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(54) **Fan impeller**

(57) An impeller for a fan, comprising a hub and a plurality of blades extending from the hub, wherein each blade has a leading edge and a trailing edge and wherein each blade has a first portion made from a rigid material and a second portion formed on the leading edge of the first portion and formed from a resilient material. The impeller increases the safety of the impeller by reducing the potential damage or injury caused by collision with the impeller. Consequently, a fan with such an impeller does not require a protective grill in order to meet safety regulations. The absence of a grill increases the efficiency of the fan and reduces the noise caused by turbulence as air passes through the grill. A method of making the impeller is also provided.

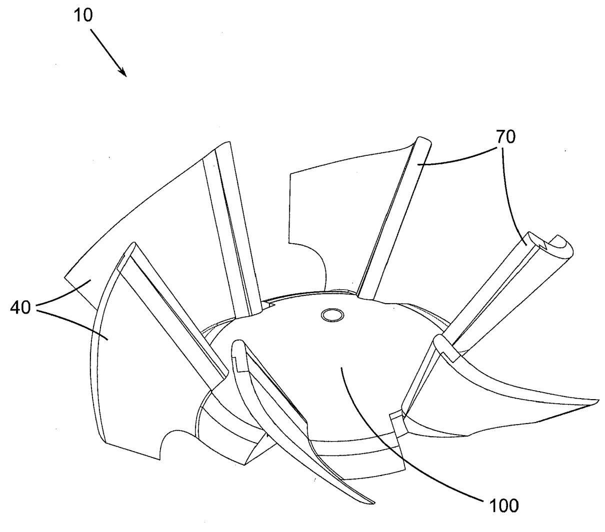

Fig. 3

EP 2 444 674 A2

Description

[0001] The invention relates to impellers for fans, particularly to domestic ventilation or extractor fans.

[0002] Ventilation fans typically employ a motor driven impeller to move air from one location to another, usually from inside a building to outside the building, possibly through ducting. Depending on the size of the impeller and the volume of air that is to be shifted, the impeller can be driven at varying speeds, typically from 800 to 3500 revolutions per minute.

[0003] For ease of access and installation, the fan is usually mounted on the inside of a room, recessed into the wall. The fan units themselves are preferably kept fairly small and so the impeller is located quite close to the interior of the room. Safety regulations mean that certain precautions have to be taken to protect users from becoming injured through contact with the spinning impeller. This is typically done by providing a grill, mesh or plate between the impeller and the room with openings large enough for air to pass, but small enough to prevent hands or fingers from being inserted into the fan towards the impeller.

[0004] However, grills or plates of any sort introduce turbulence into the air flow and consequently raise the noise levels of the fan. The fan's operation can be made significantly quieter by keeping the air flow into the fan more smooth. The grill or plate can also be unattractive to look at.

[0005] According to the invention there is provided an impeller for a fan, comprising a hub and a plurality of blades extending from the hub, wherein each blade has a leading edge and a trailing edge and wherein each blade has a first portion made from a rigid material and a second portion formed on the leading edge of the first portion and formed from a resilient material.

[0006] The resilient material formed on the leading edge of the blades is softer than the rigid material which forms the main body of the impeller (hub and blades). Consequently, in an impact between the leading edge of the blades and another object, the energy is dissipated in the resilient material, reducing the force on the object and making for a less violent collision. This means that the impeller is safer than a fully rigid impeller and consequently the impeller can be exposed within the fan without additional protection in front of it to prevent insertion of objects. The effect of the impeller is sufficient that collisions between the impeller and a human body part (e.g. a finger) are not considered dangerous and thus fans can be made without grills or plates obstructing the main airflow entrance. As such grills or plates contribute to resistance (drag) and turbulence in the incoming air stream and consequently contribute to increased noise, the impeller has the further benefit of providing higher efficiency and quieter operation.

[0007] Preferably each blade tapers from the leading edge to the trailing edge. This provides a wider surface area on the leading edge on which to attach the resilient material. The wider surface area ensures a good bond between the two materials and reduces the chances of separation of the two materials during operation. It will be appreciated that fans can operate at high speed and are designed to move significant quantities of air and it is therefore important to ensure that the two surfaces are sufficiently well bonded to comfortably resist the centrifugal and axial forces during operation.

[0008] The leading edge of the first portion may have a structure comprising a ledge extending partially across the width of the blade. The ledge creates a step in the profile of the blade and thereby increases the surface area of attachment between the two materials. Preferably the ledge is formed on the low pressure side of the blades.

[0009] The leading edge of the first portion may have a structure comprising at least one projection extending substantially perpendicular to the leading portion of the blade. The projection provides extra surface area for attachment of the two materials and can provide attachment surfaces in several different orientations, thus providing better resistance to forces from different directions. The projection may take a variety of different forms depending on the intended use of the impeller, the expected forces on it and the techniques used to attach the two portions. In preferred embodiments the projection has at least one sloping side. The at least one sloping side may form an overhang of the projection over the leading edge of the first portion. The overhang creates a region of the resilient material which is held in place against forces acting to pull the resilient material off the rigid material along the length of the blade. Preferably the sloping sides of all projections on each blade are parallel so as to allow a mould for the first portion to be removed in the direction of the sloping sides.

[0010] The resilient material may be any soft material which can absorb impact energy. Preferably it is flexible or deformable. Preferably the resilient material is an elastomeric material, more preferably rubber. In particularly preferred embodiments the resilient material has a Shore D hardness of 60 or less which is sufficient to meet safety regulations. More preferably the Shore D hardness is between 45 and 60, with the most preferred material having a Shore D hardness of about 60. This hardness has been determined to give good impact absorption between the rigid base of the impeller and a human finger while providing the best adhesion between materials during the moulding process.

[0011] Depending on the size and form of the impeller, the resilient portion may be varied in size. For example in centrifugal fans, the distal end of the blade is most likely to encounter an object first, with the end proximal to the hub being unlikely to encounter such objects. Therefore the resilient portion may be provided only on the distal portion of the leading edge. Preferably the resilient portion extends from the end of the blade distal to the hub at least halfway to the end proximal to the hub. More preferably, the resilient portion extends along the full length of the leading edge from the distal end to the proximal end of the hub. This provides full protection along the length of the blade.

[0012] Preferably each of the resilient portions on the blades are connected together via a connecting portion of resilient material formed on the hub. This arrangement is particularly advantageous as it allows the impeller to be moulded in only two pieces (one rigid piece and one resilient piece). This simplifies the assembly process. In particular, the impeller can be moulded by bi-injection moulding. Bi-injection moulding provides a particularly good bond between the two materials. With the one-piece arrangement, bi-injection moulding can be performed with only one injection point. The injection point can be placed centrally, over the axis of rotation of the impeller in the centre of the hub. The pressure of inserting the molten resilient material is then symmetrically distributed around the impeller which results in even formation of the resilient material and maintains the balance of the impeller. This is a key concern for quiet operation of the fan as any imbalances in the impeller can lead to wobble during operation which in turns increases noise and reduces efficiency.

[0013] The invention applies to centrifugal, mixed flow and axial type impellers. Centrifugal impellers have blades with the leading edge extending substantially parallel to the axis of rotation of the impeller whereas axial impellers have blades with the leading edge extending substantially perpendicular to the axis of rotation of the impeller. All types of impeller suffer from the problem of having to meet safety regulations with respect to insertion of objects and both types of fan benefit from the removal of a grill. The invention applies equally to mixed flow type impellers which are a hybrid type with blades angled in between the axial and centrifugal arrangements, i.e. the blades are angled so as to impart some radial and some axial momentum to the air.

[0014] According to a further aspect, the invention provides a method of manufacturing an impeller, comprising the steps of: forming an impeller base part from a rigid material, comprising a hub and a plurality of blades extending from the hub, each blade having a leading edge and a trailing edge; and forming a portion of resilient material on the leading edge of each blade.

[0015] Although the two materials of the impeller can be attached by any suitable method, in preferred embodiments the impeller is formed by bi-injection moulding with a first stage for moulding the rigid material and a second stage for moulding the resilient material. Bi-injection moulding provides a particularly strong bond between the two materials and therefore increases the life of the impeller.

[0016] According to a further aspect, the invention provides a fan comprising an impeller as described above. Preferably the fan does not have a protective grill in front of the impeller. As described above, the absence of a grill or other protective plate reduces the resistance to the incoming air flow and also reduces the turbulence, thereby reducing noise and increasing efficiency.

[0017] Although the invention can be applied to any size of fan and for any purpose, in preferred embodiments the fan is a domestic ventilation fan such as those used in household kitchens and bathrooms. These fans are subject to building regulations with regard to the safety of the fan, particularly with regard to the dangers of users (e.g. homeowners or contracted installers) inserting hands or fingers into the opening for the airflow and risking contact with the spinning impeller.

[0018] Preferred embodiments of the invention will now be described by way of example only, and with reference to the accompanying drawings in which:

> Fig. 1 is a front view of a base part of the impeller;
> Fig. 2 is a perspective view of a base part of the impeller; and
> Fig. 3 is a perspective view of the complete impeller with resilient material bonded to the base part of the impeller.

[0019] Figs. 1 and 2 show a base part 20 of a fan impeller 10 for use in a domestic ventilation fan. The impeller base 20 has a domed hub 30 and a plurality (six in this embodiment) blades 40 protruding from the hub 30. In this embodiment the hub 30 is a conical dome although in other embodiments it may be a spherical dome. The base part 20 is made from a rigid material such as ABS plastic.

[0020] The impeller 10 of this embodiment is a mixed flow impeller, i.e. one which combines the principles of axial flow impellers and centrifugal flow impellers. The blades of an axial flow impeller extend substantially radially out from the hub, i.e. perpendicular to the axis of rotation. The blades of a centrifugal flow impeller extend substantially perpendicularly to the radius of the hub, i.e. parallel to the axis of rotation. The blades 40 of the mixed flow impeller shown here extend out from the hub 30 at an angle in between these extremes and therefore impart some axial and some radial flow to the air.

[0021] The centrifugal aspects of the impeller 10 allow the fan to maintain a greater pressure difference across the impeller 10 and thereby makes the impeller 10 more resistant to the presence of back pressure which can arise for example from changing wind speed and direction outside of the building. The axial aspects of the impeller 10 allow the fan to shift a greater quantity of air.

[0022] Each blade 40 of the impeller 10 has a leading edge 50 and a trailing edge 60. As illustrated in Fig. 3, the leading edge 50 of each blade 40 is formed of rubber 70. It is the leading edge 50 of the blade 40 which is furthest forward in the fan (i.e. closest to the room) and most accessible and is therefore the part of the impeller 10 which first comes into contact with any foreign object inserted into the fan from within the room. Therefore if a person were to insert a hand or finger into the front opening of the fan, their hand or finger would come into contact with the rubber tip 70 of one or more of the blades 40 which, being softer than the rigid base 20, will not cause significant pain or injury. The soft impact will be sufficient either to provide a warning of the presence of the impeller 10 and the potential for injury or to slow or stop the impeller 10, thus preventing further injury.

[0023] To ensure that the rubber tip 70 bonds well to the rigid impeller base 20, a bonding structure is provided on the leading edge 50 of each blade 40. The purpose of the bonding structure is to provide increased surface area for contact between the two materials and overlaps to resist separation of the two materials. The blades 40 taper from the leading edge 50 toward the trailing edge 60, i.e. the blades 40 are thicker at the leading edge 50. This provides increased surface area for bonding the rubber tips 70 onto the rigid part of the blades 40 and also provides sufficient strength in the region of the join between the hub 20 and the blades 40.

[0024] As can be seen in Fig. 2, the structure on the leading edge 50 of each blade 40 comprises a ledge 80 extending partially across the width of the blade 40 (i.e. across the smallest dimension of the blade, extending from the low pressure side to the high pressure side). The structure also comprises a number (three shown in this embodiment) of projections 90 which extend outwards in the direction from the trailing edge 60 to the leading edge 50. The projections 90 have sloping sides 92, 94 which create extra surface area and overlap between the rigid base 20 and the flexible rubber tips 70. The sloping sides can be at any angles, but in this embodiment they all slope the same way, namely away from the dome of the base 20. This facilitates the bi-injection moulding process as one of the moulding parts has to be removed and the second moulding part moved into position for rubber formation as described below. However, it should be noted that the impeller 10 need not be formed by bi-injection moulding. In other embodiments different processes may be used, such as overmoulding.

[0025] Fig. 3 shows the complete impeller comprising the impeller base 20 and the rubber tips 70. It can be seen in this figure that the rubber tips 70 each extend the full height of the blade 40 from the proximal end where the blade 40 joins the hub 30 to the distal end furthest from the hub 30. The proximal ends of the rubber tips 70 are connected via a rubber dome 100 which lies on top of the dome of the hub 30. The rubber dome 100 connects all of the rubber tips 70 together into a single piece of rubber. This arrangement is particularly beneficial for forming the impeller 10 by bi-injection moulding. By forming the rubber part of the impeller as a single piece, the rubber can be moulded onto the base 20 with fewer injection points. This is particularly beneficial for maintaining a good balance on the impeller. With the arrangement shown, a single injection point at the centre of the dome 100 can be used. From there the molten rubber can flow over the dome of the base 20 and up the leading edges 50 of each of the blades 40. The pressure from the injection is symmetrical for each blade 40 and so the resultant impeller 10 is well balanced and will run smoothly and quietly in the fan.

[0026] Although the above embodiment uses rubber, it will be appreciated that the leading edges 50 of the blades 40 can alternatively be made from other soft, flexible, resilient and/or elastic materials, including other elastomers. In the embodiment described above, the rubber has a Shore D hardness of about 60. This ensures that the blades 40 have sufficient rigidity for moving air without significant deformation (thus maintaining smooth and quiet operation) while still being soft enough to prevent injury as described above. The Shore D hardness of 60 or less meets the safety requirements. A Shore D hardness of about 60 gives good adhesion between the rubber and the plastic base material.

Claims

1. An impeller for a fan, comprising a hub and a plurality of blades extending from the hub, wherein each blade has a leading edge and a trailing edge and wherein each blade has a first portion made from a rigid material and a second portion formed on the leading edge of the first portion and formed from a resilient material.

2. An impeller as claimed in claim 1, wherein each blade tapers from the leading edge to the trailing edge.

3. An impeller as claimed in claim 1 or 2, wherein the leading edge of the first portion has a structure comprising a ledge extending partially across the width of the blade.

4. An impeller as claimed in claim 1, 2 or 3, wherein the leading edge of the first portion has a structure comprising at least one projection extending substantially perpendicular to the leading portion of the blade.

5. An impeller as claimed in claim 4, wherein the projection has at least one sloping side.

6. An impeller as claimed in claim 5, wherein at least one sloping side forms an overhang of the projection over the leading edge of the first portion.

7. An impeller as claimed in any preceding claim, wherein the resilient material is an elastomeric material, preferably rubber.

8. An impeller as claimed in any preceding claim, wherein the resilient material has a Shore D hardness 60 or less, preferably between 45 and 60.

9. An impeller as claimed in any preceding claim, wherein the resilient portion extends along the full length of the leading edge from the distal end to the proximal end of the hub.

10. An impeller as claimed in claim 9, wherein each of the resilient portions on the blades are connected together via a connecting portion of resilient material formed on the hub.

11. An impeller as claimed in any preceding claim, wherein the impeller is a mixed flow type impeller.

12. A method of manufacturing an impeller as claimed in any preceding claim, comprising the steps of:

forming an impeller base part from a rigid material, comprising a hub and a plurality of blades extending from the hub, each blade having a leading edge and a trailing edge; and
forming a portion of resilient material on the leading edge of each blade.

13. A method as claimed in claim 12, wherein the impeller is formed by bi-injection moulding with a first stage for moulding the rigid material and a second stage for moulding the resilient material.

14. A fan comprising an impeller as claimed in any of claims 1 to 11.

15. A fan as claimed in claim 14, wherein the fan does not have a protective grill in front of the impeller.

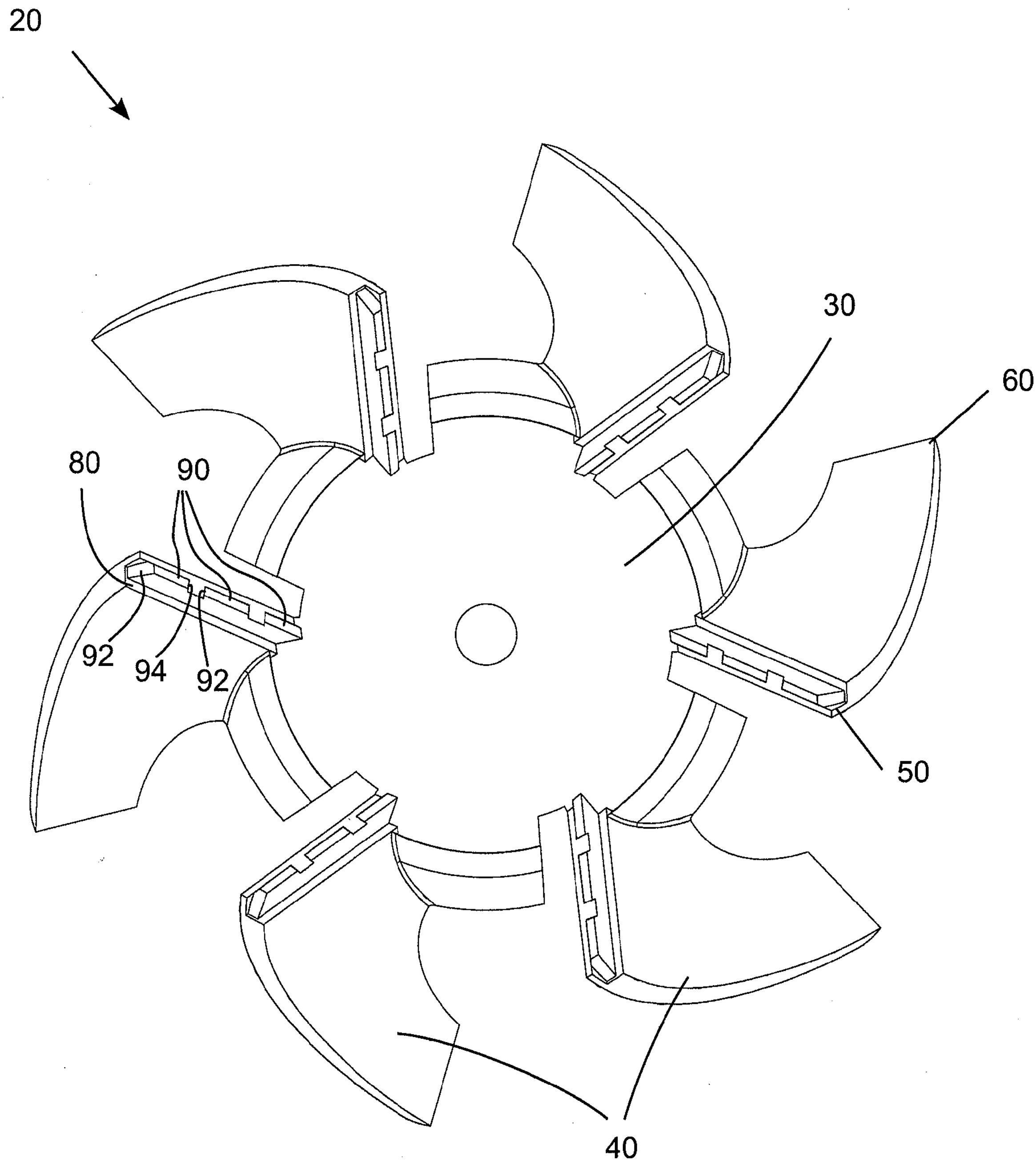

Fig. 1

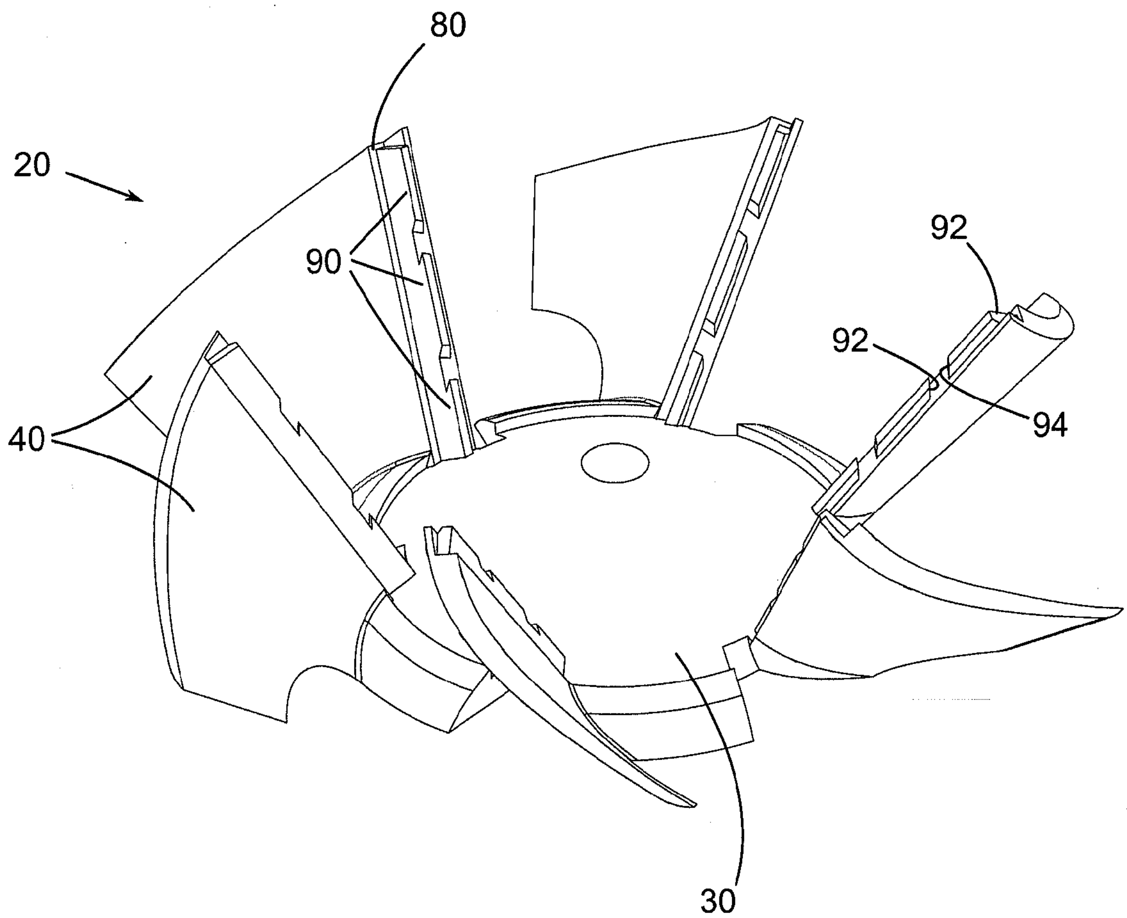

Fig. 2

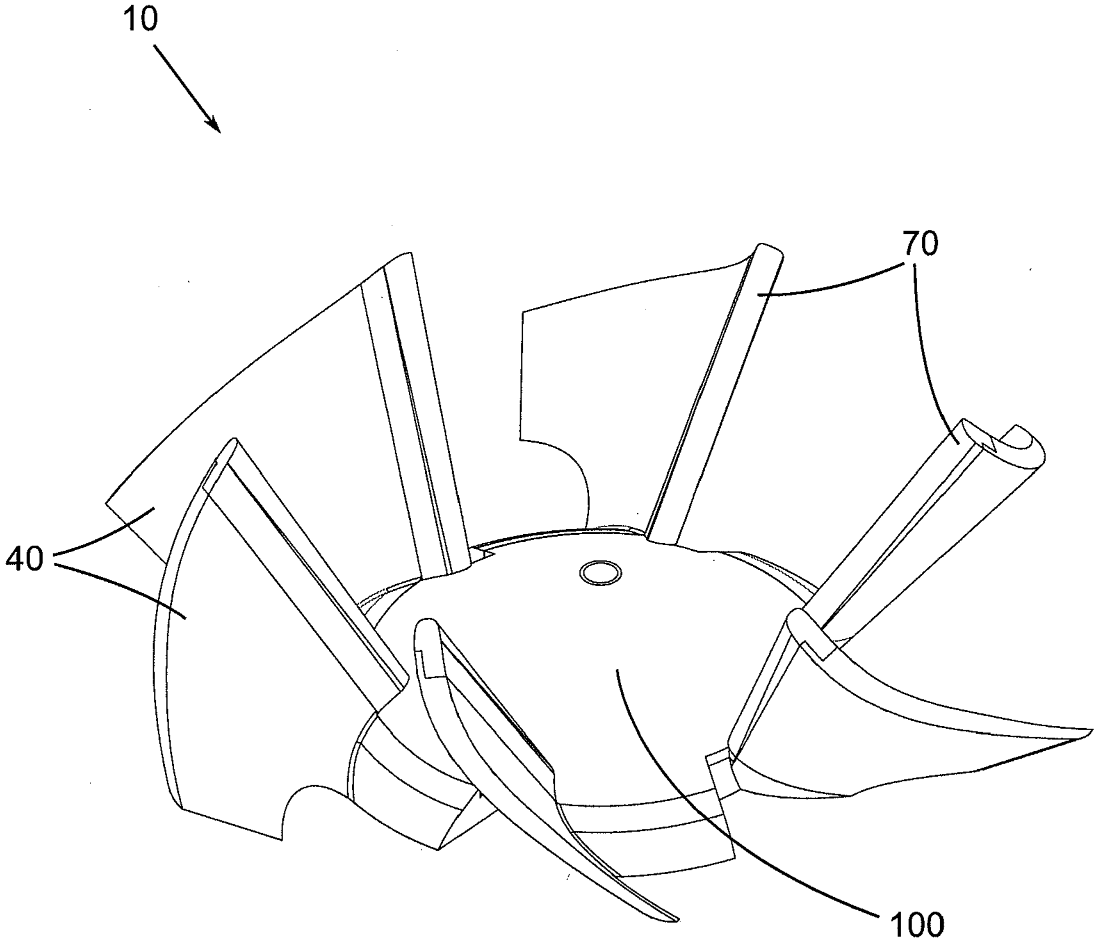

Fig. 3