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(71) Applicant (for all designated States except US): **DYSON TECHNOLOGY LIMITED** [GB/GB]; Tetbury Hill, Malmesbury Wiltshire SN16 0RP (GB).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **FITTON, Nicholas** [GB/GB]; Dyson Technology Limited, Tetbury Hill, Malmesbury Wiltshire SN16 0RP (GB). **SUTTON, John** [GB/GB]; Dyson Technology Limited, Tetbury Hill, Malmesbury Wiltshire SN16 0RP (GB). **GAMMACK, Peter** [GB/GB]; Dyson Technology Limited, Tetbury Hill, Malmesbury Wiltshire SN16 0RP (GB). **DYSON, James** [GB/GB]; Dyson Technology Limited, Tetbury Hill, Malmesbury Wiltshire SN16 0RP (GB).

(74) Agents: **BOOTH, Andrew** et al.; Dyson Technology Limited, Intellectual Property Department, Tetbury Hill, Malmesbury Wiltshire SN16 0RP (GB).

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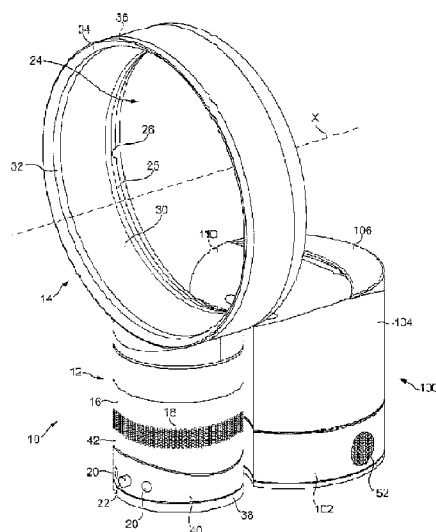


FIG. 1

(57) Abstract: Humidifying apparatus comprises a fan assembly (10) and, located behind the fan assembly, a humidifier (100) for emitting moist air into the atmosphere. The fan assembly (10) comprises means (52, 56) for creating an air flow and a nozzle (14) comprising an interior passage (86) for receiving the air flow and a mouth (26) for emitting the air flow. The nozzle (14) extends about and defines an opening (24) through which both air from outside the nozzle (14) and the moist air emitted from the humidifier (100) are drawn by the air flow emitted from the mouth (26).



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### **Humidifying Apparatus**

The present invention relates to humidifying apparatus. In a preferred embodiment, the present invention relates to humidifying apparatus comprising a fan assembly for  
5 generating an air current for dispersing moist air within a domestic environment, such as a room, office or the like.

Domestic humidifying apparatus is generally in the form of a portable appliance having a casing comprising a water tank for storing a volume of water, and a fan for creating a  
10 flow of air through an air duct of the casing. The stored water is conveyed, usually under gravity, to an atomizing device for producing water droplets from the received water. This device may be in the form of high frequency vibrating device, such as a transducer. The water droplets enter the flow of air passing through the air duct, resulting in the emission of a mist into the environment. The appliance may include a  
15 sensor for detecting the relative humidity of the air in the environment. The sensor outputs a signal indicative of the detected relative humidity to a drive circuit, which controls the transducer to maintain the relative humidity of the air in the environment around a desired level. Typically, the actuation of the transducer is stopped when the detected relative humidity is around 5% higher than the desired level, and is restarted  
20 when the detected relative humidity is around 5% lower than the desired level.

The flow rate of the air emitted from such a humidifier tends to be relatively low, for example in the range from 1 to 2 litres per second, and so the rate at which the humid air is dispersed into a room can be very low. Furthermore, as the relative humidity of  
25 the air in the local environment of the humidifier will rise relatively rapidly in comparison to that of the air in the local environment of the user, the relative humidity detected by the sensor will not, at least initially, be indicative of the relative humidity of the air local to the user. As a result, the actuation of the transducer may be stopped when the relative humidity of the air in the local environment of the user is significantly  
30 below the desired level. Due to the relative low rate at which the humid air is dispersed into the room, it can then take some time for the detected relative humidity to fall to a

level at which the actuation of the transducer is restarted. Consequently, it may take a long period of time for the relative humidity of the air in the local environment of the user to reach the desired level.

5 In a first aspect the present invention provides humidifying apparatus comprising a humidifier for emitting moist air into an external environment, a fan assembly for generating an air current within the external environment for conveying the emitted moist air away from the humidifier, the fan assembly comprising means for creating an air flow and a nozzle comprising an interior passage for receiving the air flow and a  
10 mouth for emitting the air flow, the humidifier being located behind nozzle, the nozzle extending about and defining an opening through which both air from outside the nozzle and the moist air emitted from the humidifier are drawn by the air flow emitted from the mouth.

15 An advantage for a user is that through the entrainment of the moist air emitted from the humidifier within an air current generated by the fan assembly, the moisture within the air current can be rapidly conveyed away from the humidifier to a distance of up to several metres. This can enable a user located several metres away from the humidifier to experience a rapid rise in the relative humidity of the air in its local environment.

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In order to promote a rapid rise in the relative humidity of the air in the environment local to the user, the humidifier may comprise a plurality of transducers for atomizing water stored in the reservoir, and a drive circuit arranged to actuate an initial number  $n_1$  of the transducers to increase the relative humidity detected by the sensor to a preset  
25 level. This level may be preset by a user using a user-operable dial or button located on the humidifier, and may, for example, be any relative humidity within the range from 30 to 80% at 20°C. In a preferred embodiment the humidifier comprises two transducers and initially these two transducers are actuated simultaneously by the drive circuit to increase the relative humidity detected by the sensor to the preset level. Thus,  $n_1$  may  
30 be two, but the humidifier may be provided with a greater number of transducers, for example three, four or six, depending on the relative size of the humidifying apparatus.

The actuation of the initial number  $n_1$  of the transducers may be stopped when the preset level has been detected by the sensor, or when the detected relative humidity is a certain amount over the preset level. For example, in a preferred embodiment the actuation of the initial number  $n_1$  of the transducers is stopped when the detected relative humidity is 1% at 20°C higher than the preset level.

The drive circuit may be arranged to actuate a subsequent lower number  $n_2$  of the transducers to maintain the detected relative humidity around the preset level. The actuation of the lower number  $n_2$  of the transducers is preferably started when the detected relative humidity has fallen beneath the preset level by a certain amount. For example, in the preferred embodiment the actuation of the lower number  $n_2$  of the transducers is started when the detected relative humidity has fallen beneath the preset level by approximately 1% at 20°C, and is continued until the detected relative humidity has risen above the preset level by approximately 1% at 20°C. A lower number  $n_2$  of the transducers is thus periodically actuated to maintain the detected relative humidity around the preset level until the water stored within the reservoir has been depleted or until the humidifier is switched off, either manually by the user or at the end of a preset time period. We have found that actuation of this lower number  $n_2$  of the transducers is sufficient to maintain the detected relative humidity around the preset level. Consequently, the life time of the plurality of transducers may be increased in comparison to a situation in which the initial number  $n_1$  of the transducers is actuated to maintain the detected relative humidity around the preset level.

The plurality of transducers preferably comprises a first subset of  $n_2$  transducers and a second subset of  $n_2$  transducers, and the drive circuit is preferably arranged to actuate a selected one of the first and second subsets of transducers when the detected relative humidity has fallen below the preset level. In order to maximise the life time of each of these subsets of  $n_2$  transducers, the drive circuit is preferably arranged to actuate the first and second subsets of transducers alternately. In a preferred embodiment each subset of transducers comprises a single transducer but each subset may comprise a

higher number of transducers depending on the overall number of transducers within the humidifier.

5 By conveying the emitted moist air away from the humidifier the relative humidity detected by the sensor may provide a more accurate indication of the relative humidity of the air in the environment in which the humidifying apparatus is located than when no such fan assembly is used to convey the emitted moist air away from the humidifier. The sensor may be conveniently housed in the humidifier, but the sensor may be located outside the humidifier, for example on a power cable for supplying electrical power to  
10 the humidifier.

The fan assembly may be integral with the humidifier. However, the fan assembly is preferably a free standing fan assembly located in front of the humidifier so that the moist air emitted from the humidifier is drawn into the air generated by the fan  
15 assembly.

The fan assembly is preferably in the form of a bladeless fan assembly. Through use of a bladeless fan assembly an air current can be generated without the use of a bladed fan. In comparison to a bladed fan assembly, the bladeless fan assembly leads to a reduction  
20 in both moving parts and complexity. Furthermore, without the use of a bladed fan to project the air current from the fan assembly, a relatively uniform air current can be generated and guided into a room or towards a user. The air current can travel efficiently out from the nozzle, losing little energy and velocity to turbulence.

25 The term 'bladeless' is used to describe a fan assembly in which air flow is emitted or projected forward from the fan assembly without the use of moving blades. Consequently, a bladeless fan assembly can be considered to have an output area, or emission zone, absent moving blades from which the air flow is directed towards a user or into a room. The output area of the bladeless fan assembly may be supplied with a  
30 primary air flow generated by one of a variety of different sources, such as pumps, generators, motors or other fluid transfer devices, and which may include a rotating

device such as a motor rotor and/or a bladed impeller for generating the air flow. The generated primary air flow can pass from the room space or other environment outside the fan assembly through the interior passage to the nozzle, and then back out to the room space through the mouth of the nozzle.

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Hence, the description of a fan assembly as bladeless is not intended to extend to the description of the power source and components such as motors that are required for secondary fan functions. Examples of secondary fan functions can include lighting, adjustment and oscillation of the fan assembly.

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The shape of the nozzle of a bladeless fan assembly is thus not constrained by the requirement to include space for a bladed fan. Preferably, the nozzle surrounds the opening. The nozzle may be an annular nozzle which preferably has a height in the range from 200 to 400 mm. The interior passage is preferably annular, and is preferably shaped to divide the air flow into two air streams which flow in opposite directions around the opening.

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Preferably, the mouth of the nozzle extends about the opening, and is preferably annular. The nozzle preferably comprises an inner casing section and an outer casing section which define the interior passage and the mouth of the nozzle. Each section is preferably formed from a respective annular member, but each section may be provided by a plurality of members connected together or otherwise assembled to form that section. The outer casing section is preferably shaped so as to partially overlap the inner casing section to define an outlet of the mouth between overlapping portions of the external surface of the inner casing section and the internal surface of the outer casing section of the nozzle. The outlet is preferably in the form of a slot, preferably having a width in the range from 0.5 to 5 mm. The nozzle may comprise a plurality of spacers for urging apart the overlapping portions of the inner casing section and the outer casing section of the nozzle. This can assist in maintaining a substantially uniform outlet width about the opening. The spacers are preferably evenly spaced along the outlet.

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The nozzle may be inclined so that the air current is emitted upwardly from the fan assembly. For example, the nozzle may be inclined so that the air current is emitted at an angle in the range from 5 to 25° to the horizontal. This can enable the current of moist air emitted from the apparatus to be angled away from a floor or other surface upon which the apparatus is located. This can reduce the risk of the moisture within the air flow collecting on the surface, rather than evaporating into the atmosphere. The fan assembly preferably comprises means for oscillating the nozzle relative to the humidifier so that the humid air current is swept over an arc, preferably in the range from 60 to 120°. For example, a base of the fan assembly may comprise means for oscillating an upper part of the base, to which the nozzle is connected, relative to a lower part of the base.

The nozzle may comprise a surface located adjacent the mouth and over which the mouth is arranged to direct the air flow emitted therefrom. This surface is preferably a Coanda surface. Preferably, the external surface of the inner casing section of the nozzle is shaped to define the Coanda surface. The Coanda surface preferably extends about the opening. A Coanda surface is a known type of surface over which fluid flow exiting an output orifice close to the surface exhibits the Coanda effect. The fluid tends to flow over the surface closely, almost 'clinging to' or 'hugging' the surface. The Coanda effect is already a proven, well documented method of entrainment in which a primary air flow is directed over a Coanda surface. A description of the features of a Coanda surface, and the effect of fluid flow over a Coanda surface, can be found in articles such as Reba, Scientific American, Volume 214, June 1966 pages 84 to 92. Through use of a Coanda surface, an increased amount of air from outside the fan assembly is drawn through the opening by the air emitted from the mouth.

In the present invention an air flow is created through the nozzle of the fan assembly. In the following description this air flow will be referred to as a primary air flow. The primary air flow is emitted from the mouth of the nozzle and preferably passes over a Coanda surface. The primary air flow entrains air surrounding the mouth of the nozzle,

which acts as an air amplifier to supply both the primary air flow and the entrained air to the user. The entrained air will be referred to here as a secondary air flow. The secondary air flow is drawn from the room space, region or external environment surrounding the mouth of the nozzle and, by displacement, from other regions around the fan assembly, and passes predominantly through the opening defined by the nozzle. The primary air flow directed over the Coanda surface combined with the entrained secondary air flow equates to a total air flow emitted or projected forward from the opening defined by the nozzle.

10 Preferably, the humidifier comprises a mist outlet located directly behind part, preferably the lowest part, of the Coanda surface of the nozzle. The speed at which the air flows through the opening of the nozzle tends to reach a maximum value adjacent the Coanda surface, and so through positioning the mist outlet directly behind part of the Coanda surface the mist can become entrained within the part of the air flow drawn into the opening with the greatest speed. This can maximise the speed with which the water droplets within the air current are emitted from the humidifying apparatus. The humidifying apparatus may be provided with a support upon which the humidifier may be located in order to raise the humidifier so that mist outlet is substantially level with the lowest part of the Coanda surface of the nozzle.

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Preferably, the nozzle comprises a diffuser surface located downstream of the Coanda surface. The external surface of the inner casing section of the nozzle is preferably shaped to define the diffuser surface.

25 Preferably the means for creating an air flow through the nozzle comprises an impeller driven by a motor. This can provide a fan assembly with efficient air flow generation. The means for creating an air flow preferably comprises a DC brushless motor and a mixed flow impeller. This can avoid frictional losses and carbon debris from the brushes used in a traditional brushed motor. Reducing carbon debris and emissions is advantageous in a clean or pollutant sensitive environment such as a hospital or around those with allergies. While induction motors, which are generally used in bladed fans,

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also have no brushes, a DC brushless motor can provide a much wider range of operating speeds than an induction motor.

5 The humidifier may comprise a base having a lower surface shaped to define a channel for receiving a mains cable of the fan assembly. Allowing part of a mains cable of the fan assembly to be arranged beneath the base of the humidifier reduces the amount of that cable which is exposed, for example on a work counter.

10 In a second aspect the present invention provides humidifying apparatus comprising a humidifier for emitting moist air into an external environment, a fan assembly for generating an air current within the external environment for conveying the emitted moist air away from the humidifier, and a sensor for detecting the relative humidity of air in the external environment, the humidifier comprising a water reservoir, a plurality of transducers for atomizing water stored in the reservoir, and a drive circuit arranged to  
15 actuate an initial number  $n_1$  of the transducers to increase the relative humidity detected by the sensor to a preset level, and to actuate a subsequent, preferably lower, number  $n_2$  of the transducers to maintain the detected relative humidity around the preset level.

20 Features described above in connection with the first aspect of the invention are equally applicable to the second aspect of the invention.

An embodiment of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

25 Figure 1 is a perspective view of a humidifying apparatus;

Figure 2 is a side view of the apparatus of Figure 1;

Figure 3 is a side sectional view of the fan assembly of the apparatus of Figure 1;

Figure 4 is an enlarged sectional view of part of the nozzle of the fan assembly of the apparatus of Figure 1;

Figure 5 is a top view of the humidifier of the apparatus of Figure 1;

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Figure 6 is a side sectional view of the humidifier, taken along line D-D in Figure 5;

Figure 7 is a top view of the base of the humidifier of Figure 5;

10 Figure 8 is a top sectional view of the base of the humidifier, taken along line E-E in Figure 6;

Figure 9 is a side sectional view of the base of the humidifier, taken along line J-J in Figure 7;

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Figure 10 is a schematic illustration of the control system of the humidifier;

Figure 11 is a graph illustrating the variation with time of the relative humidity detected by the sensor of the humidifying apparatus of Figure 1.

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With reference first to Figures 1 and 2, an example of a humidifying apparatus comprises a fan assembly 10 and a humidifier 100 located behind the fan assembly 10. The fan assembly 10 is preferably in the form of a bladeless fan assembly comprising a stand 12 and a nozzle 14 mounted on and supported by the stand 12. The stand 12 comprises a substantially cylindrical outer casing 16 having a plurality of air inlets in the form of a grille 18 formed in the outer casing 16 and through which a primary air flow is drawn into the stand 12 from the external environment. The stand 12 further comprises a plurality of user-operable buttons 20 and a user-operable dial 22 for controlling the operation of the fan assembly 10. In this example the stand 12 has a height in the range from 200 to 300 mm, and the outer casing 16 has an external diameter in the range from 100 to 200 mm.

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The nozzle 14 has an annular shape and defines a central opening 24. The nozzle 14 has a height in the range from 200 to 400 mm. The nozzle 14 comprises a mouth 26 located towards the rear of the fan assembly 10 for emitting air from the fan assembly 10 and through the opening 24. The mouth 26 extends at least partially about the opening 24. The inner periphery of the nozzle 14 comprises a Coanda surface 28 located adjacent the mouth 26 and over which the mouth 26 directs the air emitted from the fan assembly 10, a diffuser surface 30 located downstream of the Coanda surface 28 and a guide surface 32 located downstream of the diffuser surface 30. The diffuser surface 30 is arranged to taper away from the central axis X of the opening 24 in such a way so as to assist the flow of air emitted from the fan assembly 10. The angle subtended between the diffuser surface 30 and the central axis X of the opening 24 is in the range from 5 to 25°, and in this example is around 15°. The guide surface 32 is arranged at an angle to the diffuser surface 30 to further assist the efficient delivery of a cooling air flow from the fan assembly 10. The guide surface 32 is preferably arranged substantially parallel to the central axis X of the opening 24 to present a substantially flat and substantially smooth face to the air flow emitted from the mouth 26. A visually appealing tapered surface 34 is located downstream from the guide surface 32, terminating at a tip surface 36 lying substantially perpendicular to the central axis X of the opening 24. The angle subtended between the tapered surface 34 and the central axis X of the opening 24 is preferably around 45°. The overall depth of the nozzle 24 in a direction extending along the central axis X of the opening 24 is in the range from 100 to 150 mm, and in this example is around 110 mm.

Figure 3 illustrates a sectional view through the fan assembly 10. The stand 12 comprises a base formed from a lower base member 38 and an upper base member 40 mounted on the lower base member 38, and a main body 42 mounted on the base. The lower base member 38 has a substantially flat bottom surface 43. The upper base member 40 houses a controller 44 for controlling the operation of the fan assembly 10 in response to depression of the user operable buttons 20 shown in Figures 1 and 2, and/or manipulation of the user operable dial 22. The lower base member 38 may

house an oscillating mechanism 46 for oscillating the upper base member 40 and the main body 42 relative to the lower base member 38. The range of each oscillation cycle of the main body 42 is preferably between 60° and 120°, and in this example is around 90°. In this example, the oscillating mechanism 46 is arranged to perform around 3 to 5 oscillation cycles per minute. A mains power cable 48 extends through an aperture formed in the lower base member 38 for supplying electrical power to the fan assembly 10.

The main body 42 of the stand 12 has an open upper end to which the nozzle 14 is connected, for example by a snap-fit connection. The main body 42 houses an impeller 52 for drawing a primary air flow through the apertures of the grille 18 and into the stand 12. Preferably, the impeller 52 is in the form of a mixed flow impeller. The impeller 52 is connected to a rotary shaft 54 extending outwardly from a motor 56. In this example, the motor 56 is a DC brushless motor having a speed which is variable by the controller 44 in response to user manipulation of the dial 22. Cable 57 connects the controller 44 to the motor 56. The maximum speed of the motor 56 is preferably in the range from 5,000 to 10,000 rpm. The motor 56 is housed within a motor bucket comprising an upper portion 58 connected to a lower portion 60. One of the upper portion 58 and the lower portion 60 of the motor bucket comprises a diffuser 62 in the form of a stationary disc having spiral blades, and which is located downstream from the impeller 52.

The motor bucket is located within, and mounted on, an impeller housing 64. The impeller housing 64 is, in turn, mounted on a plurality of angularly spaced supports 66, in this example three supports, located within the main body 42 of the stand 12. A generally frusto-conical shroud 68 is located within the impeller housing 64. The shroud 68 is shaped so that the outer edges of the impeller 52 are in close proximity to, but do not contact, the inner surface of the shroud 68. A substantially annular inlet member 70 is connected to the bottom of the impeller housing 64 for guiding the primary air flow into the impeller housing 64. Preferably, the stand 12 further comprises silencing foam for reducing noise emissions from the stand 12. In this

example, the main body 42 of the stand 12 comprises a disc-shaped foam member 72 located towards the base of the main body 42, and a substantially annular foam member 74 located within the motor bucket.

5 Figure 4 illustrates a sectional view through the nozzle 14. The nozzle 14 comprises an annular outer casing section 80 connected to and extending about an annular inner casing section 82. Each of these sections may be formed from a plurality of connected parts, but in this embodiment each of the outer casing section 80 and the inner casing section 82 is formed from a respective, single moulded part. The inner casing section  
10 82 defines the central opening 24 of the nozzle 14, and has an external peripheral surface 84 which is shaped to define the Coanda surface 28, diffuser surface 30, guide surface 32 and tapered surface 34.

The outer casing section 80 and the inner casing section 82 together define an annular  
15 interior passage 86 of the nozzle 14. Thus, the interior passage 86 extends about the opening 24. The interior passage 86 is bounded by the internal peripheral surface 88 of the outer casing section 80 and the internal peripheral surface 90 of the inner casing section 82. The outer casing section 80 comprises a base 92 which is connected to, and over, the open upper end of the main body 42 of the stand 12, for example by a snap-fit  
20 connection. The base 92 of the outer casing section 80 comprises an aperture through which the primary air flow enters the interior passage 86 of the nozzle 14 from the open upper end of the main body 42 of the stand 12.

The mouth 26 of the nozzle 14 is located towards the rear of the fan assembly 10. The  
25 mouth 26 is defined by overlapping, or facing, portions 94, 96 of the internal peripheral surface 88 of the outer casing section 80 and the external peripheral surface 84 of the inner casing section 82, respectively. In this example, the mouth 26 is substantially annular and, as illustrated in Figure 4, has a substantially U-shaped cross-section when sectioned along a line passing diametrically through the nozzle 14. In this example, the  
30 overlapping portions 94, 96 of the internal peripheral surface 88 of the outer casing section 80 and the external peripheral surface 84 of the inner casing section 82 are

shaped so that the mouth 26 tapers towards an outlet 98 arranged to direct the primary flow over the Coanda surface 28. The outlet 98 is in the form of an annular slot, preferably having a relatively constant width in the range from 0.5 to 5 mm. In this example the outlet 98 has a width of around 1.0 mm. Spacers may be spaced about the mouth 26 for urging apart the overlapping portions 94, 96 of the internal peripheral surface 88 of the outer casing section 80 and the external peripheral surface 84 of the inner casing section 82 to maintain the width of the outlet 98 at the desired level. These spacers may be integral with either the internal peripheral surface 88 of the outer casing section 80 or the external peripheral surface 84 of the inner casing section 82.

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Turning now to Figures 1, 2 and 5, the humidifier 100 comprises a base 102 and a water tank 104 removably mountable on the base 102. The water tank 104 preferably has a capacity in the range from 2 to 4 litres. The upper surface of the water tank 104 is shaped to define a handle 106 to enable a user to lift the water tank 104 from the base 102 using one hand. The water tank 104 comprises a mist outlet 108 located in the upper surface 110 of the water tank 104 for emitting moist air, or mist, from the humidifier 100. With reference to Figure 6, mist is conveyed to the mist outlet 108 from a duct 112 passing upwardly through the water tank 104, resulting in the emission of mist from the humidifier 100 in a generally vertical direction. Baffles 113 are located within the duct 112 to inhibit the emission of relatively large water droplets from the humidifier 100.

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The base 102 and the water tank 104 each comprise a concave front section having a radius which is approximately the same size as the radius of the outer casing 16 of the stand 12 of the fan assembly 10. This allows the humidifier 100 to be located adjacent the fan assembly 100 so that the mist outlet 108 is in close proximity to the nozzle 14 of the fan assembly. In this example, the mist outlet 108 can be spaced from the rear surface of the nozzle 14 of the fan assembly 10 by a minimum distance in the range from 5 to 30 cm. The mist outlet 108 is preferably located directly behind, and approximately level with, the lowest portion of the Coanda surface 28 of the nozzle 14 of the fan assembly 10. If required, the humidifier 100 may be mounted on a support

(not shown) to raise the mist outlet 108 so that it is level with the lowest portion of the Coanda surface 28 of the nozzle 14.

The water tank 104 has a lower surface 114 to which a spout 116 is removably  
5 connected, for example through co-operating threaded connections. In this example the water tank 104 is filled by removing the water tank 104 from the base 102 and inverting the water tank 104 so that the spout 116 is projecting upwardly. The spout 116 is then unscrewed from the lower surface 114 of the water tank 104 and water is introduced into the water tank 104 through an aperture exposed when the spout 116 is disconnected  
10 from the lower surface 114 of the water tank 104. Once the water tank 104 has been filled, the user reconnects the spout 116 to the lower surface 114 of the water tank 104, re-inverts the water tank 104 and replaces the water tank 104 on the base 102. A spring-loaded valve 118 is located within the spout 116 for preventing leakage of water through a water outlet 120 of the spout 116 when the water tank 104 is re-inverted. The  
15 valve 118 is biased towards a position in which a skirt 122 of the valve 118 engages the upper surface of the spout 116 to prevent water entering a water inlet 124 of the spout 116 from the water tank 104.

A water softener cartridge 126 is removably connected to the spout 116, for example  
20 through co-operating threaded connections. The cartridge 126 may contain an ion-exchange resin, threshold inhibitor chemical, such as polyphosphate, or other media to affect the precipitation of limescale. The cartridge 126 defines a serpentine path, illustrated at P in Figure 6, along which water flows as it passes from the water tank 104 to the spout 116 to increase the residence time of the water within the cartridge 126.  
25 Perforations may be formed on the upper surface of the cartridge 126 to allow air within the cartridge 126 to be displaced therefrom as water enters the cartridge 126 from the water tank 104.

With reference also to Figures 7 to 9, the base 102 has an upper surface 128. The upper  
30 surface 128 of the base 102 comprises a recessed portion 130 which defines a water reservoir 132 for receiving water from the water tank 104. A pin 134 extending

upwardly from the recessed portion 130 of the upper surface 128 protrudes into the spout 116 when the water tank 104 is located on the base 102. The pin 134 pushes the valve 118 upwardly to open the spout 116, thereby allowing water to pass under gravity into the water reservoir 132 from the water tank 104. This results in the water reservoir  
5 132 becoming filled with water to a level which is substantially co-planar with the upper surface of the pin 134. A magnetic level sensor 136 is located within the water reservoir 132 for detecting the level of water within the water reservoir 132.

The recessed portion 130 of the upper surface 128 comprises two apertures 138 each for  
10 exposing the surface of a respective piezoelectric transducer 140a, 140b located beneath the upper surface 128 of the base 102 for atomising water stored in the water reservoir 132. An annular metallic heat sink 142 is located between the base 102 and each transducer 140a, 140b for transferring heat from the transducer to the water stored in the water reservoir 132. Each heat sink 142 has a conical upper surface 144 for increasing  
15 the rate of atomisation of water by the transducers 140a, 140b. The atomisation rate is further increased by inclining the upper surfaces of the transducers 140a, 140b at an angle in the range from 5 to 10° to the horizontal. An annular sealing member 144 forms a water-tight seal between each transducer 140a, 140b and its heat sink 142. A drive circuit 146 is located beneath the upper surface 128 of the base 102 for actuating  
20 ultrasonic vibration of the transducers 140a, 140b to atomise water within the water reservoir 132. As illustrated in Figure 10, the drive circuit 146 may be arranged to receive a signal from the level sensor 136 which is indicative of the level of the water in the water reservoir 132 falling below a minimum level. In response to this signal, the drive circuit 146 terminates actuation of the transducers 140a, 140b.

25

The base 102 further comprises a motor-driven fan 148 for generating an air flow through the humidifier 100, preferably at a rate in the range from 1 to 2 litres per second. The drive circuit 146 preferably controls the actuation and the speed of the motor 149 for driving the fan 148. The fan 148 is located within a fan housing 150  
30 formed in the base 102 of the humidifier 100. The fan housing 150 comprises an air inlet in the form of a plurality of apertures 152 formed in the side wall of the base 102



and through which an air flow is drawn into the fan housing 150 by rotation of the fan 148, and an air outlet 154 through which the air flow passes into an air duct 156 located to one side of the water reservoir 132. Apertures 158 are located on the upper periphery of the air duct 156 for emitting the air flow from the air duct at a level which is above  
5 the maximum level for water stored in the water reservoir 132 so that the air flow emitted from the air duct 156 passes over the surface of the water located in the water reservoir 132 before entering the duct 112 of the water tank 102.

A user interface for controlling the operation of the humidifier 100 is located on the side  
10 wall of the base 102. In this example, the user interface comprises a plurality of user-operable buttons 160a, 160b and a user-operable dial 162. The dial 162 may be manipulated by the user to set a desired level for the relative humidity of the environment in which the humidifying apparatus is located, such as a room, office or other domestic environment. For example, the desired relative humidity level may be  
15 selected within a range from 30 to 80% at 20°C through manipulation of the dial 162. One of the buttons 160a is an on/off button for the humidifier 100, whereas the other button 160b may be depressed to override the dial setting so that the humidifier 100 continues to operate until the water tank 102 has emptied. The user interface further comprises a user interface circuit 164 which outputs control signals to the drive circuit  
20 146 which are indicative of the angular position of the dial 162 and upon depression of one of the buttons 160, and which receives control signals output by the drive circuit 146. The user interface may also comprise one or more LEDs (shown in Figure 10) for providing a visual alert depending on a status of the humidifier 100. For example, an LED 165a may be illuminated by the drive circuit 146 indicating that the water tank 104  
25 has become depleted, as indicated by a signal received by the drive circuit 146 from the level sensor 136.

The humidifier 100 further comprises a humidity sensor 166 for detecting the relative humidity of air in the external environment, and for supplying a signal indicative of the  
30 detected relative humidity to the drive circuit 146. In this example the humidity sensor 166 is located immediately behind the apertures 152 formed in the side wall of the base

102 to detect the relative humidity of the air flow drawn into the base 104 of the humidifier 100 by the fan 148. The user interface may comprise an LED 165b which is illuminated by the drive circuit 146 when an output from the humidity sensor 166 indicates that the relative humidity of the air flow entering the base 102 is at or above  
5 the desired relative humidity level set by the user.

The humidifier 100 also comprises a power supply 168 for supplying power to the various electrical components of the humidifier 100, including the drive circuit 146, the motor for driving the fan 148 and the user interface circuit 164. A mains power cable  
10 (not shown) extends through an aperture formed in the base 102 for supplying electrical power to the power supply 168.

The operation of the humidifying apparatus will now be described.

15 To operate the fan assembly 10, the user depresses an appropriate one of the buttons 20 on the stand 12 of the fan assembly 10, in response to which the controller 44 activates the motor 56 to rotate the impeller 52. The rotation of the impeller 52 causes a primary air flow to be drawn into the stand 12 of the fan assembly 10 through the grille 18. The primary air flow passes sequentially through the impeller housing 64 and the aperture  
20 formed in the base 92 of the outer casing section 80 of the nozzle 14 to enter the interior passage 86 of the nozzle 14. Within the nozzle 14, the primary air flow is divided into two air streams which pass in opposite directions around the central opening 24 of the nozzle 14. As the air streams pass through the interior passage 86, air enters the mouth  
25 26 of the nozzle 14. The air flow into the mouth 26 is preferably substantially even about the opening 24 of the nozzle 14. Within each section of the mouth 26, the flow direction of the portion of the air stream is substantially reversed. The portion of the air stream is constricted by the tapering section of the mouth 26 and emitted through the outlet 98.

30 The primary air flow emitted from the mouth 26 is directed over the Coanda surface 28 of the nozzle 14, causing a secondary air flow to be generated by the entrainment of air

from the external environment, specifically from the region around the outlet 98 of the mouth 26 and from around the rear of the nozzle 14. This secondary air flow passes through the central opening 24 of the nozzle 14, where it combines with the primary air flow to produce a total air flow, or air current, projected forward from the nozzle 14.

5 Depending on the speed of the motor 56, the mass flow rate of the air current projected forward from the fan assembly 10 may be up to 400 litres per second, preferably up to 600 litres per second.

The even distribution of the primary air flow along the mouth 26 of the nozzle 14  
10 ensures that the air flow passes evenly over the diffuser surface 30. The diffuser surface 30 causes the mean speed of the air flow to be reduced by moving the air flow through a region of controlled expansion. The relatively shallow angle of the diffuser surface 30 to the central axis X of the opening 24 allows the expansion of the air flow to occur gradually. A harsh or rapid divergence would otherwise cause the air flow to become  
15 disrupted, generating vortices in the expansion region. Such vortices can lead to an increase in turbulence and associated noise in the air flow which can be undesirable, particularly in a domestic product such as a fan. The air flow projected forwards beyond the diffuser surface 30 can tend to continue to diverge. The presence of the guide surface 32 extending substantially parallel to the central axis X of the opening 30  
20 further converges the air flow. As a result, the air flow can travel efficiently out from the nozzle 14, enabling the air flow can be experienced rapidly at a distance of several metres from the fan assembly 10.

When the fan assembly 10 is operating, the user may switch on the humidifier 100 by  
25 pressing the appropriate button 160a of the user interface of the humidifier 100. In response to the depression of the button 160a, the drive circuit 146 activates the motor 149 to rotate the fan 148 to generate an air flow through the humidifier 100. Simultaneous with the actuation of the motor 149 of the fan 148, the drive circuit 146 actuates the vibration of both of the transducers 140a, 140b, preferably at a frequency in  
30 the range from 1 to 2 MHz, to atomise water present within the water reservoir 132. This creates airborne water droplets above the water located within the water reservoir

132. As water within the water reservoir 132 is atomised, the water reservoir 132 is constantly replenished with water from the water tank 104, so that the level of water within the water reservoir 132 remains substantially constant while the level of water within the water tank 104 gradually falls.

5

With rotation of the fan 148, an air flow is drawn into the humidifier 100 through the apertures 152 formed in the side wall of the base 102. The air flow passes through the fan housing 150 and into the air duct 156, from which it is emitted through the apertures 158. The air flow passes over the water located in the water reservoir 132, causing the airborne water droplets to become entrained within the air flow generated by the fan 148. The – now moist - air flow passes upwardly through the spout 112 and is emitted from the mist outlet 108 in the form of a mist or fog. This mist is drawn through the central opening 24 of the nozzle 14 as part of the secondary air flow generated by the emission of the primary air flow from the mouth 26 of the nozzle 14. Consequently, the mist is conveyed away from the humidifier 100 within the air current generated by the fan assembly 10, thereby enabling a humid air current to be experienced rapidly at a distance of several metres from the humidifier 100. Through oscillation of the main body 42 of the stand 12, and thus oscillation of the nozzle 14, relative to the humidifier 100, this humid air current can be swept over an arc in the range from 60 to 120°, preferably around 90°, to increase rapidly the dispersion of the humid air into the external environment.

Provided that the button 160b has not been depressed, the moist air flow is emitted from the humidifier 100 until the relative humidity of the air flow entering the humidifier 100, as detected by the humidity sensor 166, is 1% at 20°C higher than the relative humidity level selected by the user using the dial 162. The emission of a moist air flow from the humidifier 100 is then terminated by the drive circuit 146, through terminating the supply of actuating signals to the transducers 140a, 140b. Optionally, the motor 149 may also be stopped so that no air flow is emitted from the humidifier 100 but when the humidity sensor 166 is located in close proximity to the motor 149, as in this example, it is preferred that the motor 149 is continually operated to avoid undesirable temperature

fluctuation in the local environment of the humidity sensor 166. When the humidity sensor 166 is located outside the humidifier 100, for example, the motor 149 may also be stopped when the relative humidity of the air of the environment local to the humidity sensor 166 is 1% at 20°C higher than the relative humidity level selected by the user.

As a result of the termination of the emission of a moist air flow from the humidifier 100, the relative humidity detected by the humidity sensor 166 will begin to fall. Once the relative humidity of the air of the environment local to the humidity sensor 166 has fallen to 1% at 20°C below the relative humidity level selected by the user, the drive circuit 146 outputs actuating signals to a selected one of the transducers, for example transducer 140a, to re-start the emission of a moist air flow from the humidifier 100. As before, the moist air flow is emitted from the humidifier 100 until the relative humidity detected by the humidity sensor 166 is 1% at 20°C higher than the relative humidity level selected by the user, at which point the actuation of the transducer 140a is terminated. Once the relative humidity of the air of the environment local to the humidity sensor 166 has again fallen to 1% at 20°C below the relative humidity level selected by the user, the drive circuit 146 outputs actuating signals to the other transducer, for example transducer 140b, to re-start the emission of a moist air flow from the humidifier 100. Again, the moist air flow is emitted from the humidifier 100 until the relative humidity detected by the humidity sensor 166 is 1% at 20°C higher than the relative humidity level selected by the user, at which point the actuation of the transducer 140b is terminated.

This sequence of alternate actuation of the transducers 140a, 140b to maintain the detected humidity level around the level selected by the user continues until the button 160a is depressed to switch off the humidifier 100 or until a signal is received from the level sensor 136 indicating that the level of water within the water reservoir 132 has fallen by the minimum level.

The relative humidity detected by the humidity sensor 166 is thus maintained around the level selected by the user using the dial 162 by the subsequent actuation of a reduced number  $n_2$  of transducers (one) in comparison to the number  $n_1$  of transducers (two) used to initially increase the relative humidity in the external environment to the selected level. The advantage associated with the actuation of a greater number of transducers to initially raise the relative humidity in the external environment to the selected level is indicated in Figure 11. Figure 11 is a graph illustrating the variation of the detected relative humidity with time for two operations of the humidifying apparatus. In the first operation both transducers 140a, 140b are actuated initially to raise the relative humidity to 50% at 20°C. In the second operation, only transducer 140a is actuated to initially raise the relative humidity to 50% at 20°C. The variation of the detected relative humidity with time for the first operation is indicated by line 180 in Figure 11, whereas the variation of the detected relative humidity with time for the second operation is indicated by line 182 in Figure 11. As can be seen from Figure 11, the time taken for the detected relative humidity to increase from a base level of around 30% at 20°C to the preset level was considerably shorter when both transducers 140a, 140b were used to raise the relative humidity to 50% at 20°C.

As an alternative to actuating a reduced number  $n_2$  of transducers to maintain the detected relative humidity around the preset level, the same number  $n_1$  of transducers (two) used to initially increase the relative humidity in the external environment to the selected level may also be used to maintain the detected relative humidity around the preset level. In this case, the duration of the actuation of the  $n_1$  transducers from when the detected relative humidity of the air of the environment local to the humidity sensor 166 has again fallen to 1% at 20°C below the relative humidity level to when the relative humidity detected by the humidity sensor 166 is 1% at 20°C higher than the relative humidity level selected by the user is shorter than when the reduced number  $n_2$  of transducers to maintain the detected relative humidity around the preset level. With reference again to Figure 11, in the first operation both transducers 140a, 140b are actuated to maintain the detected relative humidity around the preset level, whereas in the second operation only a single actuator is used to maintain the detected relative

humidity around the preset level. Similar to when a reduced number  $n_2$  of transducers is used to maintain the detected relative humidity around the preset level, this can enable the life time of the transducers 140a, 140b to be prolonged.

**CLAIMS**

1. Humidifying apparatus comprising a humidifier for emitting moist air into an  
5 external environment, a fan assembly for generating an air current within the external  
environment for conveying the emitted moist air away from the humidifier, the fan  
assembly comprising means for creating an air flow and a nozzle comprising an interior  
passage for receiving the air flow and a mouth for emitting the air flow, the humidifier  
being located behind nozzle, the nozzle extending about and defining an opening  
10 through which both air from outside the nozzle and the moist air emitted from the  
humidifier are drawn by the air flow emitted from the mouth.
2. Humidifying apparatus as claimed in claim 1, wherein the fan assembly is a  
bladeless fan assembly.  
15
3. Humidifying apparatus as claimed in claim 1 or claim 2, wherein the interior  
passage is shaped to divide the received air flow into two air streams each flowing along  
a respective side of the opening.
- 20 4. Humidifying apparatus as claimed in any of the preceding claims, wherein the  
interior passage is substantially annular.
5. Humidifying apparatus as claimed in any of the preceding claims, wherein the  
mouth extends about the opening.  
25
6. Humidifying apparatus as claimed in any of the preceding claims, wherein the  
nozzle comprises an inner casing section and an outer casing section which together  
define the interior passage and the mouth.



7. Humidifying apparatus as claimed in claim 6, wherein the mouth comprises an outlet located between an external surface of the inner casing section of the nozzle and an internal surface of the outer casing section of the nozzle.

5 8. Humidifying apparatus as claimed in claim 7, wherein the outlet is in the form of a slot extending at least partially about the opening.

9. Humidifying apparatus as claimed in claim 7 or claim 8, wherein the outlet has a width in the range from 0.5 to 5 mm.

10

10. Humidifying apparatus as claimed in any of the preceding claims, wherein the nozzle comprises a surface located adjacent the mouth and over which the mouth is arranged to direct the air flow.

15 11. Humidifying apparatus as claimed in claim 10, wherein the surface is a Coanda surface.

12. Humidifying apparatus as claimed in claim 11, wherein the Coanda surface extends about the opening.

20

13. Humidifying apparatus as claimed in claim 11 or claim 12, wherein the humidifier comprises a mist outlet located directly behind part of the Coanda surface of the nozzle.

25 14. Humidifying apparatus as claimed in claim 13, wherein the mist outlet is located directly behind the lowest part of the Coanda surface.

15. Humidifying apparatus as claimed in any of claims 11 to 14, wherein the nozzle comprises a diffuser located downstream of the Coanda surface.

30

16. Humidifying apparatus substantially as hereinbefore described with reference to the accompanying drawings.

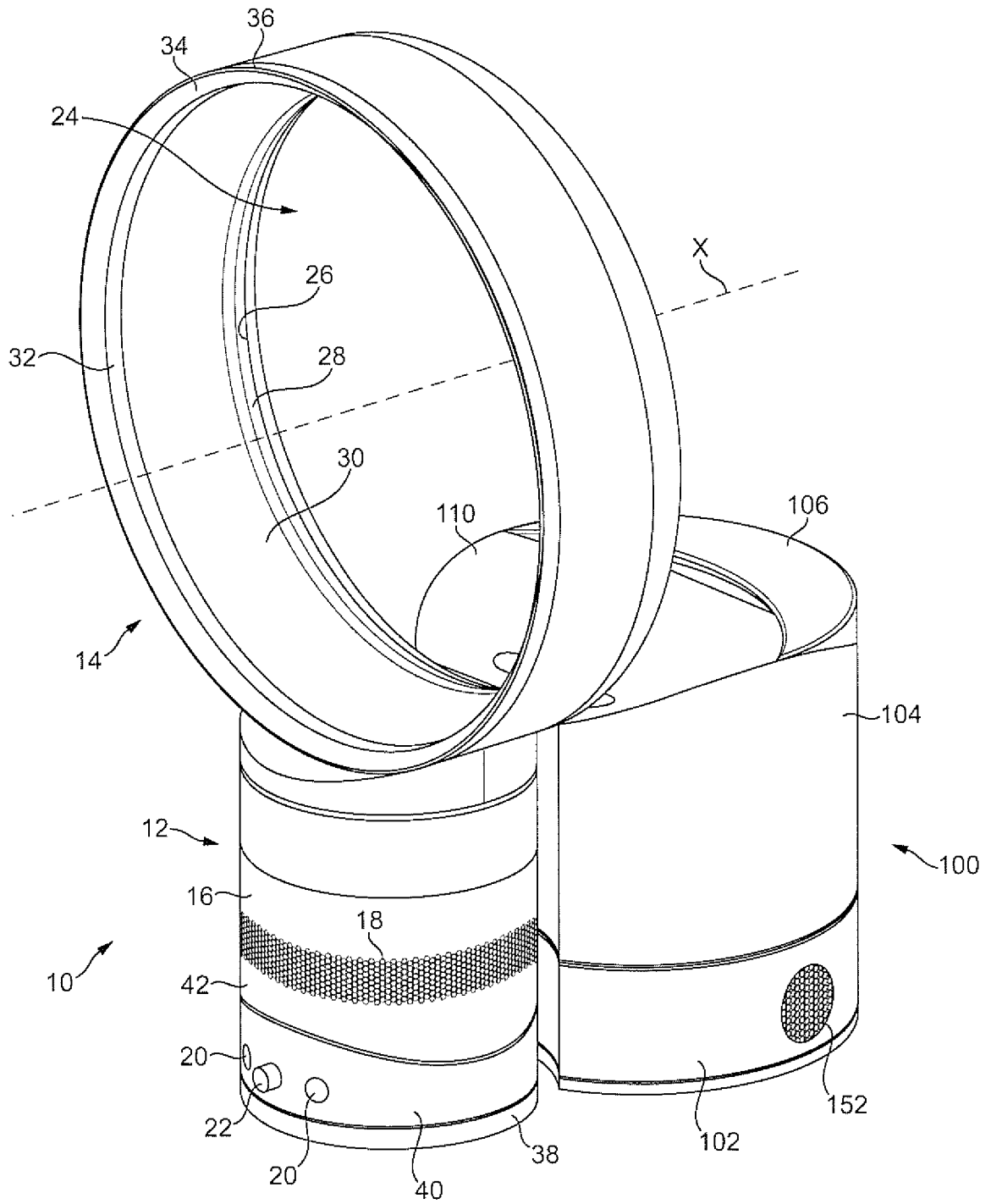


FIG. 1

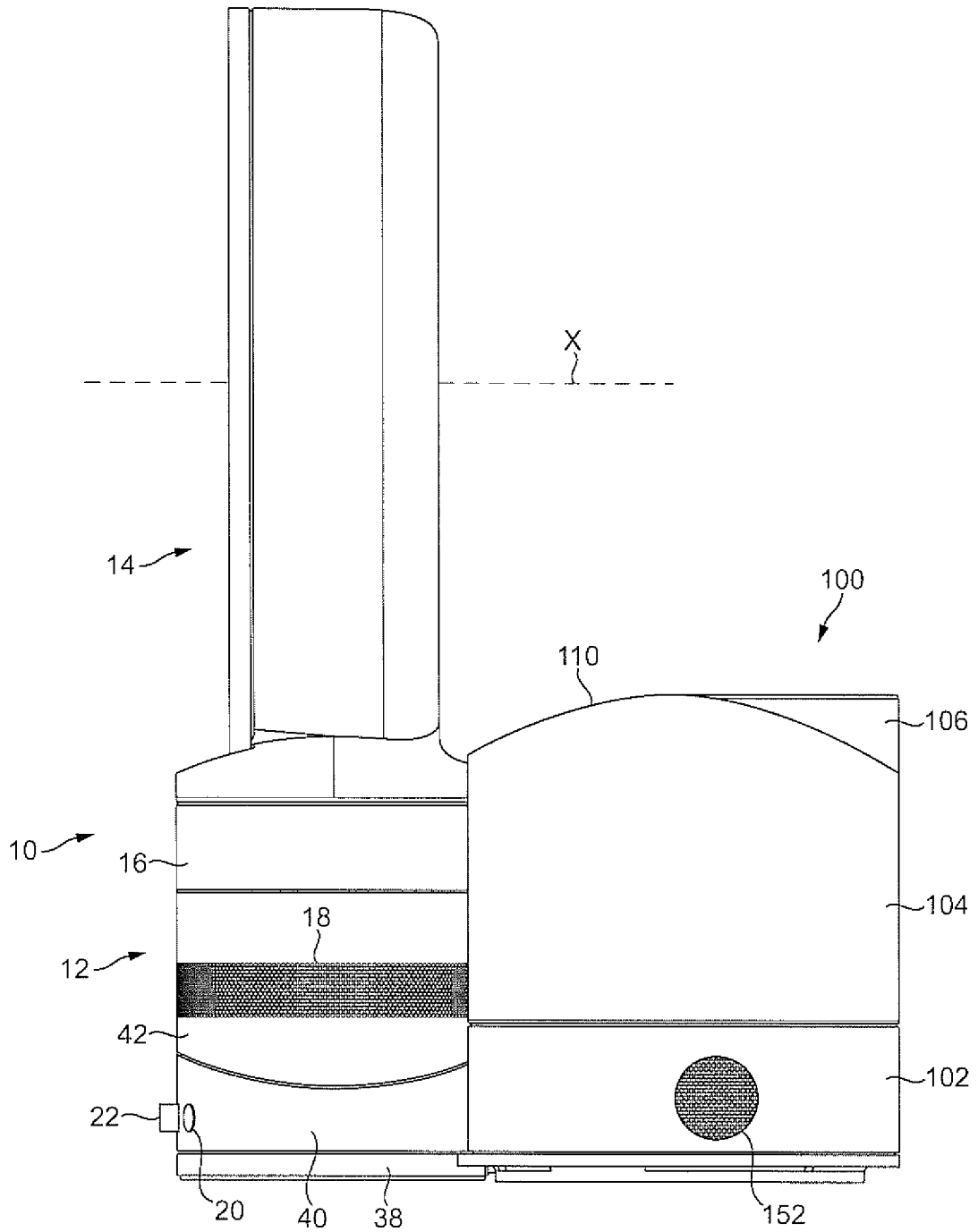


FIG. 2

3 / 10

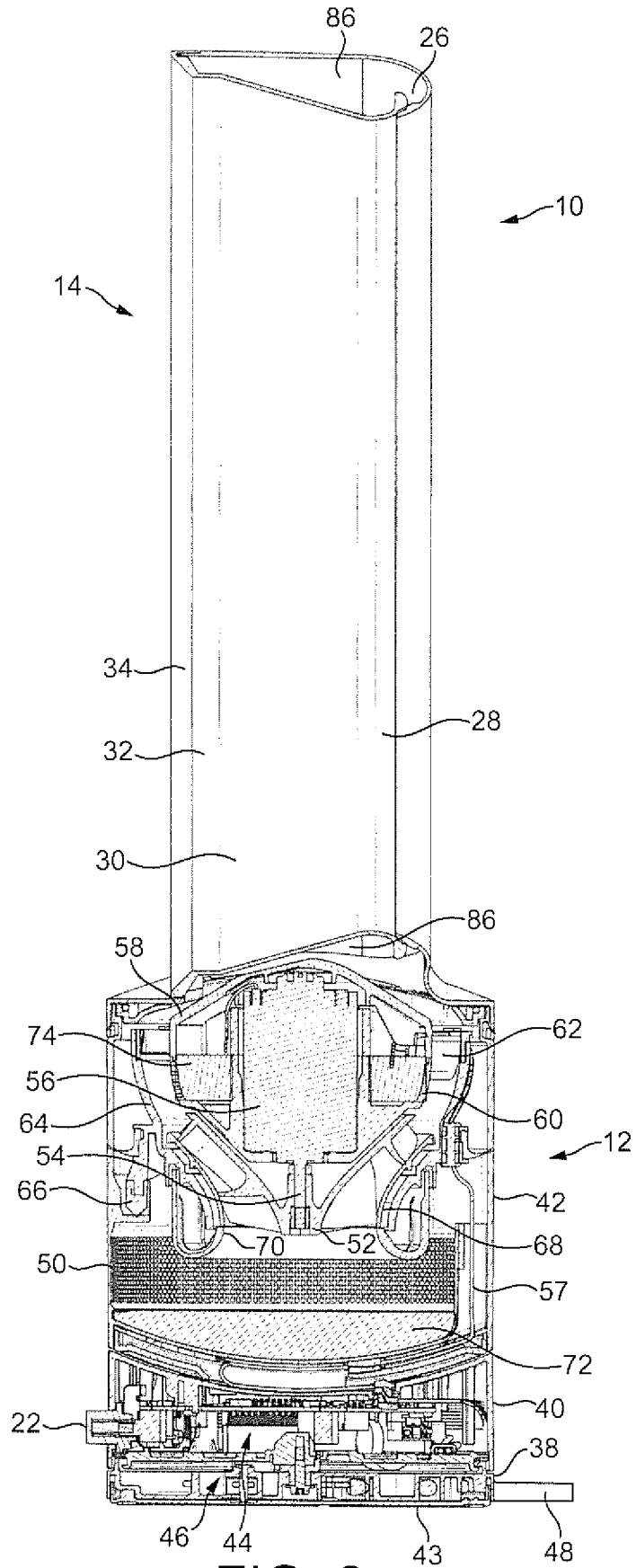


FIG. 3

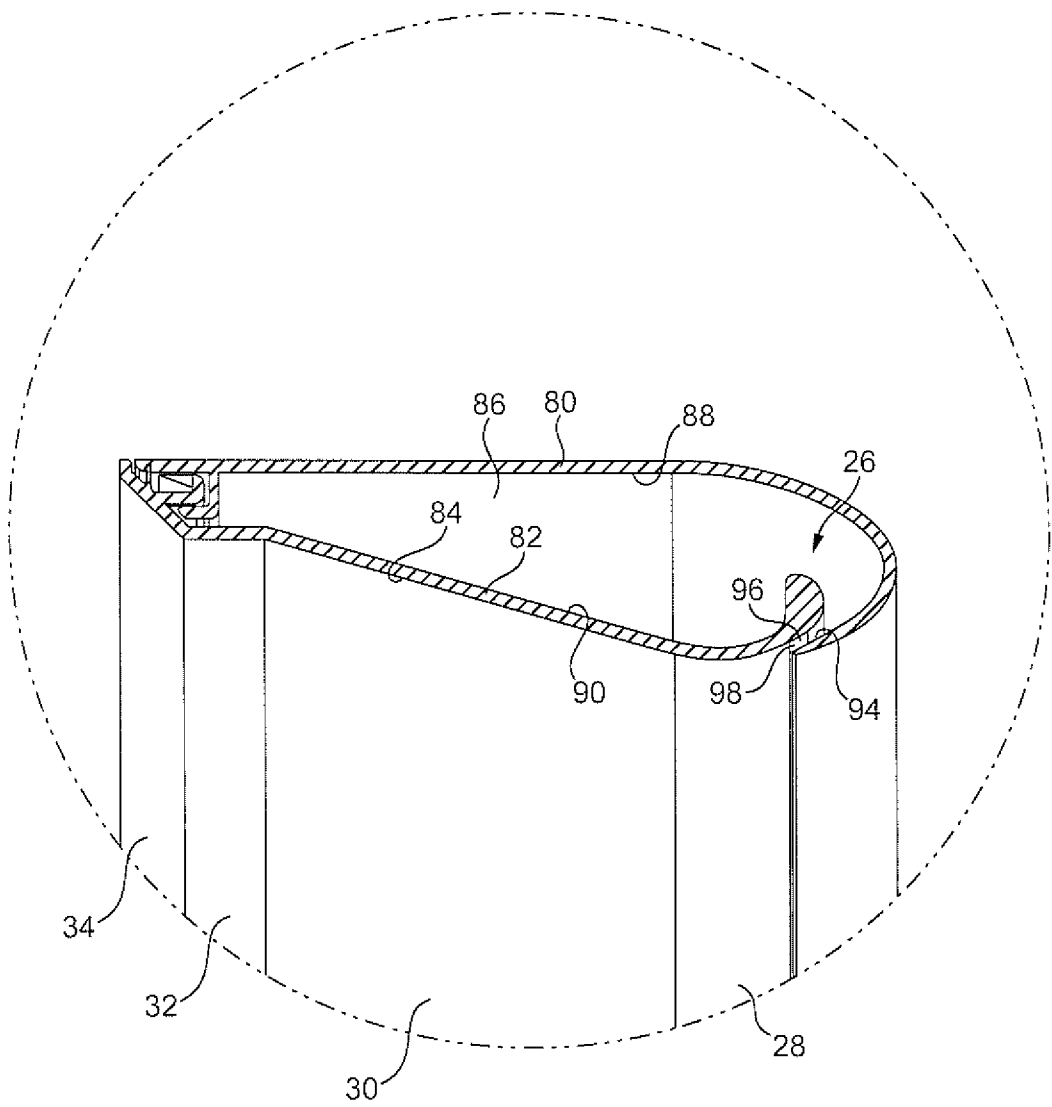


FIG. 4

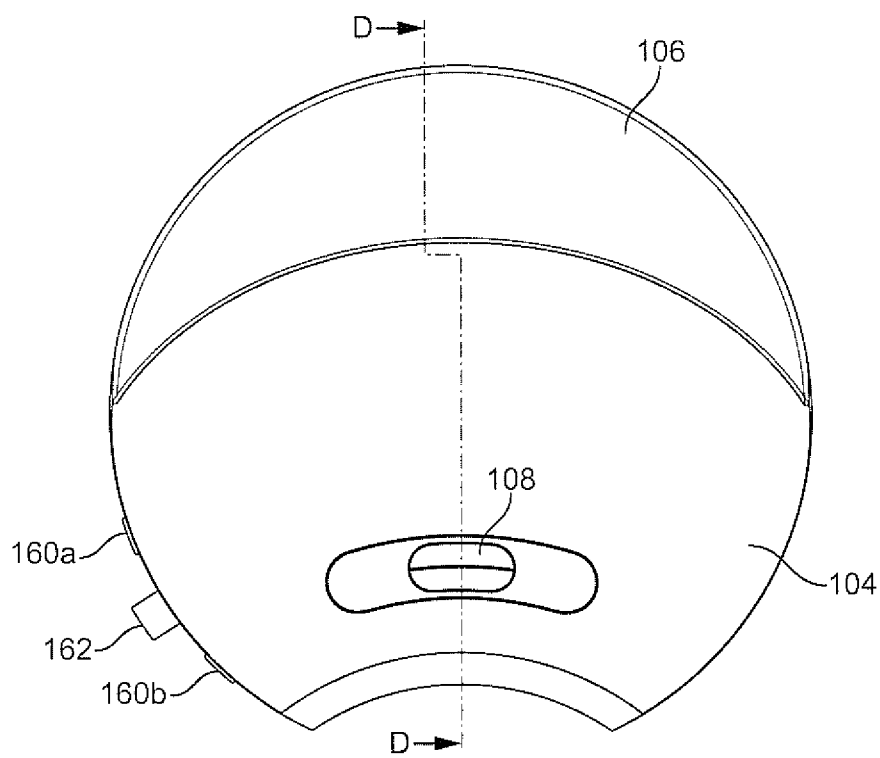


FIG. 5

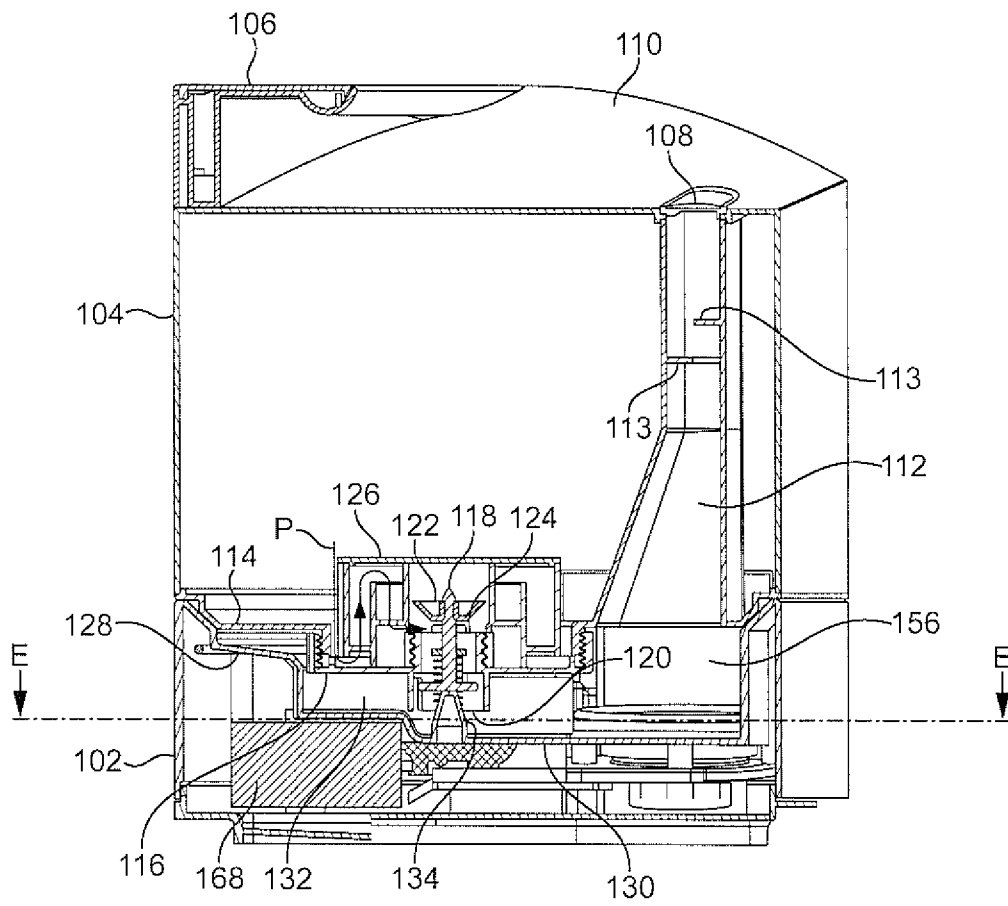


FIG. 6



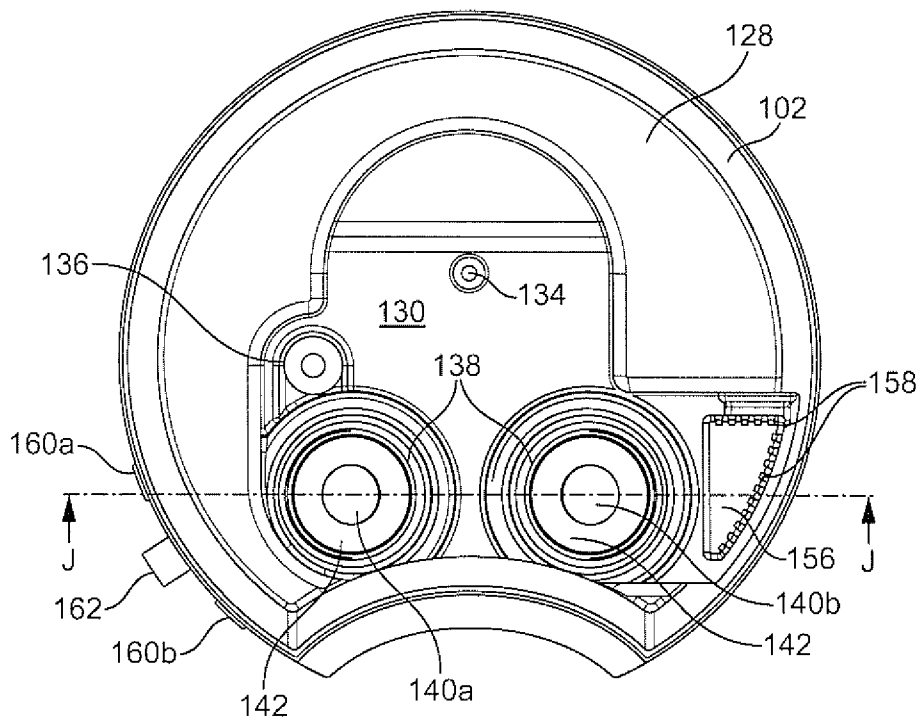


FIG. 7

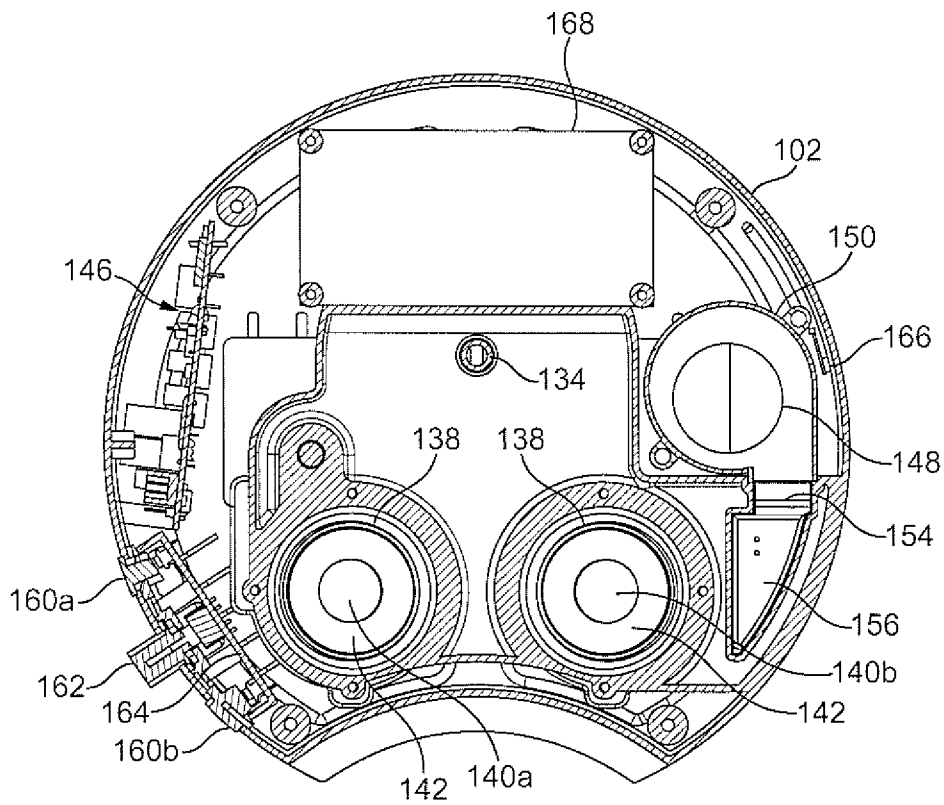


FIG. 8

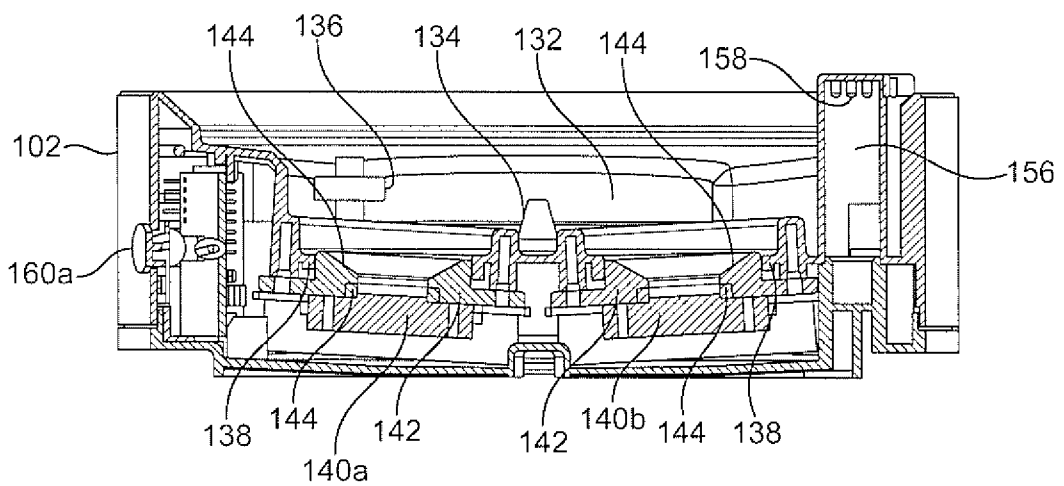


FIG. 9

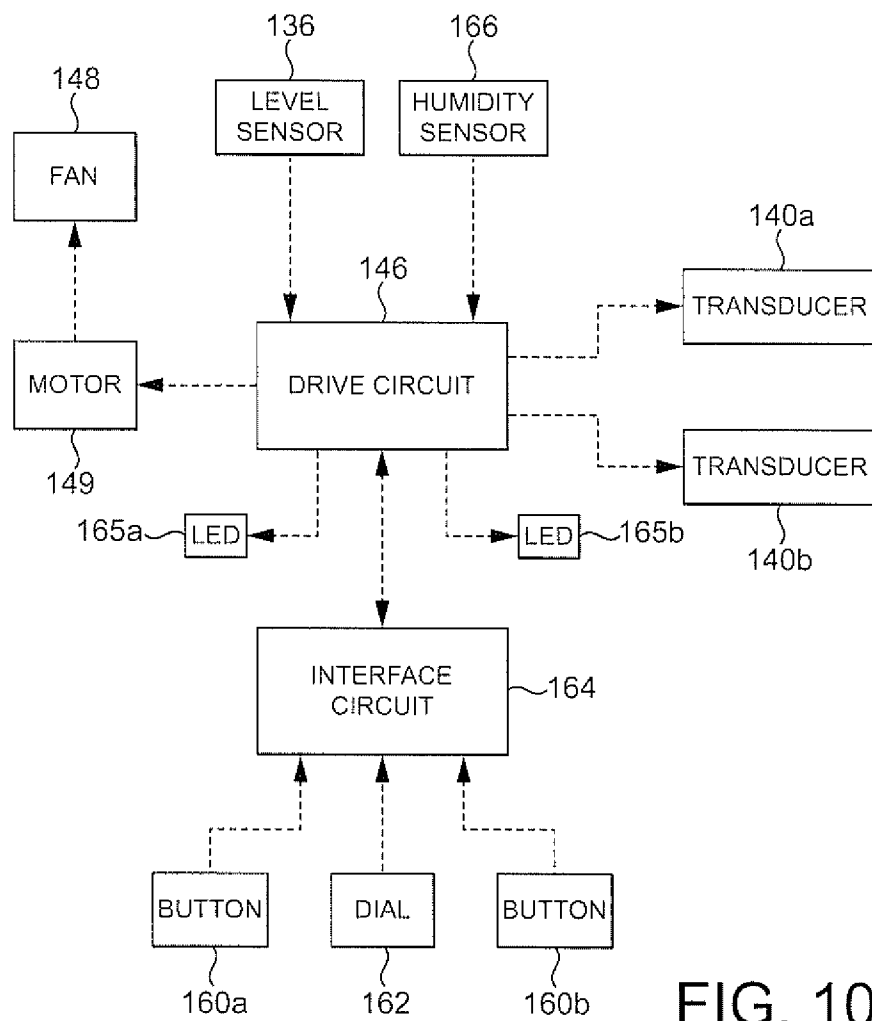


FIG. 10

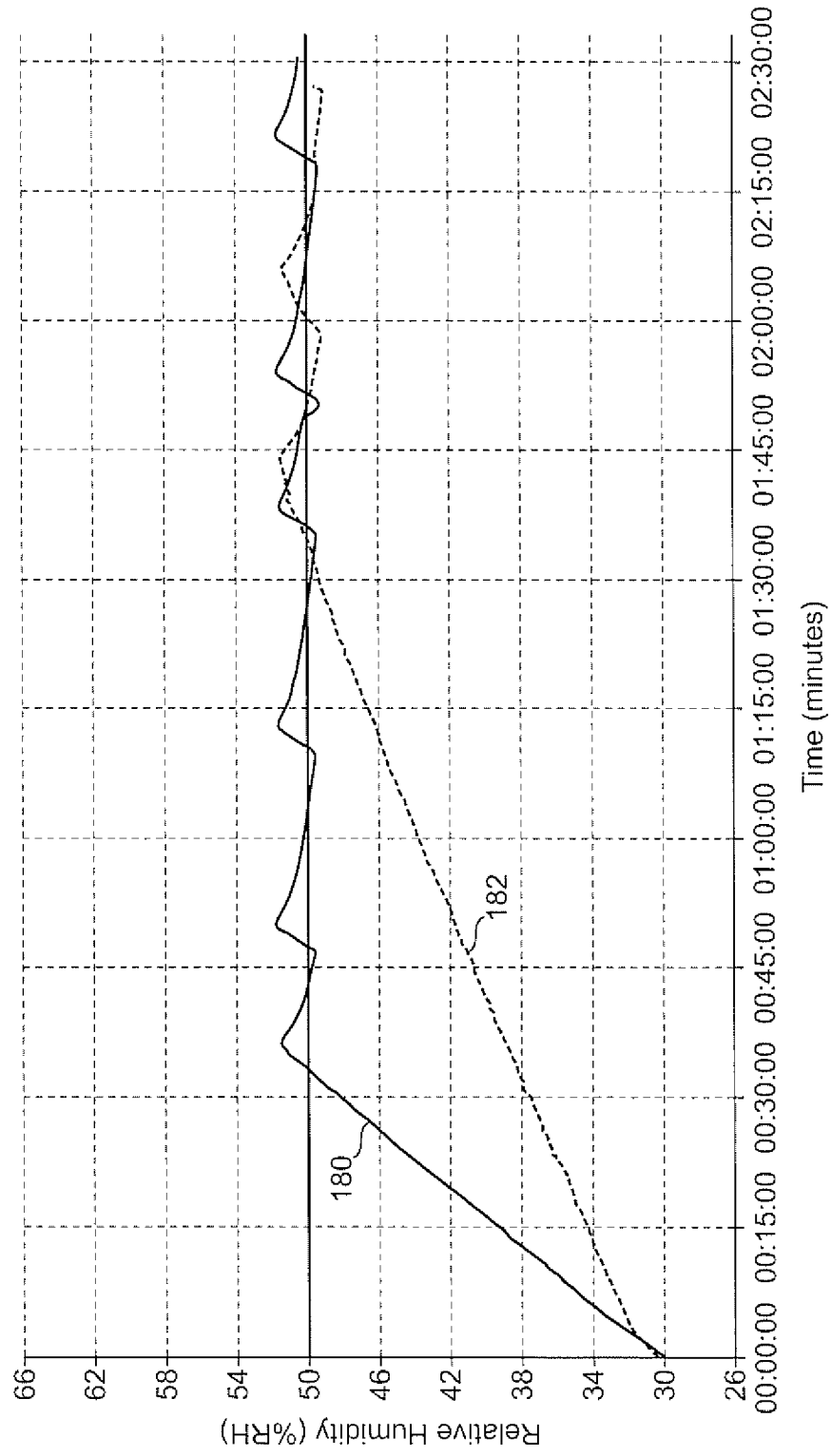


FIG. 11

# INTERNATIONAL SEARCH REPORT

International application No PCT/GB2010/050283
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**A. CLASSIFICATION OF SUBJECT MATTER**  
 INV. F24F1/01 F24F6/14 F24F13/26  
 ADD.

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)  
 F24F F04D

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

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

EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 24 51 557 A1 (SCHEEL ARNOLD DIPL ING) 6 May 1976 (1976-05-06) page 1, line 1 - page 2, line 11; claims 1-4; figure 1	1-15
X	JP 4 366330 A (TAIKISHA KK) 18 December 1992 (1992-12-18) * abstract; figures 1,3,4	1-15
A	US 4 342 204 A (MELIKIAN ZOGRAB A ET AL) 3 August 1982 (1982-08-03) column 6, line 35 - line 64; figure 1	1-15
A	WO 2008/024569 A2 (WIND MERCHANTS IP LLC [US]; COLWELL DAVID [US]) 28 February 2008 (2008-02-28) page 2, paragraph 16; figure 3	1-15
-/--		

Further documents are listed in the continuation of Box C.

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" earlier 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

30 July 2010

Date of mailing of the international search report

11/08/2010

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2  
 NL - 2280 HV Rijswijk  
 Tel. (+31-70) 340-2040,  
 Fax: (+31-70) 340-3016

Authorized officer

Vuc, Arianda

# INTERNATIONAL SEARCH REPORT

International application No  
PCT/GB2010/050283

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 02/073096 A1 (BIROT YANN [FR]) 19 September 2002 (2002-09-19) claims 7,8; figure 2 -----	1-15

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/GB2010/050283

## Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.  Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
  
2.  Claims Nos.: 16  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:  
see FURTHER INFORMATION sheet PCT/ISA/210
  
3.  Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1.  As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2.  As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3.  As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4.  No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

### Remark on Protest

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.2

Claims Nos.: 16

Claim 16 does not meet the requirements of Article 6 PCT in that the matter for which protection is sought is not clearly defined. The mere reference to the accompanying drawings does not enable the skilled person to determine which technical features are necessary to perform the function of such an apparatus, and therefore no meaningful search was possible for claim 16 (see Rule 6.2(a) PCT).

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guideline C-VI, 8.2), should the problems which led to the Article 17(2) declaration be overcome.



# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No PCT/GB2010/050283
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Patent document cited in search report	Publication date	Publication date	Patent family member(s)	Publication date
DE 2451557	A1	06-05-1976	NONE	
JP 4366330	A	18-12-1992	NONE	
US 4342204	A	03-08-1982	DE 2944027 A1 JP 56066632 A	07-05-1981 05-06-1981
WO 2008024569	A2	28-02-2008	US 2008047291 A1	28-02-2008
WO 02073096	A1	19-09-2002	FR 2821922 A1	13-09-2002