space is even. Due to a high mixing ratio of incoming and indoor air, the temperature differences equalize, so even cold incoming air can be supplied to the occupied area without a 'drop' in the flow. Draught does not occur at the floor level even with a temperature difference of 15 centigrades.

Air flow can be controlled within wide limits. Active displacement is thus very well applicable to cooling. This kind of air distribution is disclosed in Finnish Patents 79,608, 73,513, 72,800 and 71,417.

However, if incoming air is considerably warmer than indoor air, a minor temperature difference even after efficient mixing makes the air rise upward from the occupied area. Active displacement is thus poorly applicable to heating. Attempts have been made to eliminate this drawback in various ways. For instance, Finnish Patent 90,466 discloses an apparatus in which incoming air is conducted in heating and cooling situations through various flow paths to nozzles from which it is blown into different directions in such a way that in summer the flow field differs from that in winter. Consequently, the good features in cooling, such as high cooling power, draught-free air distribution, temperature stratification, and so on, remain. The apparatus also functions in heating with moderately overheated air.

However, the apparatus has some drawbacks. Firstly, the temperature stratification cannot be made disappear, which leads to a considerable increase in the consumption of energy as compared with the nozzle blowing system. The price of the apparatus is also high, which results from the fact that an exchange damper and its actuator, as well as a partition wall, are relatively expensive. Moreover, the flow paths of both winter and summer season have to be designed for full air flow, which increases the diameter of the supply duct. Naturally, the costs rise, and moreover, it is often difficult to arrange a large-diameter supply duct in a room space.

The object of the invention is to provide an apparatus by means of which the drawbacks of the prior art can be eliminated. This is achieved by means of the apparatus in accordance with the invention, characterized in that the apparatus has, one after the other, a nozzle blowing device or devices and a displacing air distribution device or displacing air distribution devices.

The basic idea of the invention is to combine nozzle blowing and active displacement into an apparatus retaining the advantages of both. The apparatus comprises a plurality of elongated air distribution devices that are substantially parallel, and substantially in a horizontal position. The apparatus has, one after the other, nozzle blowing devices and displacing air distribution devices as stated above. Both the displacing air distribution devices and the nozzle blowing devices have a separate distribution ductwork which can be closed completely or partly, and through which passes the air flow that can be controlled, if necessary. Air that has been conditioned in various ways may flow in the distribution ducts.

By means of the apparatus in accordance with the invention air that is 15 °C underheated and 15 °C overheated can be supplied into a room space. Thus it is applicable even to air heating systems. Temperature stratification can be preserved in summer and removed in winter, which leads to lower consumption of thermal energy than in any known apparatus. Thermal energy refers here to heating and cooling. The air flows are controllable within wide limits, which decreases the consumption of both thermal energy and electric energy. The distribution of air is draught-free and its noise level is very low, much lower than, for instance, in the above-described nozzle blowing system. The pressure loss of the apparatus is low. The apparatus is suited even for low room spaces that are up to about 3 metres high. Almost the entire apparatus can be used both in summer and in winter, thanks to which the investment costs are lower than, for instance, those of the apparatus disclosed in Finnish Patent 90,466. The costs are further decreased by the fact that the devices have no exchange damper. It is possible to automate the manufacture of the apparatus, and it is quick to install the apparatus and adjust the flow field, which further decreases the costs. The pressure loss of the apparatus and consequently the consumption of electric power and the noise level are considerably lower than in known nozzle blowing devices.

In the apparatus of the invention, nozzle blowing is effected through a plurality of aligned small nozzles which efficiently remove the temperature stratum in winter, and the jets starting therefrom join at a short distance, usually less than 1 m from the nozzles. As a consequence, a ribbon-like, joined jet in principle as wide as the entire room is formed, by which a throw of up to 15 m can be achieved, if necessary. The jets starting from the small nozzles induce ambient air very efficiently from the uppermost part of the space, but when the jets have joined to form a ribbon-like main jet, induction decreases substantially and the jet extends far.

As is well known, both the displacing air distribution systems and the nozzle blowing systems operate within a very wide air flow range, so the total air flow of the apparatus as well as partial air flows supplied to air distribution device sets can be controlled within wide limits, and thus the characteristics of the apparatus can be arranged to correspond to the use situation in the most optimal way, and thus both thermal energy and electric energy can be saved.

In both types of air distribution the air flows into the room space from a plurality of small openings with a low volume of noise generated therein. In addition, noise passing a small opening attenuates effectively, due to so called orifice attenuation, and consequently, the apparatus also attenuates the noise of the fan of the air conditioning apparatus effectively.

In winter, the apparatus operates in such a way that incoming air, whose temperature is higher than the room temperature, is fed to both air distribution devices. As is well known, overheated air tends to rise upwards to the ceiling from the displacing air distribution device and to form an intense temperature stratum. However, the ribbon-like jet from the jet blowing device forces major part of the upward flowing air to the occupied area, and the part that has reached the upper part of the space is induced with the jet at its starting point. This is how the displacing air distribution can operate also in a heating situation and the temperature stratum can be removed in winter. The apparatus also operates in very low spaces, when it is realized that the air jet need not be directed vertically downwards, but it conducts the air, which tends to rise upwards from the displacing incoming air device, more efficiently downwards if the displacing air distribution device and the jet blowing device are horizontally at a suitable distance from one another, and the jets are directed obliquely downwards, the more horizontally the lower the space and/or the more powerful the jet needed for conducting the upward rising air to the occupied area.

In summer, the jet blowing apparatus is closed completely or partly, and the apparatus only operates on the displacement principle, whereby a temperature stratum is formed in the space. The jet blowing apparatus can be kept running in such parts of the space that do not form a temperature stratum due to disturbance currents, moving machines, absence of sources of heat or some other such reason. As stated above, the air flow of the jet blowing apparatus is small, in general less than 20% of the total air flow. Hence a considerably smaller part of the total apparatus is excluded from use than, for instance, in the solution disclosed in Finnish Patent 90,466.

In both air distribution devices, the manufacture of small nozzles positioned in straight ducts can be automated in principle, so the manufacturing costs remain reasonable. The installation costs are also reasonable, since the air flow per air distribution unit is great. On the whole, the costs per one cubic metre of incoming air are fully competitive with the air distribution devices available on the market.

Instead, the capacity is unique. According to measurements, the apparatus is capable of supplying draught-free cooling power in excess of 150 W/m^2 and heating power in excess of 100 W/m^2 to a space to be ventilated, retaining or removing the temperature stratum and controlling separately the jet blowing air flow and the displacing air flow, in addition to the total air flow. No known system is nearly so capable as this.

In the following the invention will be described in greater detail with reference to the embodiments illustrated in the attached drawing, in which

Figure 1 is a schematic side view of an example of a prior art solution,

Figure 2 is a schematic end view of the solution of Figure 1,

Figures 3A and 3B are schematic views of an example of a flow field generated by the prior art apparatus,

Figure 4 is a schematic end view of a first embodiment of an apparatus of the invention,

Figure 5 is a schematic side view of the first embodiment of the apparatus of the invention,

Figure 6 is a schematic top view of the first embodiment of the apparatus of the invention,

Figure 7 is a schematic view of a second embodiment of the apparatus of the invention,

Figure 8 is a schematic view of a third embodiment of the apparatus of the invention,

Figure 9 is a schematic view of a fourth embodiment of the apparatus of the invention,

Figure 10 is a schematic view of a fifth embodiment of the apparatus of the invention, and

Figure 11 is a schematic view of a sixth embodiment of the apparatus of the invention.

The prior art apparatus of Figures 1 to 3B illustrates a displacing air distribution device. In Figure 1, a damper 7 is in a position corresponding to summer season use, whereby incoming air flows through a duct 4 to small (3 to 8 mm) nozzles 8, from which it is released into a space to be ventilated as small jets having a relatively high flow rate, and thus they induce a large amount of ambient air with them, whereby the flow rate retards at a very short distance below the draught limit 0.2 m/s (300 to 600 mm). Since the temperature of incoming air is lower than room temperature, the flow turns downward and a flow field, which is very stable and draught-free, is formed in accordance with Figure 3A.

In winter, the damper 7 is in a position indicated by broken lines in Figure 1, and the incoming air flows through a duct 5 and nozzles 9, and hence a flow field in accordance with Figure 3B is formed in the space to be ventilated. However, the air cannot be much overheated, at most 4 to 5 °C, because otherwise it rises up from the occupied area. Excellent induction, which is very useful in a cooling situation, retards the flow rate of the incoming air also in a heating situation, when the incoming air that is warmer than indoor air rises upwards away from the occupied area. For instance, a temperature difference of 4 to 5 °C as compared with room temperature covers the control range required by very high-standard ventilation, but it is quite insufficient for air heating. It does not remove the temperature stratum either, and it also has the other above-described drawbacks.

Figures 4 to 6 show a first embodiment of the apparatus of the invention, in which the air flows through a gate valve 8, a filter 9, a heat recovery device 10, and a heating radiator 11 in a conventional way to a fan 12 which blows it through a damper 13 into a distribution duct 7 of displacing air distribution 1, and in winter through a damper 14 into a distribution duct 6 of jet blowing devices 2.

The incoming air being warmer than indoor air flows from the displacing incoming air device 1 in the manner shown by arrows in Figure 4 and starts flowing upwards. Part of it rises up to a ceiling 4 level. Air jets having a high exit velocity at nozzles 3 of nozzle i.e. jet blowing devices 2 draw the warm air, accumulated at the ceiling level, by induction along with them down to the occupied area. The jets also turn the major part of the incoming air from the distribution device 1 to flow downwards, and as a consequence all incoming air is supplied to the occupied area and the temperature stratum is removed.

The nozzles 3 are small, with a diameter of e.g. 8 to 25 mm, and they are installed in-line in an elongated distribution device 2 in accordance with Figure 5. As is well known, induction of a small jet takes place at a very short distance, i.e. the jets take along the warmest air at the ceiling level very effectively, much more effectively than the prior art jet blowing devices with a nozzle diameter of 35 to 150 mm, in general.

The velocity of a small jet retards at a short distance. However, as is well known, the air jets expand when the distance from the nozzle increases, whereby the jets positioned close to each other join at a given distance from the nozzles. If the diameters and mutual distance of the nozzles 3 are suitably selected, the jets are brought to join before their velocity retards excessively. Hence a ribbon-like, joined jet as wide as the entire nozzle blowing device is formed, the induction of which is substantially weaker than that of a single round jet, and hence the jet extends far. In principle, the joined jet behaves in the same way as the jet from a slot nozzle by which the longest possible throw is obtained, as is well known.

In the vicinity of the ceiling, the induction of the apparatus of the invention is substantially more effective and the throw is longer than those of known nozzle blowing devices. As is known, both are directly proportional to air velocity. Inversely, a specific induction and throw can be obtained by a lower nozzle velocity with the apparatus of the invention than with prior art devices. Consequently, the pressure loss and power consumption directly proportional thereto are lower and the noise level is lower than in the prior art devices. For instance, the above fact enables the use of the nozzle blowing system in spaces which have relatively strict standards for noise level, for instance, in assembly rooms, offices, and so on, which has not been possible by means of the prior art.

As appears from Figure 4, the air does not flow from the nozzles vertically down, but obliquely downwards. This makes it possible to apply the apparatus to spaces of different heights. By changing the nozzle blow angles, air velocity in the nozzles and the mutual distance between the air distribution devices 1, 2 horizontally and in particular vertically, the apparatus consisting of the same components can be modified in a simple manner to fit into spaces differing greatly in heights and/or in air flows per one floor square meter. The apparatus is applicable to rooms up to 3 m high, even though its advantages are then limited. The nozzles 3 then blow almost horizontally and the difference in levels of the distribution devices 1, 2 is small. At the other extreme, in buildings exceeding 20 m in height the difference in levels is great and the nozzles 3 blow nearly or completely vertically downwards.

The body of the air distribution devices 1, 2 may be a conventional spiral-weld air-conditioning duct that can be manufactured in accordance with the prior art at a very low cost by a conventional spiral-welding machine. Small nozzles for the distribution devices 1, 2 can be drawn with a pressing tool either in a finished duct or preferably in a strip of sheet used as a raw material, by adding the nozzle drawing with a pressing tool as a pretreatment step to a strip of sheet fed into the spiral-welding machine, whereby the nozzles are provided/produced practically without any costs in the duct manufacturing process.

Naturally, it is possible to produce in series separate nozzles or nozzle sets, which are secured, for instance, with an embossing tool to a duct made of a perforated strip of sheet or perforated when finished. It is possible to automate the steps.

The above-described manufacturing methods are only examples by which the low manufacturing costs are demonstrated. All manufacturing methods known per se are naturally within the scope of the invention.

The low installation costs mainly result from the fact that the units to be installed comprise a plurality of nozzles. With a conventional 6 m unit length, for instance, the air flow in an incoming air unit of the displacing air distribution is 0.5 m^3/s. By one directing operation several nozzles can be directed in a manner described later in the text.

It has been found that in this apparatus the direction of nozzles is not so important as in the conventional nozzle blowing system. Besides, in this system it can be replaced with air flow control or by altering the difference in air distribution device levels, which mainly requires readily adjustable suspension devices, known per se, for the nozzle blowing devices 2.

Instead, the control of air flows independently for both distribution ducts 1, 2 is very important especially in air heating. The consumption of both electric and thermal energy can be reduced substantially as compared with the prior art, if the temperature of incoming air is kept stable when the heat demand decreases, and instead of temperature, the incoming air flow is controlled. The consumption of thermal energy decreases, mainly due to the fact that the efficiency of a heat recovery device 11 increases, but the electric consumption of the fan decreases considerably more.

The control can be performed in accordance with Figure 6 by means of dampers 13, 14. However, this kind of control has a disadvantage that the electric consumption only decreases approximately in direct proportion to the air flow. With decreasing air flow, the pressure loss of the displacing air distribution devices 1 would also decrease in proportion to the air flow squared, consequently, for this portion, i.e. more than 80 %, energy consumption could be decreased in proportion to the air flow i.e. heat consumption cubed. Since the peak value of heat consumption occurs only for less than 20 hours, duration of heating period is 5,000 to 6,000 hours and the average consumption is less than 50 % of the peak value, the electric consumption of the fan could be reduced to less than 30 % by providing the fan 12 with rotation rate control and by using the dampers 13, 14 only for maintaining the correct relation between the pressure levels of the distribution devices 1,2.

However, this is not possible, because the air flow of the nozzle blowing devices 2 cannot be reduced considerably, since the jet is to extend to the occupied area. A slightly weaker jet is sufficient for turning the reduced air of the distribution devices 1, but the change is rather insignificant. Thus the fan has to maintain nearly constant pressure level, from which the excess is 'killed' with the damper 14.

However, if a small auxiliary fan 17 is placed in the distribution duct 7 in accordance with Figure 7, the fan 12 pressure can be lowered to the level required by the displacement devices 1, and the additional pressure required by the nozzle blowing devices 2 can be generated by the fan 17. The annual energy consumption of the apparatus decreases to less than a third as compared with the conventional nozzle blowing system, for instance.

Even smaller energy consumption and lower costs are achieved in such a way that the nozzle blowing part 2, 6, 17 of the apparatus is not connected to the air-conditioning apparatus 8 to 12, but it operates as an independent entity of parts, which may take the air needed from the space to be ventilated. The air-conditioning apparatus 8 to 12 is reduced corresponding to the air flow of the nozzle blowing apparatus 1, 6, 17, and from this part of the air flow the pressure loss caused by the devices 8 to 11 is excluded.

The figures show that the total air flow is drawn through a heat recovery device 10, i.e. from outdoors. Naturally, it is obvious that a solution known per se, in which only the air flow needed for maintaining the air quality is drawn through the heat recovery device, and the additional air flow needed for heating is drawn as a circulation air flow from the space to be ventilated, for instance, between the heat recovery 10 and the heating radiator 11, is within the scope of the invention, as well as all solutions to air-conditioning devices and systems known per se.

When the temperature of outdoor air rises and the heating demand turns into cooling demand, the nozzle blowing devices 2 are withdrawn from use by closing a damper 14 of Figure 6 or by switching off the fan 17 of Figure 7. In spaces where an intense temperature stratum is formed, the temperature of the occupied area may fall inconveniently, but usually that is settled by taking the heat recovery 10 into use again. It should be borne in mind that in a correctly designed apparatus also the temperature of exhaust air rises because of the temperature stratum.

In spaces where the temperature stratum is not formed in summer or it is formed only in a part of the space to be ventilated, the nozzle blowing apparatus can be kept in operation. This kind of application is shown in Figure 8, in which the nozzle blowing devices 2 are closed off by means of a damper 15 from an area B indicated by broken lines. A typical example of a space where the temperature stratum is formed only in winter is a space provided with radiator heating, without any other sources of heat.

If the nozzle blowing devices 2 are not in use during the cooling period, it is preferable to arrange a cooling radiator 16 in the distribution duct 7 of displacing air distribution. Correspondingly, part of the thermal power can be supplied exclusively by a radiator 18 arranged in a distribution duct 6 of the nozzle blowing devices in accordance with Figure 9. This is necessary especially when the distribution duct 6 is not connected to the air-conditioning apparatus 8 to 12, but it is independent and provided with a separate fan. The radiator 16 can naturally be placed in a conventional manner between the heating radiator 11 and the fan 12.

It has been stated above that the direction of air jets from the nozzles 3 is not generally necessary. It can be replaced with height control or, for instance, by providing the nozzle blowing devices 2 with single control dampers. Directional nozzles known per se can also be used, as well as one or, in accordance with Figure 10, two nozzle blowing devices 2 with only one row of nozzles. The direction is effected by simply turning the distribution device 2.

In the above, the invention is described by its most preferable embodiment, in which the air distribution devices 1, 2 form an air conducting duct at the same time. Naturally, it is possible to implement the basic idea also in accordance with Figure 11 by connecting aligned, separate, displacing supply air devices 20 to separate air conducting ducts 7. Correspondingly, the nozzle blowing device can be replaced with a separate air conducting duct and, for instance, with the nozzle blowing devices known from German publication 32 42 215 A1.

The above embodiments are not intended to restrict the invention in any way, but the invention can be varied quite freely within the scope of the claims. It is thus obvious that the apparatus of the invention or the details thereof need not necessarily be exactly as described in the figures, but other kinds of solutions are also possible. In the examples the invention is described only connected to a specific type of an air-conditioning apparatus 8 to 12, for instance. However, it is obvious that the invention can be applied in connection with all device and system solutions known per se, for instance, in connection with the integrated system in accordance with Finnish publication 92,867.

CLAIMS

1. An apparatus for distribution of incoming air particularly to large and/or medium-high rooms to be ventilated, the apparatus comprising a plurality of elongated air distribution devices that are installed substantially in parallel and substantially in a horizontal position, **characterized** in that the apparatus has, one after the other, a nozzle blowing device or devices (2) and a displacing air distribution device or displacing air distribution devices (1).

2. An apparatus as claimed in claim 1, **characterized** in that the nozzle blowing devices (2) are positioned in vertical direction above the displacing air distribution devices (1).

3. An apparatus as claimed in claim 1 or 2, **characterized** in that the air is arranged to be supplied to the displacing air distribution devices (1) through a first distribution duct (7) or distribution duct set, and to the nozzle blowing devices (2) through a second distribution duct (6) or distribution duct set.

4. An apparatus as claimed in any one of preceding claims 1 to 3, **characterized** in that outflow openings (3) of the nozzle blowing device (2) are arranged to form one or more longitudinal rows.

5. An apparatus as claimed in any one of preceding claims 1 to 4, **characterized** in that the outflow openings (3) of the nozzle blowing device (2) are small nozzles or nozzle sets.

6. An apparatus as claimed in any one of preceding claims 1 to 5, **characterized** in that the outflow openings (3) of the nozzle blowing device (2) are directed in such a way that the flow therefrom is directed to the vicinity of the displacing air distribution device (1).

7. An apparatus as claimed in any one of preceding claims 1 to 6, **characterized** in that the distribution duct (6) of the nozzle blowing devices (2) has a closing device or closing devices (14,15) which are arranged to exclude the nozzle blowing devices (2) partly or completely from use.

8. An apparatus as claimed in any one of preceding claims 1 to 7, **characterized** in that a booster fan (17) is arranged at the beginning of the distribution duct (6) of the nozzle blowing devices (2).

9. An apparatus as claimed in claim 8, **characterized** in that the distribution ducts (6, 7) or distribution duct sets of the nozzle blowing apparatus (2) and of the displacing air distribution (1) are parts that are separate from each other.

10. An apparatus as claimed in any one of preceding claims 1 to 9, **characterized** in that a heating radiator (18) is arranged in the forepart of the distribution duct (6) of the nozzle blowing device (2).

11. An apparatus as claimed in any one of preceding claims 1 to 10, **characterized** in that a cooling radiator (16) is arranged in the forepart of the distribution duct (7) of the displacing air distribution (1).

12. An apparatus as claimed in any one of preceding claims 1 to 11, **characterized** in that the displacing air distribution apparatus (1) comprises an air conducting duct (7) to which a plurality of aligned, separate air distribution devices (20) are connected.

13. An apparatus as claimed in any one of preceding claims 1 to 12, **characterized** in that the nozzle blowing apparatus (2) comprises an air conducting duct (6) to which a plurality of aligned, separate air distribution devices are connected.

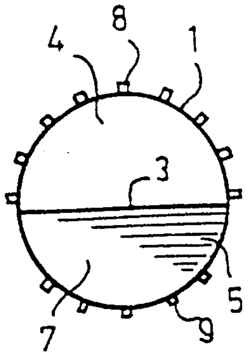


FIG 2

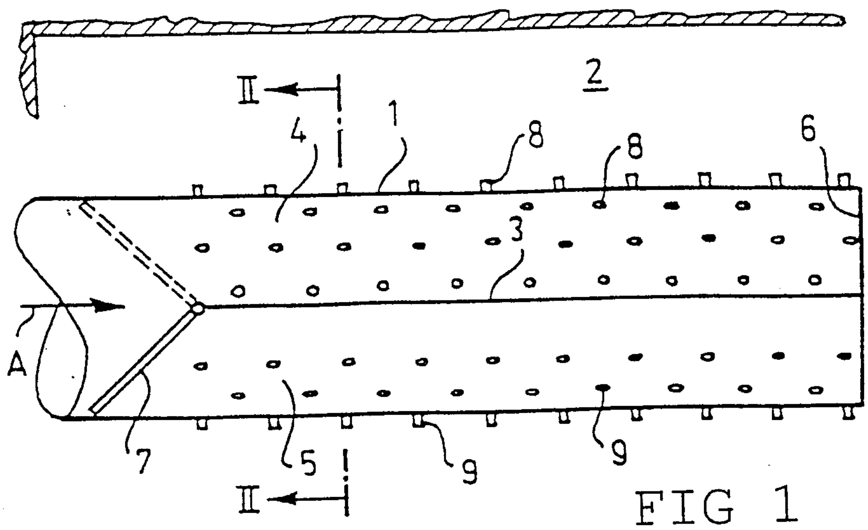


FIG 1

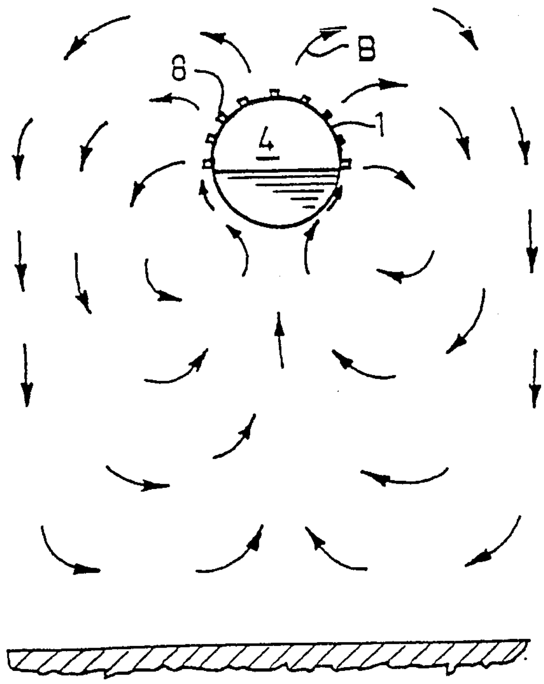


FIG 3A

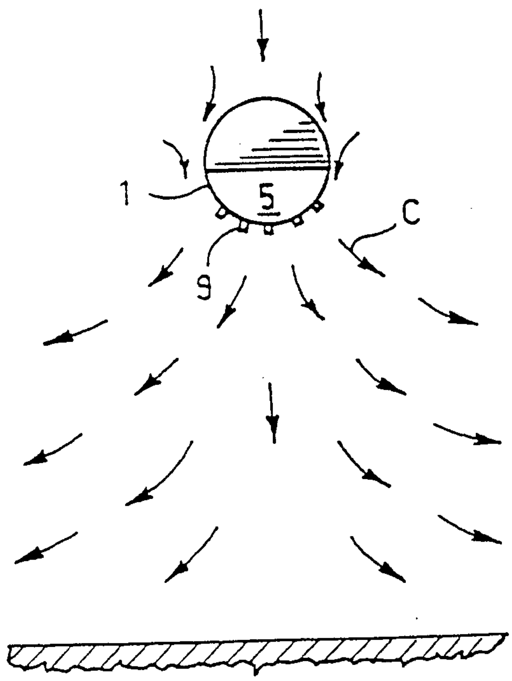


FIG 3B

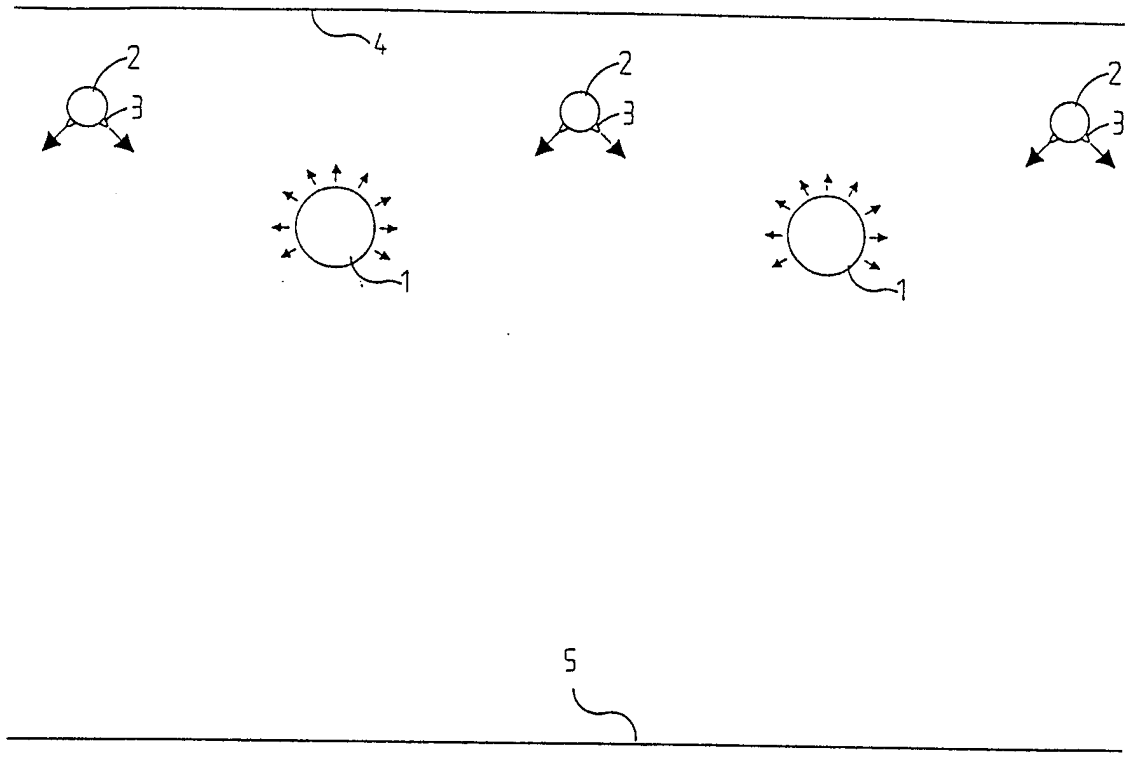


FIG. 4.

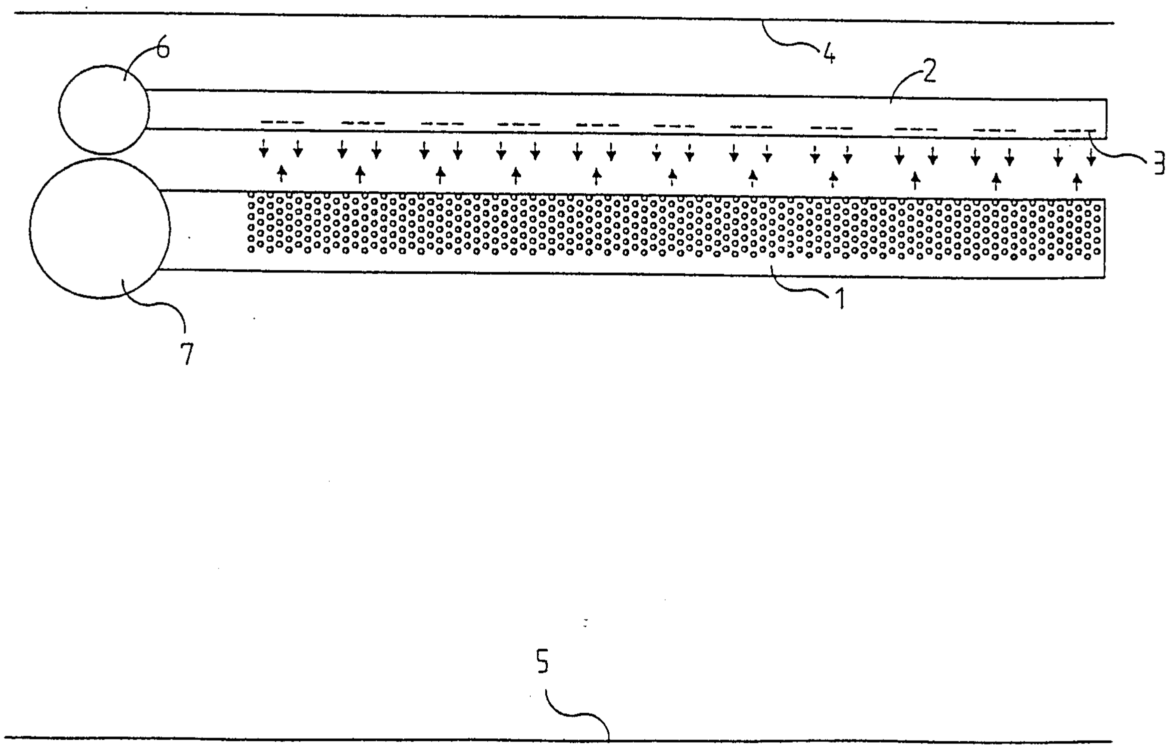


FIG. 5.

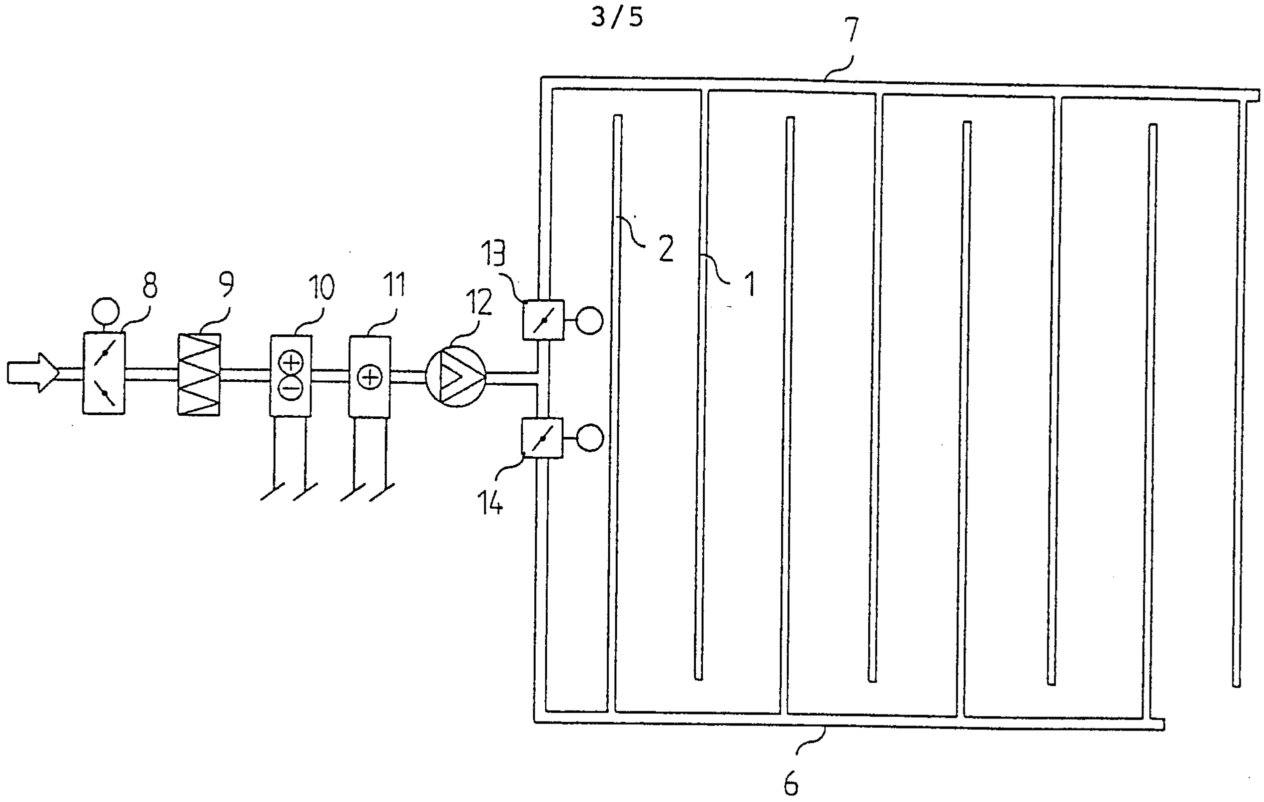


FIG.6.

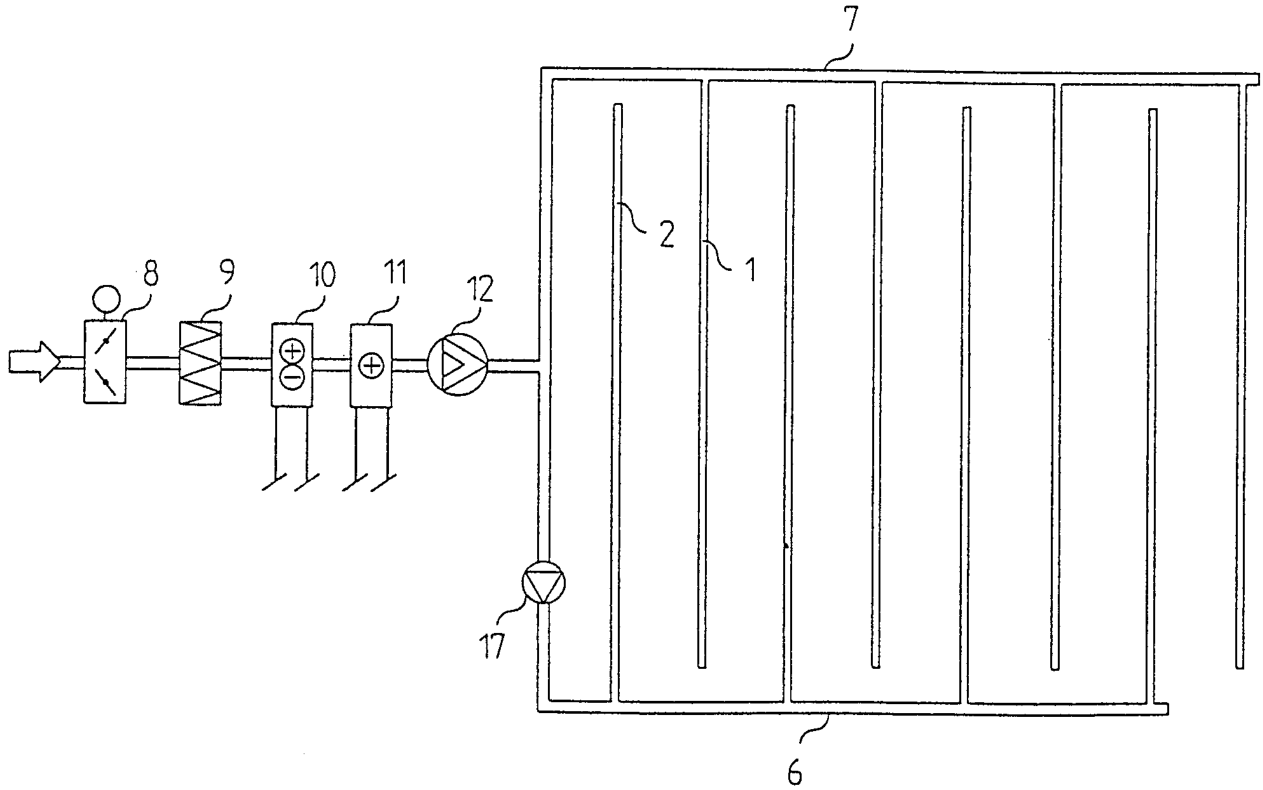


FIG.7.

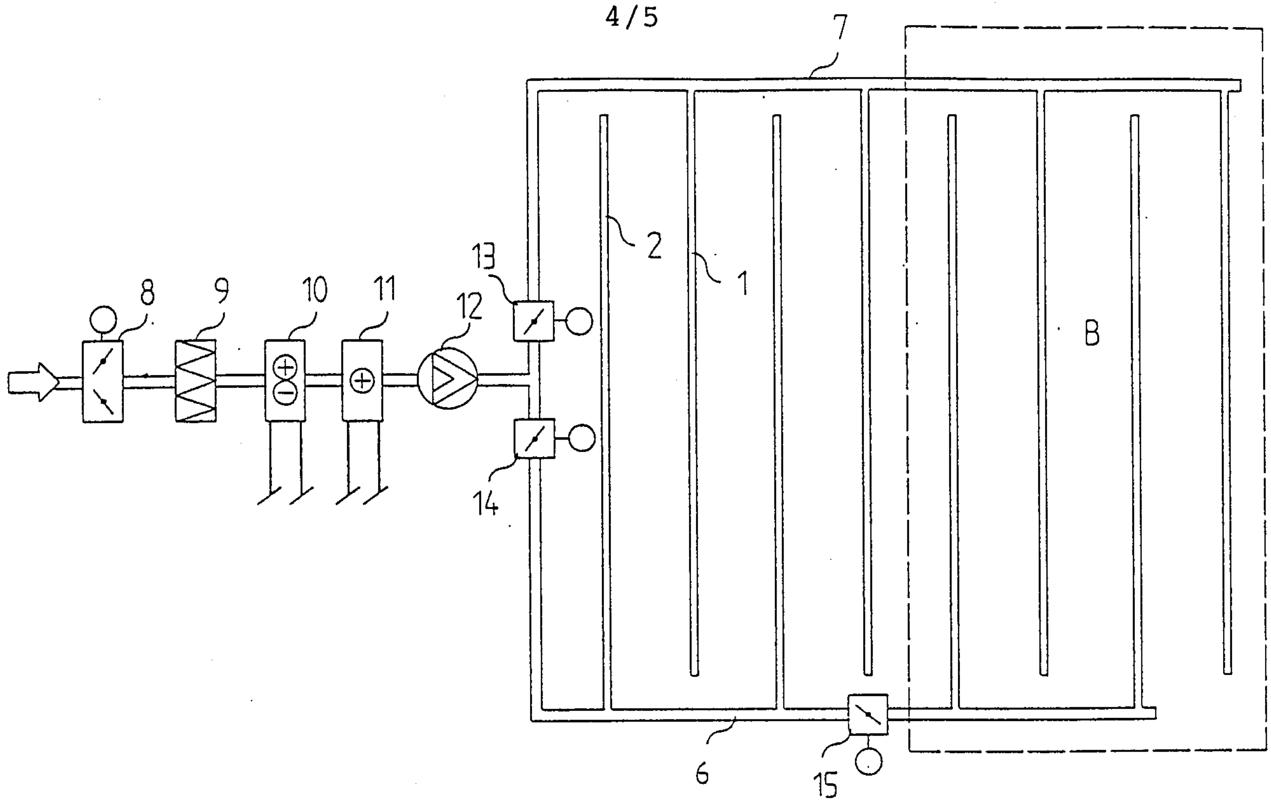


FIG.8.

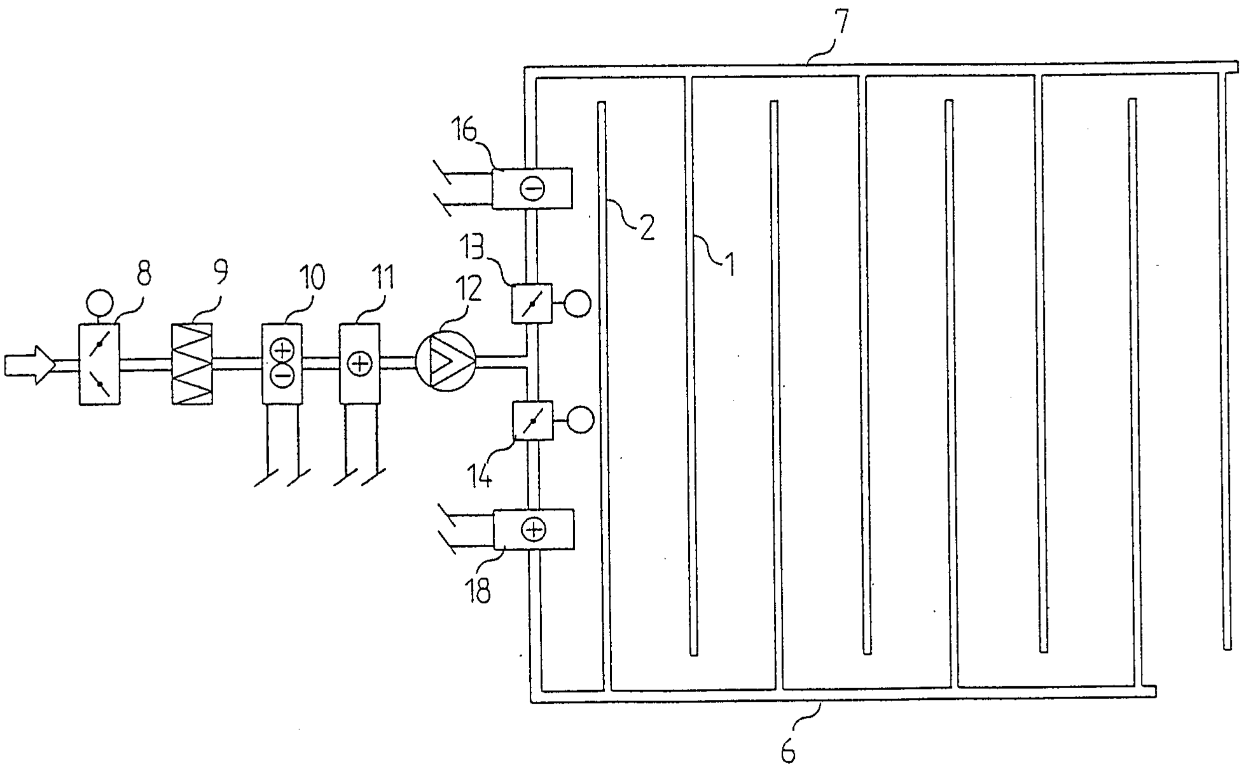


FIG.9.

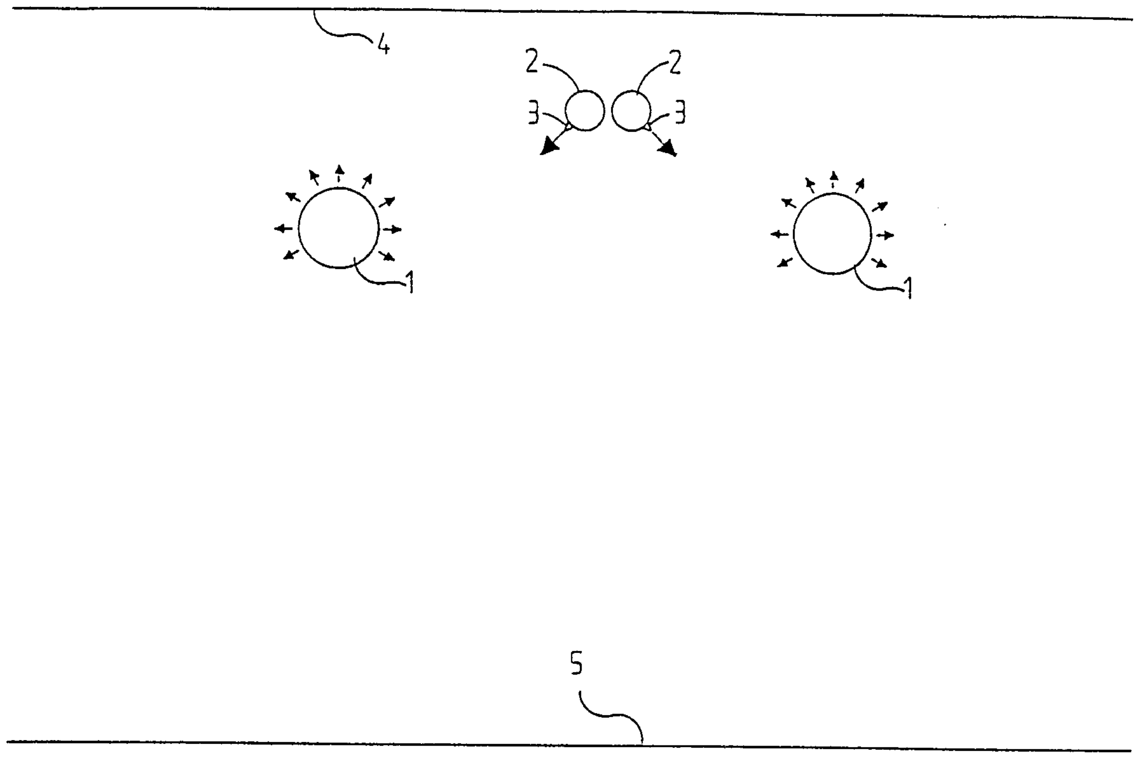


FIG. 10.

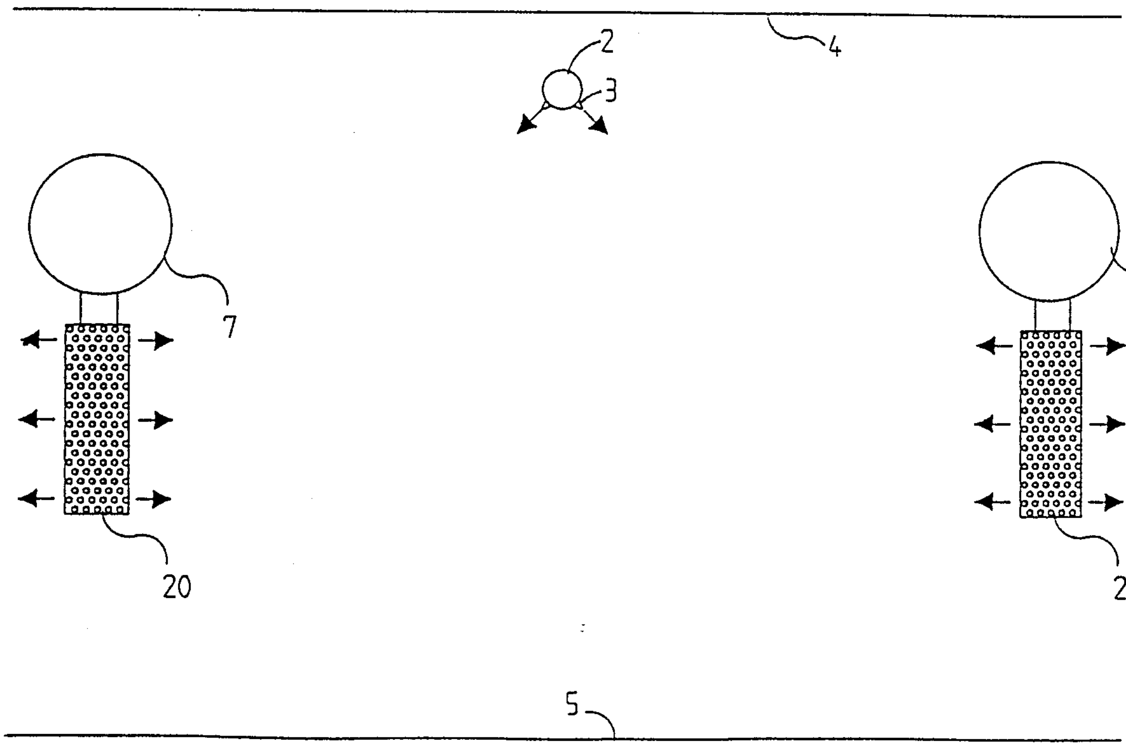


FIG. 11.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 98/00325

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: F24F 13/068, F24F 13/26
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: F24F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 8600123 A1 (ZENNER, WOLFGANG), 3 January 1986 (03.01.86), figure 5, abstract	
	--	
A	FR 694289 A (SOCIETE ANONYME DESETABLISSEMENTS NEU), 2 December 1930 (02.12.30)	2-13
Y		1
	--	
Y	EP 0038159 A1 (FLÄKT LIMITED), 21 October 1981 (21.10.81)	1,13
A		2-12
	--	

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 July 1998	09 -07- 1998
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Heléne Eliasson Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 98/00325

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E	WO 9801712 A1 (ABB INSTALAATIOT OY), 15 January 1998 (15.01.98) --	
A	EP 0276810 A2 (FLÄKT AKTIEBOLAG), 3 August 1988 (03.08.88) --	
A	WO 9214973 A1 (LESKINEN, SEPPO), 3 Sept 1992 (03.09.92) --	1-13
Y	WO 9315366 A1 (DANIELSEN, FREDE), 5 August 1993 (05.08.93)	1
A	 --	2-13
Y	Produktionskatalog, Bevent Luftdon 6.1, mars 1996,sid 14-17, Närzonsdon BVOL --	1,13
A	EP 0085428 A1 (FLÄKT AKTIEBOLAG), 10 August 1983 (10.08.83) --	
A	EP 0639744 A2 (RENZ, LUKAS), 22 February 1995 (22.02.95) -- --------	

INTERNATIONAL SEARCH REPORT
Information on patent family members

30/06/98

International application No.
PCT/FI 98/00325

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 8600123 A1	03/01/86	EP 0185695 A	02/07/86
		FI 71417 B,C	09/09/86
		FI 72800 B,C	31/03/87
		FI 73513 B,C	30/06/87
		FI 842383 A	14/12/85
		FI 852348 A	14/12/85
		FI 852349 A	14/12/85
FR 694289 A	02/12/30	NONE	
EP 0038159 A1	21/10/81	SE 0038159 T3	
		DK 151481 A	12/10/81
		DK 156149 B,C	26/06/89
		FI 66076 B,C	30/04/84
		FI 811106 A	12/10/81
		GB 2074718 A,B	04/11/81
		JP 56160538 A	10/12/81
		US 4426917 A	24/01/84
WO 9801712 A1	15/01/98	AU 3445197 A	02/02/98
		FI 962774 A	06/01/98
EP 0276810 A2	03/08/88	SE 0276810 T3	
		DE 3872532 A	13/08/92
		DK 34988 A	28/07/88
		DK 164374 B,C	15/06/92
		FI 79608 B,C	29/09/89
		FI 870345 A	28/07/88
WO 9214973 A1	03/09/92	AT 152232 T	15/05/97
		AU 1257592 A	15/09/92
		DE 69219320 D,T	25/09/97
		DK 571478 T	20/10/97
		EP 0571478 A,B	01/12/93
		SE 0571478 T3	
		FI 90466 B	29/10/93
		FI 910729 A	15/08/92
WO 9315366 A1	05/08/93	AT 131275 T	15/12/95
		AU 3626493 A	01/09/93
		DE 9390009 U	13/10/94
		DE 69300970 D,T	08/08/96
		DK 624236 T	08/01/96
		DK 9400295 U	01/08/94
		EP 0624236 A,B	17/11/94
		ES 2085150 T	16/05/96
		US 5490813 A	13/02/96

INTERNATIONAL SEARCH REPORT
Information on patent family members

30/06/98

International application No.
PCT/FI 98/00325

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0085428 A1	10/08/83	SE 0085428 T3	
		FI 66484 B,C	29/06/84
		FI 820325 A	03/08/83
EP 0639744 A2	22/02/95	NONE	