

Drying Apparatus

The invention relates to drying apparatus which makes use of a narrow jet of high velocity, high pressure air to dry an object, including part of the human body. Particularly, but not exclusively, the invention relates to a hand dryer in which the air jet is emitted through a slot-like opening in the casing of the hand dryer.

The use of air jets to dry hands is well known. Examples of hand dryers which emit at least one air jet through a slot-like opening are shown in GB 2249026A, JP 2002-034835A and JP 2002306370A. However, in practice it is very difficult to achieve an airflow of sufficiently high momentum to dry the user's hands efficiently in an acceptably short length of time. The prior art does not achieve this.

It is an object of the invention to provide drying apparatus which, in use, emits an air jet through an opening which is capable of drying an object in a short time as compared to the prior art. It is another object to provide a hand dryer which is capable of drying the user's hands in a short time in comparison to the prior art. It is a further object of the invention to provide an improved hand dryer in which the drying efficiency is improved in comparison to the prior art.

The invention provides drying apparatus having a casing, a cavity formed in the casing for receiving an object, a fan located in the casing and capable of creating an airflow, a motor arranged to drive the fan, and at least one opening communicating with the fan and arranged in the casing so as to direct an airflow transversely across the cavity, wherein, in use, the pressure of the airflow emitted through the opening is at least 8 kPa.

By providing a fan or fan apparatus capable of generating a high pressure airflow, the momentum of the airflow emitted through the opening is greatly increased in comparison to that of the prior art devices. This increases the efficiency of the dryer by

virtue of the fact that more water is blown from the object during each pass thereof through the airflow exiting the slot-like openings.

Preferably, the high pressure airflow is generated by providing a high speed motor to drive a fan, more preferably the rotor is capable of rotating at a speed of at least 80,000 rpm and preferably at a speed of at least 100, 000rpm. More preferably, the motor is a switched-reluctance motor. This preferred arrangement provides the airflow with a particularly effective level of momentum.

Alternatively, the motor includes a first and a second motor, the first motor being arranged to drive a first fan and the second motor being arranged to drive a second fan. The first and second motors are arranged to drive the first and second fan in series. In a further alternative arrangement the fan is a two stage fan, and the motor is arranged to drive the first and second stages of the fan in parallel.

In a preferred embodiment, a hand dryer has a pair of opposed slot-like openings arranged to direct an airflow across the cavity. The preferred width of the slot-like openings is no more than 0.5mm. Such an arrangement has been found to be highly effective in producing a hand dryer which is capable of drying a user's hands effectively and quickly.

An embodiment of the invention in the form of a hand dryer will now be described with reference to the accompanying drawings, in which:

Figure 1 is a side view of a hand dryer according to the invention;

Figure 2 is a perspective view of the hand dryer of Figure 1;

Figure 3 is a side sectional view of the hand dryer of Figure 1;

Figure 4 is a side sectional view, shown on an enlarged scale, of the upper ends of the air ducts forming part of the hand dryer of Figure 1;

Figure 5 is a schematic sectional side view, shown on a further enlarged scale, of the slot-like opening located in the front wall of the cavity of the hand dryer of Figure 1;

Figure 6 is a schematic sectional side view, shown on the same further enlarged scale, of the slot-like opening located in the rear wall of the cavity of the hand dryer of Figure 1;

Figure 7a is a plan view of the cavity entrance of a hand dryer according to a second embodiment of the invention;

Figure 7b is a front view of the slot-like opening located in the rear wall of the cavity of the hand dryer of Figure 7a;

Figure 8a is a schematic sectional front view, viewed from direction Y of Figure 2, of a motor arrangement for a hand dryer according to a third embodiment of the invention;

Figure 8b is a schematic sectional side view of the motor arrangement of Figure 8a;

Figure 9a is a schematic sectional front view, viewed from direction Y of Figure 2, of a motor arrangement for a hand dryer according to a fourth embodiment of the invention; and

Figure 9b is a schematic sectional side view of the motor arrangement of Figure 9a.

Referring firstly to Figures 1 and 2, the hand dryer 10 shown in the drawings comprises an outer casing 12 having a front wall 14, a rear wall 16, an upper face 18 and side walls 20, 22. The rear wall 16 can incorporate fixing devices (not shown) for securing the hand dryer 10 to a wall or other structure prior to use. An electrical connection (not

shown) is also provided on the rear wall or elsewhere on the casing 12. A cavity 30 is formed in the upper part of the casing 12 as can be seen from Figures 1 and 2. The cavity 30 is open at its upper end and delimited thereat by the top of the front wall 14 and the front of the upper face 18. The space between the top of the front wall 14 and the front of the upper face 18 forms a cavity entrance 32 which is sufficiently wide to allow a user's hands to be introduced to the cavity 30 through the cavity entrance 32. The cavity 30 is also open to the sides of the hand dryer 10 by appropriate shaping of the side walls 20, 22.

10 The cavity 30 has a front wall 34 and a rear wall 36 which delimit the cavity 30 to the front and rear respectively. Located in the lowermost end of the cavity 30 is a drain 38 which communicates with a reservoir (not shown) located in the lower part of the casing 12. The purpose of the drain and reservoir will be described below.

15 As shown in Figure 3, a motor 39 is located inside the casing 12 and a fan 40, which is driven by the motor 39, is also located inside the casing 12. The motor 39 is a brushless switched-reluctance motor and is connected to the electrical connection and is controlled by a controller 41. The inlet 42 of the fan 40 communicates with an air inlet 44 formed in the casing 12. A filter 46 is located in the air passageway connecting the air inlet 44 to the fan inlet 42 so as to prevent the ingress of any debris which might cause damage to the motor or the fan 40. The outlet of the fan 40 communicates with a pair of air ducts 50, 52 which are located inside the casing 12. The front air duct 50 is located primarily between the front wall 14 of the casing 12 and the front wall 34 of the cavity 30, and the rear air duct 52 is located primarily between the rear wall 16 of the casing 12 and the rear wall 36 of the cavity 30.

The air ducts 50, 52 are arranged to conduct air from the fan 40 to a pair of opposed slot-like openings 60, 62 which are located in the front and rear walls 34, 36 respectively of the cavity 30. The slot-like openings 60, 62 are arranged at the upper end of the cavity 30 in the vicinity of the cavity entrance 32. The slot-like openings 60, 62 are each configured so as to direct an airflow generally across the cavity entrance 32

towards the opposite wall of the cavity 30. The slot-like openings 60, 62 are offset in the vertical direction and angled towards the lowermost end of the cavity 30.

Figure 4 shows the upper ends of the air ducts 50, 52 and the slot-like openings 60, 62 in greater detail. As can be seen, the walls 54a, 54b of the air duct 50 converge to form the slot-like opening 60 and the walls 56a, 56b of the air duct 52 converge to form the slot-like opening 62. Even greater detail can be seen in Figures 5 and 6. Figure 5 shows that the slot-like opening 60 has a width of W1 and Figure 6 shows that the slot-like opening 62 has a width of W2. The width W1 of the slot-like opening 60 is smaller than the width W2 of the slot-like opening 62. The width W1 is 0.3mm and the width W2 is 0.4mm.

Sensors 64 are positioned in the front and rear walls 34, 36 of the cavity 30 immediately below the slot-like openings 60, 62. These sensors 64 detect the presence of a user's hands which are inserted into the cavity 30 via the cavity entrance 32 and are arranged to send a signal to the motor when a user's hands are introduced to the cavity 30. As can be seen from Figures 1 and 3, the walls 54a, 54b, 56a, 56b of the ducts 50, 52 project slightly beyond the surface of the front and rear walls 34, 36 of the cavity 30. The inward projection of the walls 54a, 54b, 56a, 56b of the ducts 50, 52 reduces the tendency of the user's hands to be sucked towards one or other of the walls 34, 36 of the cavity, which enhances the ease with which the hand dryer 10 can be used. The positioning of the sensors 64 immediately below the inwardly projecting walls 54a, 54b, 56a, 56b of the ducts 50, 52 also reduces the risk of the sensors 64 becoming dirty and inoperative.

As can be seen from Figure 2, the shape of the cavity entrance 32 is such that the front edge 32a is generally straight and extends laterally across the width of the hand dryer 10. However, the rear edge 32b has a shape which consists of two curved portions 33 which generally follow the shape of the backs of a pair of human hands as they are inserted downwardly into the cavity 30 through the cavity entrance 32. The rear edge 32b of the cavity entrance 32 is substantially symmetrical about the centre line of the

hand dryer 10. The intention of the shaping and dimensioning of the front and rear edges 32a, 32b of the cavity entrance 32 is that, when a user's hands are inserted into the cavity 30 through the cavity entrance 32, the distance from any point on the user's hands to the nearest slot-like opening is substantially uniform.

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The hand dryer 10 described above operates in the following manner. When a user's hands are first inserted into the cavity 30 through the cavity entrance 32, the sensors 64 detect the presence of the user's hands and send a signal to the motor 39 to drive the fan 40. The motor 39 has a rotor which is then driven at a very high speed, namely at a speed of at least 80,000 rpm and preferably at a speed of at least 100,000 rpm. The fan 40 is thus rotated at a similarly very high speed and air is drawn into the hand dryer 10 via the air inlet 44 at a rate of approximately 20 to 40 litres per second and preferably at a rate of least 25 to 27 litres per second, more preferably air is drawn into the hand dryer 10 at a rate of 31 to 35 litres per second. The air passes through the filter 46 and along the fan inlet 42 to the fan 40. The airflow leaving the fan 40 is divided into two separate airflows; one passing along the front air duct 50 to the slot-like opening 60 and the other passing along the rear air duct 52 to the slot-like opening 62.

The airflow ejected from the slot-like openings 60, 62 in the form of very thin, stratified sheets of high velocity air. The airflow approaching the slot-like openings is in the form of sheets of high velocity, high pressure air. As the airflows approach and leave the slot-like openings 60, 62, the air pressure is at least 15 kPa and preferably approximately 20 to 23 kPa, or preferably at least 23kPa and more preferably 25 to 30kPa. Furthermore, the speed of the airflow leaving the slot-like openings 60, 62 is at least 80 m/s and preferably at least 100 or 150 m/s, more preferably approximately 180m/s. Because the size of the slot-like opening 62 located at the end of the rear duct 52 is greater than the size of the slot-like opening 60 located at the end of the front duct 50, a larger volume of air is emitted from the duct 52 than from the duct 50. This provides a greater mass of air for drying the backs of the user's hands which is advantageous.

The two thin sheets of stratified, high velocity, high pressure air are directed towards the surfaces of the user's hands which, during use, are inserted fully into the cavity 30 and are subsequently withdrawn from the cavity 30 via the cavity entrance 32. As the user's hands pass into and out of the cavity 30, the sheets of air blow any existing water off the user's hands. This is achieved reliably and effectively because of the high pressure of the air moving towards the slot-like openings 60, and 62 and due to the momentum of the air leaving the slot-like openings 60, 62 and also because the airflow is evenly distributed along the length of each slot-like opening 60, 62.

Each stratified sheet of air is directed towards the wall of the cavity 30 which is remote from the slot-like opening through which the respective sheet of air is emitted. Because the slot-like openings 60, 62 are also inclined towards the lowermost end of the cavity 30, the emitted airflows are directed into the cavity 30. This reduces the risk of turbulent air movement being felt by the user outside the casing, eg in the user's face.

It is envisaged that it will take only a small number of "passes" of the hand dryer described above to dry a user's hands to a satisfactory degree. (By "pass", we mean a single insertion of the hands into the cavity and subsequent removal therefrom at a speed which is not unacceptable to an average user. We envisage that a single pass will have a duration of no more than 3 seconds.) The momentum achieved by the airflows is sufficient to remove the majority of water found on the surface of the user's hands after washing during a single pass.

The water removed by the airflows is collected inside the cavity 30. Each airflow will rapidly lose its momentum once it has passed the user's hands and the water droplets will fall to the lower end of the cavity 30 under the forces of gravity whilst the air exits the cavity 30 either through the cavity entrance 32 or via the open sides of the cavity 30. The water, however, is collected by the drain 38 and passed to a reservoir (not shown) where it is collected for disposal. The reservoir can be emptied manually if desired. Alternatively, the hand dryer 10 can incorporate some form of water dispersal system including, for example, a heater for evaporating the collected water into the atmosphere.

The means by which the collected water is dispersed does not form part of the present invention.

In an alternative embodiment shown in Figures 7a and 7b the slot-like openings are not
5 of constant width across the length L of the cavity of the hand dryer. Figure 7a shows a plan view of the cavity entrance of length L. The dotted lines indicate the position and shape of the user's hands as they are normally inserted into the cavity 30 between the front and rear edges 32a, 32b. The arrows 80 shown in Figure 7a indicate the direction of the airflow emitted from the slot-like openings 60, 62 located in the edges 32a, 32b of
10 the cavity entrance 32. In this embodiment the curved portions 33 of the rear edge 32b are symmetrical about the centre line A-A of the cavity entrance 32 with the centre portion of the rear edge 32b being closer to the front edge 32a at the centre line than at a position spaced from the centre line. The minimum distance d between the front and rear edges 32a, 32b is at the centre line. The distance between the front edge 32a and
15 the rear edge 32b is at a maximum, D, at the mid point of each curved portion. Figure 7b shows the shape of the slot-like opening located in the rear wall of the cavity.

Preferably, the width of the slot-like opening in the rear wall varies gradually, increasing towards the mid point of the opening, at centre line A-A of cavity entrance
20 32.

In this alternative embodiment it is preferred that the variation in width of the opening is achieved by varying the distance of the upper wall of the slot-like opening away from the lower wall, in the shape of a curve, preferably in a smoothly curving shape. More
25 preferably the curve is symmetrical about centre line A-A of the cavity entrance 32. Preferably the maximum width R of the opening is at centre line A-A and is 0.7mm.

Preferably, the width r is substantially constant in regions F and G with the varying width region (region E in Figures 7a and 7b) comprising at least half the total length L
30 of the cavity entrance, most preferably the central half. Preferably r is 0.4mm.

In region E of the hand dryer the width of the slot-like opening 62 is greater than the width of the slot-like opening 62 in regions F and G. The increase in size of the slot-like opening 62 provides a greater mass of air 80 from rear duct 52 for drying the backs of the user's hands in the thumb and forefinger area which is advantageous. The greater
5 mass of air in region E and the momentum achieved by the airflow is sufficient to remove the majority of water found on the backs of the user's hands after washing during a single pass.

In a further alternative embodiment shown in Figures 8a and 8b the high pressure
10 airflows are generated with an alternative motor and fan arrangement. The arrows shown in Figures 8a and 8b represent the airflows through the motor arrangement. Motors 90 and 92, and fans 91 and 93, which are driven by motors 90 and 92, are located inside the casing 12. As shown in Figure 8a fan 91 is driven by motor 90 and fan 93 is driven by motor 92. The motors are AC motors and each is connected to the
15 electrical connection and is controlled by a controller. The inlet 94, 95 of each fan 91, 93 communicates with an air inlet 44 (not shown) formed in the casing 12. The outlet 96, 97 of each fan 91, 93 is in the form of a scroll or collector and communicates with a common collector 98. A diffuser element 99 is provided in outlet scrolls 96, 97 to increase the airflow pressure. The common collector 98 communicates with a pair of air
20 ducts 50, 52 which are located inside the casing 12.

The motor 90, 92 and fan 91, 93 arrangement described above operates in the following manner. As in the first embodiment described above, when a user's hands are first inserted into the cavity 30 through the cavity entrance 32, the sensors 64 detect the
25 presence of the user's hands and send a signal to motors 90, 92 to drive the fans 91, 93. Each motor 90, 92 has a rotor which is then driven at a speed, of approximately 30, 000 to 40, 000 rpm. Each fan 91, 93 is thus rotated at a similar speed and air is drawn into the hand dryer 10 via the air inlet 44 at a rate of approximately 20 to 40 litres per second. The arrangement of the fans in parallel creates a high volume airflow. The air
30 passes along fan inlet 94 to the fan 91 and air passes along fan inlet 95 to the fan 93. The airflow leaving fan 91 is collected in scroll 96 and the airflow leaving fan 93 is

collected in scroll 97. The airflows are collected in a common collector 98. The airflow leaving the common collector 98 is divided into two separate airflows; one passing along front air duct 50 to the slot-like opening 60 and the other passing along the rear air duct 52 to the slot-like opening 62.

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In a further alternative embodiment shown in Figures 9a and 9b the high pressure airflows are generated with a second, alternative motor and fan arrangement. The arrows shown in Figures 9a and 9b represent the airflows through the motor arrangement. Motor 100 and fans 101 and 103, driven by motor 100, are located inside the casing 12. As shown in Figure 9a fan 101 and fan 103 are driven in series by motor 100. Motor 100 is connected to the electrical connection and is controlled by a controller. The motor 100 may be an AC motor or a brushless switched-reluctance motor. The inlet 104, 105 of each fan 101, 103 communicates with an air inlet 44 (not shown) formed in the casing 12. The outlet 106, 107 of each fan 101, 103 is in the form of a scroll or collector. Outlet 106 communicates with a return bend or scroll 108 which communicates with inlet 105. The outlet 107 communicates with a pair of air ducts 50, 52 which are located inside the casing 12. A diffuser element 99 is provided in outlet scrolls 106, 107 to increase the airflow pressure.

20 The motor 100 and fan 101, 103 arrangement described above operates in the following manner. As in the first embodiment, when a user's hands are first inserted into the cavity 30 through the cavity entrance 32, the sensors 64 detect the presence of the user's hands and send a signal to motor 100 to drive the fans 101, 103. The motor 100 has a rotor which is then driven at a speed, of approximately 30, 000 to 40, 000 rpm, or alternatively at speeds up to 80, 000rpm or 100, 000 rpm. Each fan 101, 103 is thus rotated at a similar speed and air is drawn into the hand dryer 10 via the air inlet 44 at a rate of approximately 20 to 40 litres per second. The arrangement of the fans in series creates a high pressure airflow, even with a low speed motor. The air passes along fan inlet 104 to the fan 101, the air leaving fan 101 is collected at outlet 106. The airflow leaving outlet 106 is returned to inlet 105 along return bend 108. The airflow from bend 108 is directed to fan inlet 105 and then to the fan 103. A diffuser element 109 is

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provided in outlet scrolls 106, 107 to increase the airflow pressure. The airflow leaving the outlet 107 is divided into two separate airflows; one passing along front air duct 50 to the slot-like opening 60 and the other passing along the rear air duct 52 to the slot-like opening 62.

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The alternative arrangements shown in Figures 8a, 8b, 9a and 9b provide fan apparatus capable of generating a high pressure airflow with a particularly effective level of momentum emitted through the opening. The arrangements of motors and fans, including different types of fan, for example a compressor fan and one or more
10 impellers could be altered without departing from the essence of the present invention. Other elements could also be altered such as the number of fans, the shape of fan and also the fan outlets and the shape of the collectors could be altered.

The invention is not intended to be limited to the precise detail of the embodiments
15 described above. Modifications and variations to the detail which do not alter the scope of the invention will be apparent to a skilled reader. For example, the shape of the cavity 30 and its entrance 32 may be altered without departing from the essence of the present invention. Also, the slot-like openings described above may be replaced by
20 lines of individual nozzles, each of which emits a jet of air towards the object placed within the cavity.

CLAIMS

1. Drying apparatus having a casing, a cavity formed in the casing for receiving an
5 object, a fan located in the casing and capable of creating an airflow, a motor arranged
to drive the fan, and at least one opening communicating with the fan and arranged in
the casing so as to direct an airflow transversely across the cavity, wherein, in use, the
pressure of the airflow emitted through the opening is at least 8 kPa.
- 10 2. Drying apparatus as claimed in claim 1, wherein the motor has a rotor which, in
use, is capable of rotating at a speed of at least 80,000 rpm.
3. Drying apparatus as claimed in claim 1 or 2, wherein the motor has a rotor
which, in use, is capable of rotating at a speed of at least 100,000 rpm.
- 15 4. Drying apparatus as claimed in any one of claims 1, 2 or 3, wherein the motor is
a switched-reluctance motor.
5. Drying apparatus as claimed in claim 1, wherein the fan is a two stage fan, the
20 motor arranged to drive the first and second stages in parallel.
6. Drying apparatus as claimed in claim 1, the motor comprising a first and a
second motor, the first motor arranged to drive a first fan and the second motor arranged
to drive a second fan, wherein the first and second motors are arranged to drive the first
25 and second fan in series.
7. Drying apparatus as claimed in any one of the preceding claims, wherein the at
least one opening comprises a pair of opposed slot-like openings arranged to direct an
airflow across the cavity.

8. Drying apparatus as claimed in claim 7, wherein the width of each slot-like opening is no more than 0.5 mm.
9. Drying apparatus as claimed in claim 8, wherein, in use, the velocity of the
5 airflow emitted through the slot-like opening is at least 100 m/s.
10. Drying apparatus as claimed in any one of the preceding claims, wherein, in use, the pressure of the airflow emitted through the slot-like opening is at least 15 kPa.
- 10 11. Drying apparatus as claimed in any one of the preceding claims, wherein, in use, the pressure of the airflow emitted through the slot-like opening is at least 20 kPa.
12. Drying apparatus as claimed in any one of the preceding claims, wherein the drying apparatus is a hand dryer.
- 15 13. Drying apparatus substantially as hereinbefore described with reference to the accompanying drawings.