(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 286 502 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
18.10.2023 Bulletin 2023/42

(21) Application number: **16719914.0**

(22) Date of filing: **15.04.2016**

(51) International Patent Classification (IPC):
F24F 5/00 *(2006.01)* ***F28D 1/02*** *(2006.01)*
F28D 1/053 *(2006.01)* ***F24F 1/0043*** *(2019.01)*
F24F 13/20 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F24F 13/20; F24F 1/0043; F24F 2005/006; F28D 1/05366; F28D 2001/0286; F28F 2250/08; F28F 2260/02

(86) International application number:
PCT/IB2016/052156

(87) International publication number:
WO 2016/170456 (27.10.2016 Gazette 2016/43)

(54) **DIFFUSION UNIT FOR THE AIR-CONDITIONING OF AN INDOOR ENVIRONMENT**

DIFFUSIONEINHEIT ZUR KLIMATISIERUNG EINES INNENRAUMS

UNITÉ DE DIFFUSION D'AIR POUR LE CONDITIONNEMENT D'AIR DANS UN ENVIRONNEMENT INTÉRIEUR

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **20.04.2015 IT VR20150064**

(43) Date of publication of application:
28.02.2018 Bulletin 2018/09

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Description

[0001] The present invention relates to a diffusion unit for the air-conditioning of indoor environments.

[0002] The present invention finds advantageous application in the field of the air-conditioning of environments inside buildings and the like, to which the following description will make explicit reference without thereby losing in generality, in order to allow by heat exchange both the heating during winter and the air-conditioning during summer, through the use of air and water as air-conditioning vector fluids.

[0003] In general, air-conditioning of indoor environments (or air-conditioning of confined environments) is defined as the set of the operational steps to allow, at any time of the year and in any external weather condition, the thermo-hygrometric conditions suitable to the comfortable enjoyment by people within indoor environments.

[0004] The set includes the steps of heating, air-conditioning, ventilation, humidification or dehumidification according to the characteristics of the external weather and the activity within the buildings, with related possible endogenous heat production.

[0005] In order to achieve such operational steps, air-conditioning system are generally known, which are substantially composed of four subsystems: energy production/transformation plant (heating or cooling production), distribution network of the vector fluids (water, air, refrigerant gases), diffusion terminals (by convection, conduction, radiation), and adjustment assemblies (such as control units, programmable thermostats, thermostatic valves).

[0006] Currently, different types of the mentioned diffusion terminals are known, such as heaters or radiators, heated towel rails, convector heaters, baseboard terminals, radiating panels, fan coils, and active/passive chilled beams.

[0007] According to the legislative development of the recent years and the consequent refinement of the construction technique of the buildings, it is possible to state that the future in the building industry implicates extremely efficient buildings that consume roughly 50% less energy than the current low-energy buildings and 75% - 90% less than those built in the '70s.

[0008] With this drastic reduction in the energy demand for winter heating and summer air-conditioning, the air-conditioning plants inside the buildings and the related today's diffusion terminals (designed to provide high amounts of energy) are not always able to cope efficiently with the lower energy demand and the reaction velocity required to maintain the comfort at acceptable levels inside the increasingly thermally insulated buildings.

[0009] Furthermore, the low levels of energy consumption of the buildings and the variables depending on the use of the spaces (such as, for instance, the crowding of the environments and internal loads) may implicate variable and sudden heating and cooling loads, which favour diffusion terminals able to respond also abruptly in both conditions (heating and cooling).

[0010] Therefore, looking at the solutions currently available in the field of the above-mentioned diffusion terminals, it is clear that each type of terminal has its own peculiarities that make it more or less suitable to different conditions and building types.

[0011] Currently, however, no kind of the aforementioned terminal can meet all the requirements of the low-energy buildings.

[0012] In particular, it is possible to highlight the following problems: radiators, heated towel rails, convector heaters, radiant baseboard are suitable to the only heating, while for the air-conditioning they require an additional plant; radiant floors generate a good level of comfort, however, they have an unacceptable thermal inertia for the nearly zero energy buildings (NZEB); radiant ceilings, as well as chilled beams, generate a good level of comfort and have a valid application in the renovation of existing buildings, but they can be not comfortable for heating; the radiant walls generate a good level of comfort, but can show lack of homogeneity in heating the more distant areas from the wall, besides presenting space constraints for the furnishing; fan coils, instead, are very efficient because of the low inertia and the short time to make them operative, however, they have significant limitations in terms of comfort, generating winter layering and cold air currents in summer.

[0013] According to closest prior art for the invention as claimed, a known conditioning unit is disclosed in EP2827071 and also in EP2023049. However these documents do not disclose a diffusion unit configured to be fixed to a wall, a unit configured to be fed by water, a diffusion unit provided with a microchannel exchanger, inlet and outlet of water feeding means for microchannels of the microchannel exchanger, a monocoque bodyshell made by polystyrene.

[0014] Object of the present invention is to realize a diffusion unit able to overcome the drawbacks and problems of known diffusion terminal means specified above.

[0015] In particular, an object of the present invention is to realize a diffusion unit, which has high-energy efficiency and provides high comfort levels of air-conditioning both during summer and during winter.

[0016] Another object is to realize a diffusion unit, which is reliable, robust and resistant, and at the same time light and with a fine aesthetic appearance of furnishing.

[0017] A further object of the present diffusion unit is to be industrially feasible with extremely competitive costs with respect to conventional diffusion terminals aforementioned.

[0018] The structural and functional characteristics of the present invention and its advantages over the known art will be clearer and more evident from the claims below, and in particular from an examination of the following description, referring to the attached drawings, which show the schematic representations of a preferred but

nonlimiting embodiment of the present diffusion unit, wherein:

- Figure 1 is an exploded perspective view of the diffusion unit of the present invention;
- Figure 2 is another exploded view of the unit of Figure 1, in which the construction components of the unit itself are highlighted;
- Figure 3 illustrates in enlarged scale some front, side and perspective views of a component of the unit of Figure 2;
- Figure 4 shows a detail of the component of Figure 3;
- Figure 5 is a perspective view of a further component of the unit shown in Figure 2;
- Figure 6 is a front view of the unit, with the cover partly removed to show more clearly the inside of the unit; and
- Figure 7 is a vertical sectional view of the unit.

[0019] With reference to the attached figures, U globally indicates a diffusion unit for the air-conditioning of indoor building environments in general, which makes use, in particular, of the heat exchange technology known by the term "microchannel", i.e. is suitable to use water as a vector fluid for diffusing heat and cold through air, allowing the efficient winter heating and summer air-conditioning in buildings and environments in which people dwell, live, work, and have fun.

[0020] As illustrated in Figures 1 and 2, the unit U includes a cabinet-like outer covering structure S in monolithic metal, preferably aluminium, which has an extremely linear and simple structure, suitable to be normally wall mounted, at a height of about 20-25 cm from the floor, through a self-levelling template D which is also, preferably, made of aluminium.□

[0021] The structure S is provided, only on its front vertical surface, with a plurality of through holes F for the air-conditioned air diffusion and suitable to define a large-surface diffusion array G, which, besides determining a best comfort, confers a pleasant aesthetic appearance; the shape of the holes F of the array G may be customized depending on the needs and the environment type, in an almost infinite number of motifs and patterns.

[0022] The structure S is suitable to be secured to a single piece frame 2, preferably also made of aluminium, which frame 2 is suitable to contain a monocoque bearing or bodyshell structure 3 made of polystyrene or expanded styrofoam.

[0023] As illustrated in Figure 2, the monocoque structure 3 is, in turn, suitable to define a supporting frame assembly, by means of insulating supports 5 made of rubber, and upper and lower plate means 6 and 8, for at least a heat exchanger 4 belonging to the microchannel technology type.

[0024] The unit U further includes a motorized ventilator assembly 7, preferably but not limited to the tangential type, which is inferiorly attached to the frame 3 via the plate 6 adjacent to the plate 9 shaped as a bowl, and metallic (Cl. G1) or acrylic (cl. G3) filter means 10, which comply with the current legislation EN779:2005, housed in use in the structure 3.

[0025] The following innovative characteristics and advantages of the construction components described above are highlighted:

Frame 2: The containment frame 2 is mounted on wall using the template D ("backpack" interlocking) made of aluminium for the wall mounting.

[0026] Advantages of this technical solution: for wall mounting is sufficient to attach the self-levelling template perfectly levelled, and as a result, the unit will be automatically anchored properly. This greatly simplifies the attachment operations, as the attachment operation of the template to the wall with screws is easier than of that of the entire unit directly. All the weight of the unit U is thus unloaded on the monocoque containment frame 2, therefore all the equipment is free from tensions and attachment constraints. This is very important because in the traditional fan coil the fastening is normally done by means of screws directly applied to the wall and attached on the unit frame. This operation, which is inherently difficult, especially in case of wall mounting on walls that are not perfectly levelled, during screw tightening steps may generate tensions and bending of the structure, which also deform the geometry by a few millimetres, which results in difficulties in fastening of the covering furniture, as well as possible "creaking" noises during the operation of the unit U. Structure 3: Such structure 3 has a highly innovative and distinctive element of the present invention with use of a monocoque bearing structure and completely made of styrofoam (commonly also called: EPS, polystyrene or expanded styrofoam) in contrast to the traditional devices formed by numerous and complex parts made of galvanized steel sheet, plastics and various types of insulating elements joined together by numerous screws and various adhesives. Such polystyrene structure provides a comfortable and easy housing of all the equipment and their support, the perfect thermal insulation, and the reduction of the number of the used parts. Advantages of this technical solution: Polystyrene is a material widely used in industry and in the building industry, due to very limited costs and excellent thermal insulation. The styrofoam has a very low thermal conductivity, due to the closed cell structure, in which air accounts for 98%. It has unique and certified recyclability and self-extinguishing features, which allow a wide use in construction industry. In a few years, the styrofoam has become the most used material in thermal insulation measures for buildings ("coat"). This material has excellent physical and mechanical properties, a reduced thermal conductivity, a good stability from the dimensional point of view, a homogeneous density, and a high mechanical strength. In the specific case of the monocoque bearing structure, used with a density of 20-30kg/m3, it allows excellent supporting and housing of all the equipment inside the unit, which, being made of aluminium (and, thus, lightweight), are very well combined with the

styrofoam chosen as bearing structure. The styrofoam used for thermal insulation is obtained from natural resources, and has a much lower environmental impact compared to other materials. It is a highly recyclable material. Its recyclability is definitely a plus, which, thus, in environmental terms, makes it preferable to other synthetic materials, able to perform the same function, but with a heavier environmental impact. Polystyrene is considered a safe material with respect to the human and environmental health, in fact, contrary to some insulating materials, it is not carcinogenic. It has been found, by means of some tests, that styrene (the monomer from which the expanded polystyrene is produced) is also present in nature in many foods, including strawberries, beans, nuts, beer, wine, coffee and cinnamon seeds, therefore, it cannot be defined harmful neither to humans nor to the environment. Moreover, EPS - polystyrene-expanded styrofoam is permeable to water vapour, thus it is breathable, but, at the same time, it is waterproof. The permeability to water vapour ensures that inside or adjacent the polystyrene - expanded styrofoam, moulds do not form. With respect to water, it is known that this latter does not dissolve the polystyrene, and it does not pass through the walls of the closed cells. The capillarity absorption of this material is practically zero.

[0027] Microchannel heat exchanger 4: has a significantly higher efficiency (around +40%) compared to the traditional copper tube bundle and aluminium mechanically mandrelled finning exchangers (in short "Copper-Aluminium Assemblies"). The innovation underling the present invention is the result of the greater efficiency that makes the use of this technology extremely innovative within the invention, but also of the fact that these microchannel exchangers have a monolithic design (in contrast to the usual Copper-Aluminium Assemblies, which, instead, are a set of different materials extremely less integral with each other and which need a frame, generally in metal sheet). The monolithic nature of the microchannel exchanger allows its interlocking insertion into the monocoque bearing structure 3 completely made of styrofoam, with advantages in assembly times of the unit unrivaled compared to traditional diffusion terminals. A microchannel exchanger is also completely made of aluminium, and may be easily recycled, without the necessity of any kind of separation. Moreover, a microchannel exchanger has the following remarkable advantages:
- Reduced ventilation energy with an average reduction of air-side load losses of 25%: at aeraulic level, the limited thickness of the finned pack (generally 25mm) and the improved fluid dynamics, of the primary tube geometry favour an important reduction of the air-side load losses compared to traditional copper-aluminium assemblies. This affects the decrease of the electric power used for the ventilation: lower consumption and lower noise.

- Reduced pumping energy of the vector fluids with a reduction of water-side load losses of 65%: at hydraulic level, there is a substantial reduction of the water-side load losses, because generally in the microchannel exchangers water makes only two passages inside the exchanger. This peculiarity of the microchannel exchangers results in the decreasing of the pumping energy needed for the system pump to circulate the water (monophase fluid) in the pipes; in the traditional copper-aluminium assemblies, instead, in order to increase water turbulence inside the pipes the passages are many more, and this generates greater load losses.
- Lower cost level of both the raw material and the exchangers. The aluminium is the third chemical element in order of abundance on the earth's crust (8.3 wt%), more than iron (6.2%) from which the steel is obtained, second only to oxygen (45.5%) and silicon (25.7%). The cost of the microchannel exchangers is generally lower than that of copper-aluminium assemblies, and tend to be more stable to fluctuations in trades. From the industrial point of view, this light metal (its density is 2.71 g/cm3) has unique characteristics that makes it preferable to many other metallic materials, in a many areas. Concerning the metal alloys made of aluminium, the common peculiarities are: low melting temperature (between 510 and 650°C), low specific weight, between 2.66 and 2.85 g/cm3, very high electrical and thermal conductivity, 100% recyclable.

[0028] In use, the unit U sucks air from the environment in which they are placed through the two air inlets A and B placed at the bottom of the unit U itself (Figures 6 and 7). The intake air is then filtered by the filters 10 and vertically conveyed from the fan 7 into the channel 12 within the structure S.

[0029] Therefore, the air enters in a calm zone, decreases its speed and proceeds through the microchannel exchanger 4, where it is heated, cooled and/or dehumidified, according to the water temperature with which the exchanger 4 is fed and to the conditions of the ambient air.

[0030] The water inlet and outlet are placed in the points C and D, respectively, where there are two male threaded attachments to which the water distribution system delivery and return pipes are connected, respectively. Downstream of the exchanger 4 the heated, cooled and/or dehumidified air flows out of the array of holes G on the front surface of the unit U, through which it spreads uniformly at a low speed and at the desired temperature.

[0031] Finally, with the diffusion units U described above the following remarkable advantages are achieved:

- all year round air-conditioning
- increased energy efficiency of the generators
- low inertia
- short time to be operative
- reduced overall dimensions
- increased comfort

- robustness
- lightness
- recyclability
- increased aesthetic integration with the furnishings.

Claims

1. A diffusion unit (U) for air conditioning of indoor environments suitable for being fed by water, comprising a frame (2) configured to be fixed to a wall; a monocoque bodyshell structure (3) configured to be secured to said frame (2), exchanging heat means (4) configured to be supported by the said monocoque bodyshell structure (3) and enclosed by said monocoque structure (3) without outwards heat dispersion areas, said heat means (4) comprising at least one microchannel exchanger (4) comprising fan means (7) and filter means; and a cover structure (S) provided at the front of said diffusion unit (U) with a grid (G) of holes (F) for the diffusion of conditioned air, the diffusion unit being
characterized in that said monocoque bodyshell structure (3) is entirely made of polystyrene or expanded styrofoam and said microchannel exchanger (4) is provided with water inlet and outlet feeding means for water feeding microchannels of said microchannel exchanger (4) when in use.

2. The diffusion unit according to claim 1, **characterized in that** said filter means (10) are made of metallic material.

3. The diffusion unit according to claim 1, **characterized in that** said filter means (10) are made of acrylic material.

Patentansprüche

1. Diffusionseinheit (U) zur Klimatisierung von Innenräumen, geeignet für die Versorgung mit Wasser, bestehend aus einem Rahmen (2), der zur Befestigung an einer Wand geeignet ist; eine Monocoque-Karosseriestruktur (3), die dazu geeignet ist, am Rahmen (2) befestigt zu werden, Wärmeaustauschmittel (4), die von der Monocoque-Karosseriestruktur (3) getragen werden können und von der Monocoque-Struktur (3) ohne Wärmeverteilungszonen gegen das Äußere umgeben sind, wobei die Wärmemittel (4) mindestens einen Mikrokanal-Wärmetauscher (4) umfassen, der Ventilatormittel (7) und Filtermittel umfasst; und eine Abdeckstruktur (S), die an der Vorderseite der Diffusionseinheit (U) mit einem Gitter (G) angeordnet ist, die aus Löchern (F) für die Diffusion von klimatisierten Luft versehen ist, wobei die Diffusionseinheit ist **dadurch gekennzeichnet, dass** die Monocoque-Karosseriestruktur (3) vollständig aus Polystyrol oder aus expandiertem Polystyrol hergestellt ist und der Mikrokanal-Wärmetauscher (4) am Einlass und am Auslass mit Wasserversorgungsmitteln für das Wasser versehen ist, das die Mikrokanäle des Mikrokanal-Wärmetauschers (4) während seines Gebrauchs versorgt.

2. Diffusionseinheit nach Anspruch 1, **dadurch gekennzeichnet, dass** die Filtermittel (10) aus einem metallischen Material bestehen.

3. Diffusionseinheit nach Anspruch 1, **dadurch gekennzeichnet, dass** die Filtermittel (10) aus einem Acrylmaterial bestehen.

Revendications

1. Unité de diffusion (U) pour la climatisation d'environnements intérieurs, apte à être alimentée avec de l'eau, comprenant un châssis (2) adapté pour être fixé à un mur; une structure de carrosserie monocoque (3) adaptée pour être fixée audit châssis (2), des moyens d'échange de chaleur (4) adaptés pour être supportés par ladite structure de carrosserie monocoque (3) et entourés par ladite structure monocoque (3) sans des zones de dispersion de chaleur vers l'extérieur, lesdits moyens de chaleur (4) comprenant au moins un échangeur (4) à microcanal comprenant des moyens de ventilateur (7) et des moyens de filtrage ; et une structure de couverture (S) munie à l'avant de ladite unité (U) d'une grille (G) de trous (F) pour la diffusion de l'air conditionné, l'unité de diffusion étant **caractérisée en ce que** la structure de carrosserie monocoque (3) est réalisée entièrement en polystyrène ou en polystyrène expansé, et l'échangeur à microcanal (4) est pourvu de moyens d'alimentation de l'eau en entrée et en sortie pour l'eau qui alimente les microcanaux de l'échangeur à microcanal (4) pendant l'utilisation de celui-ci.

2. Unité de diffusion selon la revendication 1, **caractérisée en ce que** les moyens de filtrage (10) sont constitués d'un matériau métallique.

3. Unité de diffusion selon la revendication 1, **caractérisée en ce que** lesdits moyens de filtrage (10) sont constitués d'un matériau acrylique.

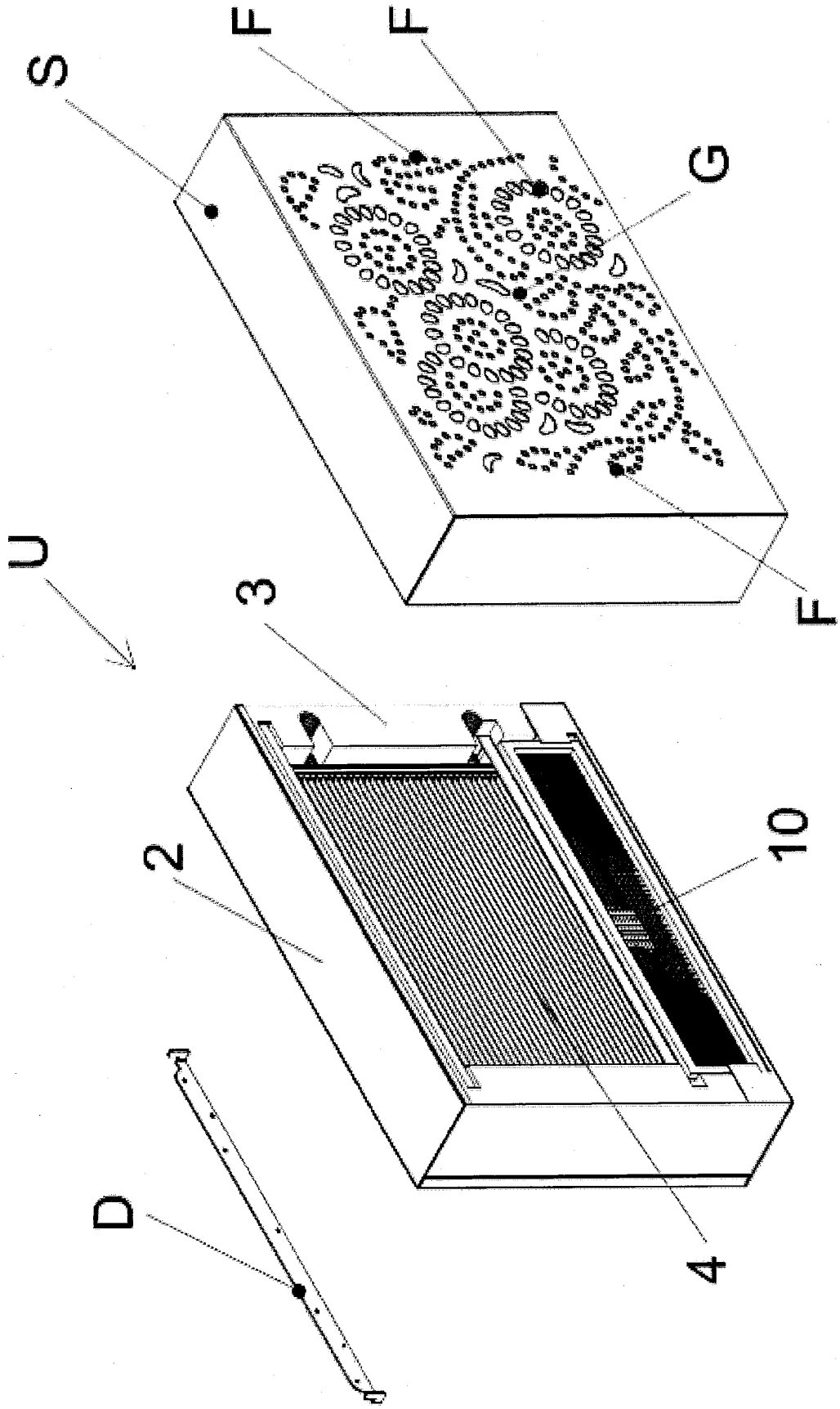


Fig. 1

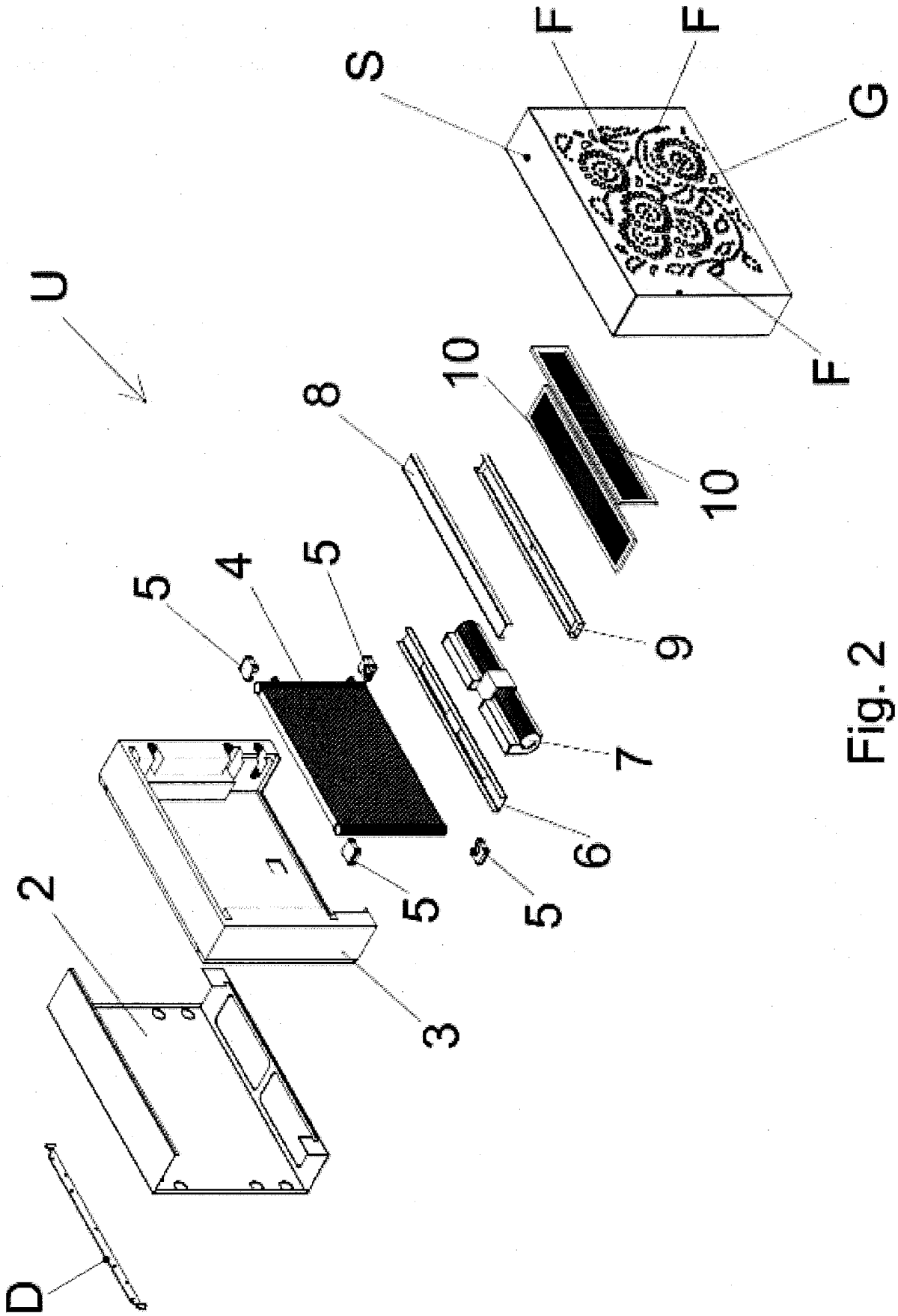
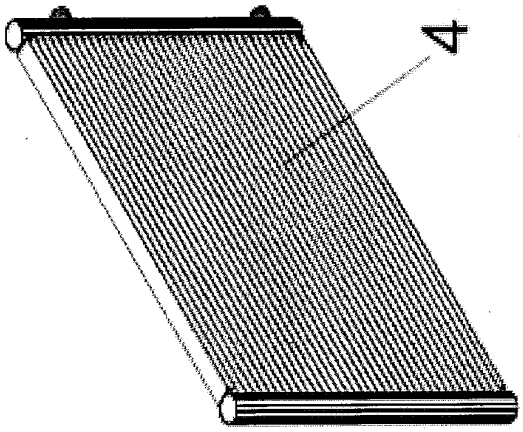


Fig. 2



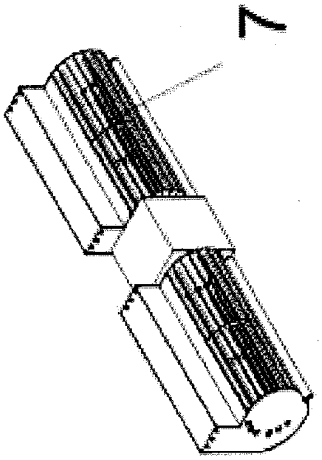


Fig. 5

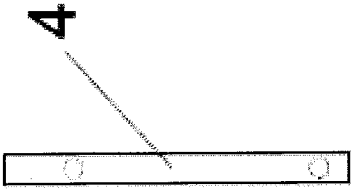


Fig. 3

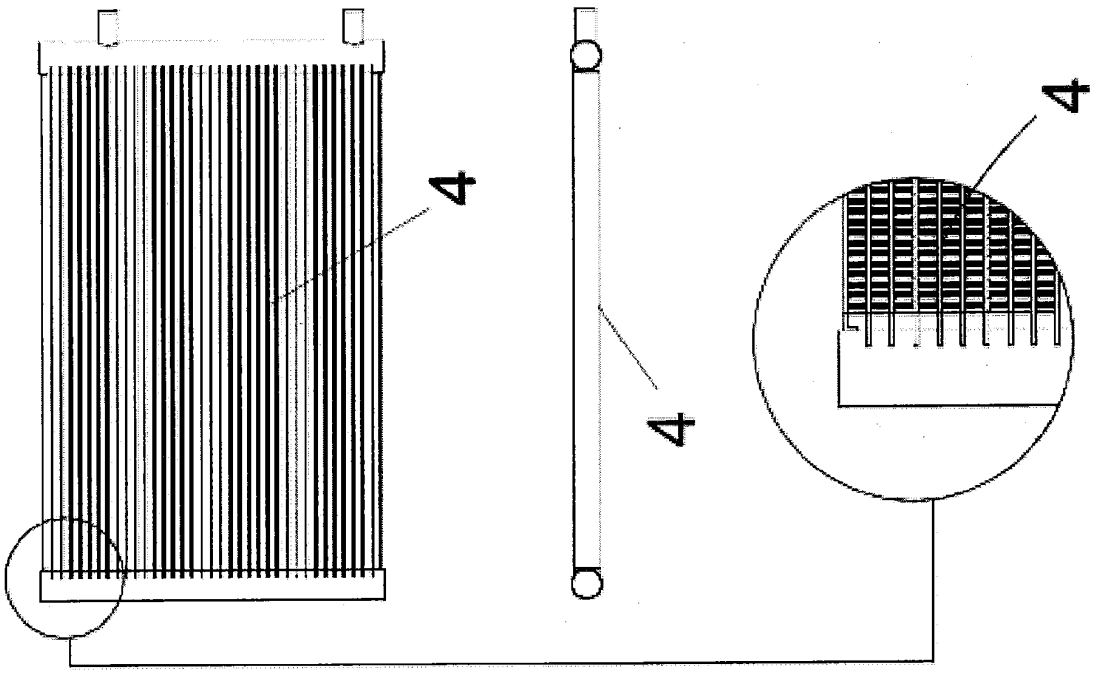


Fig. 4

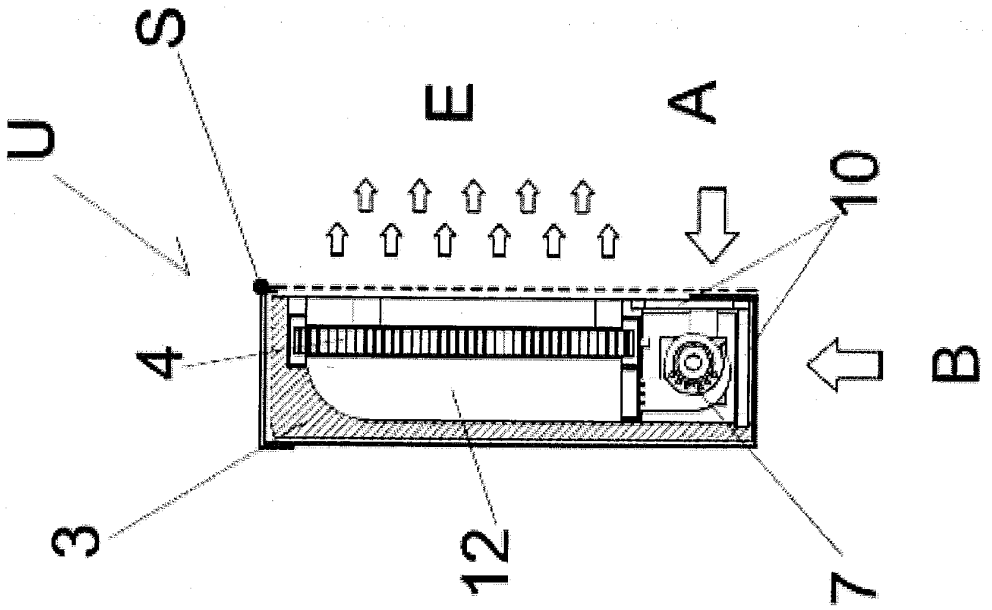


Fig. 7

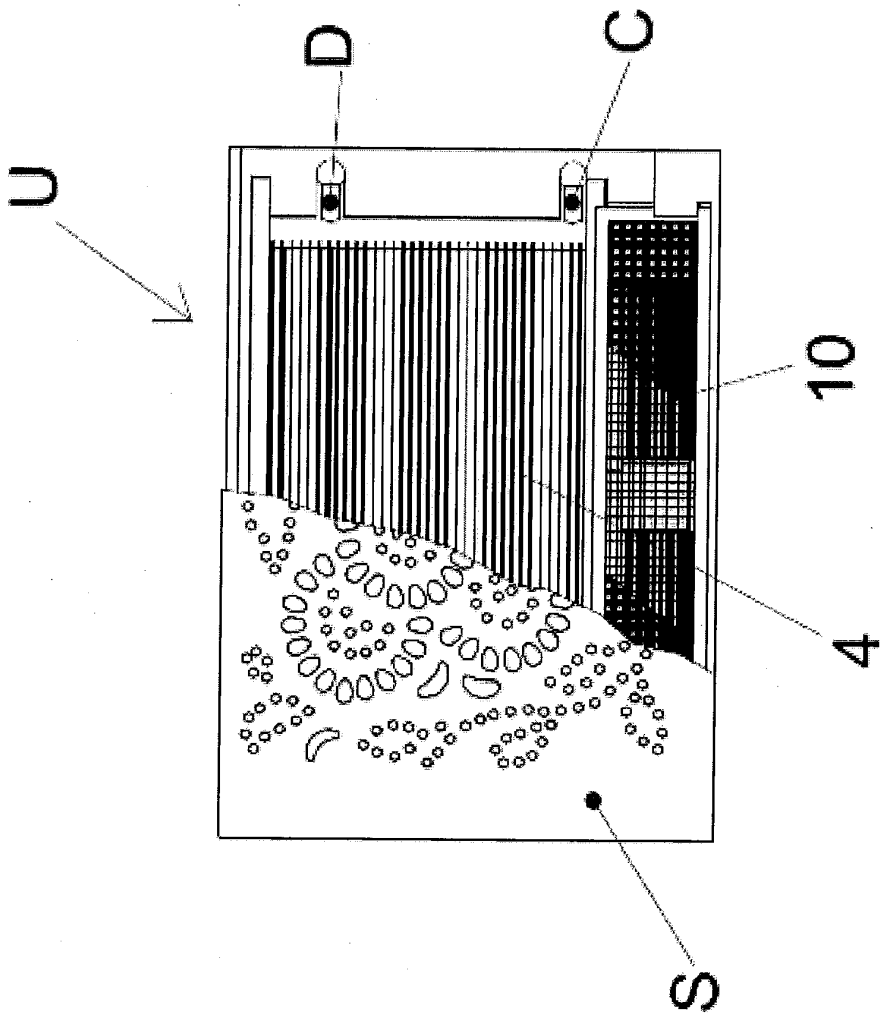


Fig. 6

REFERENCES CITED IN THE DESCRIPTION

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