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(54) **Device for the forced cooling of the condenser of household refrigerators and kitchen tool integrating said device**

(57) A forced-ventilation arrangement is disclosed for application to a condenser of a household fridge, of the type comprising a fan body (2) provided with a drive motor and with a fan (1) capable of creating a forced air flow, further comprising at least a diffuser body (3) downstream of said fan body (1) and conveying means (4) having an outlet vent capable of directing said air flow to lick said condenser in a direction substantially aligned to the vector of the air flow which would be established by natural convection on said condenser.

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Description

Field of the Invention

[0001] The present invention concerns a cooling device for the condenser of household refrigerators. In particular, it concerns a fan device for external condensers.

Background Art

[0002] As known, household refrigerating apparatuses require the use of a condenser acting as a heat exchanger, since said exchanger is designed to promote the transfer to the environment air of the heat absorbed by a working fluid, used for the refrigeration cycle, so that said fluid returns to a liquid state from a gaseous one.

[0003] Typically, a heat-exchanger condenser for a refrigeration cycle is in the shape of a small pipe which develops into a serpentine, supported on a plane by a consolidation grille, which is then mounted on the rear, external vertical side of the fridge body.

[0004] From a theoretical point of view, very large condensers would be required, because that increases the heat transfer to the outside and hence heat pump efficiency. Of course, due to practical considerations, condensers cannot be too large and they are generally sized to be on average suitable for the requirements of the fridge they are applied to, despite resorting to natural convection of room air on the exchanger.

[0005] However, since the maximum available surface substantially corresponds to the rear dimensions of the fridge, the condenser is not necessarily always suited to requirements.

[0006] In particular, condenser efficiency is at risk in small fridges mounted in narrow spaces (typically the small minibars built-in in hotel cabinets), where natural air convection is not sufficient to dissipate the heat as required. The problem is perceived in particular for gas-powered fridges (absorption fridges), which have more problems with external temperature than those equipped with a compressor.

[0007] There are hence fan devices available on the market which are designed in particular to be mounted on fridges installed in camper vans/caravans: such components determine forced convection around the condenser, thereby improving heat transfer to room air.

[0008] However, these auxiliary devices are conceived to achieve at least satisfactory operating conditions of the condenser - which would otherwise be so inefficient that the fridge would be even unable to cool foodstuffs - and they hence have a relatively high power (15-20 W) and power consumption: from an energy point of view, therefore, they are not efficient at all. In substance, with these devices the fridge cools adequately, but at a higher energy cost than the one it would pay without forced convection.

[0009] At the same time, home appliance manufacturers have developed fridges with a fan-cooled compact condenser. This solution, too, has advantages in terms of apparatus compactness, but does not allow to achieve energy savings.

[0010] The object of the present invention instead is to provide a device which allows to reduce electric power consumption of household fridges and deep-freezers. In particular, it is intended to achieve such reduction by improving as far as possible heat removal from the outer exchanger (condenser) of the fridge, promoting the natural convection of the exchanger without using an inefficient amount of energy.

[0011] This solution, as can be guessed from what is available on the market, is not within a technician's easy reach.

[0012] In particular, it can be easily realised that the power consumption of a forced-ventilation device, which traditionally pushes an air flow through the heat exchanger plane, is higher than the saving which may be achieved by the resulting efficiency improvement of the exchanger. So much so that this prior art solution is implemented only to achieve the desired refrigeration, and not for the purpose of energy savings.

[0013] The Applicant has run a number of experimental and theoretical field trials, aimed at understanding how to optimise fan power use.

[0014] From the trials performed, it resulted that the maximum saving which can be achieved in household fridges, by improved convection on the exchanger, is slightly below 20% of the power used by the gas compressor; as a precautionary measure, such saving was hence taken as the energy-saving limit beyond which the technique of cooling the outer exchanger is not technically feasible.

[0015] In such conditions, starting from the consideration that a standard B-class fridge uses about 400-450 kWh/year, the power absorbed by the fan including the power supply thereof - which should reasonably be about 15% of the achievable savings - would be about 12 kWh/year, i.e. approximately equal to 1.3 Wh/h.

[0016] In order to reduce as much as possible the power absorbed by the fan, it is assumed that said fan remains in operation only when the condenser is to be cooled, i.e. only when the gas compressor is in operation: assuming a 50% "duty-cycle" (for class-A fridges it may be even smaller) and a loss of about 0.5 W in the fan power supply, it results that the fan may have a maximum power of about 2 W.

[0017] Per se, the smallness of this power expendable by the fan is such that conventional mounting on the condenser would not allow at all to achieve acceptable energy consumption savings.

Summary of the Invention

[0018] Therefore, the object set forth above is achieved, according to the invention, by a new and innovative arrangement as described in essential terms in the attached main claim.

[0019] In particular, according to the invention, a DRF device is provided, substantially consisting of three parts: a fan body, within which the fan used for moving the cooling air is installed, a connecting diffuser body, which may take up different shapes, and channelling means, which serve to suitably channel the air moved by the fan on the external condenser of the fridge.

[0020] Other inventive aspects peculiar of the invention are described in the dependent claims.

Brief Description of the Drawings

[0021] Further features and advantages of the device according to the invention will in any case be more evident from the following detailed description, given by way of example and illustrated in the accompanying drawings, wherein:

figs. 1A and 1B are side elevation and rear elevation views, respectively, of a device according to a first embodiment of the invention for self-contained fridges;

figs. 2A and 2B are side elevation and rear elevation views, respectively, of a second embodiment for built-in fridges; and

fig. 3 is a perspective view of a variant of the device of figs. 2A and 2B.

Description of Preferred Embodiments

[0022] Fig. 1 shows, as an example, an embodiment of the forced cooling device according to the invention, which will be referred to by the acronym DRF in the following. The embodiment shown there can be advantageously used for self-contained fridges and/or deep-freezers.

[0023] A fan with a corresponding drive motor 1, of a type known per se, is housed in a fan body 2 which suitably supports and embraces fan 1, so that the desired air flow may be established from the area upstream of the fan to the downstream area.

[0024] The fan and corresponding electric motor 1 must be of a low-energy-absorption type, in particular of a power below 2 W. An exemplifying fan suitable for the purpose is model KDE1206PTV2 manufactured by Sunon with 1.1 W absorbed power at 12 V.

[0025] Preferably, in fan body 2 a transformer is also included, for changing network voltage (110 V or 220 V) into low voltage (12 V) for the operation of fan 1.

[0026] Fan body 2 is mounted to a mouthpiece of a diffuser body 3, possibly provided with a connecting hose. Diffuser body 3 has a diverging shape, at least according to a main dimension thereof. Inside the diffuser, conveying and smoothening flaps may be provided, whose purpose is to suitably and evenly direct the air flow with the smallest possible drag loss.

[0027] This shape, together with the presence of the above-said flaps, has the object of diffusing in a controlled and even way the inner air flow coming from motor-powered fan 1 - which, being low-power, typically has a few-cm width - to the heat exchanger of the fridge, which instead normally extends across a significant width, for example of 50 cm.

[0028] Downstream of diffuser body 3, conveying means 4 are provided specifically for concentrating and directing the air flow so that it licks the heat exchanger of a fridge on the plane thereof.

[0029] In particular, it has been detected that, in order to achieve the desired energy efficiency for the device, it is necessary for the final, low-speed air flow to be directed from one edge of the heat exchanger to the opposite edge thereof, licking the plane whereon it lies, preferably from the lower edge of a classic, rectangular heat exchanger to the upper edge thereof.

[0030] In particular, in order to maximise the cooling effects, the vector representing the speed of output air from the conveying means must preferably have the same direction as that representing air velocity around the exchanger due to natural convection, so that the resulting speed - the vectorial sum of the two - has the maximum modulus and heat exchange is more efficient. Accordingly, since the air tends to rise by natural convection along a vertically-arranged condenser, according to the invention, conveying means 4 are preferably directed upwards against the lower edge of the exchanger.

[0031] Only in this way is it possible to achieve an energy benefit from the cooling of the exchanger, even employing a very-low-power fan (below 2 W). As a matter of fact, the device of the invention manages to promote natural convection and hence, in the light of the minimum energy absorption by fan 1, it is possible to obtain a marked efficiency increase of the heat exchanger of the fridge and hence an overall energy improvement of the fridge+DFR assembly.

[0032] Conveying means 4 hence provide an outlet vent which preferably faces the lower edge of the exchanger and directs the air flow upwards in the plane thereof. Advantageously, the vent has an elongated, rectangular shape and the shorter side thereof is of the same order of magnitude as the exchanger cross-section. More preferably, where possible, such outlet vent has an aperture of a shape and area overall of the same order of magnitude as the transversal bulk cross-section of the heat exchanger for which the device is intended. For example, such aperture may be up to 50 cm long and up to a lower limit of 5 mm wide.

[0033] The task of diffuser 3 is hence that of guiding the air flow from the useful section of fan 1 (for example a square cross-section of 5x5 cm, equal to 25 cm^2) to the working cross-section of the outlet vent (for example a rectangular cross-section of 25x1 cm, again equal to 25 cm^2), so that the flow is directed at efficiently licking a significant portion of the heat exchanger, as desired.

[0034] In such respect, it has been detected that a condition is preferable wherein the working area of the outlet vent is equal or substantially equivalent to the area of the useful section of the air flow of fan 1.

[0035] The shape and tilting of the walls of diffuser 3 may be diverse, also depending on the overall length thereof. In this context such arrangement will not be described in further detail, since it is within the reach of any skilled person in the field who wishes to apply the teaching offered here with the lowest possible drag loss, hence also possibly in the attempt of keeping a laminar flow.

[0036] Moreover, depending on the position where the DRF is to be arranged, the arrangement and orientation of the diffuser/conveying assembly may be changed.

[0037] Figs. 1A and 1B show a diffuser body 3 which engages with the top aperture of a connecting hose 5 of fan body 2. Such aperture, with which the diffuser engages, has a circular section and a vertical axis. In such case, in order to allow an easier positioning of the device on the rear of the fridge, the diffuser is provided to be freely rotated (up to $\pm$ 90°) about the vertical axis thereof on the aperture of hose 5. The DRF device is conceived to rest on the floor on feet P and to be arranged below a self-contained fridge, with diffuser body 3 arranged on the back of the fridge and below the corresponding condenser.

[0038] The diffuser body extends entirely in a vertical direction, hence behind the fridge, for exploiting the available room. Diffuser 3 extends on the vertical plane and is rotatably supported on connecting hose 5.

[0039] Fig. 2 shows, as an example, a DRF variant to be used for in-built fridges and/or deep-freezers.

[0040] In this case the space available in the rear area of the fridge is accessible with difficulty, therefore diffuser body 3 is shaped so as to extend substantially in a horizontal direction, below the fridge where instead a suitable space is always provided for functional reasons. As can be seen in figs. 2A and 2B, the device is hence conceived so that only conveying means 4 and a short connecting portion to diffuser body 3 extend vertically in the rear area of the fridge.

[0041] Diffuser 3 extends on a horizontal plane and also has stabiliser feet P to be supported on the floor.

[0042] Should the vertical bulk of the device be sufficiently limited, this DRF variant may be installed by simply introducing it below the fridge, from the front side, without having to disassemble any component.

[0043] Fig. 3 shows a further variant of the device of fig. 2, wherein conveying means 4 are in the shape of a plurality (three) of connecting, L-shaped pipes.

[0044] According to a particularly preferred embodiment (not shown), the diffuser and the conveying means are arranged with respect to fan body 1 so that the air flow generated by the fan remains always axial. Accordingly, unlike the embodiments shown above, the fan is mounted with a vertical rotation axis, so as to withdraw air from below and direct it upwards, into the diffuser, the conveying means, and finally to lick the heat exchanger. This arrangement is particularly efficient because it does not even experience the energy losses connected with the vector deviation of the air flow.

[0045] The device according to the invention allows to brilliantly achieve the objects set forth in the preliminary remarks. As a matter of fact, such device achieves a cooling of the condenser element of the fridge at the cost of a minimal power dissipated by the fan motor, which is hence widely compensated by the energy saving resulting from the increased efficiency of the heat exchanger. The achievable benefits are hence substantially twofold:

- improved efficiency of the heat pump, with resulting reduction of gross consumption of primary energy;
- increased available refrigerating power, with resulting improvement of the food refrigeration capability, especially in the hot season.

[0046] In principle the device is applicable to fridges and deep-freezers belonging to any class (including A+ and A++), but it is of course more convenient for higher-consumption classes (B, C, D, E), since larger energy savings are achieved.

[0047] From numerous tests carried out, it emerged that, by adopting a fan absorbing about 1 W of power on a B-class fridge, a net yearly saving per fridge of about 50 kWh may be achieved.

[0048] It is understood, however, that protection of the invention described above is not limited to the particular arrangement illustrated, but extends to any other construction variant which does not depart from the scope of protection as defined in the attached claims.

[0049] For example, although a device has always been shown intended to rest on the floor plane, in the proximity of and/or below a fridge/deep-freezer, it is not ruled out that it may be designed for arrangement above a self-contained fridge. In such case, the conveying means will be arranged in the proximity of the upper edge of the heat exchanger, but they will work in suction promoting the upward outflow of the heated air which rises back up from the condenser behind the fridge.

[0050] In such case, the outer shape of fan body 2 and of diffuser 3 can be of a higher aesthetic standard, in order to make the presence thereof above the fridge attractive, as well as - from a technical point of view - to achieve additional functions (for example, integrating it into a kitchen tool, such as a scales plane, for weighing goods, or a storage compartment, or a sealing machine for deep-freezing bags and so on). Since the device of the invention is preferably provided also with a voltage transformer, any further electrical devices integrated in the tool might advantageously exploit the same low-voltage power supply.

[0051] Finally, it is not ruled out that in certain cases multiple DRF devices must be used to achieve the desired energy saving. For example, in large top-load deep-freezers, wherein the condenser is rather low but very wide and power absorption is high, it may be advantageous to arrange two or more DRFs side-by-side, which achieves a better efficiency than a single one with a very large diffuser. From experiments carried out by the Applicant, it has been detected that a reasonable width limit of the diffuser/conveyor is about 50 cm, beyond which it is convenient to employ multiple DRFs.

Claims

1. Cooling arrangement for application to a condenser of a household fridge, of the type comprising a fan body (2) provided with a drive motor and a fan (1) capable of creating an air flow, **characterised in that** it further comprises at least a diffuser body (3) downstream of said fan body (1) and conveying means (4) having an outlet vent capable of directing said air flow to lick said condenser in a direction substantially aligned to the vector of the air flow which would establish itself by natural convection on said condenser.

2. Arrangement as claimed in claim 1), wherein said outlet vent (4) has a transversal cross-section aperture substantially equivalent to the transversal cross-section of the condenser.

3. Arrangement as claimed in claim 1) or 2), wherein said outlet vent (4) has an aperture of an area substantially equal to the useful flow section of the fan body (1).

4. Arrangement as claimed in claim 1), 2) or 3), wherein said drive motor of the fan is of a power below 2 W, preferably below 1 W.

5. Arrangement as claimed in any one of claims 1) to 4), wherein said diffuser body (3) extends triangular-shaped from said fan body (1) to said conveying means (4).

6. Arrangement as claimed in claim 5), wherein said diffuser (3) has air flow conveying and smoothening flaps inside.

7. Arrangement as claimed in any one of the preceding claims, wherein at least said fan body (1) has stabiliser feet (P) to rest on a floor.

8. Arrangement as claimed in any one of the preceding claims, wherein said conveying means (4) are provided for directing the air flow substantially along a plane perpendicular to the axis of rotation of said fan.

9. Arrangement as claimed in claim 8), wherein said diffuser body (3) extends substantially into a direction perpendicular to the axis of said fan and a connection (5) is further provided between said fan body (2) and the diffuser body (3).

10. Arrangement as claimed in claim 9), wherein said connection (5) has a circular section and said diffuser body (3) is rotatably mounted at one end of said connection.

11. Arrangement as claimed in claim 8), wherein said diffuser body (3) extends substantially into a direction parallel to the axis of said fan and said conveying means (4) develop substantially in a perpendicular direction.

12. Arrangement as claimed in claim 11), wherein also said conveyor body (3) has stabiliser feet (P).

13. Arrangement as claimed in any one of claims 1) to 7), wherein said conveying means (4) are provided for directing the air flow substantially along a plane parallel to the axis of rotation of said fan.

14. Arrangement as claimed in any one of the preceding claims, wherein said aperture has an elongated, rectangular shape, whose longer dimension is less than 50 cm.

15. Arrangement as claimed in claim 14), wherein the shorter dimension of said aperture measures more than 5 mm.

16. Kitchen tool, **characterised in that** it has resting means apt to rest on a fridge/deep-freezer and **in that** it incorporates a device as in any one of the preceding claims, the conveying means (4) being designed for establishing an upward, vertical, forced air flow and at the same time for establishing a suction flow from below.

17. Fan device and condenser assembly for a household fridge developing on a vertical plane, of the type comprising a fan body (2) provided with a drive motor and with a fan (1) capable of creating an air flow on said condenser, **characterised in that** it further comprises, downstream of said fan body (2), at least a diffuser body (3) and conveying means (4) having an outlet vent with an elongated aperture, arranged in the proximity of an edge of said condenser and capable of directing a forced air flow to lick said condenser on the development plane thereof with a direction substantially equivalent to the vector of the natural convection air flow.

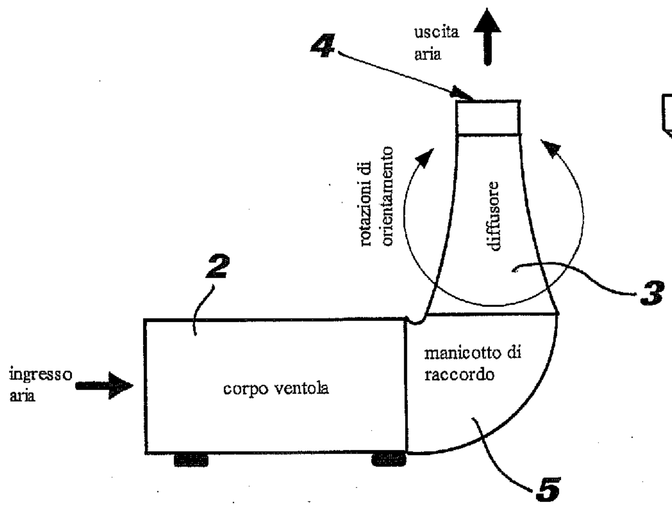

Fig.1A

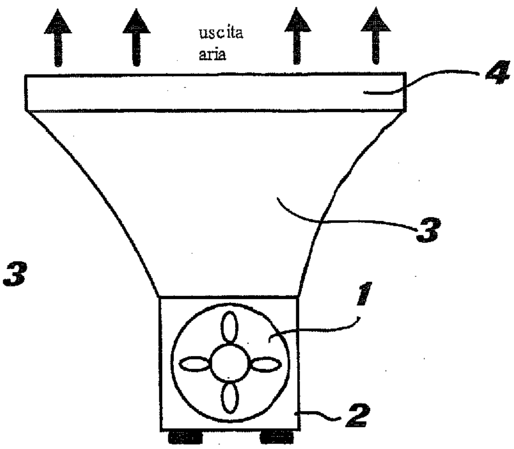

Fig.1B

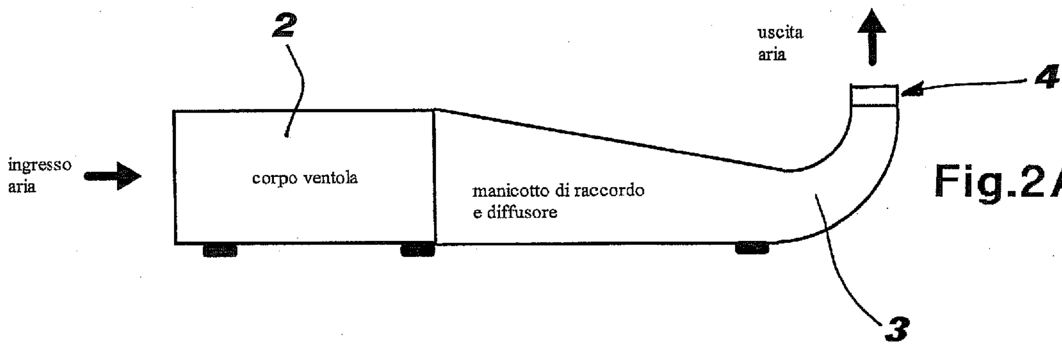

Fig.2A

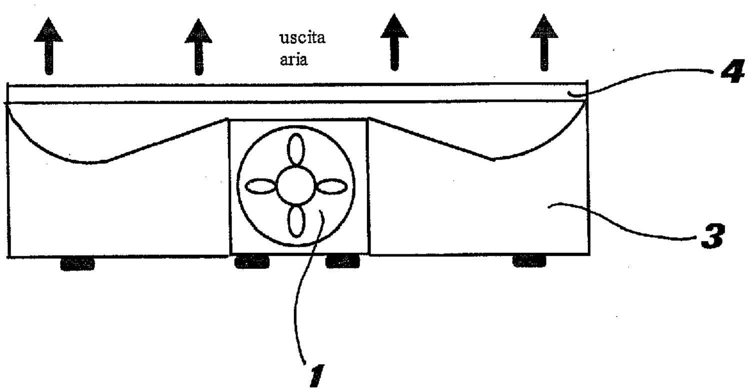

Fig.2B

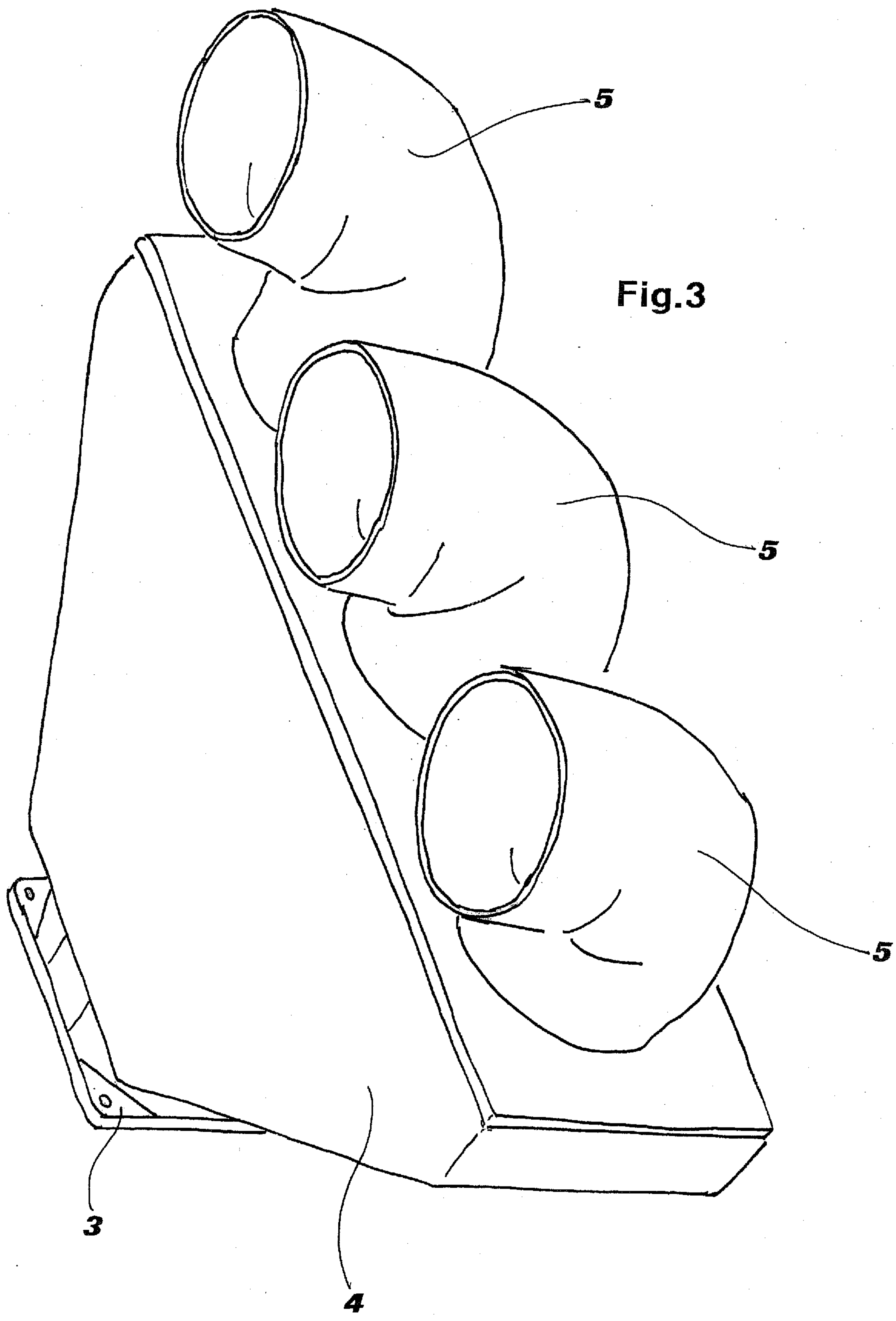

Fig.3